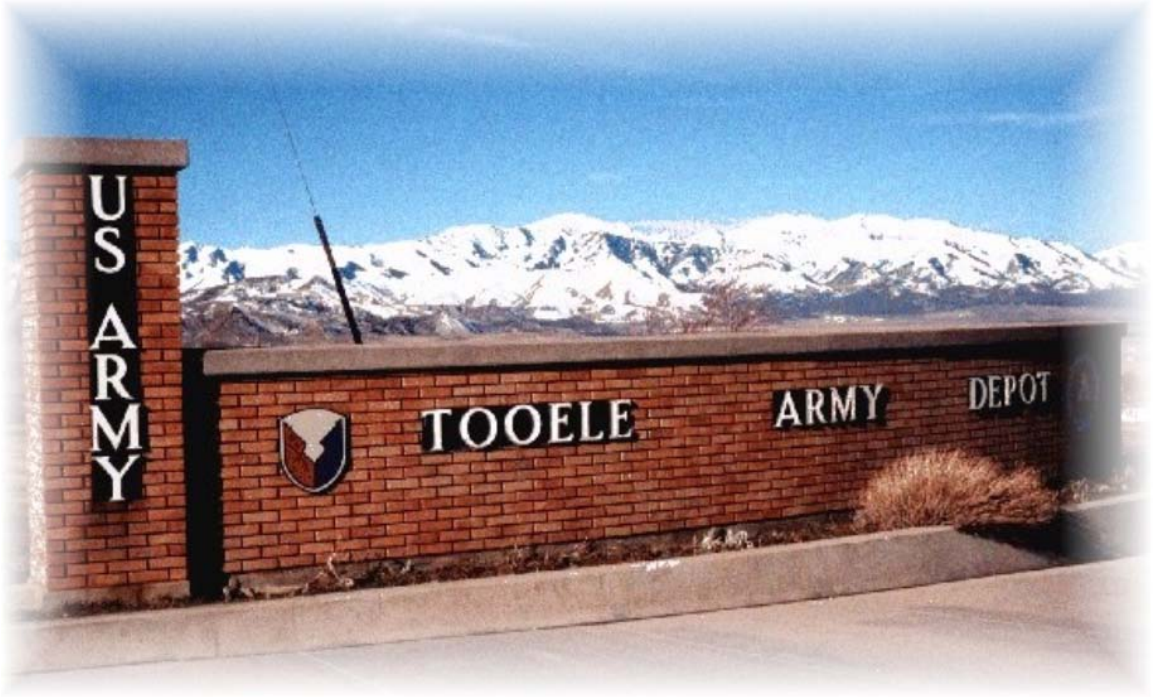
# CHEMICAL DATA QUALITY MANAGEMENT PLAN (CDQMP)

## Tooele Army Depot
## Tooele, Utah




**Revised Final - Version 5**

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This appendix includes standard operating procedures for use by field and administrative personnel represent and supplement the information presented in the CDQMP in a procedural format.

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|---|---|---|
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**Example Forms**

# Appendix E

## *Electronic Data Deliverable Specification*

*Electronic Data Specification* - This specification provides for a deliverable consistent with the latest Environmental Restoration Program Information Management System (ERPIMS) format. The *ERPIMS '98 Data Loading Handbook, Version 4.0* (October 1997) is incorporated by reference.

# Appendix F

## *DoD QSM Appendix F and G SW846 Analytical Requirements*

## *List of Acronyms*

| | |
|---|---|
| *ACS* | *American Chemical Society* |
| *ANSI* | *American National Standards Institute* |
| *AR/COC* | *Analysis Request/Chain of Custody Record* |
| *ARAR* | *Appropriate, Relevant, and Applicable Requirements* |
| *ASQC* | *American Society for Quality Control* |
| *ASTM* | *American Society of Testing and Materials* |
| *ATL* | *Audit Team Leader* |
| *BRAC* | *Base Realignment and Closure* |
| *BS/BSD* | *Blank Spike/Blank Spike Duplicate* |
| *BTEX* | *Benzene, Toluene, Ethylbenzene, and Xylene* |
| *CAE* | *Contractor Acquired Equipment* |
| *CAR* | *Corrective Action Requests* |
| *CDQAR* | *Chemical Data Quality Assessment Report* |
| *CDQMP* | *Chemical Data Quality Management Plan* |
| *CERCLA* | *Comprehensive Environmental Response Compensation and Liability Act* |
| *CIH* | *Certified Industrial Hygienist* |
| *CLP* | *EPA Contract Laboratory Program* |
| *CMD* | *Corrective Measures Design* |
| *CMS* | *Corrective Measures Study* |
| *COC* | *Chain-of-Custody* |
| *DERP* | *Defense Environmental Restoration Program* |
| *DOD* | *Department of Defense* |
| *DOE* | *U.S. Department of Energy* |
| *DOT* | *U.S. Department of Transportation* |
| *DQCR* | *Daily Quality Control Report* |
| *DQO* | *Data Quality Objective* |
| *DRO* | *Diesel Range Organics* |
| *EB* | *Equipment Blank* |
| *EE/CA* | *Engineering Evaluation/Cost Analysis* |
| *ELAP* | *Environmental Laboratory Accreditation Program* |
| *EM* | *Engineer Manual* |
| *EPA* | *United States Environmental Protection Agency* |
| *ER* | *Engineer Regulation* |
| *FADL* | *Field Activity Daily Log* |
| *FS* | *Feasibility Study* |
| *FSP* | *Field Sampling Plan* |
| *FUDS* | *Formerly Used Defense Sites* |
| *FWV* | *Field Work Variance* |
| *GFE* | *Government Furnished Equipment* |
| *gm* | *Gram* |
| *GRO* | *Gasoline Range Organics* |
| *H&S* | *Health and Safety* |
| *HTRW* | *Hazardous, Toxic, and Radioactive Waste* |
| *IATA* | *International Air Transportation Association* |

| | |
|---|---|
| *ID* | *Identification* |
| *IFB* | *Invitation for Bid* |
| *IRP* | *Installation Restoration Program* |
| *ISO* | *International Standards Organization* |
| *ISO* | *International Standards Organization* |
| *Kg* | *Kilogram(s)* |
| *L* | *Liter(s)* |
| *LCS/LCSD* | *Laboratory Control Sample / Laboratory Control Sample Duplicate* |
| *LQMM* | *Laboratory Quality Management Manual* |
| *LRL* | *Laboratory Reporting Limit* |
| *LUFT* | *Leaking Underground Fuel Tank* |
| *MB* | *Method Blank* |
| *MDL* | *Method Detection Limit* |
| *MFR* | *Memorandum for Record* |
| *µg* | *Microgram(s)* |
| *µl* | *Microliter(s)* |
| *MIPR* | *Military Interdepartmental Purchase Request* |
| *ml* | *Milliliter* |
| *MQL* | *Method Quantitation Limit* |
| *MS/MSD* | *Matrix Spike / Matrix Spike Duplicate* |
| *NCR* | *Nonconformance Report* |
| *NELAC* | *National Environmental Laboratory Accreditation Conference* |
| *NELAP* | *National Environmental Laboratory Accreditation Program* |
| *NEPA* | *National Environmental Policy Act* |
| *NPL* | *National Priorities List* |
| *NPL* | *Superfund National Priority List* |
| *O&M* | *Operation and Maintenance* |
| *OE* | *Ordnance and Explosives* |
| *OSHA* | *Occupational Safety and Health Administration* |
| *PA* | *Preliminary Assessment* |
| *PARCC* | *Precision, Accuracy, Representativeness, Completeness, and Comparability* |
| *PCBs* | *Polychlorinated biphenyls* |
| *PE* | *Performance Evaluation* |
| *PHSP* | *Program Health and Safety Plan* |
| *PM* | *Program Manager* |
| *PO* | *Purchase Order* |
| *POC* | *Point of Contact* |
| *ppb* | *Part(s) per Billion* |
| *ppm* | *Part(s) per Million* |
| *PRP* | *Principle Responsible Party* |
| *QA* | *Quality Assurance* |
| *QA/QCM* | *QA/QC Manager* |
| *QAP* | *Quality Assurance Plan* |
| *QAPP* | *Quality Assurance Project Plan* |
| *QC* | *Quality Control* |
| *QSM* | *Quality Systems Manual* |

| | |
|---|---|
| *RAC* | *Remedial Action Contract* |
| *RCRA* | *Resource Conservation and Recovery Act* |
| *RD* | *Remedial Design* |
| *RFA* | *RCRA Facility Assessment* |
| *RFI* | *RCRA Facility Investigation* |
| *RFP* | *Request for Proposal* |
| *RI* | *Remedial Investigation* |
| *ROD* | *Record of Decision* |
| *RPD* | *Relative Percent Difference* |
| *SAP* | *Sampling and Analysis Plan* |
| *SARA* | *Superfund Amendments and Reauthorization Act* |
| *SI* | *Site Inspection* |
| *SOP* | *Standard Operating Procedure* |
| *SOV* | *Soil Organic Vapor* |
| *SQP* | *Standard Quality Procedure* |
| *SSHP* | *Site Safety and Health Plan* |
| *SVOA* | *Semivolatile Organic Analysis* |
| *TDS* | *Total Dissolved Solids* |
| *TERC* | *Total Environmental Restoration Contract* |
| *TIC* | *Tentatively Identified Compound* |
| *TM* | *Technical Manager* |
| *TNI* | *The NELAC Institute* |
| *TPH* | *Total Petroleum Hydrocarbons* |
| *TRPH* | *Total Recoverable Petroleum Hydrocarbons* |
| *TSS* | *Total Suspended Solids* |
| *UFP-QAPP* | *Uniform Federal Policy for Quality Assurance Project Plans* |
| *U.S. Army* | *U.S. Department of the Army* |
| *USACE* | *U.S. Army Corps of Engineers* |
| *UST* | *Underground Storage Tank* |
| *VECP* | *Value Engineering Change Proposals* |
| *VOA* | *Volatile Organic Analysis* |
| *VOC* | *Volatile Organic Compound* |
| *°C* | *Degrees Celsius* |

## *Terms and Definitions*

***Acceptance Criteria*** *- Specified limits placed on characteristics of an item, process, or service defined in codes, standards, or other requirement documents.*

***Accreditation:*** *The process by which an agency or organization evaluates and recognizes a laboratory as meeting certain predetermined qualifications or standards, thereby accrediting the laboratory. In the context of the National Environmental Laboratory Accreditation Program (NELAP), this process is a voluntary one.*

***Accrediting Authority:*** *The Territorial, State, or Federal agency having responsibility and accountability for environmental laboratory accreditation and which grants accreditation. (NELAC).*

***Accuracy*** *- The closeness of agreement between the measured value and the true value. Calculated as percent recovery.*

***Activities that Affect Quality*** *- Activities that, if not performed properly, could compromise the validity of information or data reported, which could result in an unacceptable risk to the environment, health, or safety of the public or the workers involved, or could have a detrimental effect on the achievement of the project objectives.*

***Activity*** *- An all-inclusive term describing a specific set of operations or related tasks to be performed, either serially or in parallel, that in total result in a product or service.*

***Assessment*** *- An all-inclusive term used to denote any of the following: audit, performance evaluation, management systems review, peer review, or surveillance performed by or for management.*

***Audit*** *- A planned and documented activity performed to determine by investigation, examination, or evaluation of objective evidence the adequacy of and compliance with established procedures, instructions, drawings, and other applicable documents, the effectiveness of implementation and whether the results are suitable to achieve objectives. An audit should not be confused with surveillance or inspection activities performed for the sole purpose of process control or product acceptance.*

***Audit Team*** *- One or more persons who are responsible for audit performance and reporting. The team may consist of, or is headed by, an individual designated as the Audit Team Leader.*

***Audit Team Leader*** *- The individual responsible who organizes and directs the audit, coordinates the preparation and issuance of the Audit Report, and evaluates the responses.*

***Bias*** *- The systemic or persistent distortion of a measurement process which causes errors in one direction.*

***CDQMP*** *- A document that describes the management system for planning, performing, and assessing work to ensure that the results demonstrate stated quality, technical, and performance objectives. The CDQMP will describe the organizational structure, QC policies and procedures,*

*functional responsibilities, levels of accountability and authority, and necessary interfaces for organizations performing activities in support of the program management office.*

***Chain-of-custody*** *- An unbroken trail of accountability that ensures the physical security of samples, data, and records.*

***Characteristic*** *- Any property or attribute of a datum, item, process, or service that is distinct, describable and/or measurable.*

***Comparability*** *- A qualitative characteristic which defines the extent to which a chemical parameter measurement is consistent with, and may be compared to, values from other sampling events.*

***Completeness*** *- A quantitative evaluation of what percent of the chemical measurements met the project data quality objectives.*

***Conformance*** *- An affirmative indication or judgment that a product or service has met the requirements of the relevant specifications, contract, or regulation.*

***Controlled Documents*** *- Documents which have been assigned a unique identifier and issued to a specific person, discipline, or facility. These documents are maintained current by accounting for their initial issue and revisions.*

***Corrective Action*** *- Measures taken to rectify conditions adverse to quality and, where possible, to preclude their recurrence.*

***Data Quality Objectives*** *- Qualitative and quantitative statements that clarify technical and quality 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 for support decisions.*

***Data Quality Assessment*** *- A statistical and scientific evaluation of the data set to determine the validity and performance of the data collection design and statistical test, and the adequacy of the data set for its intended use.*

***Data Useability Review*** *- The process of ensuring or determining whether the quality of the data produced meets the intended use of the data.*

***Data of Known Quality*** *- Data that have the qualitative and quantitative components associated with their derivation documented appropriately for their intended use, and such documentation is verifiable and defensible.*

***Data Verification*** *- The process for evaluating the completeness, correctness, consistency, and compliance of a data package against a standard or contract.*

***Data Validation*** *- The process of data assessment in accordance with EPA regional or national functional guidelines or project-specific guidelines. Confirmation by examination and provision of evidence that specified requirements have been met. (NELAC)*

***Data Assessment*** *- The all-inclusive process used to measure the effectiveness of a particular data gathering activity. This process may be comprised of data verification, data review, data evaluation, and data validation.*

***Data Evaluation*** *- The process of data assessment done by the district project chemist to produce a chemical data quality assessment report.*

***Deficiency*** *- An unauthorized deviation from approved procedures or practices, or a defect in an item.*

***Definitive Data*** *- Data that are generated using rigorous, analyte-specific analytical methods where analyte identifications and quantitations are confirmed and QA/QC requirements are satisfied.*

***Design Review*** *- A documented evaluation by a team, including personnel such as the responsible designers, the client for the work or product being designed, and a QA representative, but other than the original designers, to determine if a proposed design will meet the established design criteria and perform as expected when implemented.*

*Detection Limit (DL) Per the DOD QSM, the smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration at the 99% level of confidence. At the DL, the false positive rate (Type I error) is 1%.*

***Document*** *- Any written or pictorial information describing; defining; specifying; reporting; or certifying activities, requirements, procedures, or results.*

***Duplicate Sample*** *- A sample replicate collected as near as possible at an identical time and place as an original sample. Sometimes used in place of a split sample for volatile analytes, or to assess overall sample matrix homogeneity (see also split sample).*

***Entity*** *- Something which can be individually described and considered, such as a process, product, item, organization, or combination thereof.*

***External Audit*** *- An audit of those portions of another organization's QA program not under the direct control or within the organizational structure of the auditing organization.*

***Field Work Variance*** *- Documented authorization from the Contracting Officer to depart from specified requirements.*

***Finding*** *- A document statement of fact concerning a noncompliance or deviation from established requirements.*

***HTRW Activities*** *- Activities undertaken for the U.S. EPA's Superfund Program, the Defense Environmental Restoration Program (DERP), including Formerly Used Defense Sites (FUDS) and Installation Restoration Program (IRP) sites at active DOD facilities, HTRW actions associated with Civil Works projects, and any other mission or non-mission work performed for others at HTRW sites. Such activities include, but are not limited to, Preliminary Assessments/Site Inspections (PA/SI), Remedial Investigations (RI), Feasibility Studies (FS),*

*Engineering Evaluation/Cost Analyses (EE/CA), RCRA Facility Investigations/Corrective Measures Studies/Corrective Measures Implementation/Closure Plans/Part B Permits, or any other investigations, design activities, or remedial construction at known, suspected, or potential HTRW sites. HTRW activities also include those conducted at petroleum tank sites and construction sites containing HTRW.*

***Independent Assessment*** *- An assessment performed by a qualified individual, group, or organization that is not a part of the organization directly performing and accountable for the work being assessed.*

***Inspection*** *- Examination or measurement of an item or activity to verify conformance to specific requirements.*

***Inspector*** *- A person who performs inspection activities to verify conformance to specific requirements.*

***Internal Audit*** *- An audit of those portions of an organization's QA/QC program retained under its direct control and within its organizational structure.*

***Item*** *- An all-inclusive term used in place of any of the following: appurtenance, facility, sample, assembly, component, equipment, material, module, part, structure, subassembly, subsystem, system, unit, documented concepts, or data.*

***Limit of Detection (LOD)*** *- Is the smallest amount or concentration of a substance that must be present in a sample in order to be detected at a 99% confidence level. In other words, if a sample has a true concentration at the LOD, there is a minimum probability of 99% of reporting a "detection" (a measured value ≥ DL) and a 1% chance of reporting a non -detect (a false negative).*

***The Limit of Quantitation (LOQ )- I****s the lowest concentration of a substance that produces a quantitative result within specified limits of precision and bias. The LOQ is typically larger than the LOD (but may be equal to the LOD, depending upon the acceptance limits for precision and bias); therefore, the following is true:*

$$DL < LOD \leq LOQ$$

*Quantitative results can only be achieved at or above the LOQ. Measurements between the DL and the LOQ assure the presence of the analyte with confidence, but their numeric values are estimates.*

***Management System*** *- A structured non-technical system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for conducting work and for producing items and services.*

***Management*** *- Those individuals directly responsible and accountable for planning, implementing, and assessing work.*

***Method Detection Limit (MDL)*** *- The MDL is the minimum concentration of a substance that can be measured within a given matrix and reported with 99% confidence that the analyte concentration is greater than zero (40 CFR 136 App. B). The MDL is obtained by seven replicate analyses of the matrix for the analyte under investigation at a concentration level which is two to five times the estimated MDL. The MDL is defined as three times the standard deviation of the replicate sample results.*

***Method*** *- A body of procedures and techniques for performing an activity systematically presented in the order in which they are to be executed.*

***Nonconformance (NCR)*** *- A deficiency in characteristic documentation or procedure which renders the quality of an item unacceptable or indeterminate with respect to project criteria. Examples of nonconformances include, but are not limited to test failures, physical defects, incorrect or inadequate documentation, data losses, or deviation from prescribed processing, inspection, or procedure.*

***Objective Evidence*** *- Any documented statement of fact, other information, or record, either quantitative or qualitative, pertaining to the quality of an item or activity that is based on observations, measurements, or tests that can be verified.*

***Observation*** *- A statement of fact regarding the potential for a noncompliance which could lead to a more serious problem if not identified and/or corrected, but which does not constitute a lack of compliance with established requirements.*

***Ordnance and Explosives (OE) Activities****. - All work undertaken to manage or eliminate the immediate risks associated with OE related material. OE activities are usually response activities undertaken for DERP, FUDS, or Base Realignment and Closure (BRAC) projects. OE responses include site inventories, preliminary assessments, site investigations, public involvement, engineering estimates, cost analyses, action memoranda, removal designs, removals (both time critical & non-time critical), and clean-up of residual OE.*

***Precision*** *- A measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions, expressed generally in terms of standard deviation.*

***Preparatory Inspection*** *- A systematic, documented review of the readiness for startup or continued extended use of a facility, process, or activity. Preparatory inspections are typically conducted before proceeding beyond project milestones and prior to institution of a major phase of work activities.*

***Primary Laboratory*** *- Laboratory that analyzes the majority of the project samples.*

***Procedure*** *- A document that specifies or describes how an activity is to be performed.*

***Process*** *- A set of interrelated resources and activities which transforms inputs into outputs.*

***Procurement Document*** *- Purchase requisitions, purchase orders, drawings, contracts, specifications, or instructions used to define requirements for purchase.*

***Program Manager*** *- The organizational manager having direct responsibility for administration and direction of the Contract.*

***Project Manager*** *- The leader of the project team, responsible for managing the project parameters (budget, cost, safety, schedule, scope and quality), as well as interfacing with those involved in the project process (customers, functional elements, government, and non-government entities).*

***Project*** *- An organized set of activities within a program.*

***Qualification (Personnel)*** *- The characteristics or abilities gained through education, training, and/or experience, as measured against established requirements, such as standards, tests and/or evaluation that qualify a person to perform a required function.*

***Quality Assurance*** *- An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement that measures the degree of excellence of environmental data and communicates the information to a data generator or data user in a convincing manner.*

***Quality Assurance Laboratory*** *- The USACE HTRW chemistry laboratory, or its subcontracted agent that is responsible for analysis of the project QA samples.*

***Quality*** *- The degree to which an item or process meets or exceeds the user's requirements and expectations.*

***Quality Indicators*** *- Measurable attributes of the attainment of the necessary quality for a particular environmental decision. Indicators of data quality include precision, bias, completeness, representativeness, reproducibility, comparability, sensitivity, and statistical confidence.*

***Quality Assurance Sample*** *- A sample collected to monitor the quality of sampling operations. This type of sample is analyzed by the quality assurance laboratory and typically includes split samples, duplicate samples, and various types of blank samples.*

***Quality Assurance (QA)*** *- All of those planned and systematic actions necessary to provide confidence that a structure, system, or component will perform satisfactorily in service. When the product is a report of a significant study or investigation, QA also comprises those planned and systematic actions necessary to provide adequate confidence in the validity and integrity of the reported data, methods, and procedures and in the protection, retrievability, and replicability of the data. The quality management system includes a multidisciplinary system of management controls backed by quality verification and overview activities that demonstrate completeness and appropriateness of achieved quality.*

***Quality Assurance Documents*** *- Those documents which establish the requirements and methods to implement the client activities. These documents are identified as the Work Plan, Sampling and Analysis Plan, Contractor Quality Control Plan, Standard Quality Procedures, Standard Operating Procedures, and Field Work Variances.*

***Quality Control Program*** *- The overall program established by an organization to implement the requirements of the contract document. The program assigns responsibilities and authorities, defines policies and requirements, and provides for the performance and assessment of work. The QC program is described in the CDQMP.*

***Quality Control Record*** *- A completed document that furnishes evidence of the quality of items and/or activities affecting quality.*

***Quality Control*** *- The overall system of technical activities that monitors the degree of excellence of environmental data so that the stated requirements of defined standards are achieved.*

***Quality Control Sample*** *- A sample collected to monitor and control the quality of sampling operations. This type of sample is analyzed by the primary laboratory and typically includes split samples, duplicate samples, and various types of blank samples.*

***Reporting Limit (RL)*** *- The RL is a project-specific reporting limitbased on a regulatory action level, a risk-based screening level, or documented data quality objective . As defined in the DOD QSM, the RL is the lowest concentration value that meets project requirements for reporting quantitative data with known precision and bias for a specific analyte in a specific matrix. The project specific RLs are established to support the DQOs for collection of the data.****Representativeness*** *- A measure of the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process, or an environmental condition.*

***Reproducibility*** *- The precision, usually expressed as variance, that measures the variability among the results of measurements of a sample at different laboratories.*

***Sample Reporting Limit (SRL)*** *- The Sample Reporting Limit (SRL) is the RL adjusted for the size of the sample aliquot analyzed, any dilution/concentration factors unique to the analysis of a particular sample, and any allowances made for the sample matrix which might elevate the normal RL (i.e., moisture content of a soil or sediment).*

***Screening Level Data*** *- Data that are generated by less precise methods of analysis, less rigorous sample preparation, and less stringent QA/QC procedures. The data generated provide analyte identification and quantification, although the quantification may be relatively imprecise.*

***Significant Deficiency*** *- Any state, status, incident, or situation of an environmental process or condition, or environmental technology in which the work being performed will be adversely affected sufficiently to require corrective action to satisfy quality objectives or specifications and safety requirements.*

***Significant Condition Adverse to Quality*** *- A condition that, if left uncorrected, could have a serious effect on safety or operability. This term includes environmental and program compliance.*

***Split sample*** *- A sample which has been collected, homogenized, and divided into two or more*

*portions for analysis by multiple laboratories. Applicable for all test parameters except those involving volatile analytes where homogenization might affect the concentration of volatile substances (see also duplicate sample).*

***Standard Operating Procedure (SOP)*** *- A written document that details the process for an operation, analysis, or action, with thoroughly prescribed techniques and steps, and that is officially approved as the method for performing certain routine or repetitive tasks.*

***Stop Work Order*** *- The order to stop further processing, delivery, installation, or operation until proper disposition of a nonconformance, deficiency, or unsatisfactory condition has occurred.*

***Supplier*** *- Any individual or organization that furnishes items or services in accordance with a procurement document. An all-inclusive term used in place of any of the following: vendor, seller, contractor, subcontractor, fabricator, consultant, and their subtier levels.*

***Surveillance*** *- The act of monitoring or observing to verify whether an item or activity conforms to specified requirements.*

***Technical Systems Audit*** *- A thorough, systematic, on-site, qualitative audit of facilities, equipment, personnel, training, procedures, record keeping, data verification/ validation, data management, and reporting aspects of a system.*

***Technical Review*** *- A documented critical review of work that has been performed within the state of the art. The review is accomplished by one or more qualified reviewers who are independent of those who performed the work, but are collectively equivalent in technical expertise to those who performed the original work. The review is an in-depth analysis and evaluation of documents, activities, material, data, or items that require technical verification or validation for applicability, correctness, adequacy, completeness, and assurance that established requirements are satisfied.*

***Technical Manager*** *- The leader of the technical process, responsible for the content and quality of technical products.*

***Technical Specialist*** *- One or more persons who are assigned to the audit team due to the specialized or technical aspects of the areas to be audited. Technical Specialists are selected based on their special abilities, specialized technical training, and/or prior experience in the specialized or technical aspects of the area to be audited.*

***Traceability*** *- The ability to trace the history, application, or location of an entity by means of recorded identifications. In a data collection sense, it relates calculations and data generated throughout the project back to the requirements for quality for the project.*

***Training*** *- To impart specific information with regard to job functions which will achieve initial proficiency, maintain proficiency and adapt to changes in technology, methods or job functions.*

***Uncontrolled Document*** *- A document which is issued current but which is not maintained current with revisions.*

***Use-As-Is*** *- A disposition permitted for a nonconforming item when it can be established that the item is satisfactory for its intended use.*

# *CHEMICAL DATA QUALITY MANAGEMENT PLAN TOOELE, UTAH*

***Submitted to:***
***Tooele Army Depot***
***Environmental Management Office***
***Tooele, UT***

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## *CONTENTS*

# *QUALITY ASSURANCE PROJECT PLAN*

# EXECUTIVE SUMMARY

This Chemical Data Quality Management Plan (CDQMP) delineates the procedures that will be used to accomplish the chemical quality control items to assure accurate, precise, representative, complete, legally defensible and comparable data. The CDQMP presents functions, procedures, and specific quality assurance (QA) and quality control (QC) activities designed to achieve the data quality goals set for investigations at Tooele Army Depot. The CDQMP is composed of the Quality Assurance Project (QAPP) Plan, the Field Sampling Plan (FSP), and the Sampling and Analysis Plan (SAP). This CDQMP incorporates by reference the requirements of the following publications:

Environmental Protection Agency (EPA):

EPA SW-846 — *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* Third Edition, as updated by Updates I, II, IIA, IIB, III, IIIA, IIIB, IVA and IVB, Revision 6, February 2007; http://www.epa.gov/epaoswer/hazwaste/test/main.htm

EPA QA/G-4 — *Guidance on Systematic Planning Using the Data Quality Objectives Process,* EPA/240/B-06/001, February 2006

Department of Defense (DoD):

DoD: DTIC ADA 427785, EPA-505-B-04-900A

*Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual, Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs,* Final, Version 1, March 2005; http://www.epa.gov/fedfac/documents/qualityassurance.htm

DoD: DTIC ADA 426957, EPA-505-B-04-900B

*Uniform Federal Policy for Quality Assurance Project Plans, Part 2B, Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities*, Final, Version 1, March 2005; http://www.epa.gov/fedfac/documents/qualityassurance.htm

DoD QSM — *Department of Defense Quality Systems Manual For Environmental Laboratories,* Version 4.1 Final, June 2009; http://chppm-www.apgea.army.mil/dls/DoDV3.pdf

U.S. Army Corps of Engineers (USACE):

EM 200-1-10 *Guidance for Evaluating Performance-Based Chemical Data*, 30 June 2005; http://www.usace.army.mil/inet/usace-docs/eng-manuals/em200-1-10/toc.htm

# 1.0 PROGRAM MANAGEMENT

## 1.1 Program and Project Organization

This section details the program and project organizations of personnel expected to perform work under this CDQMP. Program personnel and their respective responsibilities are clearly delineated. Project personnel will be identified in the project specific Sampling and Analysis Plans / UFP-QAPP which will clearly identify the specific personnel that are managing or performing tasks on each project. The lines of authority and communication will be clearly delineated on a project specific organizational chart and responsibilities of key personnel will be clearly defined.

### 1.1.1 Program Manager

The Program Manager (PM) will be identified. The PM will be fully responsible and accountable for all program and contractual activities. He will serve as the focal point and main channel of communication between the TEAD and the contractor's team. Using the Program staff, he will establish and interpret program policies, monitor schedule and cost, coordinate all reporting, ensure that 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. He will also be responsible for leading the public relations effort in support of TEAD's public outreach program. Other duties, as appropriate, will include:

- Procurement, along with procurement personnel, and supervision of Program subcontractors
- Receive, negotiate, and track the performance of projects
- Assign Technical Managers and Project Leaders to direct specific projects and provide the necessary resources to these managers
- Approve and consistently implement the program planning documents (e.g., this document, Program Management Plan, Health and Safety Plan, etc.)
- Assess the overall Program for compliance with federal, state, and local regulations/laws and with specific delivery orders and directives
- Interact with regulatory/public agency clients at the request of the client
- Disseminate Program-related information from the client and others

- Provide Program change order control
- Report any significant conditions adverse to quality and obtain concurrence on proposed resolution(s)
- Provide overall Program technical, quality, and performance consistency
- Attend meetings and conferences between USACE and TEAD as appropriate
- Review Program quality assurance audit reports and any resulting corrective action disposition.

### 1.1.2 Quality Assurance Officer

The Quality Assurance Officer (QAO) will be identified and will be responsible for overseeing that Quality Control (QC) operations are executed for all field and laboratory activities. Day to day monitoring of QC functions will be designated to the appropriate staff personnel (i.e., Technical Manager, Project Manager). The Quality Assurance Officer will verify compliance with work plans and procedures by providing for periodic field audits, laboratory audits, and review of work plans, reports, and laboratory data. The Quality Assurance Officer will report to the Project Manager.

### 1.1.3 Technical Manager

The Technical Manager (TM) will be identified. The TM will be responsible for reviewing the sampling program and associated field activities, ensuring that all sampling activities conform to the SAP. The TM will provide technical support throughout the program and will provide review of all technical documents submitted to the client. The TM reports to the PM.

### 1.1.4 Project Manager

Quality assurance of field activities will be overseen by the Project Manager, who will be in the field to supervise and perform initial inspections of field activities. Prior to the start of field activities, preparatory meetings will be held with the field crew. Checklists will be used during field activities. If field conditions require modifications to protocol outlined in the CDQMP or if questions arise, the field crew will contact the Project Manager for direction. The Project Manager will be also be responsible for overseeing review of the project CDQMP program as it relates to the compilation of data. The Project Manager reports to the TM.

### 1.1.5 Project Chemist

The Project Chemist will be identified. The Project Chemist will have a "hands on" role in management of project tasks associated with sampling and analysis including instruction of field personnel in sampling and preservation requirements and general oversight of field personnel involved in sampling activities. The Project Chemist and will assist the project team in selecting the analytical laboratory and developing the project specific sampling and analysis plan (SAP). The Project Chemist will provide coordination with the analytical laboratory to insure readiness to implement project specific requirements, review of analytical data as it becomes available to insure conformance with quality standards, implementation of corrective actions in accordance with CDQMP and SAP specifications when review of data uncovers deficiencies, and serve as a point of contact for the Army appointed Chemist for issues related to environmental chemistry. The Project Chemist will oversee on-site analytical testing including field screening analyses. The Chemist will also prepare all data validation reports or review for accuracy all data validation reports prepared by subcontractors. The Project Chemist will report to the Project Manager.

### 1.1.6 Program Geologist

The Program Geologist will be identified. The Program Geologist will be responsible for design and internal review of all aspects of work related to Geology such as drilling program design and execution, monitoring well design and installation, preparation of boring logs, and groundwater modeling as directed by the Project Manager.

### 1.1.7 Health and Safety Officer

The Health and Safety Officer (HSO) will be identified. The HSO will be an experienced Industrial Hygienist. The HSO is responsible for the general health and safety plan development and training for field personnel. This individual is also responsible for ensuring that health and safety procedures are understood and followed by all field personnel, and for reporting and correcting any violations of policy or regulation.

### 1.1.8 Sampling Team Leader

The Sampling Team Leader will be responsible for implementing and overseeing field activities, data compilation, review of the project QA/QC program, and preparation of all technical documents. The Sampling Team Leader will also be responsible for quality assurance of field activities as described above and for executing all work elements related to the sampling program, including documenting field activities, maintaining field notes and photographs, maintaining a record of onsite personnel and visitors, and implementing the sampling plan. The Sampling Team Leader will be identified in the FSP and SAP. The Sampling Team Leader reports to the Project Manager.

### 1.1.9 Field Personnel

Field personnel will be responsible for performance of project mobilization, de mobilization, sample collection and oversight. Field personnel will be identified in the FSP and SAP. Field personnel will report to the Sampling Team Leader.

## 1.2 Problem Definition/Background

This section provides a general background discussion of site history, geology, and hydrogeology for the Tooele Army Depot area. A detailed discussion of site specific information will be included in project specific SAP's and FSP's.

### 1.2.1 Location and History

TEAD is 7 miles south of the Great Salt Lake and 35 miles southwest of Salt Lake City. It is separated from Salt Lake City by the Oquirrh Mountains. TEAD is located in Tooele Valley, in the central portion of northern Utah, west of the town of Tooele and south of Grantsville and Erda. The valley is a northward plunging structural basin flanked by coalescing alluvial fans that slope generally to the north. TEAD began operating in 1942 as one of the major ammunition storage and equipment maintenance installations in the continental United States. The primary missions included administration of the TEAD complex; repair and maintenance of tactical wheeled vehicles and power generation equipment; and storage, maintenance, issuance, and disposal of conventional munitions. U pholding TEAD's mission necessitated that TEAD be engaged in a wide variety of operations which involved the use of materials with toxic and hazardous properties. Hazardous wastes were generated as a result of these activities. Materials associated with the industrial waste lagoon (IWL) and other solid waste management units (SWMU) activities at TEAD include the following general categories of compounds:

- petroleum wastes
- organic solvents
- metal dusts and fumes
- plating wastes
- pesticides (herbicides and insecticides)
- explosives
- paint wastes
- strong acids and bases
- coolants
- rubber wastes

### 1.2.2 Geology

Tooele Valley is typical of basin and range physiography in which fault block mountains rise above flat, intermountain valleys filled with unconsolidated sediments of Tertiary and

Quaternary age. The unconsolidated sediments beneath TEAD consist of alluvial outwash materials and lacustrine deposits whose thickness ranges from zero at bedrock outcrops out to over 1,500 ft north of the IWL. The bedrock outcrop is a surface expression of a large bedrock block that dips to the south in a series of terraces. The northern most terrace is estimated to exist at a depth of over 200 feet below ground surface (bgs) in the vicinity of the IWL.(Geomatrix,1997)

### 1.2.3 Hydrogeology

Groundwater in the unconsolidated sediments and bedrock at TEAD is generally unconfined. The alluvial and bedrock aquifers are recharged by subsurface seepage along the Oquirrh Mountains east of TEAD, by upward flow from deeper confined aquifers, percolating precipitation, and minor subsurface flow from adjacent areas. Depth to groundwater at TEAD ranges from about 200 feet to 400 feet bgs. Groundwater flows from south to north and toward the center of Tooele Valley.

Subsurface information collected at TEAD indicates that the alluvial aquifer consists of poorly sorted, poorly rounded, silty sand, gravel, and cobbles with occasional layers of clay, sand and gravel to approximately 5 feet thick. The sand grains, gravels, and cobbles are composed of limestone and quartzite eroded from the Oquirrh Mountains. The alluvial aquifer is relatively uniform throughout TEAD. Hydraulic conductivity values of the alluvial aquifer range from approximately 10 ft/day (ft/d) to 100 f/d in shallow wells at TEAD, indicating a relatively uniform corse-grained aquifer. Results from other alluvium wells indicate that the properties of the alluvial aquifer vary with depth, with the hydraulic conductivity values ranging from approximately 0.1 ft/d to greater than 140 ft/d. This variation could be due in part to the presence of the bedrock occlusion located approximately 1,000 ft north of the IWL (Geomatrix, 1997 / Kleinfelder, 1997).

### 1.2.4 Project Specific Information

A detailed description of the problem definition from the DQO process and pertinent background information will be included in project-specific SAPs, as described below.

A narrative describing the project and specific problems to be solved or decisions to be made will be included in this section of the SAP. The goal of the environmental remedial activities will be clearly stated. A 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 will be included, as applicable. The text will include diagrams detailing areas to be sampled as relevant to the definition of the project goals. These sections will also contain a summary of site geology/hydrogeology, as known based on previous site activities. The discussion will include enough information about the problem, the past history, any previous work or data, the regulatory or legal context, and any relevant ARARs to present a clear description of the project

objectives.

## 1.3 Project Description

A detailed narrative of the project description will be included in the project-specific SAP's, using text and applicable UFP-QAPP work sheets (WSs) as described below.

### 1.3.1 Site and Project Background

This section provides the description of the project to be performed in response to the preceding problem definition. A detailed description of the project sampling strategy will be discussed, including anticipated project start and completion dates in the SAP. As a minimum, this section of the SAP will include a brief discussion of the following:

- Expected measurements and anticipated approaches
- Applicable requirements, standards, or specifications to meet Program technical, regulatory, or quality objectives
- Special project requirements for items or services
- Assessment activity to be used to evaluate Program compliance
- Project schedule with milestones.

## 1.4 Data Quality Objectives

The SAP will describe the general scope of work and background information as it relates to the acquisition of geological, geophysical, hydrogeological and chemical data. The text will explicitly describe the data that are needed to meet the objectives of the project, how that data will be used, and discuss implementation of control mechanisms and standards that will be used to obtain data of sufficient quality to meet or exceed project objectives. The discussion of Data Quality Objectives (DQO's) will follow the guidance contained in the EPA document Guidance for the Data Quality Objectives Process, EPA QA/G-4, Final, February 2006 and the requirements of this document are included by reference. Work performed by an on-site laboratory will be required to meet the same standards as a fixed site laboratory as described in this scope of work. The SAP will also describe in quantitative terms the sensitivity, precision, accuracy, and completeness goals for each major measurement parameter and for each matrix to be sampled. The SAP may need to define different types of sensitivity (e.g. quantitative, qualitative, screening) for each major measurement parameter. A qualitative discussion will be presented regarding representativeness and comparability. The section on DQO's will address the following topics in the specified order.

- ***Statement of the Problem***
  Summarize the problem that requires environmental data acquisition and identify the resources available to resolve the problem. The type of information obtained for each

site in step number one of the DQO process includes:

a. types of contaminants that were suspected at each site;
b. types of pathways and receptors present;
c. types of disposal sites present; and
d. types of contaminated media.

- ***Identification of Decisions***

a. 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 will be prioritized. The output for this DQO step includes:
b. expected decisions based on the data collected; and
c. types of actions that will be taken to determine these decisions.

- ***Identify Inputs to Decisions***

a. Identify the information needed to support the decision and specify the inputs requiring environmental measurements. T he output for this DQO step may include:
b. lists of all the data need to accomplish the objectives, including data that already exits and data that must be collected; and
c. identification of methods for establishing the action levels (e.g. regulatory threshold, risk or exposure assessment, technological limits etc.)

- ***Definition of Study Boundaries***

Specify the spatial and temporal aspects of the environmental media that the data must represent to support the decision. The output for this DQO step may include:

a. definition of site boundaries;
b. definition of boundaries for individual suspected contaminant source areas within a site;
c. density of sampling;
d. types of sampling or investigation constraints; and
e. actions that will be taken if investigation constraints are encountered.

- ***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.

- ***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 DQO's.

Project specific DQOs 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 level or standards upon which decisions will be made, including the method detection limits and practical quantitation limits for relevant parameters;
- The summary statistics 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 the stated purpose; or the acceptable limits of uncertainty.

The text will describe in quantitative terms the sensitivity, precision, accuracy, and completeness goals for each major measurement parameter and for each matrix to be sampled. The SAP may need to define different types of sensitivity (e.g. quantitative, qualitative, screening) for each major measurement parameter as applicable. A qualitative discussion will be presented regarding representativeness and comparability.

### 1.4.1 Data Categories

To assist in the interpretation of data for TEAD the following descriptive data categories will be implemented:

- Screening data
- Screening data with definitive confirmation
- Definitive data.

These three data categories are associated with specific QA/QC elements, and may be generated using a wide range of analytical methods. The particular type of data to be generated depends on the qualitative and quantitative DQOs developed during application of the DQO Process.

#### 1.4.1.1 Screening Data

Screening data are generated by rapid, less precise methods of analysis with less rigorous sample preparation. Sample preparation steps may be restricted to simple procedures such as dilution with a solvent, instead of elaborate extraction/digestion and clean-up. Screening data provide

analyte identification and quantification, although the quantification may be relatively imprecise. Screening data without associated confirmation data are not considered to be of known quality.

Screening Data QA/QC Elements

- Sample documentation (location, date and time collected, batch etc.);
- Chain of Custody (when appropriate);
- Sampling design approach (systematic, simple or stratified random, judgmental, etc.);
- Initial and continuing calibration
- Determination and documentation of detection limits;
- Analyte(s) identification;
- Analyte(s) quantification;
- Analytical error determination: An appropriate number of replicate aliquots as specified in the QAPP, are taken from at least one thoroughly homogenized sample, the replicate aliquots are analyzed and the standard laboratory QC parameters (such as variance, mean and coefficient of variation) are compared to method-specific performance requirements specified in Section 2.4.

#### 1.4.1.2 Screening Data with Definitive Confirmation

Definitive confirmation of screening data provide for data of known quality and reduces the level of uncertainty of the data set. At least 10% of the screening data are confirmed by using EPA approved analytical methods and QA/QC procedures consistent with the requirements for definitive data described below.

Definitive confirmation

As a minimum, at least three screening samples reported above the action level (if any) and three screening samples reported below the action level (or as non-detects) should be randomly selected from the appropriate group and confirmed. At least ten percent of the screening data must be confirmed with definitive data as described below.

#### 1.4.1.3 Definitive Data

Definitive data are generated using rigorous analytical methods, such as EPA approved reference methods. Data are analyte-specific, with confirmation of analyte identity and concentration. Methods produce tangible raw data (e.g., chromatograms, spectra, digital values) in the form of paper printouts or computer generated electronic files. Data may be generated at the site or at an off-site location, as long as the QA/QC requirements are satisfied. For the data to be definitive, either analytical or total error must be determined. Definitive data may be obtained from laboratory data packages which incorporate the following QA/QC elements.

Definitive Data QA/QC Elements

- Sample documentation (location, date and time collected, batch etc..)
- Chain of Custody (when appropriate)
- Sampling design approach (systematic, simple or stratified random, judgmental, etc.);

- Initial and continuing calibration
- Determination and documentation of detection limits
- Analyte(s) identification
- Analyte(s) quantification
- QC blanks (trip, method, rinsate)
- Matrix spike recoveries
- Performance Evaluation (PE) Samples (when specified)
- Analytical error determination: An appropriate number of replicate aliquots as specified in the QAPP, are taken from at least one thoroughly homogenized sample, the replicate aliquots are analyzed and the standard laboratory QC parameters (such as variance, mean and coefficient of variation) are compared to method-specific performance requirements specified in Section 2.4.
- Total measurement error determination (measures overall precision of measurement system, from sample acquisition through analysis): An appropriate number of co-located samples as determined by the SAP are independently collected from the same location and analyzed following standard operating procedures. Based on these analytical results, standard laboratory parameters such as variance, mean, and coefficient of variation should be calculated and compared to established measurement error goals. This procedure may be required for each matrix under investigation, and may be repeated at more than one location at the site.

## 1.5 Documentation and Records

The following sections itemize the information and records which will be maintained for all projects covered by this CDQMP at TEAD.

### 1.5.1 Field Documentation

#### 1.5.1.1 Field Log Books

A field notebook bound with serially-numbered pages will be used to record sample identification numbers, chain-of-custody numbers, and any significant observations or events. The project name, project number, site location, sampling event, project manager, telephone number and address of contractor office (should the book be misplaced or lost) will be listed in ink. The field notebook is intended to record events during sampling activities in sufficient detail to allow field personnel to reconstruct events that transpired during the project. The field notebook will be maintained by the Project Leader, who will sign and date the notebook prior to initiation of fieldwork. Detailed procedures for Field Activity and Documentation are presented in SOP 1.2.

If it is necessary to transfer the logbook to alternative personnel during the course of field work, the person relinquishing the logbook will sign and date the logbook at the time the logbook is transferred and the person receiving the logbook will do likewise. Corrections to erroneous data will be made by crossing a line through the entry and entering the correct information. The correction will be initialed and dated by the person making the entry. Unused portions of

logbook pages will be crossed out, signed, and dated at the end of each workday. Logbook entries must be dated, legible, in ink, and contain accurate documentation. Language used will be objective, factual, and free of personal opinions. Hypotheses for observed phenomena may be recorded, however, they must be clearly indicated as such and only relate to the subject observation.

The date and time of sampling preparation and collection, and personnel who conducted sampling are recorded with the sample identification number in the field log book and on the chain-of-custody form. The names of visitors and any other persons on site are also recorded in the field log book. S ampling personnel will also record the ambient weather conditions and other conditions at the sampling location that may affect sample collection, the apparent representativeness of the sample, or sample analysis in the field log book.

#### 1.5.1.2 Photographs

Photographs will be used to supplement written descriptions of field activities, such as sampling. Photographs will be completely documented to include the project name and number, date of the photograph, weather conditions, the photographer, subject and a brief description of the purpose of the photograph. Photographs should be uniquely identified by photo number and traceable to negatives.

#### 1.5.1.3 Chain of Custody Records

The specific sampling location of each sample is recorded with each sample identification number in the field log book and on the sample Chain-Of-Custody (COC) record. The type of sample media is recorded with the sample identification number in the field log book and on the COC record. Laboratory analyses to be conducted on the sample are recorded with the sample identification number in the field log book and on the chain-of-custody record.

Custody of samples must be maintained and documented from the time of sample collection to completion of the analyses. Each sample will be considered to be in the sampler's custody, and the sampler will be personally responsible for the care and custody of the samples until they are delivered to the courier service for delivery to the laboratory. A sample is considered to be under a person's custody if:

- The sample is in the person's physical possession;
- The sample is in view of the person after that person has taken possession;
- The sample is secured by that person so that no one can tamper with the sample;
- The sample is secured by that person in an area that is restricted to authorized personnel;

All samples will be accompanied to the laboratory by a chain-of-custody record. T he chain-of-custody form contains the following information:

- Project name;
- Sample numbers;
- Sample collection point;
- Sampling date;
- Time of collection of samples (must match the time recorded on the sample label);
- Sample matrix description;
- Analyses requested for each sample;
- Preservation method;
- Number and type of containers used;
- Any special handling or analysis requirements.
- Signature of person collecting the samples;
- Signature of persons involved in the chain of possession.

The chain-of-custody record forms will be filled out with indelible ink. When the samples are transferred from one party to another, the individuals will sign, date, and note the time on the form. A separate form will accompany each delivery of samples to the laboratory. The chain-of-custody form will be included in the cooler used for preservation and transport of the samples. The sampling personnel will retain a copy of the form. Detailed procedure for completion of the COC record is presented in SOP 1.1.

#### 1.5.1.4 Sample Identification

A unique identification number will be assigned to each sample. This number is typically an alphanumeric sequence or integer that serves as an acronym to identify the sample. Specific sample identification procedures will follow a strategy as outlined in the site specific SAP. All information pertaining to a particular sample is referenced by its identification number. The sample identification number is recorded on the sample container, in the field log book, and on the sample COC record. Following sample collection, the sample label is completed in waterproof ink and secured to the sample container with clear, tape which is wider than the label itself.

Each sample collected at the site will be labeled with the following information:

- Sample identification number;
- Sample location;
- Date and time of collection;
- Initials of person collecting the sample;
- Analysis requested;
- Preservation;
- Any other information pertinent to the sample.

### 1.5.2 Laboratory Documentation and Records

The laboratory will have all standard operating procedures (SOPs) formalized in writing and readily available for all staff. At a minimum, SOPs will be written for the following areas to include all their associated procedures and methods: sample receipt/control, sample preparation/extraction, sample analysis, result calculation, database management, health and safety, and the QA/QC program. In general, all steps of sample preparation/extraction, sample analysis, and result calculation will be documented in bound laboratory notebooks. Alternatively, computer-generated forms may be used if each page contains the date printed and is sequentially numbered. Such forms will be bound for long-term storage.

#### 1.5.2.1 Sample Receipt/Laboratory Custody

All samples received at the laboratory will be carefully checked for label identification, and complete, accurate chain-of-custody documentation. The condition of the samples will be checked and the ambient temperature in the cooler and the temperature blank will be measured immediately after the cooler is opened. These results will be recorded on the Cooler Receipt Form. Photographs are recommended to document the condition of samples if significant out-of-control conditions are noted at the time of sample receipt. The laboratory will determine pH of samples for metals analysis upon receipt of sample coolers and will record measurements on the cooler receipt form. The pH of VOA samples will be measured at the time of analysis and recorded in laboratory injection logbooks.

Within one working day of sample receipt by the laboratory, an acknowledgment and cooler receipt form will be faxed to the Project Chemist at the fax number provided in the site specific SAP.

A unique laboratory identification number will be assigned through a computerized Laboratory Information Management System (LIMS) that stores all identification and essential information. The LIMS system tracks the sample from storage through each step in the laboratory until the analytical process is complete and the sample is returned to the custody of Sample Control for disposal. Access to the laboratory will be restricted to prevent any unauthorized contact with samples, extracts, or documentation.

#### 1.5.2.2 Data Reporting / Comprehensive Certificates of Analysis

This section provides a detail of the requirements for each type of data reporting format which may be provided by the laboratory. The type of report will be determined on a project-specific basis. Preliminary certificates of analysis will be provided within 10 business days of sample receipt. The preliminary certificate of analysis will contain analytical results and basic QC

information including MS/MSD, LCS, and method blank results, and chain-of-custody and cooler receipt forms. Comprehensive certificates of analysis will be submitted to TEAD within 21 calendar days of sample receipt. Project SAPs may include other turnaround times which will replace these for that project only. Preliminary certificates of analysis will be shipped to TEAD as soon as they are available. Final comprehensive certificates of analysis will be submitted to TEAD within 21 calendar days after the last sample is collected for a delivery order. Each comprehensive certificate of analysis will contain the following items:

- Original copies of cooler receipt forms documenting sample conditions upon arrival at the laboratory and chain of custody/request for analysis (COC) forms for the samples included in the certificate

- Results for each sample and analytical method as a detected concentration or as less than the limit of quantitation (LOQ) for each analyte with appropriate data qualifiers, as needed. All samples with out of control spike recoveries being attributed to matrix interference will be designated as such. Soil sample results and LOQs will be reported on a dry weight basis with the percent moisture reported for each sample. Dilution factors and rationale for dilution, date of extraction, date of analysis, and analytical method will be reported for each analyte.

- Method blank results for all analytes and each analytical method. Sample results must be associated with a particular method blank. Any concentration above one half the LOQ detected in the method blank should be reported.

- Surrogate spike recoveries and control limits for all applicable methods (organic analyses), with any out-of-control recoveries flagged.

- Matrix spike/matrix spike duplicate (MS/MSD) results for all analyses, with recoveries, relative percent differences (RPD), and control limits for each spiked analyte. Sample results must be associated with a particular project-specific MS/MSD set. If a MS/MSD set is reanalyzed because of out of control results and the reanalysis is also out of control, both results will be reported and the data flagged. (MS/MSD sets with results not meeting specified acceptance criteria will be re-analyzed once. If re-analysis results are out of control both sets will be reported and the data flagged as appropriate.).

- Laboratory duplicate results with RPD and control limits for each analyte.

- Laboratory control samples (LCS) results with control limits. Sample results must be associated with a particular LCS.

- Initial and continuing calibration summaries and injection logs

- A summary of all samples with detected concentrations of target compounds indexed by method and by sample ID (to be provided when database is implemented)

- A summary of all surrogate recoveries for organic analyses for each applicable method

with the acceptable recovery range clearly indicated. This summary will be performed for all samples for each analytical method involving surrogate spikes

- A summary of all matrix spike/matrix spike duplicate analyses for each applicable method indicating acceptable recovery ranges and QC acceptance criteria for RPD

- A summary of all laboratory duplicates with QC acceptance criteria for RPD clearly indicated

- A summary (prepared by the contractor) of all field duplicates with QC acceptance criteria for RPD clearly indicated

- A table (prepared by the contractor) identifying all QA samples and the corresponding primary samples.

- A narrative section identifying all out of control conditions, corrective actions taken, and affected samples. A detailed discussion of all relevant quality control data will be included for out of control recoveries attributed to matrix effects.

- All data for analyses during the period covered by the comprehensive certificate of analysis will be included as an appendix to the comprehensive report. This data will be presented on numbered pages with an index or table of contents describing the contents of the appendix.

#### 1.5.2.3 Raw Data Packages

Raw data packages will be requested for 10 percent of all samples submitted to the Laboratory. Raw data packages will be delivered within 21 days of a request for the data (or within 28 days of the last sample that is submitted for a project). The raw data package for organic/inorganic analyses will consist of a case narrative, chain-of-custody 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 organics/inorganics raw data package are provided in the following sections.

##### 1.5.2.3.1 Case Narrative

A case narrative will be written on laboratory letterhead and the release of data will be authorized by the laboratory manager or his/her 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 (EPA 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 reasons for out of control QA/QC criteria, and observations regarding any occurrences which may effect sample integrity or data quality.

#### 1.5.2.3.2 Chain-of-Custody Documentation

Legible copies of COC forms for each sample will be maintained in the data package. Cooler log-in sheets will be associated with the corresponding COC form. Any internal laboratory tracking document will be included.

#### 1.5.2.3.3 Summary of Environmental Results

For each environmental sample analysis, this summary will 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, instrument specifications, 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 or sample quantitation limit, definitions of any data qualifiers used, and analytical results.

#### 1.5.2.3.4 Summary of QA/QC Results

The following QA/QC results will be presented in summary form. Details specified in section 1.5.4.3.3 Summary of Environmental Results (Organic or Inorganic Analysis) will be included in the summary of QA/QC results. Acceptance limits for all categories of QC criteria will be provided with the data. All summaries will be presented on standard forms. Standard instrument output alone will not be submitted to satisfy the requirements of raw data packages.

#### 1.5.2.3.5 Instrument Calibration

The order of reporting of calibrations for each analyte must follow the temporal order in which standards were analyzed.

#### 1.5.2.3.6 Initial Calibration

The source of calibration standards true values and found values of concentrations and percent recovery will be noted. In addition, the concentrations of the standards used for analysis and the date and time of analysis, the correlation coefficient (r), coefficient of determination ($r^2$), calibration factor, relative 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.

#### 1.5.2.3.7 Continuing Calibration

The concentration and source of the calibration standard used for daily calibration and/or 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) as well as percent recovery for each element analyzed. Daily calibration information will be linked to sample analyses by summary or by daily injection or analysis logs.

#### 1.5.2.3.8 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. The date and time will also be reported.

#### 1.5.2.3.9 Interference Check Sample

The concentrations and source of the interference check sample will be reported, as well as the percent recovery for each element analyzed, and the date and time of analysis.

#### 1.5.2.3.10 Surrogate Standard Recovery

The name and concentration of each surrogate compound added will be reported. The percent recovery of each surrogate compound in the samples, method blanks, matrix spike/matrix spike duplicates, and other QA/QC analyses will be summarized with sample Ids such that the information can be linked to sample and QA/QC analyses.

#### 1.5.2.3.11 Precision and Accuracy

For matrix spike/matrix spike duplicate analyses and LCS/LCS duplicate analyses, the sample results, spiked sample results, percent recovery, and RPD with the associated control limits will be reported. For laboratory duplicates, the original concentrations, RPD, and acceptable control limits for each analyte will also be reported. All batch QC information will be linked to the corresponding sample groups. For post digestion spikes, the concentration of the spiked sample, the sample results, the spiking solution added, percent recovery, and control limits will be detailed. Date and time for all analyses will be recorded.

#### 1.5.2.3.12 Retention Time Windows (GC, GC/MS, HPLC)

The retention time window for each analyte for both primary and confirmation analyses will be reported. Retention time windows will be updated daily per EPA SW-846.

#### 1.5.2.3.13 Compound Identification (GC, GC/MS, HPLC)

The retention times, mass spectra and the concentrations for each analyte detected in environmental and QA/QC samples will be reported for both primary and confirmation analyses (when applicable.

#### 1.5.2.3.14 Method Detection Limits

Results of the most current detection limit study will be provided in the raw data package.

#### 1.5.2.3.15 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 (initial calibration, continuing calibration check, method blank, matrix spikes, etc.).

#### 1.5.2.3.16 Method of Standard Additions (MSA)

This summary will be included when MSA analyses are required. The absorbance 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.

#### 1.5.2.3.17 Inductively Coupled Plasma (ICP) Serial Dilution

The initial and serial dilution results with percent difference will be reported.

#### 1.5.2.3.18 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.

#### 1.5.2.3.19 ICP Interelement 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.

#### 1.5.2.3.20 Method Detection Limits

Results of the most current method detection limit (MDL) study will be provided in the raw data package.

#### 1.5.2.3.21 Analysis Record

Analysis 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 (initial calibration, continuing calibration check, method blank, matrix spikes, etc.).

#### 1.5.2.3.22 Raw Data

Raw data will be organized systematically on numbered pages. The data package will include

legible copies of the raw data for environmental samples (arranged in increasing order of field ID), instrument calibrations, QA/QC analyses, sample extraction and cleanup logs, instrument analysis logs for each instrument used. Instrument analysis logs will be provided for all days on which analysis was performed. Measurement printouts and quantitation reports for each instrument used will also be submitted. Records of absorbance, titrimetric or other measurements for wet chemical analysis will be recorded. All raw data will be presented on standard forms and accompanied by the instrument output.

#### 1.5.2.3.23 HPLC/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 extraction and cleanup logs, instrument analysis logs (injection record) for each instrument used, and GC/MS confirmation 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.

#### 1.5.2.3.24 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 extraction 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 standard, and surrogate compounds labelled by name) and enhanced spectra of target compounds and/or tentatively identified compounds with the associated best matched spectra. Quantitation reports for all analyses will be included in the data package.

### 1.5.2.4 Electronic Data Deliverables

The contract laboratory shall provide sample data and all associated quality control data in electronic format as described in the *Electronic Data Specification* contained in Appendix E. This specification provides for a deliverable consistent with the latest Environmental Restoration Program Information Management System (ERPIMS) format. The *ERPIMS '98 Data Loading Handbook, Version 4.0* (October 1997) is incorporated by reference.

All electronic data submitted by the contract laboratory is required to be error-free, and in complete agreement with the hardcopy data. Data files are to be delivered both by email and on disks accompanying the hardcopy data reports. A software application will be supplied to the laboratory that will format the deliverable for email transmission. The disk must be submitted with a transmittal letter from the laboratory that certifies that the file is in agreement with

hardcopy data reports and has been found to be free of errors using the latest version of the evaluation software provided to the laboratory. The contract laboratory, at their cost, will correct any errors identified by the USACE, Sacramento District.

It is desired that analytical results be transferred electronically from instrument data systems to the laboratory's information management system (LIMS), at which point the electronic deliverable is generated in an automated fashion. In some analytical procedures where results are not captured by the analytical system, such as certain wet chemistry analyses, hand entry of results into the LIMS is necessary. In general, however, hand entry of any results is strongly discouraged.

### 1.5.3 Calculations

Data reduction calculations are typically included on the standard reporting forms developed by the laboratories and associated with each individual method or groups of methods. Calculations not present on standard reporting forms include computer-based data reduction programs. 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 down-load 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 recorded in the same laboratory notebook.

### 1.5.4 Data Integrity and Treatment of Outliers

All QC information will be recorded in the laboratory notebooks and printouts in the same format used for sample results. It is the analyst's responsibility to check the QC information against limits for the analysis. When an analysis of a QC sample (blank, spike, check standard,

replicate, or similar sample) shows that the analysis of that batch of samples is not in control, the analyst will immediately bring the matter to the attention of the group leader. The group leader will, if necessary, consult with the laboratory QC manager and/or the laboratory project manager to determine whether the analysis can proceed, or if selected samples should be rerun, or specific corrective action needs to be taken before analyzing additional samples. Out-of-control analyses and any corrective actions associated with TEAD project work must be documented and the records maintained by the laboratory. The analyst or group leader will file a Nonconformance Report with the laboratory QC manager for laboratory analysis out of control events that require documentation. The SAP will identify potential matrix interferences for laboratory analyses attributed to site characteristics. The associated methods for compensating for expected or unexpected interferences will be identified.

### 1.5.5 Data Management

The management of data takes place at varied levels within the full range of environmental services encompassing the scope of work. Program procedures, plans, and project-specific documents provide specific details of the individual positions responsible for data management, activities involved with data management, and minimum requisite credentials associated with these tasks. In general, the qualifications of individuals associated with data management activities will be commensurate with level of expertise necessary to ensure the intended level of evaluation.

### 1.5.6 Data Archive

Records management, including data archive, is specified in Section 4.0 of this document. Industry-standard hardware and software may be used for the development, processing, retrieval, and reporting of data stored on magnetic media. Contract laboratories will maintain all data records associated with a project for a minimum of five years following submission of the certificates of analysis (laboratory reports). As necessary, specific controls will be detailed in project-specific documents that require archiving protocols beyond that as specified in Section 4.0 of this document.

# 2.0 MEASUREMENTS / DATA ACQUISITION

This section describes the sample method requirements, analytical methods and quality control requirements, instrument calibration and data acquisition requirements.

## 2.1 Sampling Process Design

Project-specific SAPs will provide reference to applicable requirements that are to be followed from program level requirements (i.e. CDQMP and SOPs) and any project-specific details that may differ from this predefined guidance. In addition, the SAP will provide project-specific details of the experimental design to include the following:

- Sampling network design
- Types of samples required
- Sampling frequencies
- Sample matrices
- Measurement parameters of interest.

The rationale for the sampling design will be described for all sites where samples will be collected. Sample locations will be clearly identified on figures or other suitable means. Applicable measurement parameters will include, but are not limited to, geological, geophysical, hydrogeological, and chemical parameters. If field locations and sites are to be determined in the field based on observation (e.g., cone penetrometer, hydropunch, monitoring well), the criteria and guidelines to be used for this assessment will be specified. Similarly, the design for monitoring well installation, to include filter packs and well screens will be defined.

## 2.2 Sampling Methods Requirements

Samples will be collected in accordance with approved plans and SOP's which include qualitative and quantitative requirements for the specific collection methods to be utilized. These procedures will consider the mitigation of collection errors which may affect the representativeness of the sample and impact the established data quality objectives for the project. Soil sampling procedures will include split spoon sampling, shallow hand auger sampling, grab sampling, EnCore™ sampling, and stockpile soil sampling. Water sampling procedures will include groundwater sampling, surface water sampling, and drum (waste) sampling. The Field Sampling Plan component of this CDQMP provides a detailed discussion for each of the above mentioned procedures. The SAP will provide a detailed project specific discussion of the requirements and reference applicable procedures as they pertain to that project.

Table 2-1 outlines the required sample containers, preservative, and holding times for each analytical method and matrix.

To uniquely identify and track each sample, a unique sample number will be affixed to the sample container in accordance with SOP 2.1 and 2.2. A duplicate sample number, identical to the sample number on the sample label, will be placed in the field sample logbook along with all pertinent sample identification information.

Routinely, the selection of samples to be batched for extraction and the samples to be used for QC analysis purposes (i.e. matrix spikes and duplicates) in the laboratory will be designated by field personnel. This information will be communicated to the laboratory via COC. However, the laboratory will be responsible for ensuring that QC analysis is performed for each batch of samples/extracts for each parameter.

## 2.3 Sampling Handling Procedures

Samples will be collected in accordance with approved Field Sampling Plans and SOP's which include qualitative and quantitative requirements for the specific collection methods to be utilized. These procedures will consider the mitigation of collection errors which affect the representativeness of the sample and the established data quality objectives for the project.

Samples will be collected in containers appropriately labeled to uniquely identify each sample. The sample label information will include sample type, date, time, and sample number. Whenever possible labels will be placed on all sample containers prior to sample collection in accordance with SOP 2.1.

To uniquely identify and track each sample, a unique sample number will be affixed to the sample container in accordance with SOP 2.2. A duplicate sample number, identical to the sample number on the sample label, will be placed in the field sample logbook along with all pertinent sample identification information.

Routinely, the selection of samples to be batched for extraction and the samples to be used for QC analysis purposes (i.e. matrix spikes and duplicates) in the laboratory will be designated by field personnel. This information will be communicated to the laboratory via COC. However, the laboratory will be responsible for ensuring that QC analysis is performed for each batch of samples/extracts for each parameter.

### 2.3.1 Packing

Samples will be transported as soon as possible after sample collection to the laboratory for analysis. The following procedures are to be used when packing and transporting samples to the laboratory:

- Use waterproof metal or equivalent strength plastic ice chests or coolers;
- Place absorbent material in the bottom of the cooler;

- Package samples in individual plastic bags and place in cooler;
- Fill cooler with cushioning material;
- Package wet ice in plastic bags and place bags around, among, below, and on top of the samples;
- Put paperwork (chain-of-custody record, etc.) in a waterproof plastic bag and tape it to the inside lid of the cooler;
- Tape the cooler lid and drain shut with fiber-reinforced tape;
- Place two numbered and signed custody seals on cooler, one at the front right and one at the back left of cooler ;
- Put "This Side Up" and "Fragile" labels on all sides of any cooler containing glass bottles or jars;
- Attach completed shipping label to the top of cooler and ship following the carrier's instructions.

Detailed procedures for sample packaging is provided in SOP 2.0.

### 2.3.2 Shipping

Sample coolers are typically shipped by overnight express carrier to the laboratory. A copy of the bill of lading (air bill) is to be retained and becomes part of the sample custody documentation. The laboratory should be notified in advance of all shipments preferably by advanced scheduling and by telephone on the day of shipment. Detailed procedures for sample shipping is provided in SOP 2.0.

### 2.3.3 Sample Preservation and Holding Times

Chemical preservatives will be used in samples where appropriate and all samples will be placed on ice and cooled in ice chests for shipment to approximately 4 degrees Celsius (°C). Upon receipt at the laboratory, the samples will be stored in controlled and locked refrigerators at 4°C ±2°C until analyzed. The pH of acid or base preserved non-volatile aqueous samples and the temperature of the temperature blank will be checked upon sample delivery at the laboratory. VOA vials for sample analysis will not be opened until analysis begins. The laboratory will record the temperature and condition of the samples at the time of receipt on the COC. For samples received with a nonconforming pH or with temperature outside the acceptable range (4°C ± 2°C), the Project Chemist will be notified within 8 hours of nonconformance discovery. The Project Chemist in concurrence with the TM will decide on a project specific basis whether the analysis should proceed, or if samples should be recollected and resubmitted for analysis. Regardless, laboratory personnel will adjust the sample to proper pH as soon as possible. Samples collected and delivered to a laboratory within four hours of collection will be exempted from the temperature requirement as long as the samples were handled in accordance with the specified procedures. Sample containers, preservatives and holding times of samples will be observed as indicated in Table 2-1.

### 2.3.4 Laboratory Receipt and Entry of Samples

The integrity and documentation of sample custody starts when cleaned sample containers are shipped to the field under custody. Samples shipped to laboratories from the field are received by the sample custodian. Upon receipt of samples in the laboratory, the integrity of the shipping container is checked by verifying that the custody seal is not broken. The internal cooler temperature will be measured by means of a temperature blank. Sample containers are inspected for breakage, leakage, damage and the contents of the shipping container are verified against the COC records. Chain-of-custody Records are checked for accuracy and completeness, and receipt conditions will be documented on the COC. If the samples and documentation are acceptable, each sample container is assigned a unique laboratory identification number from the Laboratory Information Management Systems (LIMS) database. If the samples, documentation, or coolers are not acceptable, the Laboratory Project Manager (LPM) is informed verbally and with a completed laboratory NCR. The LPM will immediately notify the Project Chemist and TM. After discrepancies have been resolved, a LIMS record hard copy is generated to document the following:

- Date of sample receipt
- Sample accession number
- Source of sample

Each sample received will be assigned a unique laboratory sample accession number by the LIMS system at the time samples are logged in. One of the functions of the LIMS is to assist in tracking samples while they are in the custody of the laboratory. Other information recorded will include date and time of sampling, sample description, due dates, and required analytical tests. Samples are batched in lots of 20 or less at the time of sample preparation or at the time of analysis if no preparation is required. When LIMS log-in has been completed, the samples are transferred to the appropriate refrigerators in the sample control area. In order to minimize the potential for cross-contamination of samples, separate refrigerators are used for samples suspected to contain high levels of organic compounds and for samples receiving analysis for volatile compounds. The sample refrigerators are kept at 4°C ± 2°C and their temperatures are recorded daily with thermometers verified against National Institute of Standards and Technology (NIST) thermometers. The refrigerators storing samples for volatile analysis are monitored for contamination with refrigerator blanks, which are analyzed weekly.

Samples are distributed to the laboratory from sample control by either a sample custodian or laboratory chemist. Internal chain of custody is initiated whenever a sample is removed from the sample control area. When samples are returned to the sample control refrigerators by laboratory personnel, internal chain of custody is completed.

The following illustrates the process that a sample takes from receipt to storage for disposal:

- Document physical condition of sample and sample preservation
- Verify documentation and parameter assignment
- Log into LIMS
- Laboratory Project Manager sends acknowledgment FAX with cooler receipt to the Project Chemist
- Store sample according to preservation guidelines
- Transfer sample to lab with proper documentation (lab personnel removes samples from sample control and signs samples on lab sample custody sheet)
- Document analytical work
- Return unused portion of samples to sample control
- Return sample to client or arrange for sample disposal

### 2.3.5 Pre-Analysis Storage

Personnel from the laboratory will receive and log in the samples. The samples are then placed into temporary storage until analyzed. Samples are stored as prescribed in the approved Laboratory QA manual. Methods of storage are intended generally to:

- Retard biological action
- Retard hydrolysis of chemical compounds and complexes
- Reduce volatility of constituents
- Reduce adsorption effects.

Preservation methods are generally limited to pH control, chemical addition, and refrigeration.

### 2.3.6 Post-Analysis Storage

Original water samples will be stored refrigerated at 4°C ± 2°C for a minimum of 2 months after the final data are submitted. Original soil samples and all sample extracts/digestates will be stored at 4°C ± 2°C for a minimum of 6 months after final data are submitted. Samples for metals analysis only and metals digestates may be stored at room temperature. Disposal of all samples and extracts/digestates will be in accordance with federal and state regulations.

## 2.4 Analytical Methods Requirements

### 2.4.1 Overview of Analytical Methods

This section contains an overview of the preparation and instrumental procedures to be used for this project. Detailed descriptions of specific methods, with tables summarizing calibration procedures, QC sample acceptance values and corrective action, and LOQs, are given in Section 2.4.2 and the method specific tables located in Appendix B.

#### 2.4.1.1 Organic Analyses

Organic Extractions

Prior to analysis on an instrument, analytes of interest must be separated from the matrix and concentrated. Target analytes are removed by serially extracting a known volume or weight with a solvent, collecting, then concentrating the solvent to a specified volume.

For aqueous organic extraction methods, it is recommended that volume be measured as described below:

- On the sample container, mark the top of the water column
- Pour the contents of the sample container into a separatory funnel
- Rinse the emptied sample container with solvent and add to the separatory funnel
- Fill the sample container with water
- Measure the water in the sample container with a graduated cylinder.

General Gas Chromatography

Gas chromatographs achieve separation by partitioning solutes between a mobile gas phase and a stationary liquid phase on solid support material. A typical analysis would proceed as follows. The organic extract of a sample is injected into a heated injection port. The solvent and solutes are immediately vaporized and swept onto a separation column by inert carrier gas. The solutes are adsorbed onto the stationary phase of the column and then are desorbed by fresh carrier gas. The sorption-desorption process occurs repeatedly as the sample moves through the column and each analyte will be retained based on its unique solubility with the stationary phase. After passing through the column, the solutes are eluted into a detector system.

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, non-MS GC methods often require sample extracts to be analyzed on a second, dissimilar column to decrease the probability of false positives.

Second column confirmation will be provided for gas chromatography methods for all single peak analytes found above the reporting limits given in the first table of the method specific tables found in Appendix B of this document using a dissimilar column.

Although SW-846 3rd Edition permits the use of higher order calibration curves, this CDQMP specifies that only linear curve fits be used in the quantitation of confirmed analytes. The analyst may choose to use either a linear curve forced through the origin or the linear curve as determined through regression routines. Specific criteria to be used for either type of linear curve is specified in the text and Appendix B, Tables, for the applicable methods.

General Detector Systems

Detector systems detect target analytes in the column effluent. Some are specific to classes of compounds (e.g., photoionization and electron capture), and some are relatively unselective (e.g., flame ionization). Selective detectors often provide lower reporting limits by increasing the signal to noise ratio and by their selectivity and provide an additional level of confidence during compound identification. Mass spectrometers provide a high level of confidence in compound identification because they provide a characteristic ion pattern for fragmented target analyte molecules.

Once they are calibrated, detectors enable quantitation of target analytes. Calibration consists of the establishment of a dynamic working range and periodic continuing standards to show that the instrument is still operating within acceptable limits.

General Gas Chromatography/Mass Spectroscopy Methods (GC/MS)

GC/MS methods couple gas chromatographic techniques with mass spectrometry to allow confirmation of a compounds' identity and concentration. After partitioning by GC, the sample is metered into a mass spectrometer and bombarded with ions until molecular fragments result. Each molecular fragment is characteristic for a compound and can then be compared to reference spectra using computer routines. The reference spectra plus the retention time are used to confirm the identity of the compound. Quantitation is performed by comparing the response of the primary (or secondary as necessary) ions relative to an internal standard with a multipoint initial calibration curve.

#### 2.4.1.2 Metals Analyses

Two techniques, inductively coupled plasma (ICP) atomic emission spectroscopy and atomic absorption (AA), will be employed to measure levels of specified metals in the samples. Sample digestion is required prior to most ICP and AA analyses.

Inductively Coupled Plasma/Atomic Emission Spectroscopy (ICP) Procedures

ICP determines elements in solution. All matrices including groundwater, surface water, aqueous samples, industrial wastes, soils, sludges, TCLP and STLC extracts, and sediments require digestion prior to analysis. Aqueous samples and leachates may be digested using preparation methods SW-3010A or SW-3020A as described in the text. Solid samples may be digested using methods SW-3050B.

Method SW-6010B provides a simultaneous or sequential multi-element determination of elements by ICP. Element-emitted light is measured by optical spectrometry. Samples are nebulized and the resulting aerosol is transported to the plasma torch. Element-specific atomic line 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.

Inductively Coupled Plasma/Mass Spectrometry (ICP/MS) Procedures

ICPMS determines elements in solution. All matrices including groundwater, surface water, aqueous samples, industrial wastes, soils, sludges, and sediments require digestion by Methods SW-3020A (water) or SW-3050B (soil - modified for ICP/MS analysis) prior to analysis. Method SW-6020 Modified provides a simultaneous multi-element determination by ICP/MS. The method measures ions produced by radio-frequency ICP. Analytes are nebulized from the sample and the resulting aerosol is transported by argon gas to the plasma torch. The ions are entrained in the plasma gas and introduced, by means of a water-cooled interface, into a quadropole mass spectrometer. The ions are sorted according to their mass-to-charge ratios and quantified by a channel electron multiplier. Interferences must be assessed and valid corrections applied or the data flagged to indicate non-conformance. Interference correction must include compensation for background ions contributed by the plasma gas, reagents, and constituents of the sample matrix.

Analysis by Atomic Absorption Spectroscopy

Elements such as arsenic, selenium and lead may be determined using atomic absorption techniques rather than ICP, in order to achieve the required detection limits or where interferences are encountered. If required because of interferences, thallium may also be determined using atomic absorption spectroscopy.

Graphite Furnace AA

Metals in solution can be determined by atomic absorption(AA). Prior to analysis, soil samples are prepared using the digestion procedure described in Method SW-3050B. Aqueous or leachate samples may be prepared using Method SW-3010A or SW-3020A. The digestate is introduced into the graphite furnace, electrothermally dried, charred, and atomized. The resulting absorption of a specific light beam from the hollow cathode or electrodeless discharge lamp (EDL) lamp is proportional to the metal concentration. Background correction will be used for all analyses. Samples with concentrations outside the linear calibration range will be diluted. The matrix may be modified by the addition of certain compounds or elements, as recommended by the determinative methods, to reduce interferences. The presence of interferences will be verified and documented by applying the procedures as outlined in the method specific table located in Appendix B.

Flame (Direct Aspiration) AA

Direct aspiration is used for organic lead determinations (LUFT Manual, 1989, and Method SW-

7420), and may be used for other metals upon prior arrangement with the laboratory. Prior to analysis by direct aspiration, samples are extracted using the procedure described for organic lead LUFT and Method SW-3010A. Following sample preparation, a representative aliquot is aspirated into an air/acetylene flame. The resulting absorption of a specific light beam from the hollow cathode or EDL lamp will be proportional to the metal concentration. Background correction will be employed for all analyses.

Mercury by Cold Vapor Atomic Absorption

Mercury will be determined in selected solid samples using SW-7471A and in water samples using SW-7470A. Methods SW-7470A and SW-7471A are cold-vapor atomic absorption procedures for determining the concentration of mercury in extracts, groundwater, and waste samples. Sample preparation is specified in the method. Following dissolution, mercury in the sample is reduced to the elemental state, aerated from solution, and the vapor passed through a cell positioned in the light path of an atomic absorption spectrometer. Permanganate is added to the sample during preparation to reduce interferences from sulfides and chlorides.

### 2.4.2 Method Descriptions

The following text provides a brief summary description for each analytical method. Method specific tables are located in Appendix B. Since EPA has discontinued promulgation of new and improved methods, for all analytical methods performed for TEAD projects, the most recently published version of the EPA method shall be used. The actual version of the method used shall be recorded in the site specific documents and laboratory reports.

#### 2.4.2.1 Organics

##### 2.4.2.1.1 Sample Preparation

SW-3510- Separatory Funnel Liquid-Liquid Extraction

Method 3510 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.

SW-3520 - Continuous Liquid-Liquid Extraction

Method SW-3520 is a procedure for 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 hours 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.

SW-3540 - Soxhlet Extraction

The procedure extracts nonvolatile and semivolatile organic compounds from solids such as soils, sludges, and wastes. It is applicable to the isolation of water-insoluble and slightly water soluble organics 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.

SW-3550 - Sonication Extraction

Method SW-3550 is a procedure for extracting nonvolatile and semivolatile organic compounds 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. 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.

SW-5030 - Purge and Trap

For 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 which are detected by the appropriate detector. An extraction method can be employed for nonaqueous and solid samples when high concentrations are expected. This involves one dilution of the sample into methanol. An aliquot of this methanol extract is then added to reagent water and purged as discussed above. For low-level soil samples, five grams of the sample is combined with five milliliters of reagent water, and the purge chamber is heated to 40°C. Twenty five milliliters of a sample are typically purged when performing low-level aqueous analyses.

SW-5035 - Closed System Purge and Trap and Extraction

For low-level soil samples, five grams of the sample are weighed in the field at the time of collection and added to the pre-weighed, septum sealed, screw-cap vial which already contains a stirring bar and sodium bisulfate preservative solution. Alternatively, the sample is collected with an EnCore™ sampler and the sampler is used as the storage device. Analysis must be performed within 48 hours unless the EnCore™ sampler is frozen during storage. Immediately prior to analysis, five milliliters of reagent water, surrogates and internal standards (as applicable) are added, without opening the sampling vial. The vial containing the sample is heated to 40°C. The contents of the vial are then purged using an inert gas combined with agitation and the volatile components are transferred 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 which are detected by the appropriate detector.

An extraction method can be employed for oil soluble in water-miscible solvents and solid samples when high concentrations are expected. This involves one dilution of the sample into methanol. An aliquot of this methanol extract is then added to reagent water and purged as discussed in SW-5030.

#### 2.4.2.1.2 Gas Chromatography

SW-8021 - Halogenated Volatile Organic Compounds by GC/HECD and Purgeable Aromatic Compounds by GC/PID

Method SW-8021 is a purge-and-trap (method SW-5030 or SW-5035) based procedure to determine halogenated volatile organic compounds and aromatic volatile organic compounds by gas chromatography. A temperature program is used in the gas chromatograph to effect an efficient separation of the organic sample components. Halogenated compounds are detected by a Hall Electrolytic Conductivity Detector (HECD). Aromatic compounds are detected by a photoionization detector (PID).

Volatile compounds in water or low-level contaminated soils can be introduced directly into the gas chromatograph by purge-and-trap, method SW-5030 or SW-5035. Medium-level contaminated soils may require methanolic extraction, as described in method SW-5030, prior to purge-and-trap. The sample volume or sample weight purged may vary to meet contract required quantitation limits as described in the project specific QA plan.

SW-8015 Modified - Total Petroleum Hydrocarbons by GC/FID

This method determines total petroleum hydrocarbons as gasoline, diesel or jet fuel by SW-8015B Modified. Volatile petroleum hydrocarbons (gasoline) are analyzed by purge-and-trap

method SW-5030 or SW-5035. Semivolatile petroleum hydrocarbons such as diesel and/or jet fuels are analyzed after extraction by SW-3510 (aqueous) or SW-3550 (soils). A 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). Generally, the carbon ranges listed below are typical of the fuels described:

| | |
|---|---|
| Gasoline | C-6 to C-10 |
| Diesel | C-10 to C-24 |
| JP-4 | C-8 to C-13 |
| Motor Oil | C-24 to C-36 |

Gasoline in aqueous or low-level contaminated soil samples can be determined directly by purge-and-trap, method SW-5030 or SW-5035, and desorption into the gas chromatograph. Medium level contaminated soils may require methanolic extraction, as described in method SW-5030 prior to purge-and-trap.

Samples to be analyzed for diesel and jet fuel require extraction with methylene chloride 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. The laboratory may then calibrate and quantify the total hydrocarbon concentration using one reference fuel. For example, if both JP-4 and gasoline are analyzed by the purge-and-trap method, then the laboratory has the option to quantify the result by using either a JP-4 or gasoline curve. The laboratory should strive to be consistent in their quantitation practice and document any anomalies in the narrative accompanying the data report.

SW-8081, SW-8082 - Organochlorine Pesticides and Polychlorinated Biphenyls (PCB)

Method SW-8081 and SW-8082 are a gas chromatography/electron capture detector methods for the detection of organochlorine pesticides and polychlorinated biphenyls (PCBs, commonly identified as Aroclor mixtures). These target analytes produce chromatograms with single peaks, or in the case of Aroclors and toxaphene, multiple peaks in recognizable patterns. Identification is based on the comparison of a resulting sample chromatogram to that of a standard. Quantitation is performed relative to the initial calibration.

Water samples are extracted at a neutral pH with methylene chloride by methods SW-3510 or SW-3520C. Method SW-3510 is a separatory funnel extraction technique and SW-3520 is a continuous liquid-liquid extraction. Soil samples are extracted with methylene chloride and acetone using method SW-3550, a sonication extraction procedure. Extracts are solvent exchanged into hexane and undergo clean up procedures as deemed necessary for the sample.

If an Aroclor (or any multi-eluter) is detected in the sample, then that Aroclor (or any multi-eluter) may be quantitated on a separate GC calibrated for that compound. All multicomponent

bracketing standards must be within ± 15% from the expected concentration, as quantitated from the calibration factor as determined from the ICAL. ICAL, ICV, and CCV criteria must be met on the column used for quantitating and final reporting of the target analyte. At least five of the largest representative peaks are chosen for quantitation of the Aroclors. For the quantitation of Aroclor 1221, three peaks will be summed. PCB detections do not require a second column confirmation. The characteristic peak pattern serves as a primary level of qualitative identification.

SW-8141 - Organophosphorus Pesticides by GC

Method SW-8141 is a gas chromatographic method for the detection of various organophosphorus pesticides. 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.

Water samples are extracted at a neutral pH with methylene chloride by methods SW-3510 or SW-3520. Method SW-3510 is a separatory funnel extraction technique and SW-3520 is a continuous liquid-liquid extraction. Soil samples are extracted with methylene chloride and acetone using method SW-3550, a sonication extraction procedure. If method SW-8141 is used to analyze soils for organophosphorus pesticides, then extraction methods SW-3540 and SW-3541 will be used.

Extracts are solvent exchanged into hexane and undergo clean up procedures as deemed necessary for the sample.

SW-8151 - Chlorinated Herbicides

Method SW-8151 provides extraction, esterification and gas chromatographic conditions with electron capture detection for the analysis of chlorinated acid herbicides. Spiked samples are used to verify the applicability of the chosen extraction technique to each new sample type.

The herbicides are extracted from soil by shaker with acetone/ethyl ether, and from water by partitioning in a separatory funnel with ethyl ether. Extracts are hydrolyzed with aqueous KOH, 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 hexane.

SW-8260 - Volatile Organics by GC/MS

This method is based upon a purge-and-trap, gas chromatographic/mass spectrometric (GC/MS) procedure and is used to determine volatile organic compounds in a variety of solid waste

matrices. It is applicable to nearly all types of sample matrices, including water and soil. The volatile compounds are extracted and introduced into the gas chromatograph by the purge-and-trap method. The components are separated via the gas chromatograph and detected using mass spectrometer which provides both qualitative and quantitative information.

Volatile compounds in water or low-level contaminated soils can be introduced directly into the gas chromatograph by the purge-and-trap method (SW-5030B or SW-5035). Medium-level contaminated soils may require methanolic extraction, as described in method SW-5030B, prior to purge-and-trap.

SW-8270 - Semivolatile Organic Compounds by GC/MS

This method can be used to quantify most neutral, acidic, and basic organic compounds that are soluble in 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, samples must be prepared using the appropriate sample preparation method: for soil samples, sonication extraction (SW-3550) is used, and for water samples, separatory funnel (SW-3510) or continuous liquid/liquid extraction (SW-3520) are used.

SW-8280 - Polychlorinated Dibenzo Dioxins and Polychlorinated Dibenzofurans by GC/MS

Methods SW8280 is used to detect dioxins and furans in a variety of matrices and uses additional quality control to allow more sophisticated determinations of detection limits and matrix spike recoveries than other routine GC and GC/MS methods.

SW-8280 requires isotopically labeled analogs of target analytes to be spiked into each sample before extraction. SW-8280 uses six $C^{13}$ analogs. 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. The assessment of matrix effects on method performance, assessed by matrix spikes and matrix spike duplicates in other GC and GC/MS methods, can be met in SW-8280 with the isotopically labeled analogs. These isotopes are spiked into each sample and therefore matrix effects on method performance can be judged by the recovery of these isotopes, for each sample. Sample analysis acceptance is controlled by the performance of these isotopes in the sample. The batch specific LCS will use isotopically labeled analogs of the target analytes and unlabeled natives to control the batch. In summary, no MS/MSD will be performed for SW-8280 sample analyses and batch control will be done by the recovery of the spiked, isotopically labeled, analogs and unlabeled natives.

All PCDD and PCDF analyses performed (for EPA 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 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.

There is a three tiered approach to reporting and detection limits. In the absence of target analytes, a sample specific estimated detection limit (EDL) is calculated based on method signal to noise ratios. The target analyte is then reported as "not detected" at the EDL. When target analytes are found, they are reported down to the lower calibration limits without conditional modifiers such as a J flag. If below the lower calibration limit, the target analyte will be qualified as such.

If there is a peak which meets the signal-to-noise criteria, but not all of the other identification criteria (i.e. retention time, ion ratio, absence of diphenyl ethers, and analyst judgement), an EMPC (estimated maximum possible concentration) based on the ion peak is calculated. The target analyte is reported as "not detected" at that calculated detection limit and is qualified as an EMPC.

SW-8290 Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by High Resolution Gas Chromatography/High Resolution Mass Spectrometry (HRGC/HRMS)

This method provides instrument and extraction procedures for the detection and quantitation of PCDDs (tetra through octa-chlorinated homologues) and PCDFs (tetra through octa-chlorinated homologues) in a variety of sample matrices and part-per-trillion (ppt) to part-per-quadrillion (ppq) concentrations.

Method SW-8290 is used to detect dioxins and furans in a variety of matrices and uses additional quality controls to allow more sophisticated determinations of detection limits and matrix spike recoveries than other routine GC and GC/MS methods.

SW-8290 requires isotopically labeled analogs of target analytes to be spiked into each sample before extraction, and 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.

There is a three tiered approach to reporting and detection limits. In the absence of target analytes, a sample specific estimated detection limit (EDL) is calculated based on signal-to-noise (S/N) ratios at the retention time of the analyte. The target analyte is then reported as "not

detected" at the EDL. When target analytes are found, they are reported down to the lowest calibration standard concentration without conditional modifiers such as a J flag. Below the SW-846 specified reporting limits, qualitatively confirmed analytes are reported as "estimated" down to the target detection limit (TDL) to denote the less certain quantitation. The TDL is a value set by the lab at which there is no significant chance of false positives. If there is a peak below the TDL, and all qualitative criteria such as retention time, ion ratios, signal to noise ratio, the absence of diphenyl ether, and analyst judgment, are not met, a detection limit based on the ion peaks is calculated and the target analyte is reported as "not detected" at that calculated detection limit.

The assessment of matrix effects on method performance can be met in SW-8290 with the isotopically labeled analogs. These isotopes are spiked into each sample and therefore matrix effects on method performance can be judged by the recovery of these isotopes, for each sample. Sample analysis acceptance is controlled by the performance of these isotopes in the sample. Furthermore, the batch specific LCS are also not required since the batch specific method blank uses isotopically labeled analogs of the target analytes and controls the batch.

In summary, no MS/MSD is performed for SW-8290 sample analyses (unless specifically requested by the client), and batch control will be done by the recovery of the spiked, isotopically labeled, analogs in the method blanks.

#### 2.4.2.1.3 High Performance Liquid Chromatography

SW-8310- Polynuclear Aromatic Hydrocarbons

Method SW-8310 is a liquid chromatography method with ultra-violet and fluorescence detection for the analysis of polynuclear aromatic hydrocarbons (abbreviated as PAH or PNA). 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.

Water samples are extracted with methylene chloride by methods SW-3510 or SW-3520. Method SW-3510 is a separatory funnel extraction technique and SW-3520 is a continuous liquid-liquid extraction. Soil samples are extracted with methylene chloride and acetone using method SW-3550, a sonication extraction procedure. Soil extracts are solvent exchanged and undergo a silica gel clean up procedure. Extracts are then solvent exchanged to methanol for analysis.

SW-8330, SW-8321 Modified - Nitroaromatics and Nitroamines by HPLC.

Method SW-8330 is a high performance liquid chromatography/ultra-violet (HPLC/UV) method and Method SW-8321 Modified is a high performance liquid chromatography/mass spectrometer

(HPLC/MD) method for the extraction and detection of explosives residues in waters, soils, and sediments. All samples and extracts are analyzed on an HPLC fitted with a C-8 reverse phase column at a UV detection of 250 nm. Positive detections may be confirmed on a cyano-column.

Aqueous samples suspected of containing low level concentrations of explosives residues are extracted by "salting out" an aliquot of sample with sodium chloride, extracting with acetonitrile, then analyzing the extract. Aqueous samples suspected of containing high levels of explosive residues are analyzed on the HPLC using direct aqueous injection. High level aqueous samples are filtered prior to analysis.

For soil and sediment samples, a 2-gram sample aliquot is extracted with acetonitrile, aliquoted, treated with calcium chloride solution, filtered, then analyzed by HPLC. If soils and sediments appear non-homogeneous they are air dried, ground, and sieved through a 30 mesh screen before sample extraction.

Army Method UT094, SW-8321A Modified or equivalent (Thiodiglycol and Thiodiglycolic Acid)

Method UT094 and SW-8321A Modified are high performance liquid chromatography/ultra-violet (HPLC/UV) methods for the extraction and detection of thiodiglycol and thiodiglycolic acid in waters, soils, and sediments. All samples and extracts are analyzed on an HPLC fitted with a C-18 reverse phase column at a UV detection of 215 nm. Positive detections may be confirmed on a cyano-column.

SW-8321 Modified also allows for the use of liquid chromatography/thermo spray/mass spectrometer (LC/TSP/MS). For LC/TSP/MS, the extracts and standards are analyzed on an HPLC fitted with a reverse phase column and introduced into the mass spectrometer by thermospray. The advantage of this method is positive confirmation of target compounds by mass spectra and lower limits of detection. Quantitation is performed using internal standard techniques with $d_5$-atrizine as the internal standard.

### 2.4.2.2 Inorganics

#### 2.4.2.2.1 Sample Preparation

SW-3020 - Acid Digestion of Aqueous Samples and Extracts for Total Metals

This digestion procedure is used for the preparation of aqueous samples and extracts that contain suspended solids. The procedure is used to prepare samples for analysis by GFAA. A mixture of nitric acid and the material to be analyzed is refluxed in a covered vessel. This step is repeated with additional portions of nitric acid, 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 10-20 mls), it is cooled and brought up to volume with dilute nitric acid such that the final dilution contains 3 percent (v/v) $HNO_3$. If the sample contains suspended solids, it must be centrifuged, filtered, or allowed to settle. This procedure includes modifications to Method SW-3020. The modifications are the addition of hydrogen peroxide and the reduction in volume to 10-20 mls, rather than 5 mls as specified in the method. The modifications are included to allow for the analysis of arsenic and selenium, in that Methods SW-7060 (arsenic) and SW-7740 (selenium) call for the addition of hydrogen peroxide, and less volume reduction.

SW-3020 Modified - Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by ICP/MS

This digestion procedure is used for the preparation of aqueous samples and extracts that contain suspended solids. The procedure is used to prepare samples for analysis by ICP/MS. A mixture of nitric acid and the material to be analyzed is refluxed in a covered vessel. Hydrogen peroxide is added until the digestate is light in color or until its color has stabilized. After the digestate has been brought to a low volume (approximately 25 mls), it is cooled, 1 ml of 1:1 hydrochloric acid/water is added and the digestate is brought up to volume with deionized water. If the sample contains suspended solids, it must be centrifuged, filtered, or allowed to settle. The modifications to Method SW-3020A for analysis by ICP/MS include the addition of hydrogen peroxide and hydrochloric acid to aid in the digestion of certain elements (i.e. silver), and less volume reduction during digestion to allow for the analysis of the more volatile elements (i.e. antimony).

SW-3050 - Acid Digestion of Sediments, Sludges, and Solids

This digestion method is used to prepare sediment and soil samples for analysis by ICP, ICP/MS, graphite furnace atomic absorption (GFAA) and flame atomic absorption (FLAA). A representative portion of the sample is digested in 1:1 nitric acid. A final reflux procedure is performed using concentrated hydrochloric acid for FLAA or ICP, or concentrated nitric acid for GFAA. Hydrogen peroxide is added during the digestion procedure. The final volume is adjusted to 100 ml.

SW-3060, - Alkaline Digestion for Hexavalent Chromium

A 2 gram aliquot of sample is digested in 8ml of $NaCO_3$ /NaOH digestion solution on a hotplate for 30-45 minutes. The solution is cooled, filtered, and quantitatively transferred to a 100 ml volumetric flask. Just prior to analysis the solution is neutralized with $HNO_3$. A 9.5 ml portion of the digestate is then transferred to a 10 ml volumetric flask and is ready for analysis by method SW-7196A ($Cr^{+6}$).

#### 2.4.2.2.2 Atomic Emission

SW-6010 - Inductively Coupled Plasma (ICP)

Inductively coupled argon plasma (ICP) determines sample elements in the acid digestate of a sample. Simultaneous ICP uses multi-element atomic emission spectroscopy to identify and quantify metals. An aerosol of the sample is metered into the argon plasma. Element specific atomic emission spectra are produced by radio-frequency ICP. The spectra are dispersed and the lines monitored by photomultiplier tubes. The background is measured and the results are corrected for background levels and interelement interferences.

On a daily basis, the ICP will be calibrated using three standards. Alternatively, a laboratory may standardize the instrument using a blank and a single standard if a detection limit standard and an upper calibration range standard are included in the analysis sequence. Ongoing instrument checks must include calibration verification standards, interelement check standards, and blanks. Specific criteria and frequency are described in the method specific table located in Appendix B.

SW-6020 - Inductively Coupled Plasma/Mass Spectroscopy

On a daily basis, the instrument will be tuned prior to calibration. Alternatively, a laboratory may standardize the ICPMS using a blank and a single standard if instrument sensitivity and linearity can be demonstrated empirically. Other instrument controls include internal standard monitoring, calibration verification standards, interference correction calculation checks, and blanks. Specific criteria and frequency are described in the method specific table located in Appendix B.

#### 2.4.2.2.3 Atomic Absorption

SW-7000 - Total Metals by GFAA

Graphite furnace atomic absorption spectroscopy (GFAA) determines metals present in the acid digestate of a sample. A representative aliquot of a sample is placed into a graphite tube "furnace," evaporated, charred, and the element of interest atomized. A light beam from a hollow cathode lamp or electrodeless discharge lamp is directed through the furnace, into the monochromator, and onto a detector that measures absorbance.

The instrument is calibrated using a multipoint linear curve on each day of analysis. Instrument performance is monitored using calibration verifications, and blanks. See the method specific table located in Appendix B for specific criteria and frequency.

SW-7470, SW-7471 - Mercury by Cold Vapor AA

Sulfuric acid, nitric acid, and potassium permanganate are added sequentially to a known sample amount. Potassium persulfate is added to each sample, then digested for 15 minutes in an autoclave at 120°C at one atmosphere pressure (alternatively, a water bath may be used to digest samples at 100°C for 2 hours). After cooling, sodium chloride-hydroxylamine sulfate is added to reduce the permanganate. Stannous sulfate is added just prior to aeration of the sample and introduction into the spectrophotometer.

The instrument is calibrated using a multipoint linear curve (5 points) digested with the samples. Instrument performance is monitored using calibration verifications, and blanks. See the method specific table located in Appendix B for specific criteria and frequency.

#### 2.4.2.2.4 Spectrophotometric Methods

EPA-365.2 - Phosphorous, All Forms

Ammonium molybdate and antimony potassium tartrate react in an acid medium with dilute solutions of phosphorus to form a antimony-phosphor-molybdate complex. This complex is reduced to an intensely blue-colored complex by ascorbic acid. The color is proportional to the phosphorus concentration measure by absorbance at 650 nm.

SW-7196 - Hexavalent Chromium

This method is applicable to water samples, leachates and digestates (SW-3060). A 9.5 ml aliquot of sample is transferred to a 10 ml volumetric flask and 0.2 ml of diphenylcarbazide solution is added. Enough sulfuric acid ($H_2SO_4$) is added to adjust the pH to approximately 2, and the sample is diluted to a full volume of 10 ml with ASTM Type II water. After standing for 5-10 minutes for full color development, the absorbance is read in a 1 cm cell at 540 nm. See the method specific table located in Appendix B for specific criteria and frequency.

EPA-335.3/SW-9010 - Cyanide

These methods are applicable to the determination of cyanide in drinking water, surface waters, domestic and industrial wastes and leachates. The cyanide as hydrocyanic acid, is released from cyanide complexes by means of UV digestion and distillation. Cyanides are converted to cyanogen chloride by reactions with chloramine-T which subsequently reacts with pyridne and bartituric acid to give a red-colored complex.

#### 2.4.2.2.5 Ion Chromatography

EPA-300.0/SW-9056 - Anions by Ion Chromatography

These methods are applicable to the analysis of chloride, bromide, fluoride, nitrate, nitrite, ortho-phosphate, and sulfate in drinking, surface and saline waters, and domestic and industrial wastes. The EPA-300.0 method is primarily for drinking waters, and the SW-9056 method has been adapted for the analysis of soil matrix. Anions are determined by introducing a water or leachate sample into an ion chromatograph. The anions of interest are separated and measured using a system comprised of a guard column, separator column, suppressor column and conductivity detector. The system eluent is a $Na_2CO_3$-$NaHCO_3$ solution.

Non-aqueous samples may be analyzed by leaching a 10 gram sample for 1 hour with deionized water at a ratio of 1:5 (w/v), filtering, then analyzing the resulting leachate. See the method specific table located in Appendix B for specific criteria and frequency.

Army Method UT04 or equivalent (Organic Acids)

Organic acids are analyzed by IC. This method utilizes a gradient pump, which meters selected eluents at specific rates. The eluents used are ASTM type II water and 200 mM sodium hydroxide. High levels of chloride in a sample may interfere with methyl phosphonic acid (MPA). However, if MPA is an analyte of interest, the gradient program can be modified to help minimize this interference. Isopropylmethyl phosphonic acid (IMPA) is indistinguishable from ethylmethyl phosphonic acid (EMPA) using this method.

#### 2.4.2.2.6 Gravimetric Methods

EPA-160.1 - Total Dissolved Solids

A well shaken 100 ml aliquot of the sample is filtered through a glass fiber filter. The filtrate is then transferred to a preweighed evaporating dish and dried until a constant weight is obtained. The resultant weight of the residue (Filterable residue) is calculated in mg/L.

EPA-160.2 - Total Suspended Solids

A well shaken 100 ml aliquot of the sample is filtered through a preweighed glass fiber filter. The filter is then dried until a constant weight is obtained. The resultant weight of the residue (Non-filterable residue) is calculated in mg/L.

#### 2.4.2.2.7 Miscellaneous Methods

EPA-415.1 - Total Organic Carbon

Non-Purgeable Organic Carbon is determined by the UV promoted oxidation technique. An aliquot of sample is decanted into vials to minimize particulate interference when injected into a reaction vessel containing 2 percent $K_2S_2O_8$ and a UV lamp to promote oxidation. The resulting $CO_2$ is measured on a NDIR detector and the peak are is integrated by the instrument.

EPA-150.1/SW 9045 - pH

For water samples (EPA-150.1), the pH of the sample is determined with stirring using a combination electrode. The pH meter is calibrated using purchased standard buffers of known pH. For soil samples (SW-9045), a few drops of HCl is added to about 1 gram of sample to test for calcareousness. If the sample effervesces, it is considered calcareous. The sample is mixed (20g:20ml) with either ASTM Type II water or with a 0.01 M $CaCl_2$ solution, depending on whether the soil is calcareous or non-calcareous. The pH of the sample is then determined using a combination electrode as discussed above.

EPA-120.1- Specific Conductance

The specific conductance of a water sample is measured by the use of a self-contained, temperature corrected conductivity meter. A conductance cell and a Wheatstone bridge are used to measure the conductance of the sample as a ratio of the electric current through the cell to the applied voltage. Results are reported in umhos/cm.

EPA-180.1 - Turbidity

This method is based upon the comparison of intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference solution. The higher intensity of scattered light, the higher the turbidity. The standard reference solution used to calibrate the instrument is a suspension of Formazin, prepared under closely defined conditions. Readings are made in nephelometric turbidity units (NTUs).

### 2.4.4 Preventive Maintenance Program

The objective of a preventive maintenance program (PMP) is to ensure instrument operation is appropriate for project and method DQOs. This PMP focuses on three areas: maintenance responsibilities; maintenance schedules; and inventory of spare parts and equipment.

Maintenance Responsibilities

Maintenance responsibilities for laboratory equipment are assigned to the respective laboratory managers. The laboratory managers then establish maintenance procedures and schedules for each major equipment item. These are contained in the maintenance logbooks assigned to each instrument.

Maintenance Schedules

The effectiveness of any maintenance program depends to a large extent on adherence to specific routine maintenance for each major equipment item. Other maintenance activities may also be identified as requiring attention on an as-needed basis. Manufacturers' recommendations and/or sample throughput provide the basis for the established maintenance schedules, and manufacturers' service contracts provide primary maintenance for many major instruments (e.g., GC/MS instruments, atomic absorption spectrometers, analytical balances, etc.). Service engineers are employed on the premises to maintain and repair major instrumentation as needed. Maintenance activities for each instrument are documented in a maintenance log. Maintenance schedules and a list of spare parts for the laboratory are listed below.

Spare Parts

Along with a schedule for maintenance activities, an adequate inventory of spare parts is required to minimize equipment down time. This inventory emphasizes those parts (and supplies) which are subject to frequent failure, have limited useful lifetimes, or cannot be obtained in a timely manner should failure occur.

The respective laboratory managers are responsible for maintaining an adequate inventory of necessary spare parts. Sufficient equipment is on hand to continue analyses in the event that an instrument encounters problems. In addition to backup instrumentation, a supply of spare parts such as gas chromatography columns, fittings, septums; atomic absorption lamps, mirrors, diaphragms; graphite furnace tubes; and other ancillary equipment is maintained.

### 2.4.5 Laboratory Data Reduction and Review

Data Reduction

In most cases calculations from raw data are included in discussions of analytical procedures presented in the EPA methods. These data reduction and review procedures will not be presented in this document. Details of data reduction, calibration, and reporting not addressed in the referenced documents are discussed in this section.

Data reduction calculations used for this project are included on the standard reporting forms developed by the laboratory and associated with each individual method or group of methods. Calculations which are not present on standard reporting forms include computer-based data reduction programs. The laboratory is responsible for maintaining a list of these data reduction programs and for being able to demonstrate their validity. 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 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 and will not be covered in this document. 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) is recorded in order to enable reconstruction of the final result at a later date. All information regarding the preparation of the sample (e.g. weight or volume of sample used, percent dry weight for solids, extract volume, dilution factor used) is also maintained in order to enable reconstruction of the final result at a later date.

Some instruments are configured to operate independently without computers. 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 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 instrumental 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; calculations used are recorded in the same laboratory notebook.

Data storage and documentation will be maintained using logbooks and data sheets that will be kept on file. Computer acquired data are stored on magnetic tape, floppy disks, or other media, and are generally archived for a period of one year. Paper hard copies of raw data are kept on file for ten years.

Data Review Assessment

The laboratory system for ensuring valid data includes several levels of review. Each level commands specific action to prevent the unqualified release of erroneous data and to correct any problems discovered during the review process.

All analytical data generated at the Contract Laboratory are extensively checked for precision, accuracy, and completeness (a thorough evaluation of representativeness and comparability involves additional data which may not be available to the laboratory). The data validation process consists of data generation, reduction, and three levels of review, as described below.

The analyst who generates the analytical data has the prime responsibility for the correctness and completeness of the data. All data are generated and reduced following protocols specified in

laboratory SOPs. Each analyst reviews the quality of his or her work based on an established set of guidelines. At a minimum the analyst reviews the data package to ensure that:

Sample preparation information is correct and complete:

- Analysis information is correct and complete
- The appropriate SOPs have been followed
- Analytical results are correct and complete
- QC samples are within established control limits; blanks are acceptable
- Special sample preparation and analytical method requirements have been met
- Project-specific requirements have been met

Documentation is complete (e.g., all anomalies in the preparation and analysis have been documented, out of control forms, if required, are complete, holding times are documented, etc.).

This initial review step, performed by the analyst is designated Level 1 review. The analyst then passes the data package to an independent reviewer who performs a Level 2 review.

Level 2 review is performed by a group leader or data review specialist whose function is to provide an independent review of the data package. This review is structured to ensure that:

- Calibration data are scientifically sound, appropriate to the method, and completely documented
- QC samples are within established guidelines
- Qualitative identification of sample components is correct
- Quantitative results and calculations are correct
- There are no transcription errors
- Documentation is complete and correct (e.g., anomalies in the preparation and analysis have been documented, out-of-control forms, if required, are complete, holding times are documented, etc.)
- The data are ready for incorporation into the final report
- The data package is complete and ready for data archive.

Level 2 review is structured so that all calibration data and QC sample results are reviewed, and all of the analytical results from 10 percent of the samples are checked back to the bench sheet. If no problems are found with the data package, the review is considered complete. If any problems are found with the data package, an additional 10 percent of the samples are checked to the bench sheet. The process continues until no errors are found or until the data package has been reviewed in its entirety. Errors detected in the review process are referred to the analyst(s) for corrective action. Level 2 data review is documented and the signature of the reviewer and the date of review recorded. The reviewed data are then approved for release and a final report is prepared.

Before the report is released to the client, the Laboratory Project Manager reviews the report and chain of custody to ensure that the data meets the overall objectives of the project. This review is labeled Level 3 review. The supporting documentation includes, at a minimum:

- Laboratory name and address
- Sample information (including unique sample identification, sample collection date and time, date of sample receipt, and date(s) of sample preparation and analysis)
- Analytical results reported with an appropriate number of significant figures
- Reporting limits reflecting dilutions, interferences, and correction for dry weight as applicable
- Method references
- Appropriate QC results (correlation with sample batch traceability and documentation)
- Data qualifiers with appropriate references and narrative on the quality of results

Each step of this review process involves evaluation of data quality based on both the results of the QC data and the professional judgment of those conducting the review. This application of technical knowledge and experience to the evaluation of the data is essential in ensuring that data are consistently of high quality.

Procedures for Handling Unacceptable Data

It is the analyst's responsibility to check the QC information against the project-specific limits for the analysis. When an analysis of a QC sample (blank, spike, check standard, replicate, or similar sample) shows that the analysis of that batch of samples is not in control, the analyst will immediately bring the matter to the attention of the group leader. The group leader will, if necessary, consult with the Laboratory QA Manager and/or the Laboratory Project Manager to determine whether the analysis can proceed, if selected samples should be rerun, or specific corrective action needs to be taken before analyzing additional samples. Out-of-control analyses must be documented. The analyst or group leader will file an "Anomaly Report" with the Laboratory QA Manager for laboratory analysis out-of-control events that require documentation. The Project Chemist will be notified as soon as feasibly possible of any out-of-control events resulting in unacceptable data.

## 2.5 Quality Control Requirements

Relevant techniques associated with quality control activities for individual protocols will be specified with the description of the particular work process. This may include Program procedures, plans, and project-specific documents. In general, the quality control requirements will be commensurate with the necessary level of rigor needed to provide the appropriate level of confidence in data quality.

### 2.5.1 Analytical Quality Control Requirements

Analytical or method quality control determines whether a method is performing within acceptable limits of precision and accuracy. There is a laboratory component and a "matrix" component to this determination. The laboratory component measures the performances of the laboratory analytical processes during the sample analyses. The matrix component measures the method performance on a specific matrix. Some quality control elements uniquely measure the laboratory component of method performance but all QC elements measuring the matrix component contain the laboratory component.

Method blanks and laboratory control samples uniquely measure the laboratory component of method performance. Matrix spikes, matrix spike duplicates, laboratory sample duplicates, surrogates, post-digestion spikes measure the matrix component of method performance.

On a project or sampling event level, additional quality control elements are used to assess field sampling techniques and environmental conditions during sample collection and transportation. Field sample duplicates (in contrast to laboratory sample duplicates), field blanks, equipment blanks, and trip blanks are used to assess field precision and accuracy.

### 2.5.2 Definition of Terms

This sections states the quality control definitions which will be used for work at TEAD.

Detection and Quantitation Limits
Four detection limit terms are used:

- Instrument detection limit (IDL)
- Method detection limit (MDL)
- Limit of Detection (LOD), and
- Limit of Quantitation (LOQ).

The IDL is an empirically derived value which 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 the standard deviation of the instrument response. IDLs are used for metals methods.

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% 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, which have been processed through the preparation or extraction procedure. The guidance in 40 CFR136 Appendix B is used to produce MDLs. MDLs are updated by the laboratory annually at a minimum and after significant

instrument maintenance.

The EPA MDL procedure has been criticized as a poor estimator of the DL for the following reasons:

1. It is a single laboratory, short-term estimator that fails to account for analytical bias, changing instrument conditions, or analyst skill.
2. It assumes uniform variance across all possible spike concentrations, failing to account for the fact that variance increases at higher concentrations.
3. It assumes that measured values at the spike concentration are normally distributed. By using this procedure and spiking at very low concentrations, laboratories have been able to calculate MDLs that cannot be achieved in practice.

For the reasons discussed in the previous paragraph, the DoD QSM requires that laboratories verify measures of method sensitivity, in terms of the LOD and LOQ, at least quarterly.

Limit of Detection: Determination and Verification Requirement

A laboratory shall establish a detection limit (DL) using a scientifically valid and documented procedure for each suite of analyte-matrix-method, including surrogates. The detection limit shall be used to determine the LOD for each analyte and matrix as well as for all preparatory and cleanup methods routinely used on samples, as follows:

After each detection limit determination, the laboratory must immediately establish the LOD by spiking a quality system matrix at approximately two to three times the detection limit (for a single-analyte standard) or one to four times the detection limit (for a multi-analyte standard). This spike concentration establishes the LOD. It is specific to each combination of analyte, matrix, method (including sample preparation), and instrument configuration. The LOD must be verified quarterly. The following requirements apply to the initial detection limit/LOD determinations and to the quarterly LOD verifications.

• The apparent signal to noise ratio at the LOD must be at least three and the results must meet all method requirements for analyte identification (e.g., ion abundance, second-column confirmation, or pattern recognition.) For data systems that do not provide a measure of noise, the signal produced by the verification sample must produce a result that is at least three standard deviations greater than the mean method blank concentrations.

• If a laboratory uses multiple instruments for a given method the LOD must be verified on each.

• If the LOD verification fails, then the laboratory must repeat the detection limit determination and LOD verification at a higher concentration or perform and pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration.

• The laboratory shall maintain documentation for all detection limit determinations and LOD verifications.

Limit of Quantitation: Establishment and Verification of Requirement

For DOD projects, the LOQ must be set within the calibration range prior to sample analysis. At a minimum, the LOQ must be verified quarterly.

The laboratory procedure for establishing the LOQ must empirically demonstrate precision and bias at the LOQ. The LOQ and associated precision and bias must meet client requirements and must be reported. If the method is modified, precision and bias at the new LOQ must be demonstrated and reported.

All reported LOD, LOQ and sample reporting limits (SRL) shall be adjusted for the size of sample aliquots, concentration/dilution factors, and percent solids.

Project-Specific Requirements for Method Sensitivity

Environmental data is used to accomplish one or more of the following tasks:

- Determine whether a chemical substance is present in an environmental sample at or above some threshold value or action level;
- Verify that a pollutant concentration remains below a permit limit;
- Evaluate potential risks to human health or the environment;
- Monitor changes in concentrations of contaminants; or
- Determine the effectiveness of remediation activities.

As defined in the DoD QSM, the RL is the lowest concentration value that meets project requirements for reporting quantitative data with known precision and bias for a specific analyte in a specific matrix. The project specific RLs need to be set to support the DQOs for collection of that data.

Documenting Uncertainty for Low-Concentration Data

Detection and quantitation limits are laboratory specific. Steps must be taken to document measurement uncertainty for low concentration data as follows:

- The laboratory must provide its DL, LOD, and LOQ with associated precision and bias for each target analyte, in each matrix of concern (e.g., reagent water, clean sand, etc.), and

verify that these values meet project-specific RLs. The laboratory SOPs for establishing the DL and for establishing and verifying the LOD and LOQ must be reviewed.

- The laboratory must verify the LOD by processing an LOD verification check sample with each batch of samples. This is a quality control sample that is spiked at a concentration at or slightly above the LOD to evaluate whether the analyte of interest is in fact "detectable" in the matrix of interest. To confidently report non-detects, for TEAD projects the reporting for non-detects is less than the LOD.

- If the project-specific RL is near the LOQ, the laboratory must verify the LOQ in the project-specific matrix by analyzing a minimum of four replicate samples with known concentrations at the LOQ.

- The raw data (e.g., chromatograms) must be reviewed for low-concentration data. If a result is reported above the DL, the signal-to-noise ratio must be at least 3.

- Sample results must be compared with blank results. If sample results (including chromatograms) cannot be distinguished from blank results, then they are not meaningful.

Batch

Many analytical laboratory processes are batch process and there the batch is a basic unit for the frequency of some quality control elements. Two types of batches can be identified: the preparation and instrument batch. A preparation batch (herein referred to as "batch") is defined as a group of twenty or less samples which are prepared (e.g., extracted or digested) within the same time period or in limited continuous sequential time periods. Keeping batches "open" over several hours or days is not permissible; samples and their associated QC samples must be prepared in continuous process. The preparation batch consists of twenty or fewer environmental samples and the associated QC samples: method blank, Laboratory Control Sample (LCS), matrix spike, and matrix spike duplicate or sample duplicate. 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.

The instrument batch is a group of twenty or less 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 volatile organics analyses (VOA) 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, VOA GC and GC/MS batches are defined as twenty or less samples analyzed within a calibration (and for GC/MS, tune) time period, or within sequential continuous calibration time periods.

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 dilution requirements or matrix interference) 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 instrument 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 and MS/MSD need not be analyzed on additional instruments.)
- When preparation batches must be split among instruments to meet expedited turn around times or to meet other project requirements, each instrument batch needs to contain quality control elements equivalent to the quality control elements available in single instrument batch analyses.

When the terms (preparation) batch or instrument batch are used in this document, they are used as defined above.

Method Blank

A method blank is 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. A method blank is included with each batch of samples. Some inorganics methods do not have a distinct preparation, and for these tests, the instrument blank, which contains all reagents used with samples and is equivalent to the method blank, is considered to be the method blank.

Instrument Blank

An instrument blank is used to monitor the cleanliness of the instrument portion of a sample analysis process. Instrument blanks consist of the solvent or acid solution of the standard used to calibrate the instrument. With an exception for metals analyses, instrument blanks are analyzed each instrument batch whenever a method blank is not analyzed in that instrument batch.

Routine metals analyses receive an instrument blank every ten samples. Instrument blanks are also analyzed on an as-needed basis for troubleshooting.

Laboratory Control Samples (LCS)

Laboratory control samples are well-characterized, laboratory generated samples of a known matrix used to monitor the laboratory analytical process independent of matrix effects. LCS samples are spiked with a known quantity of specific target analytes. Sodium sulfate and/or other approved matrices may be used for LCS preparation. LCSs are taken through the entire sample preparation and analytical process. LCSs measure laboratory performance regarding the accuracy of the preparation process by measuring spiked target analyte recoveries in a controlled matrix or matrix-free sample. LCSs are prepared and analyzed with each batch of samples. LCS results, together with matrix spike results, can establish the presence of matrix effects. The LCS spike compounds are given in the method specific tables. 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.

Laboratory Control Sample Duplicates (LCS/LCSD)

Duplicate laboratory control samples are two LCS prepared and analyzed together. Accuracy (recovery) and batch precision may be determined when LCS/LCSD are used. LCS/LCSD are used when not enough sample is available to prepare a matrix spike and matrix spike duplicate for a batch.

Matrix Spikes and Matrix Spike Duplicates (MS/MSD)

Matrix spikes measure matrix specific method performance. A matrix spike sample is prepared by adding a known quantity of target analytes to a sample prior to sample digestion or extraction. The MS and MSD samples are than analyzed with a third aliquot of the sample which remains unfortified. The accuracy of the matrix specific method performance may be determined by the recovery of the spiked analytes after native concentrations of the spike analytes are subtracted. If a matrix spike duplicate (MSD) is analyzed, the matrix specific precision of the method may be calculated. In general, for organics and inorganics analyses, an MS/MSD pair are prepared and analyzed with each batch. Some methods are not amenable to the spiking of target analytes into the sample matrix (i.e, pH). Precision will be determined using a sample duplicate as described below.

Laboratory Sample Duplicates (SD)

For laboratory sample duplicate analyses, a sample is prepared and analyzed twice. The matrix specific method precision may be calculated by dividing the difference in the results by the average. Laboratory sample duplicates are prepared and analyzed with each batch of samples for inorganic analyses. For inorganic analyses the matrix spike RPD limits found in the method-specific Tables in Appendix B will be applied to the sample duplicate results. Organic analyses use MSD to obtain precision data. Corrective actions are described in the tables.

Surrogate Compounds

GC and GC/MS analyses include the addition, subsequent quantitation, and ultimate recovery calculation of surrogate compounds. Surrogate standards help to monitor both performance of the analytical system and the effectiveness of the method in dealing with each sample matrix. Surrogate compounds are:

- Compounds not requested for analysis
- Compounds that do not interfere with the determination of required analytes
- Compounds that are chemically similar to the required analytes, yet are not naturally occurring
- Compounds exhibiting similar response to analytes under determination.

Surrogate compounds are added to every sample and QC sample at the beginning of the sample preparation, and the surrogate recovery is used to monitor matrix effects and sample preparation. Surrogate control criteria are applied to all samples, QC samples, and method blanks. Re-analysis and re-extraction may be performed if surrogate criteria are not met. Specific method surrogates, the recovery acceptance windows, and the control logic are given in the method specific descriptions.

Internal Standards

Internal standards are compounds which analytically behave similarly to the target analytes. Internal standards are compounds not found in the sample, are added at the time of instrumental analysis, are used to quantitate results, and are used to correct for injection variability. Mass spectrometer methods use internal standards. Mass spectrometer methods have control limits on internal standard areas.

### 2.5.3 Laboratory Batch Quality Control Logic

Frequency of batch quality control

For organics analyses each batch will contain a method blank, an LCS, and an MS/MSD pair.

For some inorganics analyses, each batch will contain a method blank, an LCS, a MS, and a SD. For VOA GC/MS analyses, a method blank will be analyzed during each 12 hour tune.

For each shipment of twenty samples to the contract laboratory, one sample will be provided in sufficient quantity such that an MS/MSD can be analyzed in addition to actual sample analysis.

Batch Quality Control Logic

This section provides a general description of batch control logic and corrective actions which will be used. Required batch quality control samples for each analytical method is detailed in the method specific tables located in Appendix B. Analytical batches will be controlled by method blank and LCS results. For analyses which are amenable to matrix spiking**,** MS/MSD recoveries and RPD will be reviewed for systematic trends or errors which may be representative of the batch, as well as the effect of the matrix on method performance, and may result in corrective action for the batch. The sample chosen for MS/MSD analysis, therefore, should be representative of the other samples in the batch and only project specific field samples will be used for MS/MSD procedures. Samples used for MS/MSD analysis will be designated in the field and is identified on the COC. Surrogate recoveries will be reviewed for matrix effects as well as individual sample errors. For analyses which do allow matrix spiking, sample duplicates will be analyzed to measure precision.

The method blank measures laboratory introduced contamination for the sample batch and batch corrective action is initiated when contamination is found; this may include re-analysis of the blank, re-analysis of the samples, re-preparation and re-analysis of the blank, QC, and samples, and assessment of the impact of the contamination on batch sample data. Although it is a goal to have no detected target analytes in the method blanks, analytes may be periodically detected in blanks due to the nature of the analysis or the reporting limit for the analyte. For example, in organic volatile analyses methylene chloride, acetone, and 2-butanone (MEK) may sometimes be found in the blank, and in organic semi-volatiles analyses, the phthalate esters may sometimes be found in the blank. In instances where DQOs require reporting samples to the MDL, background levels of contaminants are likely to be detected.

The method blank definition in SW-846 states that no target analytes above the MDL should be detected in the method blank. This must be the goal of the laboratory but program specific requirements allow for batch acceptance when there is no blank contamination above one half the PQL. Blank acceptability may be project-specific so that project DQOs may be balanced with analytical capabilities.

The first step of corrective action is to assess the effect on the samples; for example, if an analyte is found only in the blank but not in any batch samples, or if the analyte in the blank is less than one tenth the value in the sample, re-extraction and re-analysis of the batch may not be necessary. Investigating and eliminating the source of the contamination and documenting the

evaluation would be the appropriate action. Blank subtraction is not allowed (unless required by the applicable method). During analysis, the method blank, and any samples containing the same contaminant, would be re-analyzed, and if the contamination remains, the contaminated samples of the batch would be re-extracted and re-analyzed with a new blank and QC. The Program Chemist will be contacted if batch repreparations do not lead to method blanks which meet the above criteria.

LCS are evaluated by comparing the recovery of spiked target analytes to the recovery windows given in the method-specific tables contained in this document. For organic analyses the LCS are spiked with a set of compounds representative of the target analyte list and for inorganic analyses LCS are spiked with all target analytes. The analytes spiked into the LCS are listed in the method specific tables. When a limited spike list is used, all spiked compounds must be within the recovery windows for the batch to be considered acceptable and when a full spike list is used, a batch may be considered acceptable for those analytes which had acceptable recoveries in the LCS. If analytes are outside of the acceptance windows, corrective action must be initiated.

The first step of the corrective action process is to evaluate the effect on the samples; for example, if an analyte in the LCS has a recovery above the upper acceptance window, and other QC elements of the batch and sample analysis indicate that other samples in the batch do not have detectable concentrations of target analytes, re-extraction of the batch may not be necessary, otherwise, reextract and reanalyze affected samples. Corrective action would consist of an attempt to locate the cause of the non-conformance and documenting the evaluation in the laboratory report narrative. However, if recoveries in the LCS are sufficiently above the acceptance window to cause the analyst to suspect a systematic error, then the batch must be rejected and the preparation repeated. An example of a systematic error may be inexplicable double percentage recoveries as a result of a concentrating spike solution. As a guideline, when samples results are all non-detect and recoveries exceed the acceptance window by greater than 25%, then the analysts should investigate other causes contributing to the high recoveries. In general, if recoveries of a compound or element spiked into the LCS is in excess of the upper control limit and associated sample results are non-detect then corrective action may not be necessary; if associated results are positive however, corrective action must be taken. In addition, if a compound or element spiked into the LCS has an unacceptable recovery with respect to the lower control limit then corrective action must be taken. If a compound or element spiked into the LCS has an unacceptable recovery, the LCS, Blank, and all associated samples must be re-extracted and reanalyzed. When the LCS has a representative spike list and when a full target analyte spike list is used, the batch samples, blank and LCS, must be reprepared and reanalyzed for the failed analytes.

For those analyses which do not allow matrix spikes, an LCS and sample duplicate will be analyzed with each batch of samples. Batch control will be the same as that described for LCS.

The within-batch precision is measured by calculating the relative percent difference (RPD) of any target analytes found in the primary and duplicate analysis of the sample. The acceptance windows for LCS accuracy, and the associated corrective actions for failed QC, are given in the method-specific tables in this document.

Matrix Spike and Matrix Spike Duplicate Evaluation

For those methods which are amenable to matrix spikes, an MS/MSD pair is analyzed with each batch of samples for organic analyses, and for inorganics analyses, a MS and a laboratory sample duplicate are analyzed with each batch of samples. Both organic and inorganic batches are evaluated for matrix precision and accuracy. Accuracy is evaluated by calculating the recovery of spiked analytes and precision is evaluated by calculating the relative percent difference (RPD) of the recoveries. The recovery and RPD are compared to the acceptance limits given in the method specific tables. In the event that a matrix spike analyte fails precision or accuracy criteria, corrective action must be initiated.

Matrix spike 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. The heterogeneity of soil, grab samples, and sequentially collected water samples further complicates the evaluation 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 matrix spike data. In consideration of these limitations, the laboratory will not qualify data based on matrix spike performance but will perform corrective actions as outlined below.

When an MS/MSD pair fail in accuracy or precision for any spiked analyte, the impact on the associated batch will be evaluated. If there is significant evidence that the sample matrix interferes with the precision and accuracy assessment (i.e. significant chromatographic peaks interfere with target analyte identification in a GC analysis, or poor post-spike recovery occurs for a metals analysis, or sample is visibly non-homogeneous) this evidence will be documented and included in the laboratory report and clearly described in the case narrative. If chromatographic interference is cited as a cause for poor recovery or precision, then a copy of the chromatogram will be included in the final data report. If the native concentration of target analytes in the sample chosen for spiking is high relative to the spiking concentration, the differences in the native concentration between the unspiked sample and the spiked samples may contribute a significant error to the precision and accuracy calculations making the accuracy and precision measures unrepresentative of the true method and matrix performance. For this reason, if the native concentration is four or more times the spiked concentration, the MS/MSD are not required to meet the control criteria. In these situations, no other corrective action may be necessary.

If an MS/MSD pair fail to meet accuracy or precision criteria and no significant non-target analyte interference exists, the original MS/MSD extract is re-analyzed once. If the re-analysis produces an acceptable result, only the re-analysis will be reported if it was performed within holding time. If the second analysis of the original MS/MSD extract does not meet acceptance criteria, re-extraction and re-analysis of the MS/MSD will be performed and evaluated. If re-analysis still fails to meet accuracy or precision criteria or did not meet the analytical holding time, then results from both MS/MSD analyses are reported.

Sample duplicates will be evaluated for precision in the same manner, and corrective actions will be performed as indicated in the method specific tables.

The failure of a matrix spike, spike duplicate, and/or sample duplicate analysis to meet the established control criteria will additionally result in an evaluation of the batch for systematic errors which may have affected the batch. Other information such as surrogate recoveries and the appearance of chromatograms (GC and GC/MS), post spike recoveries (metals), method blank and LCS results, expected or detected analyte concentrations, the appearance of samples or extracts, and the results of other analytical tests may be considered in this evaluation. In all situations, the evaluation and corrective actions performed will be clearly and completely documented in the laboratory report case narrative.

Additional Methods of Matrix Spike Evaluation

For inorganics methods such as metals by GFAA or ICP, additional procedures may be used by the analyst to ascertain physical or chemical interferences inherent in the sample matrix. The matrix spike sample may be serially diluted until the percent recovery is within control limits or the analyst may perform a post-digestion spike on the unspiked matrix sample then perform additional corrective actions. These procedures should be used when the matrix spike recoveries are outside project-specified control limits, there is no other apparent reason for the outlier, and the analyst chooses to cite matrix interference as the cause for anomalous recoveries.

In the absence of other guidance, analysts will evaluate post-digestion spike recoveries as follows:

- If the %R of the post-spike is within $85\% \leq \%R \leq 115\%$ and the sample result is < LOQ or ≥ LOQ, report the result.
- If the %R of the post-spike is $115\% \leq \%R \leq 150\%$, and the result is < LOQ, report the result.
- If the %R of the post-spike is $115\% \leq \%R \leq 150\%$ and result is ≥ LOQ, dilute and reanalyze. Quantitate by the method-of-standard-addition if necessary.
- If the $\%R \geq 150\%$ and the result is < LOQ, verify that there are no errors in spiking, and

report the result.

- If the %R ≥ 150% and the result > LOQ, dilute and reanalyze. Quantitate by the method-of-standard-addition if necessary.

- If the post-spike recovery is 40% ≤ %R ≤ 85% and the sample result is < 0.5 x LOQ, report as "not detected" at the LOQ.

- If the post-spike recovery is 40% ≤ %R ≤ 85% and the sample result is ≥ 0.5 x LOQ, dilute and reanalyze. Quantitate by the method-of-standard-addition if necessary.

- If the post-spike recovery is < 40% and the sample result is < LOQ or ≥ LOQ, dilute and reanalyze. Raise the reporting limit accordingly.

Labeled isotopes or internal standards added and used as described in coupled mass spectroscopy methods may also serve to indicate the presence of a matrix interferent. Refer to the method specific table located in Appendix B for specific evaluation procedures and criteria.

Laboratory Batch Quality Control for Field, Equipment and Trip Blanks

The section below outlines the quality control applied to trip blanks, field blanks, and equipment blanks from sampling equipment.

Trip blank vials are sent with empty sample containers to the field and are shipped back to the laboratory with field samples to measure potential contamination from storage, collection, and shipment in the field and laboratory. Field blanks are created in the field and are intended to measure background contamination in the field. Regardless of the matrix of the project samples, trip and field blanks are reagent water and are usually only analyzed for volatile contamination. Trip and field blanks may be processed without site- specific matrix spike analyses. These blanks may be processed with matrix spikes or laboratory sample duplicates from another site, if the matrix adequately matches the matrix of the blank. Environmental samples will be utilized for matrix spikes. If matrix spikes or sample duplicates from another project are not available, these blanks may be analyzed with two LCS.

Equipment blanks assess the decontamination procedures of the field sampling equipment, and consist of reagent water, or water known to be free of target analytes. Equipment blanks are analyzed for all the parameters which are to be performed on the associated samples. Equipment blanks from soil sampling equipment are processed in the manner described above for the field and trip blanks. Equipment blanks from water sampling equipment are processed in the same manner as the associated field samples, with the laboratory batch quality control described above, since their matrices are compatible.

### 2.5.4 Laboratory Data Completeness

Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount expected to be obtained under correct, normal conditions.

The target for completeness is 90 percent for all parameters except for holding times and sample preservation for which the target value is 100%. Data completeness is a measure of the extent to which the database resulting from a measurement effort fulfills objectives for the project. For this project each analytical procedure and sample has a target of 90% completeness and will be defined as the percentage of valid data requested.

$$C\% = S/R\ (100\%)$$

*where:*

*C = completeness*
*S = number of successful analyses*
*R = number of requested analyses*

Successful analyses are defined as those where the samples arrived at the laboratory intact, properly preserved, in sufficient quantity to perform the requested analyses, and accompanied by a completed chain of custody. Furthermore, the sample must be analyzed within the specified holding time and in such a manner that analytical QC described in this document are met. Factors that adversely affect completeness include:

- Receipt of samples in broken containers
- Receipt of samples in which chain of custody or sample integrity is compromised in some way
- Samples received with insufficient volume to perform initial analyses or repeat analyses, if initial efforts do not meet QC acceptance criteria
- Improperly preserved samples
- Samples held in the field or laboratory longer than expected, thereby jeopardizing holding time requirements
- Failure to reextract and reanalyze as required.

Despite strict adherence to a quality assurance plan, errors may occur in laboratory and field operations. While the laboratory shall strive to achieve the highest level of completeness possible, the following level of completeness will be the minimum acceptable: at least 90 percent of all analytical methods will have acceptable quality control.

Completeness for the entire project also involves completeness of field and laboratory documentation, whether all samples and analyses specified in the workplans have been processed, and the procedures specified in the, CDQMP and SAP have been implemented.

## 2.6 Instrumentation Calibration and Frequency

### 2.6.1 Standards

The accuracy of sample target analyte quantitation is directly related to the accuracy of the standards used for instrument calibration. To ensure the highest quality standard, primary reference standards used by Contract Laboratory are obtained from reliable commercial sources. Inorganic standards must be traceable to the National Institute of Standards and Technology (NIST) and organic standards must be traceable to NIST, or American Association of Laboratory Accreditation (A2LA) vendors when available. When standards are received at the laboratory, the date received, supplier, lot number, purity and concentration, and expiration date are recorded in a standard preparation log book. Vendor certifications sent with the standards are also filed and are available upon request.

Standards purchased by Contract Laboratory may be in a pure form, in a stock, or working standard solution. Often dilutions are made from vendor standards. All standards made are given a standard identification number and have the following information recorded in a standards log book: source of standard used to prepare dilution; preparer's initials; initial concentration; final concentration; solvent; source and lot number of solvent; volume of final solution; volume of standard diluted. Records must unambiguously trace the preparation of standards, their use in calibration, and the quantitation of sample results. After preparation and before routine use, the identity and concentration of standards are verified. Verification procedures include a check for chromatographic purity (if applicable) and verification of the concentration of the standard using a standard prepared at a different time or obtained from a different source. Reagents are also examined for purity by subjecting an aliquot or subsample to the analytical method in which it will be used; for example, every lot of dichloromethane (for organic extractables) is analyzed for undesirable contaminants prior to use in the laboratory. Standards are routinely checked for signs of deterioration (e.g., discoloration, formation of precipitates, and changes in concentration) and are discarded if deterioration is suspected or their expiration date has passed. Expiration dates may be taken from the vendor recommendation, the analytical methods, or from internal research.

### 2.6.2 Instrument Calibration

This section discusses general requirements for instrument calibration and standards preparation and traceability. Test specific calibration details for the methods are given in the method specific tables.

Calibration is a reproducible reference point to which all sample measurements can be correlated. Instrumentation calibration is necessary for accurate sample quantitation. Calibrations establish the dynamic range of an instrument, establish response factors to be used

for quantitation, and demonstrate instrument sensitivity. Criteria for calibration are method specific, are taken from the published analytical methods, and are executed as described in each method specific table found in Appendix B. Accurate sample quantitation also relies on accurate standards. Standard accuracy may be established by tracing the quantitation standard to a source of known and documented quality or by comparison of standards from different sources. Instrument calibrations and standards are unambiguously documented so that the process of calibration can be re-created.

#### 2.6.2.1 Organic Methods Calibration

The field of chromatography involves a variety of instrumentation and detection systems. While calibration requirements vary depending on the type of analytical system and methodology, the following principles of calibration generally apply: calibration occurs before any sample analysis; initial multipoint (five or more points) calibrations are performed prior to analysis and periodically as necessary; daily calibration verification standards are analyzed prior to sample analysis; and continuing calibration standards are analyzed at a specific frequency (every ten analyses) throughout the sample analysis. Sample quantitation must be based on the initial calibration. GC/MS and non-GC/MS chromatographic methods base quantitation on the initial multipoint calibration. Sample quantitation may be with an external calibration technique or an internal standard calibration technique. Quantitation by external calibration involves the measurement of an analyte's response in a sample compared to the instrument response obtained from a known reference standard. Internal standard calibration techniques require one or more internal standards to be spiked in all samples and standards and then quantitate target analytes relative to the internal standard response. Internal standard techniques are used for GC/MS methods and may be used for GC methods. The method-specified criteria for the performance and response of internal standards must be met to assure accurate quantitation. All samples must be bracketed by continuing calibration standards which meet the established criteria.

Gas Chromatography

This section discusses general calibration techniques for non-GC/MS methods such as SW-8021, SW-8015, SW-8081, SW-8082, SW-8141, SW-8151, and SW-8310. External or internal standard calibration techniques may be used for calibrating the gas chromatograph.

Initial calibrations are performed upon initial instrument set up, failure of the daily, or continuing standard, and upon any major change in the system. However, before initial calibrations are performed, the instrument operating conditions are verified, any routine preventative maintenance is performed, and an instrument blank is analyzed to test for, or show the absence of, interferences. The initial five point calibration consists of a standard containing each analyte of interest at five concentration levels for SW-846 8000 series methods. One of these standards must be at the LOQ). The other standards should bracket the expected concentrations in real

samples, but not exceed the working linear range of the detector being used. From the initial calibration, calibration factors are calculated for each analyte of interest to evaluate the system performance. For target analytes with multiple peaks, such as PCBs, diesel, gasoline, and toxaphene, the total area may be summed and used for the area.

The CF is used to evaluate instrument response linearity for each analyte of interest across the calibrated range. Linearity is determined by the correlation coefficient, r, or the percent relative standard deviation (%RSD) of the best-fit line. If the %RSD of the calibration factor is less than 20% over the working range, linearity through the origin can be assumed, and the average CF can be used. For SW-846 methods the %RSD must be less than or equal to 20%, or the correlation coefficient, r, must be greater than or equal to 0.995. The use of r or %RSD must be uniformly applied to a calibration sequence and instrument.

The initial calibration is checked at least daily by injecting a daily calibration standard. This standard is usually the mid-range standard of the initial calibration and is injected before any samples or method blanks are analyzed. The percent difference (%D) is calculated and should be within ±15 percent of the average response factor of the initial calibration curve or the quantitated value should be within 15% of the expected value. A continuing calibration standard is analyzed every ten analyses and at the end of an analytical run to further evaluate system performance. All samples must be bracketed by continuing calibration verification standards which meet the established criteria. The %D of the continuing calibration standards must either meet the same criteria as the daily standard or be within ±15% of the expected concentration using the average CF from the ICAL. Occasionally, an analyst may acquire an ICV or CCV where the %D is greater than the 15% window. It is the responsibility of the analyst to evaluate the standards for any adverse trends and to evaluate the data for acceptability. For example, an analyst may deem that sample data are reportable when a single, closing CCV has a %D of +25% and all of the bracketed samples have no reportable analytes.

Gas Chromatography/Mass Spectrometry (GC/MS)

Every 12 hours, prior to calibration or sample analysis, the mass spectrometer must be tuned. For volatiles methods, bromofluorobenzene (BFB) is used and for semivolatile methods, decafluorotriphenylphosphine (DFTPP) is used. The resultant mass spectra for BFB and DFTPP must meet all of the method-specified criteria before sample analysis begins. These criteria are demonstrated each 12 hour shift. Tuning criteria are given in the methods and are stated in the method specific requirements in the Appendix F tables.

Initial calibrations are performed upon instrument setup, failure of the continuing standard, or upon any major change in the system. Initial calibrations for SW-846 methods use at least five calibration concentrations with the lowest standard at or near the method reporting limit. Initial calibrations must contain all analytes of interest and contain internal standards. The initial

calibration is evaluated at least once each 12 hour shift by checking the response of certain key compounds referred to as System Performance Calibration Compounds (SPCC) and Calibration Check Compounds (CCC). The SPCC evaluate system sensitivity and the CCC evaluate system linearity. A relative response factor (RF) is calculated for the analyte of interest relative to the internal standard whose retention time is closest to that compound.

From the RF at each concentration an average RF is calculated. The SPCC are checked for a minimum average RF and the CCC are checked for maximum percent relative standard deviation (%RSD) of their RF across calibration concentrations.

After the initial calibration has been found acceptable, before sample analysis, and every 12-hours during sample analysis, a tuning standard and calibration standard must be analyzed. The initial calibration curve is verified by the analysis of a continuing calibration verification standard that is at a concentration near the midpoint concentration for the working range of the GC/MS. The acceptance criteria for continuing standards is based on SPCC and CCC criteria, retention time criteria, and internal standard area criteria. SPCCs are checked for instrument sensitivity and CCC compounds are checked for daily drift from the average RF of the initial calibration. The method-specified minimum RF for the SPCCs and the method-specified %D requirement for CCCs must be met, or corrective action must be performed, prior to sample analysis. The internal standard retention times in the continuing calibration standard must be within ±30 seconds of the previous continuing calibration standard and the internal standard areas must be within a factor of two from the last continuing calibration standard. Samples are quantitated in accordance with the method using linear curve fitting routines only.

If any criteria are failed during initial, continuing, or tuning calibration, corrective action must be taken before sample analyses may proceed.

#### 2.6.2.2 Metals Methods Calibration

The most frequently used methods for environmental metals analysis use either GFAA or ICP emission spectroscopy. The calibration standards used by these methods are initial calibrations, initial calibration verifications (ICV), initial calibration blanks (ICB), continuing calibration verifications (CCV) and continuing calibration blanks (CCB).

Inductively Coupled Plasma (ICP)

The ICP is calibrated daily prior to any sample analyses using criteria prescribed in the analytical method. It is preferable that the ICP be standardized using a curve comprised of a blank and three standards. An acceptable alternative to the use of a multipoint curve would be to standardize the instrument using a blank and a single standard. After standardization, a contract reporting limit solution (CRI) at the PQL and the high calibration standard are analyzed. The CRI should be ± 50% of the expected response. Concentration values of the upper range

standard should not deviate from the known concentration by more than ± 5%. The calibration is then verified (ICV, CCV) using a standard solution from an independent source. The ICV and CCV values must fall within ± 10% of the true value for analysis to continue. The working range of the instrument is established daily with the high level calibration standard and sample quantitation may not be performed outside this linear range.

The calibration is monitored throughout the day by analyzing a continuing calibration blank (CCB) and a continuing calibration verification standard (CCV). If the verification standards or blank do not meet established criteria, the analysis is stopped and corrective action must be performed prior to the analysis of samples. All samples must be bracketed by CCBs and CCVs which meet the established criteria. The corrective action procedures include reanalyzing samples back to the last acceptable calibration check.

An inter-element check standard is analyzed at the beginning and end of each analytical run on the ICP to verify that inter-element and background correction factors have remained constant. Results outside of the established criteria trigger reanalysis of samples. The calibration blank solution is flushed through the system for at least one minute before the analysis of each sample.

Inductively Coupled Plasma/Mass Spectrometry (ICP/MS)

The ICP/MS is tuned (optimized) according to method specifications daily. Mass calibration and resolution checks are also performed daily, and must meet the method criteria prior to sample analysis. The ICP/MS is calibrated daily prior to any sample analyses using criteria prescribed in the analytical method. The calibration is then verified using a standard from an independent source.

A calibration is established daily by analyzing a minimum of two standards, one of which is a calibration blank. The calibration standard and blank include internal standards which may be used to correct for matrix interferences. Naturally occurring isobaric interferences are automatically corrected by the instrument software and is verified by analysis of an interference check standard every 12 hours of analysis. The calibration is monitored throughout the day by analyzing a CCB and a CCV, every ten analyses. All samples must be bracketed by CCVs and CCBs which meet the established criteria. If the verification standard and blank do not meet established criteria, the analysis is stopped, and corrective action must be performed prior to the analysis of samples. The corrective action procedures include recalibration and reanalysis of samples back to the previously acceptable calibration check. A rinse blank solution (containing no internal standards) is flushed through the system between samples to prevent carry-over.

Atomic Absorption (AA)

Each AA unit is calibrated prior to any analyses being conducted. A calibration curve is prepared with a minimum of a calibration blank and three standards and then verified with a

standard that has been prepared from an independent source at a concentration near the middle of the calibration range. The calibration is then verified every ten injections on an ongoing basis with a CCB and a CCV. All samples must be bracketed by CCBs and CCVs which meet the established criteria. If the ongoing CCV and CCB do not meet established acceptance criteria, the analysis is stopped and corrective action must be performed prior to analysis of samples. The corrective action procedures include reanalysis of samples back to the previously acceptable calibration check. For GFAA, all samples are spiked after digestion to evaluate matrix effects or interferences. The method of standard additions or sample dilution is used when matrix interferences are present as determined by the results of the analytical spike. As prescribed by the determinative methods, chemical matrix modifiers are added to the digestates to reduce the effects of interferences contributed by the matrix.

#### 2.6.2.3 Wet Chemistry and Other Methods Calibration

The field of conventional, non-metals analysis (wet chemistry or general chemistry) involves a variety of instrumental and wet chemical techniques. While calibration and standardization procedures vary depending on the type of system and analytical methodology required for a specific analysis, the general principles of calibration apply universally. Each system is calibrated prior to analyses being conducted. Calibration consists of defining the working range by use of a series of standard solutions (usually 4 or 5 standard levels) and identifying potential interferences. The calibration is checked on an ongoing basis (every ten analyses) to ensure that the system remains within specifications. If the ongoing calibration check does not meet established criteria, analysis is stopped and corrective action must be performed prior to the analysis of any samples. The corrective action procedures include examination of instrument performance and analysis information, consultation with the group leader, and a decision path to determine if recalibration and reanalysis of samples back to the previous acceptable calibration check is warranted. In general, the analyst must reanalyze samples back to the last acceptable calibration check. Continuing calibrations are not performed for non-instrumental methods such as Total Dissolved Solids.

#### 2.6.2.4 Analytical Calibration and Result Calculations

##### 2.6.2.4.1 Calibration Calculations

For all laboratory analyses, the analytical system is calibrated using either an external or internal standard technique.

<u>External Standard</u>

For the external standard technique calibration standards containing each analyte of interest are prepared at concentrations required in the method. The least concentrated standard will be at a

concentration corresponding to the method detection level (MDL). The remaining standards define the working range of the instrument. For each analyte at each standard concentration a calibration factor (CF) or a response factor (RF) is calculated.

The CF or the ratio of the response to the amount injected is calculated.

$$CF = (A_s)/(M_s)$$

*where:*
$A_s$ = *Response for the analyte to be measured.*
$M_s$ = *Mass of standard injected (in nanograms).*

The RF or ratio of the standard concentration to the response is calculated:

$$RF = (C_s)/(A_s)$$

*where:*
$C_s$ = *Concentration of the analyte in the standard.*
$A_s$ = *Response for the analyte to be measured.*

Internal Standard

The internal standard technique is used for gas chromatography/mass-spectroscopy (GC/MS) analyses and is similar to the external standard technique except that one or more internal standards (compounds that exhibit similar chemical and analytical behavior to the compounds of interest and are not present in the sample) are added to each calibration standard. For each analyte, at each standard concentration, the ratio of the response to the concentration for each analyte and its corresponding internal standard, defined as the relative response factor (RRF) is calculated.

$$RRF = (A_s C_{is})/(A_{is} C_s)$$

*where:*
$A_s$ = *Response for the analyte to be measured.*
$A_{is}$ = *Response for the internal standard.*
$C_{is}$ = *Concentration of the internal standard*
$C_s$ = *Concentration of the analyte to be measured.*

For each analyte the percent relative standard deviation (%RSD) of the five calibration factors must be less than or equal to a QC limit, which allows the average CF, RF, or RRF to be used for calculation of analyte concentrations. If the %RSD of the CF or RF is greater than the QC limit over the calibration range, then linearity through the origin cannot be assumed.

When performing a linear regression of the instrument response versus the concentration of the standards, the instrument response is treated as the dependent variable (y) and the concentration

as the independent variable (x). The regression will produce the slope and intercept terms for a linear equation in the form:

$$y = ax + b$$

*where:*

*y = Instrument response.*
*a = Slope of the line (also called the coefficient of x).*
*x = Concentration of the calibration standard.*
*b = The intercept.*

The regression calculation will generate a correlation coefficient ($R^2$) that is a measure of the "goodness of fit" of the regression line to the data. A value of 1.00 indicates a perfect fit. In order to be used for quantitative purposes, $R^2$ must be greater than or equal to 0.995.

The calculated intercept value needs to be evaluated before reporting sample results. A positive value for the intercept indicates that there is some threshold instrument response which is the limiting factor in establishing linearity. A negative intercept value can be transformed into a x-intercept value that represents a threshold concentration, which is the limitation. If the intercept is positive, then, as a general rule, results where the instrument response is less than three times (3x) the intercept value may be unreliable. This will afford some protection against false positive results. If the intercept is negative, results below the concentration of the lowest concentration calibration standard may be unreliable. These adjustments to the quantitation limits will apply to all samples analyzed using the regression line.

As discussed above the evaluation of continuing calibration acceptance is determined by %D which is calculated as follows:

$$\%D = (RF_i - RF_c / RF_i) 100$$

*where:*
*%D = Percent difference*
*$RF_i$ = average relative response factor from initial calibration*
*$RF_c$ = Relative response factor from current calibration check standard.*

#### 2.6.2.4.2 Result Quantitation

Calculations to produce concentration in water and/or soil using the CF, RF, or RRF are presented in this section.

The concentration of each identified analyte in aqueous samples is quantified from the measured peak response using the CF as follows:

$$\text{Aqueous Concentration} = (A_x)(V_t)(D) / (CF)(V_i)(V_s)$$

*where:*

$A_x$ = *Response for the analyte in the sample.*
*CF* = *Average CF from initial calibration.*
$V_i$ = *Volume of extract injected. For purge and trap analysis $V_i$ = 1*
*D* = *Dilution factor, if dilution was made on the sample prior to analysis.*
$V_t$ = *Volume of total extract. For purge and trap analysis $V_t$ = 1*
$V_s$ = *Volume of sample extracted or purged, ml.*

The concentration of each identified analyte in soil samples is quantified from the measured peak response using the CF as follows:

$$\text{Concentration} = (A_x)(V_t)(D) / (CF)(V_i)(W)(P)$$

*where:*
$A_x$ = *Response for the analyte in the sample.*
*CF* = *Average CF from initial calibration.*
$V_i$ = *Volume of extract injected. For purge and trap analysis $V_i$ = 1.*
*D* = *Dilution factor, if dilution was made on the sample prior to analysis.*
$V_t$ = *Volume of total extract. For purge and trap analysis $V_t$ = 1.*
*W* = *Weight of sample extracted or purged (g).*
*P* = *Percent dry weight of sample/100, or 1 for a wet-weight basis.*

The concentration of each identified analyte in water and soil samples is quantified from the measured peak response using the RF as follows:

$$\text{Concentration } (\mu g/g \text{ or } mg/L) = (\text{mean RF})(\text{area of signal})(\text{dilution factor})$$

The concentration of each identified analyte in aqueous samples is quantified from the peak response using the RF as follows:

$$\text{Aqueous Concentration } (\mu g/L) = (A_x)(C_{is})(D) / (A_{is})(RRF)(V_s)$$

*where:*
$A_x$ = *Area of characteristic ion for compound being measured.*
$C_{is}$ = *Amount of internal standard injected (ng).*
$A_{is}$ = *Area of characteristic ion for the internal standard.*
*RRF* = *Average RF from initial calibration.*
$V_s$ = *Volume of water purged (ml), taking into consideration any dilutions made.*
*D* = *Dilution Factor, if a dilution was made on the sample prior to analysis.*

The concentration of each identified analyte in soil samples is quantified from the peak response using the RF as follows:

$$\text{Soil Concentration } (\mu g/g) = (A_x)(C_{is})(D) / (A_{is})(RF)(W)(P)$$

*where:*
$A_x$ = *Area of characteristic ion for compound being measured.*
$C_{is}$ = *Amount of internal standard injected (ng).*
$A_{is}$ = *Area of characteristic ion for the internal standard.*
*RF* = *Average RF from initial calibration.*
*D* = *Dilution Factor, if a dilution was made on the sample prior to analysis.*

*W* = *Weight of sample extracted or purged, g.*
*P* = *Percent dry weight of sample/100, or 1 for a wet-weight basis.*

In calculating sample concentrations using regression analysis, the regression equation is rearranged to solve for the concentration (x), as shown below:

$$x = (y - b) / a$$

*where:*
*y* = *Instrument response.*
*a* = *Slope of the line (also called the coefficient of x).*
*x* = *Concentration of the calibration standard.*
*b* = *y-intercept.*

## 2.7 Data Acquisition Requirements (Non-direct Measurement)

The need to assemble pertinent information previously developed by others will be determined. This is typically considered during the project planning stages. The scope of any resulting survey will be determined by the Technical Manager dependent on the needs of the project. Any limitations or potential reservations for the accuracy or credibility of acquired information that could affect project quality should be clearly identified. Acquired information may include:

- Applicable federal, state, and local regulations and rulings
- Program/site status
  - -History/background
  - -Future plans
  - -Requirements/schedule

- Methodologies available for:
  - -Field exploration, monitoring, testing, and sampling
  - -Laboratory testing
  - -Processing and volume reduction of radioactive/hazardous material
  - -Isolation and disposal of radioactive/hazardous material
  - -Numerical analysis and design

- Existing data generated for the specific region or site
  - -Demographical
  - -Geological (surface and subsurface)
  - -Hydrological/meteorological (e.g., groundwater distribution and usage)
  - -Geochemical
  - -Geotechnical
  - -Facility development and practices (past, present, and future)
  - -Type, volume, and extent of contamination
  - -Physical layout of man-made facilities

- Data generated on specific wastes, materials, or chemical compounds of interest
  - -Processing
  - -Physical
  - -Chemical
  - -Geochemical
  - -Radiological
  - -Mechanical
  - -Thermomechanical
  - -Toxicity/hazards and protection
  - -Treatability

Previous or concurrent surveys, studies, analyses, and designs of a similar or parallel nature.

Sources for the above information may include:

- Government and private regulations, standards, guidelines, journals, periodicals, and data compilations
- Textbooks and maps
- Reports and manuals previously issued by USACE, DOE, EPA, or other organizations
- Results of currently ongoing investigations by government and private agencies, corporations, and research facilities
- Personal communications
- Aerial photographs and satellite imagery
- Procurement documents issued by the client.

Information collected will be documented to indicate its source. Documentation will, as appropriate, include author or individual contacted; source title; identification of periodical or journal; standard, guideline, or report number; identification of publisher or originating organization; page location; and date. Documentation must be sufficient to allow other individuals to easily obtain or verify the information.

Whenever possible, complete copies of articles, data compilations, maps, reports, and photographs will be included in the project files. If this is not feasible, copies of title pages and pertinent sections should be included with complete source documentation.

Personal communications such as interviews, correspondence, or telephone conversations will be completely documented in the form of trip reports, meeting notes, memoranda, and telephone records and the resulting documentation included in the project files. Documentation will provide, as appropriate, the date and the name, organization, address, telephone number, and

credentials of individuals contacted. A request should be made for formal written confirmation of critical data obtained verbally to serve as final documentation.

As necessary, an estimation of the quality/credibility of the information will be made. The collection of information must be consistent with the quality objectives of the project. Formal data quality objectives will be established for a project. Particular attention should be given to information that is collected that is not published from a peer reviewed source, or collected under the controls of a documented quality assurance program. This may include, but is not limited to personal interviews, internal reports and memoranda, or newspaper articles.

# 3.0 ASSESSMENT / OVERSIGHT

## 3.1 Quality Control

The purpose of this section is to describe the Quality Control (QC) Program to be implemented. The primary purpose of this QC Program is to provide a self-inspection system which allows the USACE a m ethod of ensuring that all activities are performed in accordance with project requirements and conformance to the approved, Field Sampling Plan (FSP), Sampling and Analysis Plans (SAPs), Quality Assurance Project Plan (QAPP), and Project Health and Safety Plan (HASP).

The QC program consists of a three phase control program. The control program is implemented prior to initiating each definable feature of work and will remain in effect throughout its duration. The three phase control program includes:

- a preparatory phase;
- an initial phase; and
- a follow-up phase.

The QC program will also include inspections to be performed at the completion of a task. The Program Manager is responsible for implementing all phases of the quality control program. Health and safety audits will also be conducted to ensure that all work is being performed in compliance with the HASP. The health and safety audits will be performed by the Health and Safety Manager (HSO).

### 3.1.1 Definable Features of Work

A definable feature of work is a task which is separate and distinct from other tasks and has separate control requirements. The following definable features are identified but not limited to the following:

- field sampling;
- on-site analyses by the field laboratory;
- off-site analyses by the fixed-base laboratory;
- data management (including data reduction, validation, and reporting); and
- risk assessment.

The three phase control system will be implemented prior to the initiation of each feature of work.

### 3.1.2 Preparatory Phase

The preparatory phase of the three phase control program will occur prior to beginning work on a task. A preparatory inspection of a task may be necessary when the task is first performed at each of the sites. The preparatory inspection includes providing the contracting officer (CO) with a preparatory inspection outline and performing a preparatory phase inspection prior to beginning work on the task. The inspection will include the following items:

- A review of the SAP, FSP and CDQMP to ensure that the task has been approved by the Technical Manager.
- A check to ensure that all required permits and clearances for the task have been obtained.
- A check to ensure that all required training for the task has been obtained by all personnel performing task.
- A check to ensure that the required health and safety training and medical monitoring has been completed and that the task will be performed in strict compliance with the HASP.
- A check to ensure that all personnel performing the task have reviewed the SAP, FSP, CDQMP, and HASP.
- A discussion of the procedures which will be implemented for completing the task.
- A check to ensure that all the equipment and instruments required to perform the task are present.
- A check to ensure that all the required equipment and instruments for health and safety monitoring are present.
- A check to ensure that all the instruments are being calibrated to the manufacture and/or project specifications.
- An examination of the work area to ensure that all preliminary work has been performed and that conforms to the FSP, SAP and CDQMP.
- A check to ensure that provisions are in place to allow for the required QC and safety inspections and audits during the task.

### 3.1.3 Initial Phase

The initial inspections are performed when a representative portion of a task has been completed. The purpose of the initial phase is to ensure that tasks conform to the approved Work Plan, FSP, and QAPP. This phase includes a review of the procedures employed to complete the task and a check to ensure that the task is being performed according to the HASP.

### 3.1.4 Follow-Up Phase

Follow-up inspections will be conducted at regular intervals to ensure that the task is being performed in strict compliance to the project requirements. Follow-up inspections will be conducted at a minimum frequency of one (1) inspection per event for each task. If follow-up inspections identify items in the task which do not conform to the project requirements, additional preparatory or initial inspections may be required. A follow-up inspection may be

required at each work site for a specific task.

### 3.1.5 Completion Inspection

A completion inspection will be performed when all work on a task at a specific site is complete. A list of items which do not conform to the project requirements for the task will be developed. The Program Environmental Engineer will conduct a follow-up inspection to verify that the task was completed according to the project requirements and that corrective actions have been successfully implemented to address all deficient items.

## 3.2 Assessments and Response Actions

Both internal and external assessments are conducted to provide assurance that samples are collected and analyzed according to acceptable procedures. The assessments that are conducted include readiness reviews, system audits, surveillances, and the establishment of a NCR/CAR System.

### 3.2.1 Readiness Reviews

The goal of the readiness review is to ensure that the field team is prepared for all aspects of conducting field investigations. Items that are addressed include the review of supply procurement plans, contingency plans, securing of site clearances, and training of project personnel. Readiness reviews will be performed by the Project Leader prior to mobilization for field activities or at the direction of the Project Manager. Documentation will be in the form of a checklist that is specific to the type of field activities to be performed. Deficiencies discovered during readiness reviews will be communicated to the Project Manager prior to mobilization.

### 3.2.2 System Audits

System audits are formal evaluations of all aspects necessary to produce a desired result. This type of audit is limited to the pre-evaluation of subcontract laboratories. The purpose of the audit is to ensure that all procedures including supply procurement, sample receipt and tracking, analysis, data review and reporting, QA/QC, and nonconformance/corrective action are established prior to the first sample reaching the laboratory. The goal of the audit is to establish that the systems that are in place are sufficient to provide the quality of data necessary for the project activity.

System Audits will be conducted by the Project Chemist to verify the laboratories ability to adhere to QA/QC requirements during the analysis of environmental samples. Documentation will include an audit notification letter, an audit report, and an audit close-out letter that will be provided to the Project Manager. Audit reports will be provided to the Technical Manager within 10 days of the completion of the formal audit.

The audit notification letter will define the schedule of the audit, the activities to be reviewed, and the laboratory personnel that will be required. The audit report will include documentation of the opening meeting, results of review, documentation of the audit closing meeting, any areas found to be deficient, and schedule for completing corrective actions. The audit close-out letter will document the successful completion of corrective actions.

### 3.2.3 Surveillances

Surveillances or process audits are smaller and less extensive than system audits. The purpose of the surveillance audit is to review specific activities to ensure that established procedures are followed to achieve the desired result.

Surveillances will be conducted to verify field and laboratory adherence to requirements during the collection and analysis of environmental samples. Documentation will include descriptions of activities reviewed, discussions with project personnel, nonconformance/corrective actions, and recommendations for rectifying any quality deficiencies. Surveillance reports will be provided to the Technical Manager within 10 days of the completion of the surveillance.

### 3.2.4 Performance Evaluation Samples /Data Tracking Audits

Laboratory performance audits will consist primarily of blind performance evaluation samples submitted to the laboratory and/or data tracking audits completed on a real time basis while samples are being analyzed. PE Samples will consist of Standard Reference Materials (SRM) supplied by an approved vendor such as ERM will be submitted to the laboratories periodically throughout the course of the contract. Data from the blind PE samples and results of data tracking audits will be reviewed and provided to the Technical Manager within 10 days of the completion of the review.

## 3.3 Reports to Management

Each defined work element is responsible for producing a report to project management listing the activities conducted during a specific period of sampling and/or analysis. The reports generally will include the number of units collected or produced, NCR/CAR reports, audit/surveillance summaries, and QC summaries. All reports will be provided to the Program Environmental Engineer within the time frames discussed in the following subsections.

### 3.3.1 Field Activities

The Sampling Team Leader will provide a summary of field activities on a every other day basis to the Project Environmental Engineer, Project Geologist or Project Chemist as appropriate. The location of field activities (including field laboratory analysis), date and hours of operation, weather conditions, work performed, and any difficulties encountered during the period will be

summarized, Figure 3.6 is an example daily project report.

### 3.3.2 Drilling Subcontractors

The drilling subcontractor will provide a summary of drilling activities on a weekly basis. The location of drilling activities, date and hours of operation, work performed, and any difficulties encountered during the period will be summarized.

### 3.3.3 Subcontract Laboratory

Laboratories providing services to the Department of Defense, including USACE, must be accredited for the DOD Environmental Laboratory Accreditation Program (DOD ELAP) by a DOD approved Accrediting Body (AB) which is ISO/IEC 17011:2004 compliant. As an element of the DOD ELAP, all laboratories must demonstrate the ability to generate acceptable results from the analysis of proficiency-testing (PT) sample(s), subject to availability, using each applicable method in the specified matrix. DOD ELAP accreditation establishes that laboratories have an established and documented laboratory quality system that conforms to ISO/IEC 17025 as implemented by the *DoD Quality Systems Manual for Environmental Laboratories*, version 4.1, April 2009.

In addition to DOD ELAP accreditation, the laboratory shall hold current accreditation for all appropriate fields-of-testing under the Stae of Utah Bureau of Lab Improvement accrediting authority under the National Environmental Laboratory Accreditation Program (NELAP). Proof of current accreditation / certification for the applicable fields of testing is required prior to the laboratory acceptance of any samples for TEAD projects.

The subcontract laboratory will provide a summary of sample receipt, analysis, and reporting on a weekly basis. The report will include the number of samples received, analyzed, and reported by analysis method, discrepancies noted in sample receipt, and laboratory NCR/CAR reports. This report does not replace the requirement of the case narrative for each lot, but serves to alert project management of potential problems.

# 4.0 DATA VALIDATION AND USABILITY

## 4.1 Data Review, Validation and Verification Requirements

This section describes the approach to be used to reduce, verify, report, and manage collected data. Accurate data reduction, validation, and reporting protocols are necessary to interpret data and arrive at decisions. The quality of the data collection process will be assessed through reviews of all measurements performed. The purpose of this section is to discuss the evaluation and assessment of QC requirements necessary to document the quality of the collected data. The frequency of data review validation and verification is discussed below according to the category of data collected.

### 4.1.1 Field Sampling/Non-analytical Data

Field sampling data, including field logbooks and field activity forms, will be reviewed daily by the Project Leader. Boring logs will be reviewed by the project geologist.

### 4.1.2 Screening/Non-definitive Data

Screening data will be reviewed and verified by the analyst and the Program Chemist. The review of the data will ensure QA procedures were followed and QC requirements have been meet. Screening analysis data will be reviewed against the acceptance criteria defined in the SAP. The review consists of evaluating the QA/QC data including instrument blanks, system blanks, and calibration data to make sure QA/QC requirements have been met and appropriate corrective actions taken. Screening results will be evaluated by comparing the screening data with the definitive data. A review of the QA/QC data will be summarized and presented as part of the QCSR.

### 4.1.3 Definitive/Confirmatory Data

Definitive data will be reviewed by the laboratory, the USACE and an independent third party contractor. Data verification will be performed on 90% of the results generated. Data validation will be performed by an independent third party on a minimum of 10% of the data generated. Additional data validation may be performed at the discretion of the Project Chemist and Technical Manager.

## 4.2 Validation and Verification Methods

The validation and verification of data takes place at varied levels within the full range of environmental services encompassing the scope of work associated with the contract. Program procedures, plans, and project-specific documents provide specific details of the individual

positions responsible for verification and validation activities involved with data management. In general, quality affecting records are reviewed at a level commensurate with the information being checked.

### 4.2.1 Data Verification

The following verifications will be performed on 100 percent of the analytical data.

- The organic data will be reviewed for holding times, blank analysis results, LCS, MD/MSD and surrogate recovery.
- The inorganic data will be reviewed for holding times, blank analysis results, pre-digestion matrix spikes, sample duplicate and LCS recoveries.
- Analytical results will be qualified as a result of the data validation process in accordance with the flagging convention tables included in Appendix C of this document.

The data verification of the project analytical data will be an ongoing process that will be performed by both the analytical laboratory generating the data and the Program Chemist. The initial step of the data verification process will be performed by the analytical laboratory. During this review, the calculations, QC sample data, spike recovery, instrument performance indicators, and project specification will be thoroughly inspected through peer level review prior to its release to the laboratory Project Manager. Any problems or Nonconformance issues encountered during the analysis will be noted in the project case narrative that precedes each data package. Where unexplainable variations appear, calculations will again be checked for errors and the sample collection and analytical procedures reviewed to identify any causes for the inconsistencies. All calculation errors will be corrected and anomalies in the sampling or analytical procedures documented and reported in the project analytical data package. The raw data are then QC reviewed for technical correctness by the laboratory Project Manager before final printing. After the data package has been completed, the transcription of 100% of the data is verified by the laboratory QA/QC Manager. The laboratory QA/QC Manager will also review the data for conformance to the project data quality objectives. The Project Chemist will be notified of any existing problems and will be updated as conditions dictate.

The laboratory system for ensuring valid data includes several levels of review. Each level commands specific action to prevent the unqualified release of erroneous data and to correct any problems discovered during the review process. All analytical data generated at the Laboratory are extensively checked for accuracy and completeness. The data review process consists of data generation, reduction, and three levels of review, as described below.

The analyst who generates the analytical data has the prime responsibility for the correctness and completeness of the data. All data are generated and reduced following protocols specified in laboratory SOPs. Each analyst reviews the quality of his or her work based on an established set of guidelines. The analyst reviews the data package to ensure that:

- Sample preparation and analysis information is correct and complete
- The appropriate SOPs have been followed
- Analytical results are correct and complete
- QC samples are within established control limits; blanks are acceptable
- Special sample preparation and analytical requirements have been met
- Documentation is complete (e.g., all anomalies in the preparation and analysis have been documented, out of control forms, if required, are complete, holding times are documented, etc.).

This initial review step, performed by the analyst is designated Level 1 review. The analyst then passes the data package to an independent reviewer who performs a Level 2 review.

Level 2 review is performed by a group leader or data review specialist whose function is to provide an independent review of the data package. This review is structured to assure that:

- Calibration data are scientifically sound, appropriate to the method, and completely documented
- QC samples are within established guidelines
- Qualitative identification of sample components is correct
- Quantitative results are correct
- Documentation is complete and correct (e.g., anomalies in the preparation and analysis have been documented, out-of-control forms, if required, are complete, holding times are documented, etc.)
- The data are ready for incorporation into the final report
- The data package is complete and ready for data archive.

Level 2 review is structured so that all calibration data and QC sample results are reviewed, and all of the analytical results from 10 percent of the samples are checked back to the bench sheet. If no problems are found with the data package, the review is considered complete. If any problems are found with the data package, an additional 10 percent of the samples are checked to the bench sheet. The process continues until no errors are found or until the data package has been reviewed in its entirety. Level 2 data review is documented and the signature of the reviewer and the date of review recorded. The reviewed data are then approved for release and a final report is prepared.

All data collected during the project will be reviewed and flagged with the appropriate data qualifiers before reported. Detection limits will vary with sample type and the level of interferences associated with the sample matrix. If anomalous results are obtained, every effort will be made to identify any problems in the sample collection, sample preparation, and/or analysis that could have contributed to the anomaly. If any problems have occurred, they will be reported and will include the results, and the appropriate qualifier, with an estimate of the impact the problem may have had on the data. If the sample results do not conform with the data quality

objectives, the data will be thoroughly reviewed in order to identify any existing problems and the sample analysis will be repeated if deemed necessary.

Following the analytical laboratory data review, the sample data will be submitted to the Program Chemist who will be responsible for the review and to compare all data with the project data requirements.

### 4.2.2 Data Validation

Independent of the laboratory review, data validation will be performed on 10 0 percent of definitive analysis performed for each method of analysis using the Flagging Conventions presented in Appendix C of this document and/or current guidance as provided in the DOD QSM and USACE Guidance (see references). Analytical results will be qualified as a result of the data validation process in accordance with the CDQMP flagging conventions. An additional 10% will be reviewed back to raw data including a review of COCs, holding times, chromatograms, spectra, instrument printouts, sample calculations, calibrations, instrument run logs, preparation logs, method and field blanks, field duplicates, matrix spike/matrix spike duplicates (MS/MSD), LCS, and case narratives.

Hierarchy of Applicable Guidance Documents for Data Validation / Review

The following hierarchy will be used in applying guidance / requirements documents to the review of project specific analytical data. If a site specific QAPP is not available the default requirements including data quality indicators (DQIs) are per the most current version of the DOD QSM.

1. Site-specific SAP / UFP-QAPP
2. DOD QSM, ver 4.1 (Apr 2009) to supplement any gaps in the WP/UFP-QAPP requirements.
3. EM 200-1-10, June 2005 Qualifiers

Data flags are assigned to analytical results for both organic and inorganic data based on the project data quality control requirements. Data flags are defined below:

U The analyte was analyzed for, but was not detected above the level of the associated value. The associated numerical value (e.g., the MDL) indicates the approximate concentration.

J The analyte was analyzed for and was positively identified, but the associated numerical value is estimated and may not represent the actual amount present in the environmental sample. The data should be considered approximate but usable for decision-making purposes.

UJ The analyte was analyzed for, but was not detected above the level of the associated numerical value; however, the associated numerical value is approximate and may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The data are unusable for all purposes. The analyte was analyzed for, but the presence or absence of the analyte has not been verified.

The data validation report consists of three sections. The following describe each section.

#### 4.2.2.1 Data Validation Summary Report

The summary report is designed for each data package received from the laboratory. The report includes the analytical criteria that are reviewed for each analytical test method.

The organic data are reviewed for holding times, calibrations, blanks (i.e., laboratory blanks and field blanks), surrogates, matrix spike, matrix spike duplicates, internal standards, and laboratory control samples. The inorganic data are reviewed for holding times, blanks, calibrations, matrix spike, matrix spike duplicate or laboratory duplicate, ICP interference check, ICP serial dilution, furnace post digestion, and laboratory control samples. Field duplicate samples are reviewed if the field duplicate samples are identified for the project samples. Any major or minor deficiencies noted during the data validation process is noted in each category. If the data are required to be qualified due to any outlier in QC criteria, an explanation on how data are qualified is given in each category. The last part of the summary report includes the definitions of the data validation qualifiers that are assigned to the analytical data.

### 4.2.3 Data Usability

Analytical results will be qualified as a result of the data validation process in accordance with the flagging convention tables included in Appendix C of this document. Results will be compared to action levels and ARAR's to determine usability when QC criteria are not met.

## 4.3 Reconciliation with Data Quality Objectives

A Data Quality Assessment (DQA) will be performed and a report prepared following completion of data acquisition. The purpose of the DQA is to present an evaluation of the entire data collection program and document the successful completion of the DQOs. The DQA will provide documentation of the internal and external reviews of project operations during acquisition, validity of the collected data, and recommendations for data use. The DQA report will include:

a) Summary of project DQOs;
b) Summary of field QC operations;

c) Summary of laboratory QC operations;
d) Statistical summaries of the precision, accuracy, representativeness, and completeness of off-site laboratory data;
e) Summaries of outlying observations and impact on DQOs; and
f) Recommendations for data use.

The goal of the DQA report is to provide documentation that the data collection program has, by design, collected a sufficient quantity and quality of data to meet the needs of the project.

### 4.3.1 Analytical/Statistical Control Parameters

The purpose of this document is to facilitate implementation of the requirements of the DQOs for specific projects supporting the program and applicable regulatory requirements. To assure that data obtained is sufficiently accurate and consistent with the DQOs, the following procedures will be used for assessing the quality of the measurement data:

- Accuracy and Precision is the agreement between a measurement and the true value, and the degree of variability in the agreement, respectively. To determine the precision of the method and/or laboratory analyst, a routine program of replicate analyses is performed. The results of the replicate analyses are used to calculate the relative percent difference (RPD), which is the governing quality control parameter for precision. For replicate results relative percent difference is calculated:

  $$\%RPD = [X_1 - X_2 / (X_1 + X_2)/2] * 100$$

  *where:*
  *RPD = relative percent different*
  *$X_1$, $X_2$ = value of sample 1 and sample 2*

- To determine the accuracy of an analytical method and/or the laboratory analyst, a periodic program of sample spiking is conducted (minimum one spike and one spike duplicate per batch or one spike and one duplicate per batch). The results of sample spiking are used to calculate the quality control parameter for accuracy evaluation, the percent recovery (%R). Percent recovery is calculated:

  $$\%R = (C_1 - C_2)*100 / C_3$$

  *where:*
  *R% = Spike amount recovered*
  *$C_1$ = Concentration of analyte in spiked sample*
  *$C_2$ = Concentration of analyte in unspiked sample*
  *$C_3$ = Concentration of spike added*

- Completeness is the adequacy in quantity of valid measurements to prevent misinterpretation and to answer important questions. For this project, the data completeness objective is 90 percent. The completeness requirements for holding times

will be 100 percent. If any sample exceeds the holding time specified by EPA SW-846 (or other guidance documents for other analyses) that sample may be required to be resampled and reanalyzed.

- Representativeness is a qualitative parameter that reflects the extent to which a given sample is characteristic of a given population at a specific location or under a given environmental condition. Representativeness is best satisfied by making certain that sampling locations are selected properly, a sufficient number of samples is collected, and an appropriate sampling technique is employed. Variations at a sampling point will be evaluated based on the results of field duplicates. For TEAD projects, good representativeness will be achieved through careful, informed selection of sampling sites, drilling sites, drilling depths, and analytical parameters; and through the proper collection and handling of samples to avoid interferences and to minimize contamination and loss.

- Comparability is the extent to which comparisons among different measurements of the same quantity or quality will yield valid conclusions. For TEAD projects, comparability among field measurements will be achieved through the use of standard procedures, standard field data sheets, and uniform concentration units. To ensure comparability, field procedures will be standardized and field operations will adhere to standard operating procedures. Laboratory data comparability will be assured by use of established and approved analytical methods, consistency in the basis of analysis (wet weight, volume, etc.), and consistency in reporting units (ppm, ppb, etc.). Analysis of standard reference materials will follow USEPA or other standard analytical methods, which utilize standard units of measurement, methods of analysis, and reporting format.

- Sensitivity (Reporting Limits) Assuring the validity of quantitative measurements at low concentrations is an extremely difficult technical problem. With regulatory action levels being pushed lower and lower, the validity of any given measurement becomes even more important. The consequences of false positive or false negative data can be significant. The laboratory will report results below the reporting limit as "Not Detected" because, by definition, the reliability of the data at that level is questionable. Organic data that needs to be reported below the quantitation limit will have the data flagged accordingly.

  Quantitation Limits are the extent to which the equipment, laboratory or field, or analytical process can provide accurate, minimum data measurements of a reliable quality for specific constituents in replicate field samples. It is defined as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the value is above zero. The actual quantitation limit for a given analysis will vary depending on instrument sensitivity and matrix effects.

  If dilution to bring the reported concentration of a single compound of interest within the linear range of the calibration, results in non-detect values for all other analytes with detected concentrations in the initial sample analysis, the results of the original run and

the dilution will be reported with appropriate notations in the narrative of the report. 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 compliance with the requirements for sensitivity.

The quality assurance objectives for laboratory quality control data are designed to screen out data of unacceptable precision or accuracy and to provide data that will meet the data quality goals for the project.

Traceability is the extent to which data can be substantiated by hard-copy documentation. Traceability documentation exists in two essential forms: one that links quantitation to authoritative standards and a second that explicitly describes the history of each sample from collection to analysis.

The fundamental mechanisms that will be employed to achieve these quality goals can be categorized as prevention, assessment, and correction. These include:

- Prevention of defects in the quality through planning and design, documented instructions and procedures, and careful selection of skilled, qualified personnel
- Quality assessment through a program of regular audits and inspections to supplement continual informal review
- Permanent correction of conditions adverse to quality through a closed-loop corrective action system.

This document has been prepared in direct response to these goals. This plan describes the program and the procedures to be implemented for projects to be performed for TEAD. The objectives for precision and accuracy for each chemical are based mainly on the capabilities of the approved EPA analytical method with respect to laboratory quality control.

# *FIELD SAMPLING PLAN*

# *TABLE OF CONTENTS*

# 1.0 INTRODUCTION

The purpose of this Field Sampling Plan is to provide a comprehensive description of all sampling protocols that will be generally required for use for projects at Tooele Army Depot (TEAD). All sampling activities will be performed according to protocols, specific to each parameter of interest, promulgated by the U.S. Environmental Protection Agency (EPA) and by USACE. Where such protocols have not been established by the EPA or the USACE, protocols established by some other recognized authority (ASTM, State of Utah) will be utilized.

## 1.1 Sample Types

This section provides a description of the types of quality control samples that will be routinely obtained for specific projects. The project specific SAP will provide a description of sample types that will be relevant for each project in the discussion of Sampling Process Design.

### 1.2.1 Trip Blanks

Trip blanks are composed of purged DI water added to a clean preserved VOA vial. The trip blank accompanies sample containers from the laboratory to the field and back again to the laboratory. Trip blanks will be prepared and submitted to the Contract Laboratory (and the QA laboratory) for each shipment of environmental samples for VOC analyses (every cooler containing VOC samples will contain a trip blank that will be analyzed by the Contract Laboratory). Trip blanks will be analyzed for all VOC analyses (including 8015 mod.-gas) specified for samples in the corresponding cooler with the exception that if samples are to be analyzed for multiple VOC analyses covering the same analyte list the trip blanks will be analyzed only for the method incorporating the lowest PQL.

### 1.2.2 Quality Control (QC) Samples

Quality Control samples are blind duplicates submitted to the Contract Laboratory for the purpose of assessing Contract Laboratory precision. QC samples will be collected as 10% of the total sampling effort. Generally QC duplicates will be collected for the first sample and every tenth sample thereafter. If information regarding areas of particular interest at a site is available (i.e. highly contaminated areas) the distribution of QC samples may be placed at the discretion of field personnel with the concurrence of the project manager. QC duplicate samples will be analyzed for the same parameters as the corresponding primary sample.

### 1.2.3 Quality Assurance (QA) Samples

QA samples are duplicates that are submitted to a designated QA laboratory. The QA Laboratory may be a government laboratory or an independent laboratory chosen by the USACE. Results of these analyses compared to Contract Laboratory data will be used in preparation of the Chemical Quality Assurance Report by USACE. QA samples will not be collected for the long term monitoring program for the ground water remediation system at Tooele. QA samples will be generally collected as 10% of the total sampling effort, however the decision to collect QA samples will be determined on a project and site specific basis as a part of the technical project planning process and determined as part of the project DQOs. If information regarding areas of particular interest at a site is available (i.e. highly contaminated areas) it will be used in the determination of the distribution of QA samples. Changes in collection sites of QA samples due to field conditions may be made at the discretion of field personnel with the concurrence of the project manager. QA duplicate samples will be analyzed for the same parameters as the corresponding primary sample. The specific rate of QA samples and the laboratories that QA samples will be sent to will be directed in individual delivery orders.

### 1.2.4 Rinsate Samples

One rinsate sample will be collected for each day of sampling and for each crew performing groundwater sampling during field operations. Rinsate samples will be analyzed for all analytical methods that primary samples will be analyzed for. Rinsate samples will be performed daily for groundwater sampling activities if reusable bailers are used. If disposable bailers are utilized for sampling rinsate samples will not be required. For soil sampling the District will propose a minimum rate of rinsate sampling in project specific SAP's. Daily rinsate samples for soil sampling will generally not be required.

### 1.2.5 Field Blanks

One field blank will be obtained for each lot (5 gallon container, lot #, etc.) of water that is used for rinsing. For estimating purposes this will be assumed to be one per day of field activities involving sampling. Field blanks will only be performed for groundwater sampling activities involving VOC analyses.

# 2.0 FIELD DOCUMENTATION

## 2.1 Sample Information Documentation

All information pertinent to the environmental samples, including specific field collection data, names of sampling personnel, and laboratory observations will be recorded in permanently bound notebooks. Sample ID's will be linked to the site where the sample originated. The Contract Laboratory will also employ a specific information management system to assist in tracking the progress of each sample through the analytical process. The FSP will detail procedures for documentation of field and laboratory information that are consistent with the requirements of these specifications.

## 2.2 Preparation of Field Logbooks

The field logbook will be bound with serially numbered pages, and assigned to a specific person who is responsible for entry of information into the logbook. The logbook will be signed and dated by this person prior to initiation of field work. All entries into the logbook will be executed by this designated person. If it is necessary to transfer the logbook to alternative personnel during the course of field work the person relinquishing the logbook will sign and date the logbook at the time the logbook is transferred and the person receiving the logbook will do likewise. Corrections to erroneous data will be made by crossing a line through the entry and entering the correct information. The correction will be initialed and dated by the person making the entry. Unused portions of logbook pages will be crossed out, signed, and dated at the end of each workday. Logbook entries must be dated, legible, in ink, and contain accurate documentation. Language used will be objective, factual, and free of personal opinions. Hypotheses for observed phenomena may be recorded, however, they must be clearly indicated as such and only relate to the subject observation. Field logs will become part of the project records.

## 2.3 Photographs

When samples are being collected, photographs will be taken to support the written description of sampling activities. In all cases when a photograph is taken the date, time, weather conditions (if applicable), subject, purpose for photographs being taken, number of photograph and identifying number from roll, and the name of the person taking the photograph will be recorded. When photographs are developed the information in the field logbook will be transferred to the back of the photograph. All photographs will become part of the project file and subject to all standard document controls. All photographs will be delivered to the USACE CO at the end of the project.

# 3.0 SAMPLING EQUIPMENT AND PROCEDURES

## 3.1 Standard Operating Procedures

Standard Operating Procedures (SOP's) for use by field and administrative personnel are presented as Appendix D. The SOP's represent and supplement the information presented in the CDQMP in a procedural format.

## 3.2 Drilling and Sampling Activities

### 3.2.1 Drilling

Collection of soil and groundwater samples may also be collected during drilling operations. Drilling activities will comply with project-specific work plans, including a Health and Safety Plan. Subcontractors are responsible for complying with the Health and Safety Plan. All required permits will be obtained prior to drilling activities. Prior to initiation of drilling activities, the proper notifications for underground utilities (e.g., Underground Service Alert, geophysical clearance, utility map inspection, site inspection) will be completed.

A geologist/engineer with a minimum of 3 years experience in environmental drilling operations will provide continuous oversight of each operating drill rig. Supervision of the drilling operation will be performed by an experienced Geologist.

Four commonly used drilling methods: hollow-stem auger, mud rotary, air rotary, and dual-tube percussion, are described below. Other methods may be utilized as identified in site-specific plans warranted by site conditions.

### 3.2.2 Hollow-Stem Auger Drilling

The hollow-stem auger method is suitable for unconsolidated and consolidated soils up to a maximum depth of 100 to 200 feet (depending on subsurface conditions). Hollow stem augers achieve faster penetration rates than any other type of drilling methods in soft, sticky clay soils. Some consolidated gravels, consolidated soils, and hard bedrock may be too dense for adequate auger penetration.

Split-spoon samplers are commonly used in conjunction with hollow stem auger drilling, and can provide discrete zone or continuous core soil samples. Grab samples are obtainable, but there is less lithologic control than with other drilling methods. Hollow stem augers may be used to install monitoring wells (limited by diameter) as there is good depth control, and the auger can be progressively pulled as well construction materials are placed in the borehole. Certain auger-type rigs are significantly smaller than other types of rigs, making them the most suitable for use at job sites with significant space constraints. Detailed procedures for hollow stem auger drilling are

provided in SOP 14.0.

### 3.2.3 Mud Rotary Drilling

The mud rotary drilling method is suitable for most hard soils and gravelly soils (very loose soils may cause excessive caving), and for drilling in excess of about 100 feet deep. Some consolidated gravels and hard bedrock may be too dense for adequate or rapid drill penetration. If openhole geophysical logging is required to meet project objectives, mud rotary drilling may be necessary to maintain adequate borehole stability and provide a conductive medium (drilling mud) to run certain electric logs.

Soil samples can be obtained from the bottom of the hole but it typically requires removing the entire drill string and tripping the sampler through drilling mud; therefore, this method is not recommended when substantial soil sampling or sampling for analytical parameters are required. This method can be used to install monitoring wells; however, wells installed in mud rotary holes require lengthy and comprehensive development to remove drilling fluids and mud solids from the gravel pack and formation.

Additional considerations of using mud rotary include the potential of cross contamination, through the drilling mud column, between different aquifer units, and increased volumes of contaminated drilling mud and cuttings requiring management and disposal. The drilling mud should be composed of water from a source of known chemical composition and mud solids and additives approved by the appropriate lead regulatory agency for the site. Mud rotary rigs are typically larger than auger-type rigs and may be subject to size constraints, including overhead clearance.

### 3.2.4 Air Rotary Drilling

This method is suitable for consolidated soils and rock. When used in conjunction with drive casing (called air rotary casing hammer), this methods is also suitable for unconsolidated soils. Some consolidated boulders and hard bedrock may be too dense for rapid or adequate drill penetration.

Soil samples can be obtained from the bottom of the hole but it typically requires removing the entire drill string. A wireline punch barrel may be used with this drilling method. Air rotary casing hammer drilling is commonly applied to install monitoring wells as there is good depth control, and the drive casing can be progressively pulled as well construction materials are jet in the borehole.

Additional considerations of using air rotary casing hammer drilling includes the potential of flushing vapor phase contaminants through the surrounding soil, the possibility of vapors exiting

the hole, and the generation and containment of large volumes of contaminated formation water at the drill site. Air rotary casing hammer rigs are typically larger than auger-type rigs and may be physically restricted by site facilities, including overhead clearance.

### 3.2.5 Dual Tube Percussion Drilling

This method is most useful in unconsolidated, coarse-grained soils. Some consolidated cobble beds, thick clay or silt beds, and hard bedrock may be too dense for adequate drill penetration. Loose or soft soil cuttings are disaggregated, but consolidated materials and gravel are often retrieved in sizable pieces (up to 6 inches in diameter), making filter pack determination possible.

An advantage of the dual tube percussion method is that soil samples can be readily obtained from the bottom of the hole without requiring the removal of drill pipe (unlike rotary methods). This method is also commonly used to install monitoring wells as there is good depth control, and the drive casing can be progressively pulled as well construction materials are set in the borehole.

Additional considerations of using dual tube percussion drilling include the potential of flushing vapor phase contaminants through the surrounding soil, the possibility of vapors exiting the hole, and the generation and containment of large volumes of contaminated formation water at the drill site. Dual tube percussion rigs are typically larger than auger-type rigs and may be physically restricted by site facilities, including overhead clearance. The impact of the casing hammer is loud and sharp and should be taken into consideration when drilling in a populated surrounding.

### 3.2.6 Drilling and Development Equipment Decontamination

All downhole drilling equipment (including but not limited to drill pipe, drive casing, drill rods, augers, bits, tools, etc.) will be thoroughly decontaminated before mobilization onto each site and between borings or wells at each site or as required in the project work plans. Detailed procedures for equipment decontamination are provided in SOP 6.1.

All containerized solids and fluids derived from drilling and development equipment will be segregated, stored, labeled, and managed as per the project work plans. Sampling will be performed as required, followed by proper disposal as stated in the project work plans.
Appropriate personal protective equipment (as specified in the project work plans) will be worn by all personnel involved in the task, in order to limit personal exposure.

### 3.2.7 Lithologic Logging

All boreholes will be logged under the supervision of a experienced Geologist. All boring and well construction logs will be signed by the field geologist and the supervising Geologist. Drilling and logging information for engineering soils will be recorded in the field using Engineering Form 1836R or equivalent. Details of the format and content of soil and rock descriptions, including

headings, sampling, and construction information is provided in SOP 10.0.

### 3.2.8 Cone Penetrometer Test (CPT)

Cone penetrometer testing and soil sampling will be performed by an experienced contractor. All CPT soil sampling will be performed in accordance with the project work plans. Detailed procedures describing the preparation, drilling, and sampling of the CPT method is provided in SOP 9.2.

### 3.2.9 Soil Organic Vapor Sampling

Soil Organic Vapor (commonly refereed as soil gas) sampling locations will be marked prior to the beginning of field work and utility clearances performed prior to sampling. The purposes of the soil gas surveys is to identify the source areas of VOC contamination in trenches, disposal areas, and landfills; to locate leaks along sewer lines; and to delineate the extent of groundwater contamination. Targeted compounds will be identified in the SAP. If compounds are detected isopleth maps will be constructed to visualize the areas of contamination. Detailed procedures for soil gas sampling are to be provided in the site specific Work Plan and SAP contained in the project specific SAP.

### 3.2.10 Hydropunch Sampling

Cone Penetrometer and Hydropunch methods are used to acquire physical data for classification of subsurface lithologies and to collect groundwater and soil gas samples from most permeable zones (sand, gravel layers and lenses) without generating soil cuttings. The CPT and hydropunch activities will follow the requirements in the SOP or procedures supplied by the subcontractor. CPT surveys will be made to explore subsurface geology and locate permeable zones. The hydropunch will be used to collect groundwater and/or soil gas from these zones. Chemical analysis of the hydropunch samples will provide information about the distribution of contamination in the aquifer and will aid in well placement. Detailed procedures describing the preparation, drilling, and sampling of the CPT method is provided in SOP 9.2.

### 3.2.11 Closed System Purge and Trap Sampling/EnCore™ Sampling

Soil samples are collected in such a manor as to minimize the loss of volatile compounds. The low concentration sample vials are filled and weighed in the field and are never opened during the analytical process. Alternatively, the EnCore™ sampler is used as the storage medium with the appropriate analysis holding time observed, based on the preservation technique.

### 3.2.12 Rotosonic Drilling

Rotosonic (sonic) drilling uses high frequency mechanical vibration to acquire continuous core samples of overburden while advancing steel casing into the ground. These vibrations are generated at a frequency rate between 50 and 150 hertz or cycles per second. As this frequency

falls within the lower range that can be detected by the human ear, the term "sonic" is used to describe this drilling method.
A hydraulically powered drill head or oscillator generates the adjustable high frequency vibrational forces. The sonic head is attached directly to the drill rods and core barrel sending the high frequency vibrations down through the drill steel to the face of the drill bit (shoe). During drilling, the core barrel is advanced ahead of an outer casing in one to 20 foot increments, depending on the type of geologic material, the degree of subsurface contamination, and the sampling objectives. The subsurface material is then returned to the surface in the corebarrel as a continuous geologic core, which may be cohesive to loose, depending upon the physical properties of the sediment. The material is then vibrated from the core barrel into plastic sleeves, typically two to three-feet in length. This provides an effective means of describing the sediment lithology, and collecting samples for chemical or physical analyses. The outer casing is then advanced to the depth the core barrel penetrated and the slough produced is removed with the corebarrel prior to advancing the hole further. The corebarrel and outer casing can be advanced under dry conditions in most situations, or they can be advanced with water, air, or a drilling fluid containing additives. The decision of whether to use a drilling fluid depends upon the nature of the formation being drilled and the depth and diameter of the borehole. Once in place the outer casing prevents cross contamination and formation material sloughing and allows for very controlled placement of wells or any type of down-hole instrumentation. Sonic drilling is capable of advancing borings ranging from about 5 to 12-inches in diameter and provides superior speed, safety, logging accuracy, and less waste generation compared to conventional drilling equipment.

## 3.3 Monitoring Well Installation and Development Procedures

The installation of monitoring wells and associated testing can provide lithologic information (during drilling), potentiometric surface data, groundwater chemistry data, and aquifer parameters. Project-specific work plans may modify established procedures as site-specific conditions warrant.

### 3.3.1 Monitoring Well Installation

The installation of monitoring wells will be performed in compliance with applicable state and local agency requirements and regulations. Drilling contractors possessing a valid state licenses should be used to perform this task. Permits for well installation may also be required for a particular site. If so, the permits should be obtained from the appropriate agency at least 24 hours before drilling and installation of monitoring wells.

Monitoring wells are commonly installed through boreholes drilled by auger, rotary, and dual tube percussion methods. Shallow wells are often installed in auger holes in fine grained, unconsolidated soils. Deeper wells are most suitably installed through boreholes drilled by air rotary with casing advance or dual tube percussion methods. The mud rotary method may be used as a last resort. Detailed procedures for monitoring well installation are provided in SOP 8.1.

### 3.3.2 Filter Pack and Well Screen Slot Size Determinations

Filter packs and well screen slot sizes should be designed to minimize the entry of formational

sand, silt and clay into the well without severely reducing the well's yield. Details of the filter pack design and slot size determination are to be provided in the site specific Work Plan and SAP.

### 3.3.3 Monitoring Well Development

Within seven days of completion of the well, but not sooner than 48 hours after grouting is completed, each monitoring well will be thoroughly developed to remove residual drilling fluids and fines from the casing and filter pack, and from the adjacent formation. Detailed procedures for monitoring well development are provided in SOP 8.2.

## 3.4 Borehole and Well Abandonment Procedures

### 3.4.1 Borehole Abandonment

All boreholes that are not to be completed as wells will be properly abandoned to eliminate the potential for enhanced vertical transport of contaminants. Procedures will be in compliance with all applicable State of Utah requirements and detailed procedures are to be provided in the site specific Work Plan and SAP.

### 3.4.2 Well Abandonment

The formal abandonment of wells will be performed in compliance with all applicable regulations and state requirements. Permits will be obtained from any agency which requires one, at least 24 hours (more if specified in the work plans) prior to well abandonment. Details of well abandonment procedures, including pre-abandonment activities, are to be provided in the project Work Plan and SAP.

Any groundwater that was displaced by grouting of the borehole will be stored at the site in containers specified in SOP 16.0 and in the project work plans. The groundwater will be sampled and analyzed as appropriate to determine the proper method of disposal.

## 3.5 Split-Spoon Sampling

A variety of sampling techniques are available to collect soil samples from borings. These include split-spoon sampling, collective auger cuttings, Shelby tube sampling, and continuous coring. Split-spoon sampling is the most commonly used technique. It is an effective means of obtaining discrete, representative soil samples for chemical and geotechnical analysis. Detailed procedures for split-spoon sampling are provided in SOP 3.1. Procedures for logging split-spoon sample information, including blow counts, are provided in SOP 10.0. Additional sample handling procedures are provided in SOP 2.0.

## 3.6 Shallow Subsurface Sampling

Shallow soil borings (0 to 6 feet deep) are generally drilled with a hand auger. Soil samples may

be collected from the bottom of a boring using a sample sleeve attached to a hand-held impact sampler. This technique is useful for subsurface soil sampling in areas that are inaccessible to mechanized drill rigs, and drilling in areas that are suspected to contain uncharted or unmarked utilities. Detailed procedures for shallow subsurface soil sampling are provided in SOP 3.0.

## 3.7 Grab Sampling

Grab sampling is a soil sampling technique used in projects involving, but not limited to, excavation and sampling of potentially contaminated soil, surface sampling, and stockpile sampling.

During collection of grab samples, the soil is available as brought up from an excavation in a backhoe bucket or in a soil stockpile. The location in the bucket or pile where the sample is to be obtained will be determined by the Project Geologist or Sampling Team Leader, an onsite regulatory agency officer, or by predetermined locations indicated in approved workplans. Before the sample is obtained, the sampling area is monitored with an OVA.

If granular or loose soils and/or uniform materials are encountered, the sample can be obtained directly from the bucket or pile. The sample is obtained by scooping the soil using a decontaminated stainless steel trowel or spatula, and depositing the soil in a glass jar or other appropriate container.

If a composite sample is desired, several depths or locations are sampled and accessed. Soil in the sample jars from each of the locations to be composited is emptied into a decontaminated stainless steel mixing container. The soil is thoroughly mixed and placed into sample jars, sealed, labeled, and logged on a COC. Composite samples are not appropriate for VOC analysis. All sample compositing will follow the procedures outlined in SOP 3.2.

## 3.8 Stockpile Soil Sampling

Stockpiled soil is any soil which has been disturbed at a site after excavation, unauthorized release, spill, or other release of hazardous substances. It does not literally have to be a “pile”. For purposes of this section, disturbed soil is any soil which has had its geologic structure and contaminant distribution patterns altered by grading, excavation, or drilling. Examples of stockpiled soil include:

- Excavated soil from a tank removal
- Excavated soil placed back into a tank pit
- Graded soil
- Soil cuttings from borings or well construction

- Imported clean soil mixed with contaminated soil.

### 3.8.1 Engineering Controls For Stockpiled Soil

The following engineering controls should be implemented to minimize the potential for public exposure. Stockpiled soil should be:

- Placed on a relatively impervious surface such as asphalt, concrete, or plastic sheeting.
- Moistened to minimize dust emissions during stockpiling. No runoff is to be created during this process.
- Securely covered by heavy plastic sheeting to minimize vapor emissions and prevent runoff from rain (sheeting must be maintained in good condition).
- Configured such that surface water runoff is diverted around the stockpile and does not carry soil and/or contamination beyond the stockpile perimeter.
- Any stockpiled soil demonstrated by sampling and laboratory analysis, or determined by the generator to be hazardous waste, must be removed from a satellite storage site within 72 hours after a volume of 55 gals. is exceeded. The hazardous waste must be moved to a 90-day yard from which it must be removed within 90 days of excavation.

### 3.8.2 Stockpiled Soil Characterization

Stockpiled soil which will be taken to a permitted hazardous waste or designated waste facility for disposal, at a minimum must be sampled and analyzed in accordance with the requirements of TEAD and the receiving facility.

Composite soil samples are not acceptable for characterizing contaminated soil stockpiles for disposal to Class III landfills in any case where volatiles are contaminants of concern. Due to the losses of volatile contaminants during sample handling and the dilution of non-volatile contaminants, only discrete samples for VOC analysis will be accepted.

One protocol that can be utilized for stockpiled soil associated with an unauthorized release, spill, or other release that is not intended to be transported off site to a permitted facility, or has not been previously characterized through in-situ sampling is outlined below. This protocol provides a uniform approach for demonstrating the contaminant level within a soil mass.

Random sample points must be selected from locations on a three-dimensional grid established for each stockpile. The number of samples to be obtained from each stockpile will be described in the site-specific SAP or work plan. It is recognized that the presence of materials such as boulders and debris may make strict application of this requirement impractical. In such cases, it is appropriate to obtain the sample as close as possible to the randomly selected point without altering the spirit of the random selection process. For hydrocarbon contaminants, sample collection in either metal tubes or glass jars is acceptable, provided every effort is made to minimize the loss of volatile constituents. Metal tubes are preferred since they will minimize aeration of the samples. Containers should be completely filled, capped, and placed in a cooler with ice and maintained at 4°C ±2°C.

Stockpiled soil is assumed to have a nonhomogeneous distribution of contaminants. If a stockpile previously characterized by this protocol is split for any reason, the remaining mass must be resampled as a new stockpile, per the previously described protocol, to establish its mean contaminant concentration. Note that it is necessary to consider each individual stockpile separately. Detailed procedures for stockpiled soil are provided in SOP 12.0.

### 3.9 Groundwater Sampling

The following guidelines are designed for the consistent sampling of groundwater monitoring wells. It is assumed that the wells to be sampled are currently in place and have been properly constructed and developed. These guidelines focus on sampling groundwater for dissolved organic chemicals (e.g., fuel hydrocarbons, VOCs and SVOCs). Phase-separated product and its impact on obtaining representative groundwater samples are not considered in these guidelines at this time.

Sample results are influenced by site hydrogeology, well construction, well development, well purging, chemical characteristics, and sampling protocols. This guideline addresses only well purging and sampling.

#### 3.9.1 Definition of Terms

**Purging:** The removal of stale water from a well to allow fresh formation water to enter the well casing.

**Recovery**: The measure of a well's return to its static condition after purging. The following equation my be used to calculate the percent recovery after purging:

$$PR = \left(1 - \frac{RD}{MD}\right) \times 100$$

where:

PR= Percent recovery

RD= Residual drawdown- the difference between the static water level prior to purging and the measured water level at any given time after cessation of purging.

MD= Maximum drawdown- the difference between the static water level prior to purging and the measured water level upon cessation of purging.

**Representative Sample:** A sample that approximates the formation water as closely as possible.

**Well Volume:** The volume of water that is contained in the well casing plus the volume of water contained in the pore spaces of the filter pack in the annulus.

**Stability:** The consistency of field water quality measurements. Generally temperature, pH and specific conductance of the purged water are measured to evaluate the efficiency of the purging. Stabilization criteria will be three consecutive measurements for which:

- pH is within +/- 0.1 units,
- temperature is within +/- 1 degree Celsius,
- conductivity is within 10%.

Turbidity will be monitored in all cases but will not be used as a measure of stability.

**Fast Recharging Well:** A well is considered to be fast recharging if recovery to 80 percent or more of its static condition occurs within two hours.

**Slow Recharging Well:** A well is considered to be slow recharging if recovery to 80 percent of its static condition takes longer than two hours.

### 3.9.2 Well Sampling Procedure

Prior to groundwater sampling operations the sampling team will examine each well for signs of tampering or well deterioration. Any observations will be noted in the field notebook. After the well has been opened the air in the well head area will be tested for organic vapors with a PID or FID and for explosive atmospheres with the oxygen/combustible gas indicator. Results of these observations will be recorded in the field notebook. A plastic sheet will be placed around the well head beneath all sampling equipment to prevent contamination of surficial soils during purging

and sampling. The depth to standing water in each of the wells and total depth of the well to the bottom of the screened interval will be determined and recorded in the field notebook. This information is required to calculate the volume of stagnant water in the well and to provide a check on the integrity of the well If DNAPLs are suspected the presence and thickness of floating product (if any) will be determined using an oil/water interface probe. The top of the casing will serve as a permanent reference point from which water level measurements will be taken.

Using information on the diameter, total depth, and depth to water for the well, three casing and filter pack volumes will be calculated and that amount of water will be purged from the well. The pH, temperature and electrical conductivity of the water will be monitored as well. The pH and conductivity meters will be calibrated prior to use at each well using ASTM traceable standards. The calibration will be checked after measurements for all samples have been completed to ensure that the field instruments have remained in calibration throughout the process. Results of calibrations and final calibration checks will be recorded in the field notebook. If after three well volumes these three parameters have stabilized as defined above the well will be sampled. At least six measurements will be obtained (one for each half casing volume). Measurements for well parameters will also be obtained after sampling is completed with the results recorded in the field notes. If these three parameters have not stabilized after three volumes the purging will continue to a maximum of five volumes before sampling commences. Turbidity will be monitored with results recorded in the field notes but not used as a stabilization parameter. If purging is accomplished using a submersible pump the pump will be set just below water level so that all standing water is removed from the well. Placement of the pump for purging should take into consideration the anticipated depth to which water will be drawn down during pumping. The volume of water purged and the withdrawal rates will be recorded. Purge rates will be sustainable and executed at a rate such that drawdown is minimized to prevent cascading of water into the well. Alternatively, the wells may be purged by bailing. During the evacuation period, the appearance of the discharge water will be noted and periodic entries will be made in the sampling notebook. Use of a well purging data sheet for recording the information described above is acceptable. Detailed procedures for groundwater sampling are provided in SOP 9.0.

A complete set of sampling containers will be prepared for each sample in advance of the sampling event. Containers will be labeled with the date, time, sample number, project name, sampler's name or initials, parameters for analysis (method numbers where possible), and preservation. All samples will be collected within the screened interval in each well to ensure that the sample is representative of formation water. The bailer will be carefully lowered beneath the top of the screened interval after purging of the well. A water sample is collected. The water from the bailer

is then carefully transferred to sample containers using a valved bottom discharging device. Pouring from the top of the bailer will not be allowed. Volatile water samples will be taken with a valved bottom emptying device so that no air passes through the sample (to prevent volatiles from being stripped from the samples); the bottles will be filled by inserting the spout from the bailer to the bottom of the VOA vial with discharge of the bailer contents into the vial such that the tip of the spout is kept beneath the surface of the liquid in the vial as it is filled until there is a convex meniscus over the neck of the bottle. The Teflon side of septum (in cap) will be positioned against the meniscus, and the cap screwed on tightly; the sample will be inverted, and the bottle tapped lightly to check for air bubbles. The absence of an air bubble indicates a successful seal; if a bubble is evident the sample will be discarded. Refilling of VOA vials will not be allowed. After these sampling procedures are completed, each sample collected is entered into the field logbook and logged on a COC. All sample containers will be individually enclosed in resealable plastic bags and properly packed in coolers maintained at 4$^{o}$C for shipment to the laboratory.

All sample bottles and equipment will be kept away from fuels and solvents. Gasoline (used in generators) will be transported in a different vehicle from bailers, sample bottles, purging pumps, etc. If possible, one person should be designated to handle samples, and another person should work generators and the gas truck. Disposable gloves will be worn for each separate activity and then disposed of. Care will be taken not to spill any fuels on clothing.

## 3.10 Surface Water Sampling

### 3.10.1 Sampling for VOC Analysis

The following steps are taken when collecting samples of near-shore surface water for volatile organic compound analysis:

- A VOA vial is slowly submerged completely into water and filled. Care is taken not to disturb bottom sediments. Open ends of the vial is pointed upstream in undisturbed, gently flowing water.
- If the vial does not require preservatives, it is capped while submerged. Care is taken to remove any air bubbles from the vials before sealing.
- When preservatives are required, the water is decanted into a VOA vial containing preservatives. The vial is slightly tipped while filling until nearly filled. The vial is then straightened during topping-off, forming a meniscus above the lip of the vial.
- The vial is sealed using a cap with Teflon septa.
- The vial is then turned upside down and tapped to dislodge any bubbles remaining

in the vial. If bubbles are present, the sample is discarded and proper filling is reattempted using new vials.

- The vials are rinsed on the outside with deionized water, wiped dry, and labeled.
- A sample label is then filled out and attached to the vial and assigned a sample number per SOP's 2.1 and 2.2.
- The vial is placed in a Ziplock bag for protection, and stored in a cooler at $4^{o}C \pm 2^{o}C$.

### 3.10.2 Sampling for Other Analyses

The following steps are taken when collecting shallow-surface water samples for nonvolatile compound and metal analyses:

- An appropriate flask, dipper, pail, or pond sampler with extension handle is used to collect the water. If wading is required, the sampling area is approached from downstream and not actually entered.
- The sampling device is immersed into the water and filled. Care is taken to not disturb underlying sediments.
- A sufficient volume of water is collected to fill all sample containers. The water is placed in a stainless steel bowl and stirred to ensure homogeneity.
- If required, the water will be filtered on site for metal analysis.
- The water is decanted into the required containers. Preservatives, if required, should be added to the containers before the water is decanted into the containers.
- The containers are rinsed on the outside with deionized water, wiped dry, and labeled.
- A sample label is then filled out and attached to the vial and assigned a sample number per SOP's 2.1 and 2.2.
- The containers are placed in Ziplock bags for protection, and stored in coolers at $4^{o}C \pm 2^{o}C$.

### 3.10.3 Deep Surface-water Sampling

The following steps are taken when collecting deep surface-water samples using a weighted bottle sampler:

- The weighted sampler is lowered into the water to the specified depth.
- The stopper is removed by pulling on the sampler line.

- After the sampler is filled, the line is released to reseat the stopper, and the sampler is lifted to the surface.
- The sampler is wiped dry.
- The cap is slowly removed. The specified number of sample containers are filled by slightly tipping the sampler against the sample bottle. Multiple sampler runs may be composited in a stainless steel or Teflon container to obtain the necessary volumes. VOC and SVOC samples are not composited, but decanted directly from the sampler.
- The container is sealed with a Teflon-lined cap. VOC and SVOC samples are checked for air bubbles. If bubbles are present, the sample is discarded and new containers are filled.
- The outside of the containers are rinsed with deionized water and wiped dry.
- A sample label is then filled out and attached to the vial and assigned a sample number per SOP's 2.1 and 2.2.
- The containers are placed in Zip-lock bags for protection, and stored in a cooler at $4^{o}C \pm 2^{o}C$.

After sampling is completed, each sample collected is entered into the field logbook and logged on a COC record.

### 3.11 Field Measurements

Field measurements are also collected during soil and groundwater sampling. Parameters that are normally measured during sampling include the following:

- Water-level measurements in wells during purging and sampling to evaluate recovery, as part of a monitoring program to evaluate groundwater flow rates and directions.
- Conductivity, temperature, pH, and turbidity measurements of groundwater samples during pumping, well purging, and sampling.
- Volatile organic vapor analysis of ambient air quality and soil sample headspace using an organic vapor monitor (PID or equivalent).

Procedures for each of these measurements are presented below.

#### 3.11.1 Water-Level Measurements

Water levels in wells may be measured using a steel tape, electric sounder and/or petroleum product probe. If a pump or other equipment is in the well, measurement devices will be lowered slowly to avoid entanglements. Water-level measurements in completed wells will be made from a permanently marked reference point on the well casing. The elevation of this point will be established by survey and referenced to mean sea level. Water levels measured in boreholes or wells during construction will be made relative to the ground surface. Measurements will be made and recorded to the nearest hundredth of a foot. Detailed procedures for water-level measurements are provided in SOP 5.1.

### 3.11.2 Analytical Measurements

Electrical conductivity (EC), water temperature, pH, and turbidity measurements will be made in the field during well development, purging, and before each water sample collection. Water is collected at the well head and placed in a bottle or jar used solely for field testing. A field conductivity and pH meter with a combination electrode or equivalent will be used for EC and pH measurements. Temperature measurements will be performed using standard thermometers or equivalent temperature meters. Combination instruments capable of measuring all three of these parameters may also be used. Turbidity of water samples will be measured using a turbidity meter.

All instruments will be calibrated as necessary per manufacturer instructions prior to taking sample readings. If conductivity standards or pH buffers are used in field calibration, their values, lot numbers, and expiration dates will be recorded in the field logbook. The sample-testing bottle and all probes will be cleaned and rinsed with distilled water prior to any measurements.

### 3.11.3 Soil Organic Vapor Analyses

Volatile organic vapor present in the headspace of soil samples will be measured using an organic vapor monitor. These measurements will be obtained from soil samples in the following manner:

- A portion of the soil sample collected will be placed in a new resealable plastic bag and the bag sealed.
- The samples will be allowed to sit for at approximately 15 minutes so soil gases can equilibrate with the air in the headspace.
- The headspace will be tested for volatile organic vapors with an organic vapor monitor.

Headspace and background readings will be recorded in parts per million (ppm) and incorporated into boring logs.

### 3.12 Decontamination Procedures

During sampling activities, appropriate decontamination measures will be taken to minimize sample contamination between samples. These procedures will be consistent with those outlined in "Test Methods for Evaluating Solid Waste-Physical/Chemical Methods" (U.S. EPA SW-846, 3rd ed.). The decontamination procedure for sampling equipment will incorporate the washing steps outlined below.

All non-disposable sampling equipment used in the collection of samples will be decontaminated. Decontamination should be executed immediately prior to equipment use if possible. Whenever this is not possible or practical, measures will be taken to assure that contamination of clean equipment will not occur. Clean, disposable gloves that do not degrade when exposed to the selected decontamination solvent(s) will be worn while decontaminating sampling equipment and tools. Clean sampling equipment will not be placed on the ground or other contaminated surfaces prior to use.

The waste decontamination fluids will be collected. A composite sample will be analyzed for each parameter to determine the appropriate method of disposal. Decontamination procedures are presented in SOP 6.0 and 6.1.

# 4.0 SAMPLE HANDLING PROCEDURES

## 4.1 Sample Containers

The types of containers and procedures used for cleaning these containers will consistent with EPA and USACE requirements for the specific parameters of interest. The sample container label must include location, time and date of sampling, grab or composite, analyses to be performed, and sampler's signature. Sample containers planned for use will be described in the FSP. Table 2-1 lists applicable sample containers and preservation.

## 4.2 Sample Preservation

All samples collected will be preserved according to EPA and/or USACE protocols established for the parameters of interest as specified in Appendix F of ER-1110-1-263. Methods not specified by Appendix F will use the appropriate guidance, EPA SW-846 or other. 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. Reference to the QAPP will prove sufficient to detail sample preservation methods for all analyses to be used for the project.

## 4.3 Sample Transportation

Environmental samples will be transported to the Contract Laboratory and QA laboratory via the most rapid means. Samples will be packaged and transported according to EPA, USACE, and DOT regulations. The FSP will describe the planned mode of sample transport. Detailed packing procedures are provided in SOP 2.0.

## 4.4 Chain of Custody Procedures

Samples will be collected, transported, and received under strict chain of custody protocols consistent with procedures established by the EPA for litigation-related materials. On receiving samples at the Contract Laboratory the air temperature inside the cooler and of the temperature blank will be measured immediately after the cooler is opened with the results recorded on the Cooler Receipt Form. Water samples requiring acidic or basic preservation will also be checked for pH on arrival at the Contract Laboratory. VOA samples will be checked for preservation just prior to sample analysis. Chain of custody procedures are detailed in SOP 1.1. Copies of chain of custody forms will be provided to the Project Chemist whenever samples are shipped from the field site (facsimile transmission). Upon receipt at the laboratory, the laboratory will provide a specific mechanism through which the disposition and custody of the samples are accurately

documented during each phase of the analytical process. Cooler Receipt Forms will be used to document the condition of samples on arrival at the laboratory. The results of all checks for preservation of samples will be recorded on the Cooler Receipt Form. Examples of chain of custody forms and cooler receipt forms are provided in the QAPP.

# *SAMPLING AND ANALYSIS PLAN*
# *TOOELE, UTAH*

***CONTRACT NO.***

***Submitted to:***
***Tooele Army Depot***
***Environmental Management Office***
***Tooele, UT***

Submitted by:

Approved by:_____ Date_____

Approved by:_____ Date_____

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## EXECUTIVE SUMMARY

The executive summary shall be composed of a brief description of the context of contract or project work, the goal of the proposed investigative work, a general description of the work to be performed, and a brief statement describing the relevance of the work to be performed to the goal of the investigation as applicable. Per the requirements of the DOD Instruction 4715.15, 11, Dec 2006, the SAP(s) for TEAD will follow the organization and requirements of the DOD UFP-QAPP. The UFP-QAPP format requirements can be met by completing the UFP-QAPP work sheets (WS) including any supplementary information as needed. The UFP-QAPP work sheets and the associated manual can be located at the following EPA link: http://www.epa.gov/fedfac/documents/qualityassurance.htm.

The format of the UFP-QAPP is meant to focus on critical project elements including:

- Data Quality Objectives
- Conceptual Site Model development
- Documentation of decision path(s)
- Assurance that sampling design meets the project needs
- Management of uncertainty/error
- Development of exit strategies

It is noted that there are some redundancies in the worksheets. It is not necessary to document reference items like SOPs in more than one place. The CDQMP was developed to streamline and simplify SAP / UFP-QAPP preparation, provide consistency for TEAD projects, and reduce review cycles while documenting project specific requirements. It should continue to serve that purpose.

A summary of the UFP-QAPP elements and the associated WS structure is as follows:

- Project Management and Objectives - Worksheets 1-16
- Measurement/Data Acquisition - Worksheets 17-30
- Assessment/Oversight - Worksheets 31-33
- Data Review - Worksheets 34-37

Detailed WS organization and specific requirements are located in Table 2-1 of this document. Specific sections of the TEAD CDQMP including SOPs for field and sampling processes should be referenced in the individual WSs.

## 1.0 Project Organization

This section in the SAP shall address the specific personnel that will be responsible for execution of a delivery order. The SAP must address not only the Contractor personnel but any subcontractor interactions applicable for a delivery order. Key personnel must be identified along with their function and qualifications. The text shall include a chart showing lines of authority and communication among all project participants. Include other data users who are outside of the organization generating data, but for whom the data are nevertheless intended; e.g. modelers, risk assessors, design engineers, toxicologists, etc. Where direct contact between project managers and data users does not occur the organization chart should show the route by which information is exchanged. The organization chart shall be realistic and practical and shall reflect only the actual lines of authority and communication for the project described.

## 2.0 Problem Definition/Background

A narrative describing the project shall be included that shall state the specific problem to be solved or the decision to be made. The goal of the investigation shall be clearly stated. The Contractor shall describe 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. The text shall include diagrams detailing areas to be sampled as relevant to the definition of the investigation goals. These sections shall also contain a summary of site geology/hydrogeology as known prepared to a level of detail such as to provide a comprehensive description of the site. The discussion must include enough information about the problem, the past history, any previous work or data, the regulatory or legal context, and any relevant ARAR's to present a clear description of the project objectives.

## 3.0 Project Description

The text shall provide a description of the work to be performed. This discussion may not be lengthy or overly detailed but it shall give an overall picture of how the project will resolve the problem or questions described in the definition and background of the problem. A general description of the sampling to be carried out for this project shall be included. Anticipated project start and completion dates shall be included. Describe in general terms:

- Measurements that are expected during the course of the project 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.

- Assessment tools that will be employed for the project (program technical reviews, peer reviews, surveillances, technical audits, etc.)

Project schedule or a sequence of milestones and their expected durations. If individual sampling plans will be developed for discrete project phases include their preparation schedule.

## 4.0 Data Quality Objectives

The text shall describe the general scope of work and background information as it relates to the acquisition of geological, geophysical, hydrogeological, and chemical data. The text shall explicitly describe the data that are needed to meet the objectives of the project, how that data will be used, and discuss implementation of control mechanisms and standards that shall be used to obtain data of sufficient quality to meet or exceed all project objectives. The discussion of Data Quality Objectives (DQO's) shall follow the guidance contained in the EPA document Data Quality Objectives Process for Superfund, Interim Final guidance (EPA540-R-93-071) and the requirements of this document are included by reference. Work performed by an on-site laboratory will be required to meet the same standards as a fixed site laboratory as described in this scope of work. The section on DQO's will address the following topics in the specified order:

- Statement of the Problem. Summarize the problem that requires environmental data acquisition and identify the resources available to resolve the problem.

- Identification of Decisions. 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.

- Identify 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.

- 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 DQO's.

Statements of the problem shall be defined quantitatively if possible. Example:

> UV Treatment of Contaminated Groundwater. "The purpose of this project is to demonstrate that the residual trichloroethylene concentration in the treated water is less than 0.5 ug/L at a confidence level of 95%."

Identification of decisions and descriptions of data use shall be described with text and supported with tables and lists that describe:

- Data needed. Measurement parameters, compounds, and sample matrices.
- The action levels or standards upon which decisions will be made, including the detection limits and data reporting units for relevant parameters.
- The summary statistic(s), e.g., mean maximum, range, etc., which specify the form the data will be in when compared against action levels or standards.
- The acceptable level of confidence in the data needed for the stated purposes; or the acceptable amount of uncertainty.

The text shall describe in quantitative terms the sensitivity, precision, accuracy, and completeness goals for each major measurement parameter and for each matrix to be sampled. The QAPP may need to define different types of sensitivity (e.g. quantitative, qualitative, screening) for each major measurement parameter as applicable. A qualitative discussion shall be presented regarding representativeness and comparability.

## 5.0 Sampling Process Design

Outline specifically the experimental design of the project including the sampling network design, types of samples required, sampling frequencies, sample matrices, and measurement parameters of interest. The rationale for the design shall be clearly stated. The rationale for the design shall be described for all sites where samples shall be obtained and will be supported with figures describing the specific points where samples shall be obtained. Measurement parameters to be described shall include geological, geophysical, hydrogeological, and chemical parameters as applicable. If cone penetrometer locations, hydropunch locations, or monitoring well locations are to be chosen on the basis of field observations the text shall clearly state the evaluation criteria that shall be used in the field for these determinations. Monitoring well design criteria (if applicable) shall be clearly described to include a description of field determinations for appropriate filter packs and well screens.

## 6.0 Sampling Methods Requirements

Provide a general description of sample collection procedures. Detailed specific descriptions of these procedures shall be described in the FSP and the SAP shall reference the specific paragraphs applicable from the FSP. For each sampling method identify any support facilities needed. The discussion shall focus on Contractor procedures for addressing failures in the sampling system and responsibilities for corrective action. The text shall include a table that describes bottle requirements, preservation, and holding times to extraction and/or analysis for all analytical parameters and matrices.

## 7.0 Analytical Methods Summary

The SAP shall contain tabular summaries of analyses required for each site but does not have to contain the level of detail that will be provided in the QAPP regarding analytical procedures. These summaries should contain for each analytical method the number of samples to be obtained for each analytical method with the number of QC splits, QA splits, field blanks, decon rinse blanks, and estimates of trip blanks detailed as applicable. The following data elements need to be considered when developing project specific analytical lists and selecting applicable methods:

- The target analyte list needs to include those analytes most likely to be found on the site considering site history and other site specific data and information
- Don't include analytes that are unrelated to the project, there needs to be a DQO for each analyte and method
- List project action limits and project specific reporting limits for every target analyte
- Ensure project reporting limits are at least 3 to 5 times lower than the action limits, MDLs, or RSLs
- Ensure laboratory LOQs can meet project reporting limits

## 8.0 Investigation Derived Waste

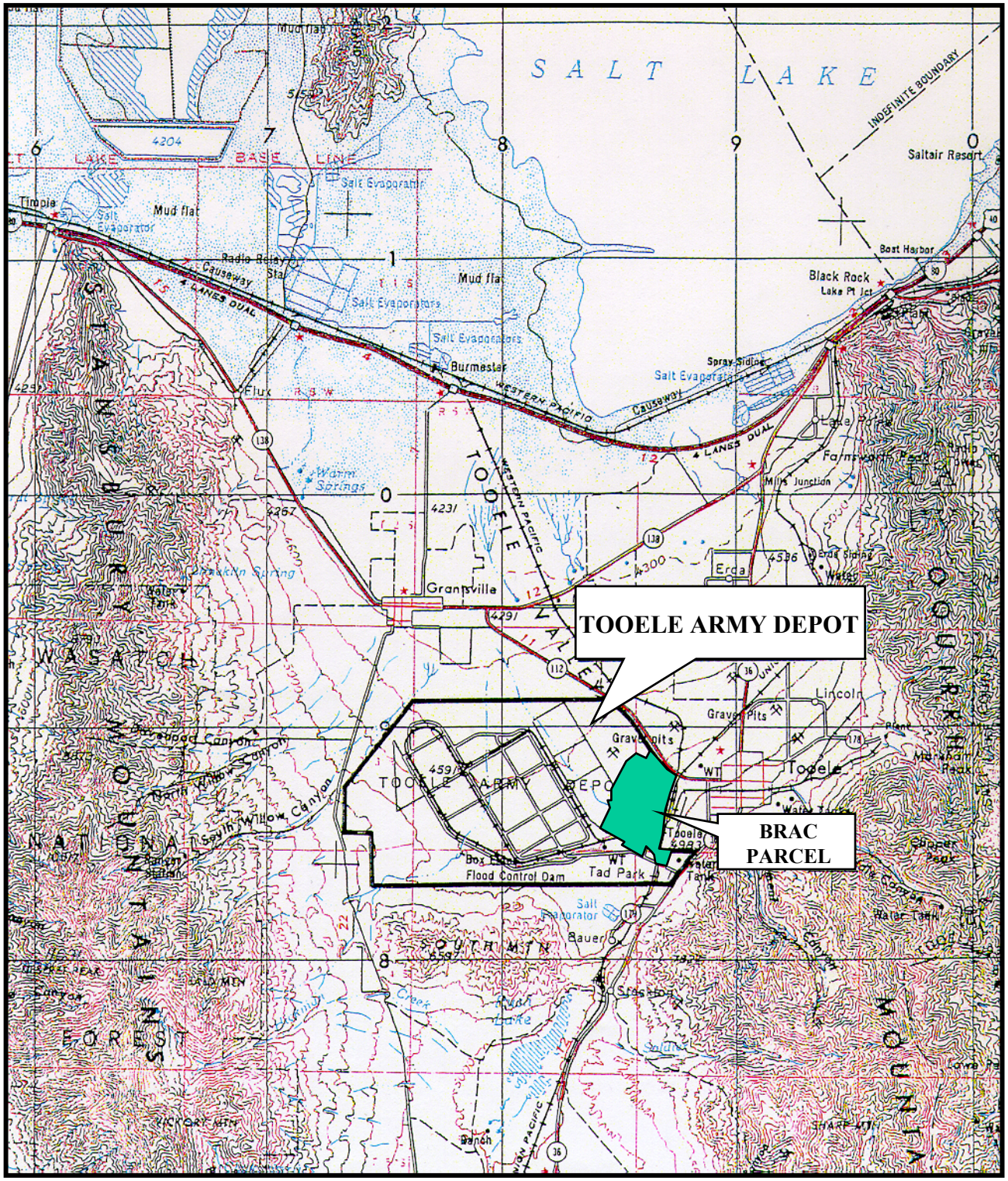
The text of the SAP shall describe the provisions that will be made for the proper handling and disposal of wastes generated on site.

## 9.0 Quality Control

The text of the SAP shall substantially reflect the specific procedures described in the CDQMP as they apply to three phase control with specific reference to the execution of field operations related to sampling and analysis. Checklists that are developed for implementation of three phase control shall be included in the text. Examples of these types of checklists are included in Appendix H of EM 200-1-3.

*Appendix A*

# *Site Location Map*




BASE MAP:
USGS TOOELE,UTAH
1 X 2 QUADRANGLE, 1970

0 1 2 3 4 5

SCALE IN MILES


Adapted from: Montgomery Watson

SLC4Q051.ppt

U. S. Army Corps of Engineers
Sacramento District

Date: 03/09/2004

# TOOELE ARMY DEPOT LOCATION MAP

FIGURE

**1-1**

# *Tables*

# Table 2-1
# UFP-QAPP Worksheet Organization
# Project Specific Information

| UFP-QAPP WORKSHEET | REQUIRED INFORMATION |
|---|---|
| **A. PROJECT MANAGEMENT** | |
| *Documentation* | |
| 1 | Title and Approval Page |
| 2 | Table of Contents and SAP Identifying Information |
| 3 | Distribution List |
| 4 | Project Personnel Sign-Off Sheet |
| *Project Organization* | |
| 5 | Project Organizational Chart |
| 6 | Communication Pathways |
| 7 | Personnel Responsibilities Table |
| 8 | Special Personnel Training Requirements Table |
| *Project Planning/Problem Definition* | |
| 9 | Project Planning Session Documentation<br>Project Scoping Session Participants Sheet |
| 10 | Problem Definition, Site History, and Background.<br>Site Maps (historical and present) |
| 11 | Site-Specific Project Quality Objectives |
| 12 | Measurement Performance Criteria Table |
| 13 | Sources of Secondary Use Data and Information<br>Secondary Use of Data Criteria and Limitations Table |
| 14 | Summary of Project Tasks |
| 15 | Detection Limits and Evaluation Table |
| 16 | Project Schedule/Timeline Table |
| **B. MEASUREMENT DATA ACQUISITION** | |
| *Sampling Tasks* | |
| 17 | Sampling Design and Rationale |
| 18 | Sampling Locations and Methods<br>Sample Location Map(s) / figures |
| 19 | Analytical Requirements Table |
| 20 | Field Quality Control Sample Summary Table |
| 21 | Project Sampling SOP References Table |
| 22 | Field Equipment Calibration, Maintenance, Testing, and Inspection Table |
| *Analytical Tasks* | |
| 23 | Analytical Method Reference Table |
| 24 | Analytical Instrument Calibration and Method QC Table |
| 25 | Analytical Instrument and Equipment Maintenance Table |
| *Sample Collection* | |
| 26 | Sample Handling System |
| 27 | Sample Custody Requirements Table |
| *Quality Control Samples* | |
| 28 | QC Samples Table |

# Table 2-1
# UFP-QAPP Worksheet Organization
# Project Specific Information

| UFP-QAPP WORKSHEET | REQUIRED INFORMATION |
|---|---|
| *Data Management Tasks* | |
| 29 | Project Documents and Records Table |
| 30 | Analytical Services Table |
| **C. ASSESSMENT OVERSIGHT** | |
| 31 | Planned Project Assessments Table |
| 32 | Assessment Findings and Corrective Action Responses Table |
| 33 | QA Management Reports Table |
| **D. DATA REVIEW** | |
| 34 | Verification (Step I) Process Table |
| 35 | Validation (Steps IIa and IIb) Process Table |
| 36 | Validation (Steps IIa and IIb) Summary Table |
| 37 | Usability Assessment |

Note: Use of UFP-QAPP work sheets is flexible and must be project specific. In some cases, certain elements will not be appropriate for a particular project. Requirements of the *Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) Manual* (EPA-505-B-04-900A, 2005) that do not apply can be addressed with a simple statement of why the information is not relevant or with a cross reference to the TEAD CDQMP in which the information appears.

# Table 2-2
# Sample Container, Preservation, and Holding Time Requirements

| Method/Analysis | Matrix | Sample Container | Chemical Preservation | Temperature Preservation | Holding Time |
|---|---|---|---|---|---|
| 8260 VOCs | water | 3-40ml VOA vial, glass[1,2] | HCl to pH < 2 | cool 4°C | 14 days[3] |
| | soils | stainless sleeve or 500 ml jar[1,2] | – | cool 4°C | 14 days[7] |
| | | or | | | |
| | | 4-40ml VOA vial, glass[1,6] | sodium bisulfate | cool 4°C | |
| | | or | | | |
| | | 2-EnCore™ samplers 5g, and 1-EnCore™ samplers 25g | – | Frozen[7] | |
| 8015 TPH-GRO | water | 3-40 ml VOA vial, glass[2] | HCl to pH < 2 | cool 4°C | 14days |
| | soil | stainless sleeve or 500 ml jar[2] | – | cool 4°C | 14 days |
| | | or | | | |
| | | 4-40ml VOA vial, glass[1,6] | sodium bisulfate | cool 4°C | |
| | | or | | | |
| | | 2-EnCore™ samplers 5g, and 1-EnCore™ samplers 25g | – | Frozen | |
| 8015 TPH-DRO | water | 2-1 liter amber glass[1] | -- | cool 4°C | 7 days / 40 days[4] |
| | soil | stainless sleeve or 500 ml jar | -- | cool 4°C | 14 days / 40 days[5] |
| 8270 SVOCs | water | 2-1 liter amber glass | -- | cool 4°C | 7 days / 40 days[4] |
| | soil | stainless sleeve or 500 ml jar | -- | cool 4°C | 14 days / 40 days[5] |
| 8280/8290 Dioxins & Furans | water | 2-1 liter amber glass | -- | cool 4°C | 28 days / 40 days[4] |
| | soil | stainless sleeve or 500 ml jar | -- | cool 4°C | 28 days / 40 days[5] |
| 8141 OP Pesticides | water | 2-1 liter amber glass | -- | cool 4°C | 7 days / 40 days[4] |
| | soil | stainless sleeve or 500 ml jar | -- | cool 4°C | 14 days / 40 days[5] |

| Method/Analysis | Matrix | Sample Container | Chemical Preservation | Temperature Preservation | Holding Time |
|---|---|---|---|---|---|
| 8151 Chlorinated Herbicides | water | 2-1 liter amber glass | -- | cool 4°C | 7 days / 40 days[4] |
| | soil | stainless sleeve or 500 ml jar | -- | cool 4°C | 14 days / 40 days[5] |
| 8310 PAHs | water | 2-1 liter amber glass | -- | cool 4°C | 7 days / 40 days[4] |
| | soil | stainless sleeve or 500 ml jar | -- | cool 4°C | 14 days / 40 days[5] |
| 8330 Explosives | water | 2-1 liter amber glass | -- | cool 4°C | 7 days / 40 days[4] |
| | soil | stainless sleeve or 500 ml jar | -- | cool 4°C | 14 days / 40 days[5] |
| 413.1 Oil & Grease | water | 2-1 liter amber glass | $H_2SO_4$ to pH < 2 | cool 4°C | 28 days |
| | soil | stainless sleeve or 500 ml jar | -- | cool 4°C | |
| 418.1 TRPH | water | 2-1 liter amber glass | $H_2SO_4$ to pH < 2 | cool 4°C | 28 days |
| | soil | stainless sleeve or 500 ml jar | -- | cool 4°C | |
| 6010 / 6020 / 7000 metals | water | 1-500 ml polyethylene | $HNO_3$ to pH < 2 | N/A | 6 months, except Hg = 28 days, $Cr^{+6}$ = 24 hrs |
| | soil | stainless sleeve or 500 ml jar | -- | N/A | 6 months, except Hg = 28 days, $Cr^{+6}$ = 24 hrs from sample prep. |
| 300.0 anions | water | 1-500 ml polyethylene | -- | cool 4°C | 28 days; except nitrate, nitrite, and o-phosphate = 48 hours |
| | soil | stainless sleeve or 500 ml jar | -- | cool 4°C | 28 days; except nitrate, nitrite, and o-phosphate = 48 hours from sample prep. |
| 310.1 alkalinity | water | 1-500 ml polyethylene | -- | cool 4°C | 14 days |
| | soil | stainless sleeve or 500 ml jar | -- | cool 4°C | 14 days |
| 335.3 / 9010 CN | water | 1-500 ml polyethylene | NaOH to pH > 12 | cool 4°C | 14 days |
| | soil | stainless sleeve or 500 ml jar | -- | cool 4°C | 14 days |

| Method/Analysis | Matrix | Sample Container | Chemical Preservation | Temperature Preservation | Holding Time |
|---|---|---|---|---|---|
| 150.1 / 9045 pH | water | 1-500 ml polyethylene | -- | cool 4°C | immediate analysis |
| | soil | stainless sleeve or 500 ml jar | -- | cool 4°C | immediate analysis |
| 160.1 TDS | water | 1-500 ml polyethylene | -- | cool 4°C | 7 days |
| | soil | N/A | N/A | N/A | N/A |
| 120.1 Conductivity | water | 1-500 ml polyethylene | -- | cool 4°C | 28 days |
| | soil | N/A | N/A | N/A | N/A |

Notes:
1. All glass bottles and jars will have teflon-lined lids or septa.
2. All jars or bottles collected for volatiles analysis will have zero head space.
3. If water sample unpreserved hold time equals 7 days / if preserved with HCl equals 14 days.
4. Extraction within 7 days / analysis of extract within 40 days.
5. Extraction required within 14 days / analysis of extract required within 40 days.
6. One vial must **not** contain preservative since it is to be used for screening, dry weight determination and high concentration analysis (as needed).
7. If the EnCore™ sampler is not frozen, the hold time equals 48 hours.

*Appendix C*

# *Flagging Conventions*

# Table 4-1
# Flagging Conventions - Data Evaluation and Validation (Organic Methods)

| Quality Control Check | Evaluation | Flag | Samples Affected |
|---|---|---|---|
| **Holding Time for Preserved Samples** | Technical holding time exceeded for extraction or analysis.<br>Positive results:<br>Non-detects: | <br><br>J- for all methods outside hold time<br>R for VOA hold times exceeded by >7 days<br>UJ non-detects for all other methods<br>UJ for VOA hold times exceeded by 1-7 days | <br><br>Sample<br>Sample<br>Sample<br>Sample |
| **Sample Preservation** | Positive results and non-detects for unpreserved samples:<br>VOA samples analyzed within 7 days<br>VOA samples not analyzed within 7 days | <br><br>no qualification<br>(see holding time flags above) | <br><br>Sample<br>Sample |
| **Temperature** | > 6°:<br>Positive results (except PCBs)<br>Non-detects (except PCBs) | <br>J-<br>UJ | <br>All samples in same cooler<br>All samples in same cooler |

| Quality Control Check | Evaluation | Flag | Samples Affected |
|---|---|---|---|
| **Calibriation Verification (ICV, CCV)** | | | |
| GC Analyses: | Positive results: | | |
| | Calibration within 85-115% recovery | no qualification | |
| | Calibration < 85% recovery | J- | All associated samples in analysis batch |
| | Calibration > 115% recovery | J+ | All associated samples in analysis batch |
| | Non-detects: | | |
| | Calibration > 85% recovery | no qualification | |
| | Calibration within 30-85% recovery | UJ | All associated samples in analysis batch |
| | Calibration < 30% recovery | R | All associated samples in analysis batch |
| GC/MS Analyses: | Non-CCC compounds: | | |
| | Positive results: | reviewer discretion | |
| | CCC within 75-125% recovery | no qualification | |
| | CCC < 75% recovery | J- | All associated samples in analysis batch |
| | CCC > 125% recovery | J+ | All associated samples in analysis batch |
| | Non-detects: | | |
| | CCC > 125% | no qualification | |
| | CCC 30- 75% | UJ | All associated samples in analysis batch |
| | CCC < 30% | R | All associated samples in analysis batch |

| Quality Control Check | Evaluation | Flag | Samples Affected |
|---|---|---|---|
| **Laboratory Control Sample (LCS)** | | | |
| GC Analyses: | Positive results: | | |
| | Recovery within 65-135% | no qualification | |
| | Recovery < 65% | J- | All samples in batch |
| | Recovery > 135% | J+ | All samples in batch |
| | RPD > 25% | J | All samples in batch |
| | Non-Detects: | | |
| | Recovery > 65% | no qualification | |
| | Recovery 30-65% | UJ | All samples in batch |
| | Recovery < 30% | R | All samples in batch |
| GC/MS Analyses: | Positive results: | | |
| | Recovery < LCL | J- | All samples in batch |
| *Evaluate as per attached Table.* | Recovery > UCL | J+ | All samples in batch |
| | Non-Detects: | | |
| | Recovery < LCL and > 10% | UJ | All samples in batch |
| | Recovery > UCL | no qualification | |
| | Recovery <10% | R | All samples in batch |
| **Method Blank** | Multiply value by 10 for common lab contaminants or 5 for other analytes | U reported results < action level | All samples in batch |
| **Equipment Blank** | Convert to soil units (if applicable) multiply by 5 or 10 as above | U flag reported results < action level | All samples (same field team, matrix and date) |
| **Trip Blank** | Convert to soil units (if applicable) multiply by 5 or 10 as above | U flag reported results < action level | All samples in the same cooler |

| Quality Control Check | Evaluation | Flag | Samples Affected |
|---|---|---|---|
| **Matrix Spike Recoveries** | | | If spike sample is considered representative of batch (otherwise sample only): |
| GC Analyses: | Positive results: | | |
| | Recovery < 65% | J- | All samples from same batch |
| | Recovery > 135% | J+ | All samples from same batch |
| | Non-detects: | | |
| | Recovery 30-65% | UJ | All samples from same batch |
| | Recovery < 30% | Reviewer discretion | |
| GC/MS Analyses: | Positive results: | | |
| | Recovery < LCL | J- | All samples from same batch |
| *Evaluate as per attached Table.* | Recovery > UCL | J+ | All samples from same batch |
| | Non-Detects: | | |
| | Recovery < LCL and > 10% | UJ | All samples from same batch |
| | Recovery > UCL | no qualification | |
| | Recovery <10% | R | All samples from same batch |
| **RPD** | | | |
| GC Analyses: | RPD > 25 (water), > 35% (soil) | J positive results | Sample only |
| GC/MS Analyses: | RPD > UCL *(See attached Table)* | J positive results | |

| Quality Control Check | Evaluation | Flag | Samples Affected |
|---|---|---|---|
| **Surrogates** | | | |
| GC Analyses: | Positive results: | | |
| | Recovery < 65% | J- | Sample |
| | Recovery > 135% | J+ | Sample |
| | Non-detects: | | |
| | Recovery 30-65% | UJ | Sample |
| | Recovery < 30% | R | Sample |
| GC/MS Analyses: | Positive results: | | |
| | Recovery < LCL | J- | Sample |
| *Evaluate as per attached Table.* | Recovery > UCL | J+ | Sample |
| | Non-Detects: | | |
| | Recovery < LCL and > 10% | UJ | Sample |
| | Recovery > UCL | no qualification | |
| | Recovery <10% | R | Sample |
| **Laboratory Duplicate** | RPD > 25% | J positive results using reviewer discretion for soil and turbid water samples | Analytical duplicate pair |
| **Field Duplicates** | RPD > 50% | Discuss qualitative impacts in narrative | Field duplicate pair |

| Quality Control Check | Evaluation | Flag | Samples Affected |
|---|---|---|---|
| **Tune** | Ion abundance criteria as described in SW-846 not met | R positive results/nondetect results | All associated samples in analysis batch |
| **Five-Point Calibration** | Calibration criteria as described in the method not met: | | |
| | Positive results | J | All samples associated with calibration |
| | Non-detects | R | All samples associated with calibration |

| Quality Control Check | Evaluation | Flag | Samples Affected |
|---|---|---|---|
| **Internal Standards** Method 8260 | RT change > UCL | J positive results | All associated samples |
| | IS extracted ion area counts greater than 2x daily CV:<br>Positive results<br>IS extracted ion area counts less than ½ daily CV:<br>Positive results<br>Non-detects | <br><br>J+<br><br><br>J-<br>UJ | <br><br>All associated samples<br><br><br>All associated samples<br>All associated samples |
| **Retention Time Windows** | Analyte peak not within RTW | Report results as non-detect | All affected analytes |

## Table 4-2
## Flagging Conventions - Data Evaluation and Validation (Inorganic Methods)

| Quality Control Check | Evaluation | Flag | Samples Affected |
|---|---|---|---|
| **Holding Time** | Holding time exceeded for digestion or analysis.<br>Positive results:<br>Non-detects | <br><br>J-<br>R flag mercury (Hg)<br>UJ for all other methods | <br><br>Sample<br>Sample<br>Sample |
| **Sample Preservation/ Temperature** | Method requirements not met.<br>Positive results:<br>Non-detects: | <br>J-<br>UJ for all methods except Hg<br>R for Hg | <br>Sample<br>Sample<br>Sample |
| **Calibration Verification (ICV, CCV)** | Positive results:<br>Calibration > 125% recovery (Hg 135%)<br>Calibration 111-125% (Hg 121-135%)<br>Calibration 75-89% recovery (Hg 65-79%)<br>Non-detects:<br>Calibration > 110% recovery (Hg 121%)<br>Calibration 75-89% recovery (Hg 65-79%)<br>Calibration < 75% recovery (Hg <65%) | <br>R<br>J+<br>J-<br><br>no qualification<br>UJ<br>R | <br>All associated samples in analysis batch<br>All associated samples in analysis batch<br>All associated samples in analysis batch<br><br><br>All associated samples in analysis batch<br>All associated samples in analysis batch |
| **Laboratory Control Sample (LCS)** | Positive results:<br>Recovery > 120%<br>Recovery < 80%<br>RPD > 20%<br>Non-Detects:<br>Recovery > 120%<br>Recovery 30-80%<br>Recovery <30% | <br>J+<br>J-<br>J<br><br>no qualification<br>UJ<br>R | <br>All samples in digestion batch<br>All samples in digestion batch<br>All samples in digestion batch<br><br>All samples in digestion batch<br>All samples in digestion batch<br>All samples in digestion batch |
| **Blank (PB, ICB, CCB)** | Multiply value by 5, convert to soil units if applicable | U reported results < action level | All samples in digestion batch (PB)<br>All samples in analysis batch (ICB, CCB) |

| Quality Control Check | Evaluation | Flag | Samples Affected |
|---|---|---|---|
| **Equipment Blank** | Convert to soil units, if applicable, multiply by 5 | U flag reported results < action level | All samples (same field team, matrix and date) |
| **Matrix Spikes Recoveries** | Positive results:<br>Recovery > 125%<br>Recovery < 75%<br>Non-detects:<br>Recovery > 125%<br>Recovery within 30-74% recovery<br>Recovery below 30% recovery | <br><br>J+<br>J-<br><br>no qualification<br>UJ<br>R | If sample is representative of site conditions (otherwise parent only):<br>All samples from same site as parent sample<br>All samples from same site as parent sample<br><br>All samples from same site as parent sample<br>All samples from same site as parent sample<br>All samples from same site as parent sample |
| **RPD** | RPD > 20% (water), > 35% (soil) | J positive results | Parent sample only. |
| **Laboratory Duplicate** | One or both sample results <5x PQL and a difference of ± PQL<br>Concentration of reported analyte >5x PQL in either sample and RPD > 20% (water) or > 35 % (soil) | J positive results using reviewer discretion based on the nature of the matrix<br>J positive results using reviewer discretion based on the nature of the matrix | Duplicated sample only. If MS/MSD noncompliant then further qualification required (reviewer discretion.) |
| **Field Duplicates** | RPD > 50% | Discuss qualitative impacts in narrative | Field duplicate pair |

*Appendix D*

# *Standard Operating Procedures*

# *Appendix D*

## *Standard Operating Procedures*

This appendix includes standard operating procedures for use by field and administrative personnel represent and supplement the information presented in the CDQMP in a procedural format.

| SOP No. | Title | Rev. |
|---|---|---|
| SOP 1.0 | Quality Control Program | 0 |
| SOP 1.1 | Chain of Custody | 0 |
| SOP 1.2 | Field Activity Documentation | 0 |
| SOP 2.0 | Sample Handling, Packaging and Shipping | 1 |
| SOP 2.1 | Sample Labeling | 0 |
| SOP 2.2 | Sample Numbering | 0 |
| SOP 2.3 | On-Site Sample Storage | 0 |
| SOP 3.0 | Surface and Shallow Subsurface Soil Sampling | 0 |
| SOP 3.1 | Subsurface Soil Sampling While Drilling | 0 |
| SOP 3.2 | Composite Sample Preparation | 0 |
| SOP 3.3 | Duplicate and Split Sample Preparation | 0 |
| SOP 3.4 | Surface Wipe Sampling | 0 |
| SOP 3.5 | Chip/Core Sampling | 0 |
| SOP 3.6 | Soil Gas Sampling | 0 |
| SOP 4.0 | Calibration and Maintenance of Measuring and Test Equipment | 0 |
| SOP 4.1 | Field Instrument QA/QC | 0 |
| SOP 5.0 | Water Level Measurements in Monitoring Wells | 0 |
| SOP 5.1 | Nonaqueous Phase Liquid Measurement in Monitoring Wells | 0 |
| SOP 6.0 | Sampling Equipment and Well Material Decontamination | 0 |
| SOP 6.1 | Drilling and Heavy Equipment Decontamination | 0 |
| SOP 7.0 | Compaction of Fill Material | 0 |
| SOP 8.1 | Monitoring Well Installation | 0 |
| SOP 8.2 | Monitoring Well Development | 0 |
| SOP 9.0 | Groundwater Sampling | 0 |
| SOP 9.1 | Passive Diffusion Bag Sampling For VOCs In Groundwater | 1 |
| SOP 9.2 | Cone Penetration Testing and Hydropunch Groundwater Sampling | 0 |
| SOP 9.3 | HydraSleeve Sampling | 1 |
| SOP 10.0 | Lithologic Logging | 0 |
| SOP 11.0 | Aquifer Testing | 0 |
| SOP 12.0 | Soil Stockpiling | 0 |
| SOP 14.0 | Hollow Stem Auger Drilling | 0 |
| SOP 15.0 | Field QC Sampling | 0 |
| SOP 16.0 | Management of Investigation-Derived Waste (IDW) | 1 |
| SOP 17.0 | Preparation, Revision and Approval of Plans and Procedures | 0 |
| SOP 18.0 | Quality Inspection and Inspection Report | 0 |

# CHAIN OF CUSTODY

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes the method and responsibilities associated with the maintenance and custody of samples which are to be used to provide data which form a basis for making project related decisions. It outlines the general procedures for maintaining and documenting sample chain of custody from the time of sample collection through sample disposition.

## 2.0 References

2.1 Tooele Army Depot - Chemical Data Quality Management Plan

2.2 USEPA, Test Methods for Evaluating Hazardous Waste, (SW-846) Rev.0, Sept. 1994

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Program Chemist* is responsible for assuring proper COC is initiated at the time the sample(s) are collected and maintained throughout the handling and subsequent transportation of the sample(s) to the designated laboratory. Additionally, he/she is the project authority for determining the disposition and fate of sample(s) which have identified deficiencies (e.g., missed holding times, elevated temperature at receipt, etc.).

3.3 *The Quality Assurance Officer (QAO)* is responsible for periodic review of Chain of Custody records are generated documentation associated with this SOP. The QAO is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

3.4 The *Sampling Team Leader(s)* is responsible for properly documenting and maintaining the COC from the time of sample collection until the sample is delivered to the lab.

3.5 *Laboratory Personnel* are responsible for receipt and entry of samples into the laboratory which have been submitted under a COC document. Additionally, samples received will be entered into the laboratory COC procedures by properly documenting and maintaining COC from the moment that they take custody of the sample at the laboratory until the sample is disposed of or returned to the client.

## *4.0 Definitions/Materials*

4.1 Chain of Custody

The Chain of Custody (COC) document is the written record that traces the sample possession from the time each sample is collected until its final disposition, sometimes called the "cradle to grave" record. Chain of Custody is maintained by compliance with one of the following criteria:

- The sample is in the individual's physical possession
- The sample is maintained in the individual's physical view after being in his/her possession
- The sample is transferred to a designated secure area restricted to authorized personnel
- The sample is sealed and maintained under lock and key to prevent tampering, after having been in physical possession.

4.2 Waybill

A document that contains a list of the goods and shipping instructions relative to a shipment.

4.3 Common Carrier

For the purpose of this procedure, the common carrier is any commercial carrier utilized for the transportation of the sample(s) from the field to the laboratory.

## *5.0 Procedure*

5.1 General

5.1.1 An overriding consideration for data resulting from laboratory analyses is the ability to demonstrate that the samples were obtained from the locations stated and that they reached the laboratory without alteration. Evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal must be documented to accomplish this. Documentation will be accomplished through a COC Record that lists each sample and the individuals performing the sample collection, shipment, and receipt.

5.1.2 The COC document is a preprinted form. The original will accompany the samples lab and a copy will be retained in the field project file.

5.2 Field Sample Custody

5.2.1 Sampling personnel, upon collection of samples for analysis, will properly complete a COC Record form (Attachment 6.1). The COC document will be the controlling document to assure that sample maintenance and custody are maintained thereby assuring the sample(s) are representative of the environment from which they were collected. At a minimum, the following information will be recorded on the COC document:

- The unique identification number assigned to each sample.
- A brief description of the sampling location and a physical description of the sample type.
- The date and time of the sample collection.
- Container type (e.g., glass, poly, brass sleeve, etc.).
- Sample volume and number of containers (e.g., 2 x 40 ml, 3 x 1 liter).
- Sample preservation (e.g., $HNO_3$, $H_2SO_4$, 4ºC).
- Requested analyses.
- Special instructions to the laboratory including handling requirements, quality assurance/quality control, health and safety, and sample disposition.
- The project name and number.
- The date the analytical report is due.
- The names of all sampling personnel.
- The name and phone number of the project contact.
- The name and phone number of the laboratory contact.
- The name of the courier and the waybill number (if applicable).
- A unique document reference number.

5.2.2 The COC document will be initiated in the field by the person collecting the sample and signed by each individual who has the samples in their possession. Each time that sample custody is transferred, the former custodian must sign over the COC as Relinquished By, and the new custodian must sign on to the COC as Received By. Each signature must be accompanied by the date, time, and the name of their project or company affiliation.

5.2.3 Transferring of COC from sampling personnel to the analytical laboratory will be performed in accordance with the requirements stated below.

5.2.3.1 If the sampling personnel deliver the samples to the laboratory, transfer of COC occurs as follows:

The sample collector delivers the samples to the laboratory and relinquishes the sample directly to a laboratory representative.

- The collector signs the COC listing his/her name, affiliation, the date, and time. Any person involved in the collection of the sample may act as the sample custodian.
- The laboratory representative must receive the samples by signing his/her name, affiliation, the date, and time on the COC. The laboratory representative may decline to take receipt of the samples if the COC is not properly completed or if the samples are not properly packaged. All designated laboratory personnel may act as the sample custodian.
- One copy of the COC is given to the sample collector to be returned to the project files and one copy is maintained with the samples at the laboratory.

5.2.3.2 If the sampling personnel transfer sample(s) to the laboratory utilizing a common carrier, sampling personnel will retain COC responsibility and the common carrier is not responsible for maintaining sample custody. The sample collectors are responsible for packaging the samples in a manner that meets the COC definition criteria, that is, the samples are sealed to prevent tampering. When transferring samples to the courier for transport, COC procedures are maintained as follows:

- The sample collector lists the courier affiliation and waybill number on the COC.
- The sample collector relinquishes custody by signing his name, affiliation, date, and time. The collector keeps a copy of the relinquished COC for the project file.
- The relinquished original COC is sealed in a watertight plastic bag and taped to the inside of the lid of the container used for transportation.
- The transportation container is sealed to prevent tampering and given to the courier for delivery to the laboratory.
- The sample collector obtains a copy of the waybill from the courier for the project file.
- The laboratory representative must receive the samples by signing his/her name, affiliation, the date, and time on the COC. This copy is maintained with the samples at the laboratory.
- The laboratory representative obtains a copy of the waybill from the courier for the project file.

5.3 Analytical Laboratory Custody

5.3.1 Upon receipt at the analytical laboratory, the field generated COC document will be signed, dated, time marked, temperature marked, and laboratory identification will be provided in the appropriate spaces. A cooler receipt form (Attachment 6.2) will be completed documenting the condition of the samples upon receipt.

5.3.2 Laboratory receipt personnel will enter the samples into the laboratory by implementing the sample custody procedures addressed within their approved Program Plan.

5.3.3 After completion of analytical testing, sample remnants not consumed during testing may be kept for six months beyond the completion of analysis, unless otherwise specified by a notation on the COC that samples are to be returned to the project site for disposal. Once this time period has elapsed, the samples will be disposed of and the disposal record number will be recorded on the laboratory record copy of the COC.

## *6.0 Required Forms*

6.1 Chain of Custody Record

6.2 Cooler Receipt Form

# QUALITY CONTROL PROGRAM

## STANDARD OPERATING PROCEDURE

## *1.0 Purpose*

1.1 This Standard Operating Procedure (SOP) describes the Quality Control Program (QCP) developed to implement the quality requirements applicable to the activities at the various sites. This program is applicable to quality affecting activities provided to Tooele Army Depot by A-E Contractors and their Subcontractors.

## *2.0 References*

2.1 None.

## *3.0 Responsibilities*

3.1 The *Program Manager* is responsible for the overall implementation of the Chemical Data Quality Management Plan (CDQMP). He/She should establish and cultivate principles and practices that integrate quality requirements into the daily work and provide individuals performing the work with proper information, tools, support and encouragement to properly perform their assigned work. He/She will coordinate the preparation of project specific Quality Control Project Plans (QCPPs) (i.e., Sampling and Analysis Plans, Field Sampling Plans).

3.2 The *Program Environmental Engineer, Program Geologist and Program Chemist* are responsible for assisting the Program Manager to assure that the project's goals and objectives are clearly stated and communicated to participating personnel. He/She will provide direct oversight and coordination of operations in order to assure that they are suitably controlled, including acting on the behalf of the Program Manager in his/her absence. He/She will prepare portions of project specific QCPP's appropriate to his/her background and experience.

3.3 The *Quality Assurance Officer (QAO)* is responsible for preparing the programatic documents and applicable SQPs which describe the implementation of the requirements of the CDQMP for QC activities. He/She will assign project specific QAOs as appropriate, and provide oversight and assistance in the implementation of the SAPs.

## 4.0 Definitions/Materials

Quality Control Project Plans.

## 5.0 Procedure

5.1 Program Basis

5.1.1 The TEAD CDQMP was developed utilizing selected concepts from the best or accepted industry quality management practices and requirements from applicable national and international standards. These practices and requirements are based upon U.S. DOE Order 5700.6c "Quality Assurance," Western Division Remedial Action Contract No. N62474-92-D-2151/001 and QAMS 005/80 (EPA, December 29, 1980) "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans."

5.1.2 The Standard Operating Procedures (SOPs), are designed to implement the quality requirements contained in the CDQMP applicable to the program/project specific activities. Specifically excluded from the program are procedures for safety, security, and project administration.

5.2 Program Organization

5.2.1 Implementing Standard Operating Procedures (SOPs) are developed to implement the requirements of the CDQMP by A-E Contract personnel, as applicable. The SOPs will be reviewed and approved by responsible management prior to their implementation.

5.2.2 Quality affecting SOPs prepared to perform delivery order activities are prepared and revised by technical/construction personnel under the direction of the Program Environmental Engineer, Program Geologist or Program Chemist and are reviewed and approved by the Program Manager, QAO and as applicable by the Health and Safety Manager.

5.2.3 The current revision of SOPs required to implement the delivery order activities are reflected in the applicable “Document Distribution Lists”, which are maintained by document control personnel.

5.2.4 Each delivery order specific QCPP prepared by the A-E Contractor through a selection of the applicable quality criteria necessary to accomplish the scope of work. The selection and documentation of the quality criteria will be provided within an individual project specific plan. This plan will, in general, reference the applicable sections of the CDQMP and SOPs appropriate

to the activities. Additional project specific requirements will be included within each plan by the inclusion of text which either adds additional requirements or modifies existing requirements. This method will enhance the Contractor's ability to provide a quick turnaround of QCPP's as existing information which was previously approved will be used as the baseline for the document. This will also provide consistency across the various projects, and allow the for a reduction in the overall time and cost required to approve QCPP's.

## *6.0 Required Forms*

None.

# FIELD ACTIVITY DOCUMENTATION

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

The purpose of this Standard Operating Procedure (SOP) is to define the minimum requirements for documenting field activities in the field logbooks. Field logbooks provide a detailed daily handwritten record, kept in real time, of field activities performed at an investigation site. Logbooks are permanently bound by glue or thread into a hard cover, and should be waterproof. Field logbooks may be assigned to specific activities, positions, or areas within the site. Field logbook covers must be sequentially numbered and indicate the position, task, activity, or area assigned to the logbook.

## 2.0 References

2.1 Tooele - Chemical Data Quality Management Plan

2.2 USEPA, Test Methods for Evaluating Hazardous Waste, (SW-846) Rev.0, Sept. 1994

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Program Environmental Engineer* is responsible for ensuring that all geotechnical measurements are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.3 *The Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with this SOP. The QAO is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

3.4 The *Sampling Team Leader(s)* are responsible for ensuring that field logbooks are completed daily in accordance with this procedure.

3.5 The *Sampling Team Members* are responsible for making timely and complete entries in the field logbook and for reporting daily activities to the Program Geologist, Environmental Engineer or QAO as appropriate.

## *4.0 Definitions/Materials*

4.1 Field logbook: surveyor's book or field book, bound and ruled/gridded, record book with sequentially numbered and waterproof pages.

4.2 Waterproof black ink pens.

## *5.0 Procedures*

5.1 Field Logbook Cover

Label the front cover of the field logbook with the project name and number, subcontractor name and client name, the start date and, when complete, the finish date. The field logbooks must be sequentially numbered.

5.2 Field Logbook

The following steps must be followed when making entries in the field logbook:

1. Enter the day and date; time the task started; weather conditions; and the names, titles, and organizations of personnel performing the task.
2. Record the name, title, organization, time of arrival, and time of departure of all visitors to the task area.
3. Describe all site activities in specific detail or indicate which forms were used to record such information (e.g., soil boring log or well completion log). A partial data list is given below:

   - Monitoring wells: complete the Monitoring Well Construction Log form.
   - Monitoring well development: complete the Well Development Log
   - Monitoring well purging and sampling: complete the Monitoring Well Purge and Sample Log form.
   -Surface water and sediment/sludge sampling: complete the Surface Water/Sediment Sampling Form.
   - Subsurface soil sampling:
     - Soil borings: complete the Soil Boring Log and include borehole size, depth, sample equipment, method, and samples collected. Detailed lithologic data will be recorded on the boring log.

- Trenches, and test pits: record the excavation dimensions, sampling equipment or method(s), and samples collected. Detailed lithologic data will be recorded on the Test Pit Information Log.
- Soil gas and geophysical surveys: grid or line dimensions, probe or sensor spacing, depths, survey and recording equipment type and serial or identification number, and location of resulting data (e.g., strip chart, analog data record, computer file, and file name). Sketches are valuable additions to field notes and should be used where possible.

4. Describe in specific detail any field tests that were conducted and instruments used. Reference any forms that were used, other data records, and the procedures followed in conducting the test. If the final results of any field activity are obtained in the field, these data should be annotated in the field logbook.

5. Changes in procedures or sample locations and reasons for change.

6. Describe in specific detail any samples collected and whether splits, duplicates, matrix spikes or blanks were prepared.

7. Upgrades or downgrades of personal protective equipment and the rationale for such action, and health and safety information such as level of personal protective equipment (PPE) used.

8. List the time, equipment type, and the procedure followed for all decontaminations carried out. Reference the page number(s) in the decontamination log (if any) where detailed information is recorded; if not referenced, detailed information shall appear in field logbook.

9. List all instrument calibrations, person(s) performing calibration, and the page number of the calibration log that provides specific information on calibration procedures and results when the calibrations occur in the field.

10. Record all photographs by number and include a description of the subject, the direction the photographer is facing, and the photographer's initials. If the event photographed is the collection of a sample, record the sample ID number.

11. List any equipment failures or breakdowns that occurred, together with a brief description of repairs or replacements.

12. No pages may be removed from the site or field logbooks for any reason. Blank pages must be marked “page intentionally left blank”.

13. Mistakes must be crossed out with a single line, initialed, and dated. Only persons authorized by the Program Geologist or Program Environmental Engineer may make entries in logbooks.

14. The Project Geologist or Sampling Team Leader must sign the field logbook at the bottom of each page.

## *6.0 Required Forms*

6.1 Field Activity Report Form

# SAMPLE HANDLING, PACKAGING AND SHIPPING

**STANDARD OPERATING PROCEDURE**

## 1.0 Purpose

This Standard Operating Procedure (SOP) outlines the methods and responsibilities for field personnel to use in the packaging and shipping of environmental samples for chemical and physical analysis. This SOP only applies to the packaging and shipping of limited quantity, low concentration environmental samples. This procedure does not apply to those samples considered hazardous materials, hazardous waste, mixed waste, radioactive waste, and/or dangerous goods. Those requirements are specified in the Department of Transportation (DOT) 49 CFR 114-327 and the International Air Transport Association (IATA) procedures. The details within this SOP are only applicable to the general requirements for sample packaging and shipping and should only be used as a guide for developing more job-specific work plans.#

## 2.0 References

2.1 EPA, September 1987, Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidelines for Conducting Remedial Investigation and Feasibility Studies under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.3 Code of Federal Regulations, DOT 49 CFR parts 100 to 177, Revised October 1, 1992.

2.4 Dangerous Goods Regulations, IATA, January 1, 1994.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Project Chemist* is responsible for the development and review of site-specific work plans which address the specific sample handling, packaging, and shipping requirements for the project. Review the project specific documentation forms to ensure they are appropriate for the field activities. The Program Chemist is also responsible for seeing that field personnel receive proper training and maintain quality assurance/quality control (QA/QC). If problems arise, the Program Chemist is responsible for swift implementation of corrective action (i.e., retraining personnel,

additional review of work plans and SOPs, variances to requirements, issuing nonconformances).

3.3 The *Quality Assurance Officer (QAO)* is responsible for the periodic review of documentation generated during sample handling, packaging, and shipping and the periodic review and audit of field personnel as they perform the work.

3.4 The *Sampling Team Leader(s)* are responsible for ensuring that samples are handled, packed and shipped in accordance with this procedure

## 4.0 Definitions/Materials

4.1 Environmental Sample

A limited quantity, low concentration sample that does not require DOT or IATA hazardous waste labeling as a hazardous waste or material.

4.2 Hazardous Waste Sample

Medium or high concentration sample requiring either DOT or IATA labeling as a hazardous waste or material.

4.3 Hazardous Waste

Any substance listed in 40 CFR Subpart D (260.30 et seq.) or otherwise characterized as ignitable, corrosive, reactive, or toxic as specified in Subpart C (261.20 et seq.) that would be subject to manifest and packaging requirements specified in 40 CFR 262. Hazardous waste is defined and regulated by the U.S. Environmental Protection Agency (USEPA).

4.4 Hazardous Material

A substance or material in a quantity or form which may pose an unreasonable risk to health, safety, and/or property when transported in commerce. Hazardous material is defined and regulated by DOT (49 CFR 173.2 and 172.101) and IATA (Section 4.2).

4.5 Sample

Physical evidence collected from a facility or the environment which is representative of conditions at the point and time at which the sample is collected.

## 5.0 Procedure

5.1 Sample Handling

5.1.1 Inspect the sampling containers (obtained from the analytical laboratory prior to the sampling event) to ensure that they are appropriate for the samples being collected, correctly preserved, and undamaged.

5.1.2 When collecting a sample always use approved/site specific personal protective equipment (e.g., gloves, etc.) to prevent cross-contamination from sample to sample but also as a health and safety requirement.

5.2 Field Packaging

5.2.1 Collect the samples in accordance with the site-specific work plans and applicable SOPs.

5.2.2 Place all containers in separate, appropriately sized, airtight, seam sealing polyethylene bags (e.g., Ziploc™ or equivalent). Seal the bag, removing any excess air.

5.2.3 Place the bagged container inside an insulating shipping container, "cooler". This cooler should have frozen blue ice inside to assure samples remain cool, 4°C ± 2°C, during transit from field to the packaging location.

5.2.4 Because blue ice does not maintain the 4°C standard required for sample shipping, it should only be used while in the field collecting samples.

5.2.5 Maintain the samples under chain of custody (COC) (Attachment 6.1) in accordance with the site-specific work plans and appropriate SOPs.

5.3 Sample Packaging

5.3.1 Inspect the integrity of the shipping container. The container is generally a "cooler" constructed of heavy plastic or metal with appropriate insulating properties so that variations in temperature during shipping are minimized. Also make sure that the drain plug has been sealed with nylon reinforced strapping tape or mailing tape.

5.3.2 Place two to four inches of absorbent packaging material (e.g., Styrofoam bubbles, Vermiculite™ etc.) in the bottom of the shipping container.

5.3.3 Carefully check the COC record against the collected sample labels and containers to ensure

that the sample numbers, sample description, date and time of collection, container type and volume, preservative, and the required analytical methods are correct and in agreement.

5.3.4 Place the samples in the shipping container, allowing sufficient room between the samples to place ice and/or packing material.

5.3.5 Double bag (ziplock™ or equivalent) and seal crushed or cubed ice in heavy-duty polyethylene bags. Place these bags of ice on top of and between samples. Blue ice should not be used for sample shipping; it does not maintain the 4 °C temperature necessary for regulatory compliance. Include a VOA vial of tap water clearly labeled "temperature blank" so that the laboratory can verify the temperature of the samples upon receipt. The remaining space will be filled with packing material.

5.3.6 All samples requiring temperature preservation stated at 4 °C will be acceptable "as in" within the range of 4°C ± 2°C. The laboratory should record the temperature of receipt upon the COC and complete a cooler receipt form (Attachment 6.2). For all samples received at less than 2°C (note if frozen), or at greater than 6°C, the sample(s) and temperature (in 1°C increments) will be identified on the COC and the Project Chemist notified, to provide a determination and written authorization to proceed to analysis.

5.4 Sample Shipping

5.4.1 The laboratory will be contacted 2 weeks prior to sample shipments. Delivery on weekends and holidays will be confirmed in 1 week advance, and one day prior to shipment. The person in charge of sample custody will time, date, and sign over relinquishment of custody on the COC. When a common carrier is to be used for sample shipment, also record the air/waybill number (tracking number) and the name of the carrier on the COC record. Place the original copy of the COC record in a sealed, clear plastic envelop or bag and tape the COC record envelope to the inside lid of the shipping container. Retain a copy of the COC record for tracking purposes.

5.4.2 Using nylon reinforced strapping tape or mailing tape, seal the shipping container.

5.4.3 Place custody tape over opposite ends of the lid.

5.4.4 Mark the container "THIS END UP", or apply arrow labels that indicate the proper position to be maintained during shipping. Place a "FRAGILE" label on any coolercontaining glass bottles.

5.4.5 Apply a label stating the name and address of the shipper and the receiving laboratory on the outside of the cooler.

5.4.5.1 If QA split samples are shipped. The Project Chemist shall notify the QA Laboratory by telephone at least two weeks in advance of sale shipment (for large numbers of samples, greater than 20) and again on the day that samples are forwarded to the QA Lab.

5.4.6 Turn the sample over to the courier or carri er for delivery to the laboratory. All sam ples should be shipped by the fastest available method to the laboratory as soon as possible after sample collection.

NOTE: The courier or carrier is not responsible for sample custody and is not required to sign the COC.

5.4.7 Contact the appropriate laboratory personnel to advise them of the sample shipment.

5.4.8 Review the COC and sample collection forms for completeness and turn them over to site or project management.

## *6.0 Required Forms*

6.1 Chain of Custody Record
6.2 Cooler Receipt Form

# SAMPLE LABELING

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for sample labeling. Sample labeling is required to identify, track and trace samples from the time of collection until the time of disposal. Additional specific procedures and requirements will be provided in the project work plans.

## 2.0 References

2.1 EPA, September 1987, Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final OSWER Directive 9355.3-01.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all sample collection and labeling activities are conducted and documented in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with this sample labeling SOP. The QAO is also responsible for the implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to sample labeling requirements, issuing nonconformances, etc.) if problems occur.

3.3 The *Sampling Team Leader(s)* assigned to sampling and sample labeling activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from the procedures to the Program Geologist.

## 4.0 Definitions/Materials

4.1 Sample Label

Sample labels include all forms of sample identification (labels or tags) that are physically attached to samples collected and provide, at a minimum, the information required by this SOP and project work plans.

## *5.0 Procedure*

This section contains the procedures involved with sample labeling. Sample labeling is required to identify, track and trace samples from the time of collection until the time of disposal. The details within this SOP should be used in conjunction with the project work plans. The project work plans will commonly provide the following information:

- Sample collection objectives
- Numbers, types and locations of samples to be collected
- Any additional sample labeling requirements or procedures beyond those covered in this SOP, as necessary.

5.1 Sample Labeling

5.1.1 Document all the information necessary on the sample label and ensure that the label is physically attached to each respective sample. Each sample label must contain at a minimum the following information:

- Project name
- Project number
- Date and time of collection
- Sample location
- Sample identification number
- Collector's name
- Preservative used (if any).

Additional information may also be required per the project work plans and must accordingly be included on all sample labels.

5.1.2 Indelible ink should be used in filling out all sample labels.

5.1.3 Ensure that each sample collected has a sample label.

5.1.4 Ensure that the information documented on the sample label corresponds with the information documented on the Sample Collection Log, Sampling Information Form for groundwater samples and Chain-of-Custody Record.

## *6.0 Required Forms*

6.1 Sample Labels

6.2 Sample Collection Log

6.3 Sampling Information Form

6.4 Chain-of-Custody Record

# SAMPLE NUMBERING

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for sample numbering. Sample numbering is required to identify, track and trace samples from the time of collection until the time of disposal. Additional specific procedures and requirements will be provided in the project work plans.

## 2.0 References

2.1 EPA, September 1987, Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a,OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final OSWER Directive 9355.3-01.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all sample collection and numbering activities are conducted and documented in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with this SOP. The QAO is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to sample numbering requirements, issuing nonconformances, etc.) if problems occur.

3.3 The *Sampling Team Leader(s)* assigned to sampling and sample numbering activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from the procedures to the Program Geologist.

## 4.0 Definitions/Materials

4.1 Sample Number

A sample number is a unique alphanumeric identification assigned to each and all physical samples collected as part of any given project.

## *5.0 Procedure*

This section contains the procedures involved with sample numbering. Sample numbering is required to provide a means by which samples can be identified, tracked and traced from the time of collection until the time of disposal. The details within this SOP should be used in conjunction with project work plans. The project work plans will generally provide the following information:

- Sample collection objectives
- Numbers, types, and locations of samples to be collected
- Project-specific character string to be used for the sample numbering
- Person responsible for issuing sample numbers to field personnel conducting sampling activities
- Any additional sample numbering requirements or procedures beyond those covered in this SOP, as necessary.

5.1 Sample Numbering

5.1.1 The alphanumeric character string (AANNNN vs. AAANNNNN) will be determined on a project-specific basis and stated in the project work plans. The sample numbers should be as simple and preferably as short as possible; however, they should also be compatible with the laboratory analytical tracking system and the data management system to be used for the project sample data.

5.1.2 A unique sample number will be assigned in the field to each sample to be submitted for analysis.

5.1.3 The sample numbers will be assigned sequentially (e.g. SB-1000, SB-1001) as the samples are collected. Both environmental (soil, sediment, groundwater, air, etc.) and QC samples will be assigned sequential sample numbers with the same prefix so that the laboratory will be unable to distinguish between the QC and non-QC samples.

5.1.4 The sample number will be recorded, using indelible ink, directly on the sample label attached to each sample per SOP 2.1.

5.1.5 The sample number must also be recorded on the Sample Collection Log, Sampling Information Form for groundwater samples, and Chain-of-Custody Record.

5.1.6 It is recommended that one person (either the Sampling Team Leader or other designee) be responsible for issuing sample numbers to field sampling personnel and ensuring that the sample sequence numbers are applied to samples in the sequence in which they are collected.

5.1.7 It is also recommended the field supervisor or designee be responsible for keeping a master sample log listing the sample numbers and a brief description of the samples collected.

## *6.0 Required Forms*

6.1 Sample Collection Log
6.2 Sampling Information Form
6.3 Chain of Custody Record

# ON-SITE SAMPLE STORAGE

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for on-site sample storage. On-site sample storage may be required for samples collected during a given project. Additional on-site sample storage procedures and requirements will be provided in the project work plans.

## 2.0 References

2.1 EPA, September 1987, Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final OSWER Directive 9355.3-01.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all on-site sample storage activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with this SOP. The QAO is also responsible for Implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to sample storage requirements, issuing nonconformance, atc.) if problems occur.

3.3 The *Sampling Team Leader(s)* assigned to sample storage activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Program Geologist.

## 4.0 Definitions/Materials

4.1 Field sample

A sample that has been collected at a project site, during the execution phase of the project, and for the purposes of the project, as defined in the project work plans.

4.2 On-site

For purposes of this SOP, "on-site" is defined as any area within the project site.

4.3 On-site sample storage

For purposes of this SOP, "on-site sample storage" applies to samples stored within the project site for a temporary period of time. Typically, samples may be stored on-site if they are in transit between the project site and a designated laboratory.

## *5.0 Procedure*

This section contains the requirements pertaining to on-site sample storage. Proper storage is essential to maintain the quality and integrity of samples collected during a field project.

The details within this SOP should be used in conjunction with project work plans. At a minimum, The project work plans will provide the following information:

- Sample collection objectives
- Numbers, types and locations of samples to be collected
- Any additional on-site sample storage requirements or procedures beyond those covered in this SOP, as necessary.

5.1 On-Site Sample Storage Requirements

5.1.1 Samples of all types of media may required to be stored on-site. The manner in which these samples are stored will be appropriate for individual samples or each sample type.

5.1.2 Samples collected for chemical analysis are typically required to be stored at approximately 4° Centigrade (° C). Therefore, such samples should either be preservedin a "cooler" using water ice, and/or in a "Sample-only" refrigerator until received by the assigned laboratory. Blue ice is not recommended for on-site sample storage as it does not maintain the 4°C temperature necessary for regulatory compliance. If a refrigerator is used to store samples at the project site, this refrigerator will be dedicated for the sole use of samples; no food, drinks or other personal items will be allowed in this refrigerator.

5.1.3 Samples that do not require refrigeration (e.g. air samples and samples for geotechnical or radionuclide analysis) should be stored on-site in a designated, marked area.

5.1.4 Samples that are stored on-site must be stored in appropriate containers per the project-specific work plans and be maintained under custody per SOP No. 1.1.

5.1.5 Samples that are stored on-site must not be stored in a manner in which they may threaten the integrity of other samples in the holding location,

5.1.6 All samples that are stored on-site must be labeled per SOP No. 2.1, numbered per SOP 2.2, and appropriately handled per SOP No. 2.1.

5.1.7 It is recommended the Sampling Team Leader or other designee be responsible for maintaining a master sample log listing sample numbers and a brief description of samples collected. The master log should be reviewed on a daily basis for samples that are under storage on site. The samples should then be appropriately shipped, following procedures per SOP No. 2.1, to ensure that holding time are not missed.

5.1.8 Samples that are not shipped to the assigned laboratory should be disposed of in a timely manner following appropriate disposal practices for the media from which the samples were initially obtained.

## *6.0 Required Forms*

None.

# SURFACE AND SHALLOW SUBSURFACE SOIL SAMPLING

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for use by field personnel in the collection and documentation of surface (0 to 6-inch depth) and shallow subsurface (6 inch to 6 feet in depth) soil samples for physical and chemical analysis. Proper collection procedures are necessary to assure the quality and integrity of all surface and shallow subsurface soil samples. Additional specific procedures and requirements will be provided in the project work plans.

## 2.0 References

2.1 EPA, September 1987, Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidelines for Conducting Remedial Investigation and Feasibility Studies under CERCLA, Interim Final OSWER Directive 9355.3-01.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 *The Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with this SOP. The QAO is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

3.3 The *Sampling Team Leader(s)* assigned to surface and shallow subsurface soil sampling activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Program Geologist or QAO as apprpriate.

## 4.0 Definitions/Materials

4.1 Surface Soil Sample

Soil collected from the surface to a depth of no more than 6 inches.

4.2 Shallow Subsurface Soil Sample

Soil collected from a depth of 6 inches to 6 feet.

4.3 Subsurface Soil Sample

Soil collected at any depth interval greater than 6 inches.

4.4 Disturbed Soil Sample

A soil sample whose in situ physical structure and fabric has been disturbed as the direct result of sample collection.

4.5 Undisturbed Soil Sample

A soil sample where in situ physical structure and fabric has not been disturbed as the result of sample collection.

4.6 Grab Samples

Representative disturbed soil sample that is collected by using such devices as a shovel, stainless steel spoon, etc.

## 5.0 Procedure

This section contains both the responsibilities and procedures involved with surface and shallow subsurface soil sampling. Proper surface and shallow soil sampling procedures are necessary to insure the quality and integrity of the samples. The details within this SOP should be used in conjunction with project work plans. The project work plans will generally provide the following information:

- Sample collection objectives
- Locations and depths of soil samples to be collected
- Numbers and volumes of soil samples to be collected
- Types of analyses to be conducted for the samples
- Specific quality control (QC) procedures and sampling required
- Any additional surface or shallow subsurface soil sampling requirements or procedures beyond those covered in this SOP, as necessary.

At a minimum, the procedures outlined below for surface and shallow subsurface soil sampling will be followed.

5.2 Surface Soil Sampling Equipment

A number of devices are available for the collection of surface soil samples. These include, but are not limited to: core samplers, hand augers, spoons, scoops, trowels, shovels, etc. These devices are constructed of a number of materials including, but not limited to, stainless steel, brass, glass, teflon, etc.

The sampling and analytical requirements, as well as site characteristics, must be taken into account when determining the proper surface soil sampling equipment to use.

At present, the method commonly used for the collection of surface samples and shallow subsurface samples, both disturbed and undisturbed, is with a core sampler. The core sampler is usually a hollow, stainless steel cylinder, tapered at the leading end. A sample sleeve (brass, stainless steel, lexan, etc.) is inserted into the trailing end. The trailing end is then connected to a piston-type drive hammer. The core is driven into the soil by the hammer so that a relatively undisturbed sample is collected in the sleeve. The sample is then handled and shipped in the sample sleeve.

When a core sample is not feasible or planned, a sample can be collected by using such devices as a stainless steel shovel, hand auger, trowel, spoon, etc. The soil is transferred from the collection device into decontaminated sample containers (commonly glass jars). The project work plans will specify the type of sampling equipment to be used. The sample containers to be used will be specified in the project work plans.

5.3 Surface Soil Sample Collection

5.3.1 Prior to sampling and between sampling locations, decontaminate the sample equipment according to SOP 6.0 and procedures outlined in the project work plans.

5.3.2 Ensure that all surface and shallow subsurface soil sampling locations have been appropriately cleared of all underground utilities and buried objects per the project work plans. Review all forms and diagrams documenting the location of the cleared sampling locations, as well as that of any underground utilities or lines, or other buried objects.

5.3.3 As required, calibrate any health and safety monitoring equipment according to the instrument manufacturer's specifications. Calibration results will be recorded on the appropriate form(s), as specified in the project work plans. Instruments that cannot be calibrated according to the manufacturer's specifications will be removed from service and tagged.

5.3.4 Don appropriate personal protection equipment as specified in the project work plans.

5.3.5 Clear the area to be sampled of surface debris and vegetation using equipment that will not be used for sample collection.

5.3.6 If using the coring device, place the sleeve into the device and drive the assembly into the soil using the drive hammer. Drive the device into the soil until the trailing end of the sleeve is at the soil surface.

5.3.7 Retrieve the device; check to see that soil recovery is adequate in the sample sleeve. If there is sufficient recovery, mark or note the leading end of the sample sleeve.

5.3.8 If using a different sample collection device (other than the coring device), use the other device to scoop or collect soil and directly transfer the soil into the sample container (e.g., glass jar, brass sample sleeve, etc.). Fill the sample container such that little to no head-space exists.

5.3.9 If using sample sleeves, place teflon squares over each end of the sleeve and seal each end with plastic end caps. With a permanent marker, write a "T" for top on the trailing end and a "B" for bottom on the leading end. Place custody tape over each end cap so that any attempt to remove the cap will cause the tape to be broken. When VOCs are collected, seal over base of cap with teflon tape.

If using glass jars, cap or seal the jars appropriately and place custody tape over the cap so that any attempt to remove the cap will cause the tape to be broken.

5.3.10 Appropriately label and number the sample containers per SOPs 2.1 and 2.2, respectively, and the project work plans. The label will be filled out with waterproof ink and will contain, at a minimum, the following information:

- Project number
- Sample number
- Sample location
- Sample depth
- Sample type
- Date and time of collection
- Parameters for analysis
- Sampler's initials.

5.3.11 Document the sampling event on the Sample Collection Log or an equivalent form as specified in the project work plans. Note any pertinent field observations, conditions or problems on the Field Activity Daily Log. Any encountered problems or unusual conditions should also be immediately brought to the attention of the field Geologist.

5.3.12 Appropriately preserve, handle, package, and ship the samples per SOP 2.0 and the project work plans. The samples shall also be maintained under custody per SOP 1.1.

5.3.13 Fill and abandon the sample hole as required by the project work plans.

5.4 Shallow Subsurface Soil Sampling

5.4.1 The common method to collect shallow subsurface soil samples is to use a hand auger to bore to the desired sampling depth and then retrieve the sample with a core sampler. The hand auger might also be used to recover the sample for direct transfer into glass jars. The exact methodology to be used will be specified in the project work plans.

For subsurface soil samples of less than 18 inches in depth, successive drives of the core sampler may potentially be used to recover shallow subsurface soil samples. In all methods cited above, borehole stability should be maintained to prevent the recovery of slough in the samples. If sloughing cannot be controlled, then another sampling methodology may have to be considered.

5.4.2 As with surface soil samples, shallow subsurface soil sampling follows the same sample collection procedures specified in Sections 4.3.1 through 4.3.13.

## *6.0 Required Forms*

6.1 Sample Collection Log

6.2 Field Activity Daily Log

6.3 Chain of Custody

# SUBSURFACE SOIL SAMPLING WHILE DRILLING

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for subsurface soil sampling while drilling. Proper collection procedures are necessary to assure the quality and integrity of all subsurface soil samples. Additional specific procedures and requirements will be provided in the project work plans, as necessary.

## 2.0 References

2.1 American Society for Testing Materials (ASTM), 1989, Standard Method for Penetration Test and Split-Barrel Sampling of Soils, Method D-1586-84, Philadelphia, PA.

2.2 American Society for Testing Materials (ASTM), 1986, Standard Practice for Thin-Walled Tube Sampling of Soils, Method D-1587-83, Philadelphia, PA, pp 304-307.

2.3 American Society for Testing Materials (ASTM), 1986, Standard Practice for Ring-Lined Barrel Sampling of Soils, Method D-3550-84, Philadelphia, PA, pp 560-563.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with this SOP. The QAO is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

3.3 The *Sampling Team Leader(s)* assigned to subsurface soil sampling activities during drilling are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Program Geologist or QAO as appropriate.

## 4.0 Definitions/Materials

4.1 Borehole

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

4.2 Split-Spoon Sampler

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

4.3 Shelby Tube Sampler

A thin-walled metal tube used to recover relatively undisturbed samples. These tubes are available in various sizes, ranging from 2 to 5 inches in outside diameter and 18 to 54 inches in length. A stationary piston device is included in the sampler to reduce sampling disturbance and increase sample recovery.

4.4 Drilling Jars

A set pair of linked, heat-treated steel bars. The jars may be attached to a wireline sampling string incorporating a split spoon or other impact sampler. The jars are used to drive the sampler into the soil ahead of the bottom of the borehole.

## 5.0 Procedure

This section contains both the responsibilities and procedures involved with subsurface soil sampling while drilling. Proper subsurface soil sampling procedures are necessary to insure the quality and integrity of the samples. The details within this SOP should be used in conjunction with project work plans. The project work plans will generally provide the following information:

- Sample collection objectives
- Locations of soil borings and target horizons or depths of soil samples to be collected
- Numbers and volumes of samples to be collected
- Types of chemical analyses to be conducted for the samples
- Specific quality control (QC) procedures and sampling required

Any additional subsurface soil boring sampling requirements or procedures beyond those covered in this SOP, as necessary.

There are many different methods which may be used for subsurface soil sample collection during drilling. This SOP focuses on the two most common methods of soil sample collection: split-spoon sampling and Shelby tube sampling. At a minimum, the procedures outlined below for these two subsurface soil sampling methods will be followed. If other subsurface soil sampling methods are deemed necessary to meet project objectives, the procedures for these methods will be updated in this SOP or included in the project work plans.

## 5.1 General Sampling Considerations

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

The procedures described in this SOP must be used in conjunction with the SOP proscribed for the specific drilling method used at the site. These also include, but are not limited to, site clearance, site preparation, and health and safety requirements. Consequently, the SOP for the specific drilling method to be used at the site, the project work plans, and this SOP must be reviewed together before the initiation of drilling and sampling.

## 5.2 Split-Spoon Sampling

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

5.2.1 Calibrate all field analytical and health and safety monitoring equipment according to the instrument manufacturer's specifications. Calibration results will be recorded on the appropriate form(s) as specified by the project-specific work plans. Instruments that cannot be calibrated according to the manufacturer's specifications will be removed from service and tagged.

5.2.2 Wear the appropriate personal protective equipment as specified in the project work plans and the applicable drilling method SOP. Personnel protection will typically include a hard hat, safety glasses, gloves, steel-toed boots, hearing protection, and coveralls.

5.2.3 Between each sampling location and prior to each sampling run, decontaminate the sampler, sleeves, and other sampling equipment as described in SOP 6.0.

5.2.4 Advance the borehole to the desired depth or target horizon where the sampling run is to begin. During drilling, monitor vapors in the breathing zone according to the project work plans, and drilling method SOP.

5.2.5 When the desired sampling depth or target horizon is reached, remove the drill bit or plug from inside the drive casing or augers.

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

5.2.7 Drive the sampler into the soil at the bottom of the borehole. Record the type of sampler assembly and hammer weight on the Visual Classification of Soils form and/or other appropriate form(s), as specified in the project work plans. To minimize off-gassing of the volatiles, the sampler should not be driven until the sampling team is ready to process the sample.

5.2.8 When conducting penetration testing, observe and record on the Visual Classification of Soils form the number of hammer blows as described in SOP 10.0.

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

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

5.2.11 Remove the sleeves one at a time, starting with the sleeve adjoining the drive shoe. Observe and record the amount of sample recovery on the Visual Classification of Soils form per SOP 10.0. Any observed field problems associated with the sampling attempt (e.g., refusal) or lack of recovery should be noted on the Visual Classification of Soils form. Clean area or stand (table) between samples.

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

5.2.13 Place teflon film over each end of sleeves to be submitted for chemical analysis and seal each end with plastic end caps. Place custody tape over each end cap so that any attempt to remove the cap will break the tape.

5.2.14 Appropriately label and number each sleeve to be submitted for analysis per SOP 2.1 and 2.2, respectively. The label will be filled out using waterproof ink and will contain, at a minimum, the following information:

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

5.2.15 Document the sampling event on the Sample Collection Log or an equivalent form as specified in the project work plans. At a minimum, this log will contain:

- Project name and number
- Date and time of the sampling event
- Drilling and sampling methods
- Sample number
- Sample location
- Boring number
- Sample depth
- Sample description
- Weather conditions
- Unusual events
- Signature or initials of the sampler.

5.2.16 Appropriately preserve, package, handle, and ship the sample in accordance with the procedures outlined in SOP 2.0 and the project work plans. The samples shall also be maintained under custody per SOP 1.1. Samples stored on-site will be subject to the provisions of SOP 2.3.

5.2.17 One of the sample sleeves shall be utilized for lithologic logging per SOP 10.0. This sleeve may not then be retained for chemical analysis as soil must be removed from the sleeve to effectively describe the soils/lithology and compile the lithologic log.

5.2.18 When VOCs or petroleum hydrocarbons are of concern, remove the soil from one of the remaining sleeves and place in a seam-sealing, polyethylene bag for organic vapor screening. Place the bag in the sunlight (warm) for at least five minutes, then using an organic vapor probe (e.g., portable photoionization detector, flame ionization detector, or other appropriate instrument), monitor the soil for organic vapors. Record the reading on the Visual Classification of Soils form, the Sample Collection Log, and any other form(s) specified in the project work plans.

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

5.3 Thin Walled or Shelby Tube Sampling

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

5.3.1 Calibrate all field analytical and health and safety monitoring equipment as discussed in Section 5.2.1.

5.3.2 Wear the appropriate personal protective equipment as described in Section 5.2.2.

5.3.3 Between each sampling location and prior to each sampling run, decontaminate the sampler and other sampling equipment as described in SOP 6.0.

5.3.4 Advance the borehole to the desired depth or target horizon where the sampling run is to begin. While drilling, monitor the breathing zone according to the project work plans and applicable drilling method SOP.

5.3.5 Connect the sampling tube to the drill rod string and advance the tube to the bottom of the boring. The tube is then pushed about 2 to 2.5 feet into the soil with a continuous, rapid motion without impact or twisting.

5.3.6 Pull the drill rod strip up from the bottom of the borehole and remove the sampling tube from the string. Observe and record the amount of sample recovery and any associated problems as discussed in Section 5.2.11.

5.3.7 Place teflon film over each end of the tube if it is to be submitted for chemical analysis and seal the ends with plastic end caps. Place custody tape over each end cap so that any attempt to remove the cap will break the tape. With a waterproof marker, write a “T” for top on the trailing end and a “B” for bottom on the leading end of the tube.

5.3.8 Appropriately label and number the tube as described in Section 5.2.14.

5.3.9 Document the sampling event on the Sample Collection Log as discussed in Section 5.2.15.

5.3.10 Appropriately preserve, package, handle and ship the sample in accordance with the procedures outlined in SOP 2.0 and the project work plans. The samples shall also be maintained under custody per SOP 1.1. Samples stored on-site will be subject to the provisions of SOP 2.3.

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

## *6.0 Required Forms*

6.1 Visual Classification of Soils Form
6.2 Sample Collection Log
6.3 Chain of Custody

# COMPOSITE SAMPLE PREPARATION

## STANDARD OPERATING PROCEDURE

## *1.0 Purpose*

This Standard Quality Operating Procedure (SOP) describes the requirements for compositing techniques.Composite samples, regardless of the media, consist of two or more subsamples taken from a specific media and site at different depth intervals. The subsamples are collected and mixed. A single average sample is taken from the mixture.

The composite sampling will be used at sites where hand augered borings are to be performed. These composited depths for a typical 7 foot boring will be 0 to 3.5 feet and 3.5 to 7.0 feet.

Composite samples are useful in estimating the overall contamination properties of a specific site. They are less expensive than non-composite samples because one sample for analysis represents many subsample locations. Composite samples do not provide detailed information of contamination variability as a function of the location.

## *2.0 References*

2.1 None.

## *3.0 Definitions/Materials*

The equipment required to obtain duplicate and/or split samples is identical to that for primary media sampling.

## *4.0 Responsibilities*

4.1 The *Program Geologist* will ensure that sampling efforts are conducted in accordance with this procedure and other SOPs pertaining to specific media sampling.

4.2 The *Quality Assurance Officer (QAO)* is responsible for ensuring that this procedure is correctly implemented and that the quantity and quality of composite samples meet the requirements of the Sampling and Analysis Plan

4.3 The Sampling Team Leader(s) assigned to this task are responsible for ensuring that field personnel collect and prepare composite samples in accordance with this procedure.

## *5.0 Procedures*

5.1 Preparation

Site preparation for the purpose of compositing samples is not different from that required for any of the media/waste sampling activities.

5.2 Surface Soil, Compositing

The following steps must be followed when compositing surface soil samples:

- Determine where composite sample(s) will be obtained as indicated in the site-specific sampling plan.
- Volatile organic compound (VOC) and, in some cases, semivolatile compound (SVOC) samples of solids (e.g., soils, sludge) must be collected and contained immediately as stand-alone samples and, therefore, cannot be composited.
- Collect a minimum of three equal-volume samples from the specified sample location. The volume of each sample must be at least the amount required for a single sample.
- Place the samples on an appropriate mixing tray. Thoroughly homogenize the pooled samples using the appropriate equipment.
- Transfer subsamples of the composited sample into the appropriate sample containers. Seal, decontaminate, and label sample containers. Use the same care in handling these samples as that used for other samples from the site.
- Document activities.

- Decontaminate sampling equipment.

## 5.3 Subsurface Soil Compositing

Compositing of subsurface soils refers to a single borehole in which several consecutively sampled depths are combined for a single sample. This is done to allow sufficient sample volume for the required analysis.

The following steps must be followed when compositing subsurface soil samples:

1. Determine where composite sample(s) will be obtained as indicated in the site-specific sampling plan.
2. Obtain samples by the methods.
3. For split-spoon or Shelby-tube cores from a specified depth or range of depths:
   - Extract or extrude the sample from the split spoon or Shelby tube onto an appropriate mixing tray, peel sample and discard ends.
   - Continue with the four-quarters method.
4. For hand auger samples:
   - The sample is acquired directly from the withdrawn auger.
   - Extract or extrude the sample from the bucket to an appropriate mixing tray.
   - Continue with the four-quarters method.
   - Document activities.
   - Decontaminate sampling equipment.

## 5.4 Surface-Water Compositing

The following steps must be followed when compositing surface-water samples:

- Determine where composite sample(s) will be obtained as detailed in the site-specific sampling plan.
- VOC and, in some cases, SVOC samples must be collected and contained immediately as stand-alone samples and, therefore, cannot be composited.
- Collect a minimum of three equal-volume samples from the specified sample

location. The volume of each sample must be at least the amount required for a single sample.

- Place the samples in the appropriate mixing container. Thoroughly homogenize the pooled samples using the appropriate equipment.
- Transfer aliquots of the composited sample into the appropriate sample containers. Seal, wipe clean, and label sample containers. Handle with the same care as that used for other samples from the site.
- Document activities.
- Decontaminate sampling equipment.

5.5 Collection of Replicate Samples

The following steps must be followed when compositing groundwater samples:

- Determine which well a composite sample will be obtained as stated in the site-specific sampling plan.
- VOC and, in some cases, SVOC samples must be collected and contained immediately as stand-alone samples and, therefore, cannot be composited.
- Collect a minimum of three equal-volume samples from the specified sample location. The volume of each sample must be at least the amount required for a single sample.
- Place the samples in the appropriate container. Thoroughly homogenize the pooled samples using the appropriate equipment.
- Transfer aliquots of the composited sample into the appropriate sample containers. Seal, wipe clean, and label sample containers. Handle with the same care as that used for other samples from the site.
- Document activities.
- Decontaminate sampling equipment.

## *6.0 Required Forms*

6.1 None.

# DUPLICATE AND SPLIT SAMPLE PREPARATION

## STANDARD OPERATING PROCEDURE

## 1.0 Objective

The objective of this procedure is to define the requirements for the collection and preparation of duplicate and/or split samples.

## 2.0 Background

Duplicate and split samples are typically obtained for either of two purposes: (1) as a means of quality control (QC) from the point of sample collection through all analytical processes (if the initial and duplicate samples are not within specification, the reasons for the discrepancy must be found and corrected, if possible), or (2) for later laboratory analyses, if needed. For TEAD projects, co-located or duplicate samples will be collected to provide information on the variability of the contaminants in the field.

Duplicate samples are samples collected from a location as close to the primary sample location as possible. They are collected to provide a means of assessing the reliability of field sampling methods and analytic data resulting from field samples.

Split samples are normally obtained for the express purpose of submitting identical samples to different laboratories for comparative analytical results. Duplicate and/or split samples may be collected as composite or grab samples from most media or waste types.

The same equipment and techniques will be required when obtaining duplicate and/or split samples as for primary samples. Briefly, the sampling requirements are: (1) grab samples will be collected for surface soil, surface water, groundwater sediment, and sludge, destined for volatile organic compound (VOC) analysis, and composite or grab sampling techniques can be used for non-VOCs; and for subsurface soils.

Comparative analyses between laboratories can also be obtained for semivolatile organic compounds and/or metals. Duplicate samples can also be obtained for VOC and non-VOC contaminated media by careful grab samples. For most split or duplicate sampling for non-VOC parameters, in all media, compositing is recommended.

## 3.0 Responsibilities

*Field Geologist*: The Field Geologist is responsible for ensuring that field personnel collect split and duplicate samples in accordance with this and other relevant procedures.

*Quality Assurance Officer(QAO)*: The QAO is responsible for ensuring that this procedure is correctly implemented and that the quantity and quality of split and duplicate samples collected meet the requirements of the Project QA/QC Plan.

## 4.0 Required Equipment

The equipment required to obtain duplicate and/or split samples is identical to that for primary media sampling.

## 5.0 Procedures

5.1 Duplicate Samples

The following steps must be followed when collecting duplicate samples:

1. Determine the frequency of obtaining duplicate samples as specified in the site-specific sampling plan.

2. Proceed with site sampling to the point that a duplicate sample is required.

3. The duplicate sample is a sample taken at the same time, as close as possible, and under the exact conditions as those required for the primary sample. Note: Any sample or portion of a sample that is to be analyzed for VOCs shall be collected and contained immediately. Do not stir, mix, or agitate samples for VOC analysis before containment.

4. Follow the specific media sampling plan. The preparation and disposition of the duplicates will be the same as those for the primary samples.

5. Obtain VOC samples first (without mixing or compositing), then proceed to Step 6. Samples for VOCs must be collected and contained immediately. Agitation by mixing, stirring, or shaking will cause vaporization of the volatile fraction to a significant degree. Resample if agitation has occurred. Mix all non-VOC duplicate samples or when taking duplicates of surface water or groundwater samples. Mixing may be accomplished by pouring a portion of the sample directly from the sampling device into the original container, and then pouring an equal portion into the duplicate container, alternating between the two until the sample containers are full.

6. Place the sample(s) in the appropriate sample container. Duplicate samples will be labeled or tagged according to their intended use as detailed in the sampling plan. If the sampling plan duplicates are to be held for possible later analyses, they may be labeled as "sample XXX duplicate", where the number "XXX" refers to the primary sample. If the duplicates are intended for QC measures, they may be given discrete sample numbers. Duplicate samples must be properly identified in the field logbook.

7. Sealed, pack, and transport duplicate samples in the sample manner as that used for other samples from the sampling site.

8. Decontaminate all equipment. Place all disposable liquids and solids in the appropriate receptacles.

9. Remove personal protective clothing and equipment and place in the designated receptacles. Field sampling personnel must be contamination-free before leaving the sampling site.

10. Document activities.

## 5.2 Split Samples for Surface Soils, Sediments, and Sludges

The following steps must be followed when collecting split samples of surface soils, sediments, and sludges:

1. Determine the number and frequency of required sample splits as specified in the site-specific sampling plan.

2. Proceed with site sampling to the point of obtaining split sample(s).

3. Follow the specific media sampling procedure.

NOTE: Split samples for VOCs are not recommended. Adequate cross-laboratory checks can be obtained by splits of non-VOC samples. If QA is required for VOC samples, obtain duplicates as outlined in Section 5.1 of this SOP. All split samples for VOC analysis for the above media are grab samples taken as specified in Step (3), Sect. 5.1 of this SOP.

4. For non-VOC grab samples, obtain a sufficient volume to fill all required sample containers, including those required for splits.

5. Composite these samples.

6. Split the composite sample equally and place the required volumes into the sample containers.

7. Seal and decontaminate the outside surfaces of the containers.

8. Label split samples as specified in the site sampling plan. Record all pertinent information in the filed logbook.

9. Split samples will have a separate chain-of-custody record.

10. Split samples will be sealed, packed, and transported in an identical manner as that specified for other samples from the site. The difference may be their destination (different laboratories) and the extent of analytical work. The site-specific sampling plan specifies the disposition of split samples.

11. Decontaminate all equipment according. Place all disposables in the appropriate receptacles.

12. Remove protective clothing and equipment and place in the designated receptacles. Field sampling personnel must be contamination-free before leaving the sampling site.

13. Document activities.

5.3 Split or Duplicate Volatile Organic Compound Sampling of Subsurface Soils with Split Spoons or Shelby Tubes

The following steps must be followed when sampling subsurface soils with split spoons or Shelby tubes:

1. Determine the number and frequency of required sample splits as stated in the site-specific sampling plan.

2. Proceed with site sampling to the point of obtaining split sample(s).

3. Follow the specific media sampling plan.

4. Most split-spoon sampling in the field is accomplished with 2-in. OD split spoons. When split or duplicate samples are required, a 2-in. OD split spoon will usually not collect sufficient sample volume if a number of analytes are to be sampled. In such situations, it is advisable to follow the American Society for Testing Materials (ASTM) D-1584 modified method of split-spoon sampling using a 300-lb. drop hammer and a 3-in. OD split spoon. If blow counts are not required for engineering

purposes, and the site soils permit, attempts may be made to drive the 3-in. split spoon by the 140-lb. weight. This deviation will ensure collection of enough sample volume.

5. Upon retrieval of the split-spoon, the sample should be peeled and the ends discarded. Divide the sample into four sections (A, B, C and D). Sample A should be immediately containerized and becomes the original sample for VOC analysis. Sample B is also immediately containerized and becomes the duplicate sample for VOC analyses. Section C and D can be composited for all other non-VOC analyses.

6. Decontaminate the outside of the sample container after sealing.

7. Label split samples as specified in the site sampling plan. Record all pertinent information in the field logbook.

8. Split samples will have a separate chain-of-custody record.

9. Split samples will be sealed, packed, and transported in an identical manner as other samples from the site. The difference may be their destination (different laboratories) and the extent of analytical work. The site sampling plan specifies the disposition of split samples.

10. Decontaminate all equipment. Place all disposables in the appropriate receptacles.

11. Remove protective clothing and equipment and place in the designated receptacles. Field sampling personnel must be contamination-free upon leaving the sampling site.

12. Document activities.

5.4 Split or Duplicate non-Volatile Organic Compounds Sampling of Subsurface Soils with Split Spoons or Shelby Tubes

The following steps should be followed when sampling subsurface soils with split spoons or Shelby tubes:

1. Determine the number and frequency of required sample splits as stated in the site-specific sampling plan.

2. Proceed with site sampling to the point of obtaining split sample(s).

3. Follow the specific media sampling procedure.

4. Peel the sample and composite the sample. (NOTE: Most split-spoon sampling in the field is accomplished with 2-in. OD split spoons. When split or duplicate

samples are required, a 2-in. OD split spoon will usually not collect sufficient sample volume if a number of analytes are to be sampled. In such situations, it is advisable to follow the ASTM D-1584 modified method of split-spoon sampling using a 300-lb. drop hammer and a 3-in. OD split spoon. This deviation will ensure collection of enough sample volume. Portion the samples, including splits, to sample containers as directed by the site-specific sampling plan.)

5. Seal sample containers and wipe outside surfaces.

6. Label split samples as specified in the site sampling plan. Record all pertinent information in the field logbook.

7. Split samples will have a separate chain-of-custody record.

8. Split samples will be sealed, packed, and transported in a manner identical to that for other samples from the site. The difference may be their destination (different laboratories) and extent of analytical work. The site sampling plan specifies the disposition of split samples.

9. Decontaminate all equipment. Place all disposables in the appropriate receptacles.

10. Remove personal protective clothing and equipment and place in the designated receptacles. Field sampling personnel must be contamination-free before leaving the sampling site.

11. Document activities.

## 5.5 Split Samples for Surface Water and Groundwater

The following steps must be followed when collecting split samples for surface water and groundwater:

1. Determine the number and frequency of required sample splits as stated in the site-specific sampling plan.

2. Proceed with site sampling to the point of obtaining split sample(s).

   Follow the specific media sampling procedure.

3. Split samples for VOCs are not recommended. Adequate cross-laboratory checks can be obtained by splits of non-VOC samples. If QA is required for VOC samples, obtain duplicates as outlined in Sect. 5.1 of this SOP. All split samples for VOC

analysis for the above media are grab samples taken as specified in Step (3), Sect. 5.1 of this SOP.

4. For non-VOC grab samples, obtain a sufficient volume to fill all required sample containers, including those required for splits.

5. Obtain VOC samples first (without mixing or compositing). Samples for VOCs must be collected and contained immediately. Agitation by mixing, stirring, or shaking will cause vaporization of the volatile fraction to a significant degree. Resample if agitation has occurred. Mix all non-VOC duplicate samples or when taking duplicates of surface water or groundwater samples. Mixing may be accomplished by pouring a portion of the sample directly from the sampling device into the original container, and then pouring an equal portion into the duplicate container, alternating between the two until the sample containers are full.

6. Split the composited sample by placing the required volumes in the sample containers, including those for split samples.

7. Seal and wipe the outside surfaces of the containers.

8. Label split samples as specified in the site sampling plan. Record all pertinent information in the field logbook.

9. Split samples will have a separate chain-of-custody record.

10. Split samples will be sealed, packed, and transported in a manner identical to that for other samples from the site. The difference may be their destination (different laboratories) and extent of analytical work. The site sampling plan specifies the disposition of split samples.

11. Decontaminate all equipment. Place all disposables in the appropriate receptacles.

12. Remove personal protective clothing and equipment and place in the designated receptacles. Field sampling personnel must be contamination-free before leaving the sampling site.

13. Document activities.

## *6.0 Required Forms*

6.1 Chain of Custody

6.2 Cooler Receipt Form

# SURFACE WIPE SAMPLING

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for use by field personnel in the collection and documentation of surface wipe samples for chemical analysis. Proper collection procedures are necessary to assure the quality and integrity of all surface wipe samples. Additional specific procedures and requirements will be provided in the project work plans.

## 2.0 References

2.1 USACE, EM 200-1-3, 1 September 1994.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 *The Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with this SOP. The QAO is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

3.3 The *Sampling Team Leader(s)* assigned to surface and shallow subsurface soil sampling activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Program Geologist or QAO as apprpriate.

## 4.0 Definitions/Materials

4.1 Surface Wipe Sample

Sample collected for monitoring surface contamination of non-volatile compounds from a non-porous surface.

## 5.0 Procedure

This section contains both the responsibilities and procedures involved with surface wipe sampling.

Proper surface wipe sampling procedures are necessary to insure the quality and integrity of the samples. The details within this SOP should be used in conjunction with project work plans. The project work plans will generally provide the following information:

- Sample collection objectives
- Locations of samples to be collected
- Numbers of samples to be collected
- Types of analyses to be conducted for the samples
- Specific quality control (QC) procedures and sampling required
- Any additional sampling requirements or procedures beyond those covered in this SOP, as necessary.

At a minimum, the procedures outlined below for surface wipe sampling will be followed.

5.2 Surface Wipe Sampling Equipment

- Appropriately sized square template (100 $cm^2$)
- Guaze pads/filter papers
- Appropriate solvent as specified in the project work plan and SAP
- Decontaminated tongs and
- Solvent resistant disposable gloves

5.3 Surface Wipe Sample Collection

5.3.1 Prior to sampling and between sampling locations, decontaminate reusable sample equipment according to SOP 6.0 and procedures outlined in the project work plans.

5.3.2 Place the required sized squire template over the area to be sampled (Toxic Substances and Control Act requires a 100 $cm^2$ surface area).

5.3.3 Remove guaze pad or filter paper from box with decontaminated tongs with gloved hands.

5.3.4 Soak the guaze pad or filter paper in the solvent required per the SAP.

5.3.5 Using the same tongs wipe the area of the surface framed by the template cutout with the moistened guaze in one direction only.

5.3.6 Without allowing the guaze to contact any other surface, fold the guaze with the exposed side in, and then fold it again to form a 90-degree angle in the center of the guaze.

5.3.7 Place the guaze in a pre-cleaned wide mouth sampling jar and cover with the teflon lined lid.

5.3.8 Appropriately label and number the sample containers per SOPs 2.1 and 2.2, respectively, and the project work plans. The label will be filled out with waterproof ink and will contain, at a

minimum, the following information:

- Project number
- Sample number
- Sample location
- Sample type
- Date and time of collection
- Parameters for analysis
- Sampler's initials.

5.3.11 Document the sampling event on the Sample Collection Log or an equivalent form as specified in the project work plans. Note any pertinent field observations, conditions or problems on the Field Activity Daily Log. Any encountered problems or unusual conditions should also be immediately brought to the attention of the Sampling Team Leader.

5.3.12 Appropriately preserve, handle, package, and ship the samples per SOP 2.0 and the project work plans. The samples shall also be maintained under custody per SOP 1.1.

## *6.0 Required Forms*

6.1 Sample Collection Log

6.2 Field Activity Daily Log

6.3 Chain of Custody form

# SURFACE CHIP/CORE SAMPLING

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for use by field personnel in the collection and documentation of surface chip and core samples for chemical analysis. Proper collection procedures are necessary to assure the quality and integrity of all samples. Additional specific procedures and requirements will be provided in the project work plans.

## 2.0 References

2.1 USACE, EM 200-1-3, 1 September 1994.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 *The Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with this SOP. The QAO is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

3.3 The *Sampling Team Leader(s)* assigned to surface and shallow subsurface soil sampling activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Program Geologist or QAO as apprpriate.

## 4.0 Definitions/Materials

4.1 Surface Chip Sample

Sample collected for monitoring surface contamination of non-volatile compounds from a porous surface such as cement, brick, or wood.

4.2 Core Sample

Sample collected for the determination of harzardous material designation and determination of appropriate landfill disposal.

## *5.0 Procedure*

This section contains both the responsibilities and procedures involved with surface chip and core sampling. Proper sampling procedures are necessary to insure the quality and integrity of the samples. The details within this SOP should be used in conjunction with project work plans. The project work plans will generally provide the following information:

- Sample collection objectives
- Locations of samples to be collected
- Numbers of samples to be collected
- Types of analyses to be conducted for the samples
- Specific quality control (QC) procedures and sampling required
- Any additional sampling requirements or procedures beyond those covered in this SOP, as necessary.

At a minimum, the procedures outlined below for surface chip sampling will be followed.

5.2 Surface Chip Sampling Equipment

- Appropriately sized square template (100 $cm^2$)
- Decontaminated chisel and hammer
- Decontaminated tongs and
- Solvent resistant disposable gloves

5.3 Surface Chip Sample Collection

5.3.1 Prior to sampling and between sampling locations, decontaminate reusable sample equipment according to SOP 6.0 and procedures outlined in the project work plans.

5.3.2 Place the required sized squire template over the area to be sampled (Toxic Substances and Control Act requires a 100 $cm^2$ surface area).

5.3.3 Use a decontaminated chisel and hammer to break up the surface to be sampled. Avoid scattering the chips.

5.3.4 Chip the area to less than ¼ inch deep and record the depth at which samples were taken.

5.3.5 Using the decontaminated tongs collect the chiped pieces using a new pair of disposable

gloves.

5.3.6 Place the chips in a pre-cleaned wide mouth sampling jar and cover with the teflon lined lid.

5.3.7 Appropriately label and number the sample containers per SOPs 2.1 and 2.2, respectively, and the project work plans. The label will be filled out with waterproof ink and will contain, at a minimum, the following information:

- Project number
- Sample number
- Sample location
- Sample type
- Date and time of collection
- Parameters for analysis
- Sampler's initials.

5.3.8 Document the sampling event on the Sample Collection Log or an equivalent form as specified in the project work plans. Note any pertinent field observations, conditions or problems on the Field Activity Daily Log. Any encountered problems or unusual conditions should also be immediately brought to the attention of the Sampling Team Leader.

5.3.9 Appropriately preserve, handle, package, and ship the samples per SOP 2.0 and the project work plans. The samples shall also be maintained under custody per SOP 1.1.

5.3.10 Core samples will be collected in a like manner using appropriate power tools and coring completely through the media to be sampled.

## *6.0 Required Forms*

6.1 Sample Collection Log
6.2 Field Activity Daily Log
6.3 Chain of Custody form

# SOIL GAS SAMPLING

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for use by field personnel in the collection and documentation of soil gas samples for chemical analysis. Proper collection procedures are necessary to assure the quality and integrity of all samples. Additional specific procedures and requirements will be provided in the project work plans.

This standard operating procedure (SOP) describes the procedures for collecting soil gas samples from:

- Surface screening;
- Slide hammer and hand auger holes;
- Pneumatic and hand-driven shallow soil gas probes;
- Hydraulically-driven shallow soil gas probes;
- Split-spoon samplers;
- Downhole (borehole) probes; and
- Soil gas piezometers and dry groundwater monitoring wells.

## 2.0 References

2.1 USACE, EM 200-1-3, 1 September 1994.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 *The Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with this SOP. The QAO is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

3.3 The *Sampling Team Leader(s)* assigned to soil sampling activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate

procedures. All staff are responsible for reporting deviations from procedures to the Program Geologist or QAO as appropriate.

## *4.0 Definitions/Materials*

This SOP includes procedures for collecting samples using:

- Real-time instruments;
- Sorbent tubes;
- Syringes;
- Evacuated, stainless-steel canisters; and
- Tedlar® bags.

## *5.0 Procedure*

This SOP applies to the collection of soil gas samples producing data to be used for risk assessment, fate and transport modeling, and monitoring of remedial activities. This SOP is applicable to the collection of soil gas samples throughout the vadose zone. Proper sampling procedures are necessary to insure the quality and integrity of the samples. The details within this SOP should be used in conjunction with the site specific SAP.

Soil gas sampling is performed using a variety of sampling techniques. Selecting the optimum soil gas sampling technique depends on the DQOs for the site or field effort, the site characteristics and accessibility, and the intended use of the analytical results. The rationale for sample collection, including sample locations, analytical methods and QC requirements, and number and type of samples collected, are described in the site-specific SAP. The analytical method selected determines the quantity of the sample, the container or media type, and the storage or holding time required. Sample collection is documented using field log books, field data forms (SOP1.2), and chain-of-custody forms (SOP1.1) as described in the quality assurance project plan section (QAPP) of this CDQMP and the procedures outlined in the applicable SOPs.

### 5.1 Sample Collection Procedures

The sample collection procedures and containers for the various sampling methods are described below. Measurements can be made using portable direct reading organic vapor analyzers (OVAs) or direct reading sorbent tubes for screening-level analyses. Soil gas syringe samples can be collected for field analyses. Stainless steel canister, Tedlar bag, or sorbent tube samples can be collected for laboratory analyses. The described procedures may vary slightly for some techniques depending on

site-specific requirements.

### 5.1.1 Direct Reading (Real-Time) Instruments

Direct reading instruments are used for field screening analyses. See the FID and PID instrument-specific instruction manuals for operating procedures.

- Attach gas intake directly to the sampling line during or after purging the soil gas probe, piezometer, well, etc. (purging is described under each individual sampling method).
- Determine total organic compound concentration in vapor from instrument meter.
- If the instrument does not draw sufficient flow for concentration measurement or individual sampling techniques require, collect a sample in a Tedlar bag and measure the soil gas concentration in the bag.

### 5.1.2 Syringe Sampling

Syringe samples are collected for field gas chromatograph (GC) analyses as follows:

- A fitting containing a Teflon® septum must be installed in the sampling line ahead of the purge pump.
- Purge the required volume (a minimum of three times the volume of the Teflon tubing). Flow rate is controlled with a flow meter to maintain a stable vacuum while purging the Teflon tubing.
- A hypodermic syringe equipped with a Mininert® valve and hypodermic needle is inserted through a Teflon septum and into the Teflon tubing connected to the probe.
- The syringe is purged a minimum of three times by extracting 40 to 50 cc (for 50 cc syringes) of soil gas into the syringe, closing the Mininert valve, removing the syringe from the septum, and expelling the gas into the air. The gas can also be injected into an organic vapor monitor (OVM) for real-time readings of soil gas concentrations. For smaller or larger size syringes, adjust the purge volume to approximately 90-100% of the rated syringe volume.
- Collect sample by drawing 10 to 50 cc of soil gas into the syringe, close Mininert valve, and remove from septum. Collect second syringe sample, if required.
- Cover syringe with foam insulation to protect from reactions with ultraviolet light. Label the sample with a sample control number, sample time, sampler's initials, and complete the field data sheet/chain-of-custody form following the procedures

described in SOP 1.1 and deliver the sample to the field lab for analysis.

### 5.1.3 Canister Sampling

Canister samples are collected for off-site laboratory analyses by GC or gas chromatography/mass spectroscopy (GC/MS) as follows:

- A tee fitting that attaches to the canister is installed in the sampling line ahead of the purge pump.
- Measure the initial canister vacuum (should be between -27 to -30 inches of mercury), attach the canister to the sample line, and the probe, etc., and depending on borehole depth, purge the required volume.
- Open the vacuum gauge valve on top of canister to observe initial pressure. Record the initial pressure.
- Slightly open the side valve to draw a sample into the canister. Soil gas should be drawn in slowly. Close the valve slightly if a hissing sound is heard.
- Monitor the canister vacuum gauge. When pressure is between -7 and- 5 inches of mercury (Hg), close both valves. Cap the sampling port on the canister and record the final pressure.
- Complete the field data sheet and chain-of-custody form following the procedures described in SOP 1.1. Ship the canister and chain-of-custody form to the laboratory for analysis.

### 5.1.4 Sorbent Tube Sampling

Sorbent tubes are used to collect samples for real-time field analysis (i.e., colorimetric tubes such as Draëger tubes) or for off-site laboratory analyses. Colorimetric tubes are read directly. Sorbent tubes are capped, stored on ice (dry ice may be required), and shipped to the laboratory. After purging the sampling line, collect sorbent tube samples as follows:

- Disconnect the purge pump or field instrument from the sampling line.
- Connect sorbent tube sampling train to sampling line. The sorbent tube sampling train will consist of a sorbent tube followed by a sampling pump and rotameter.
- Turn on sampling pump, observe rotameter for correct flow rate for type and size of sorbent tube used (adjust pumping rate as required).
- Let pump run for required sampling period needed to pass correct sample volume through tube.

### 5.1.5 Tedlar Bag Sampling

Tedlar bag samples are collected for field or off-site laboratory analyses or to provide a sample for field screening with a direct reading instrument (e.g., OVA) when the instrument pump cannot pull sufficient soil gas from the probe for analysis. This may occur when sample depths are more than approximately 10 feet or the sampling is performed in a low permeability zone.

Tedlar bag samples are collected using an evacuated chamber (i.e., lung) sampling apparatus. Use a new bag (2 to 5 liters in volume) to collect the sample. Prior to sampling, the following steps are taken:

1. Leak test the Tedlar bags as follows:
   - Pressurize the bags with Ultra High Purity (UHP) nitrogen to a pressure of 2 to 4 inches of water.
   - Connect a manometer using a "T" configuration to monitor the pressure in the bag
   - Close the valve between the cylinder and the bag and note the manometer reading.
   - Recheck the manometer indication after 10 minutes. A decrease in the bag pressure indicates that the bag is leaking.
   - Do not use bags that do not pass the leak test. Attach a label (or some form of identification) to bags that pass; discard those that fail.
   - If the bags are equipped with valves, make certain that the valve is open before assembling the lung sampler. Evacuate the bag with the vacuum pump prior to use.

2. Leak test the sampling train as follows:
   - Turn Valve A (refer to Figure 1) to the probe/bag mode.
   - Turn Valve B to the chamber/pump mode.
   - Connect the end of the sample probe to a manometer.
   - Turn on the sample pump until the manometer reads approximately 2 to 4 inches of water.
   - Turn the pump off.
   - Observe the manometer reading over a 10-minute period. If the pressure does not change, the sampling system is leak-free and may be used to collect the sample.
   - Any pressure changes indicate that the sampling system is leaking. The source of the leak must either be determined and corrected prior to use, or a different sampling system must be assembled and leak-tested.

3. The samples are collected as follows:

- Connect the probe to the sample port.
- Purge the sample line as follows:
- Turn Valve A to the probe/purge position.
- Turn Valve B to the pump/purge position.
- Turn the pump on and adjust the regulating valve to attain a sample flow of 2 liters per minute (l/min). Purge the sample line for at least one minute. If the target sampling rate cannot be attained, increase the purge interval to attain a total purge volume of 2 liters: Purge Interval (minutes) = 2 / Sampling rate (lpm). If no flow is attained, either the sampling line is plugged or the sampling probe (i.e., in the well) is positioned in an impermeable layer. During purging, position the pump away from sampling personnel (or ignition sources) to minimize exposure and potential fire hazards.

4. Initiate the sampling as follows:

- Turn Valve A to the probe/bag position.
- Turn Valve B to the chamber/pump position.
- Turn the pump on and adjust the regulating valve to attain a sample flow of 2 lpm.
- Collect sample for approximately one minute; this will yield a two liter volume of sample. If desired, adjust the sampling time such that the volume of the collected sample is between 50% and 75% of the bag's capacity.

During sampling, monitor the following:

- Sampling rate (adjust the regulating valve to maintain a relatively constant rate).
- The condition of the bag (i.e., through the view-port) and the sample probe. Look for droplets or particulate build-up in the sample probe. If a significant volume of liquid (i.e., 10 milliliters [ml]) is present in the sample line, a droplet knock-out trap should be inserted between the probe and bag.

After sampling is completed, turn off the pump and open the evacuated chamber to retrieve the bag.

- If the bag is equipped with a valve, turn the valve to the off-position. If the bag is not equipped with a valve, use Teflon tubing and/or a Swagelok cap (or plug) to seal the

bag.

- Assign a sample ID to the bag and record supporting information on the sample label (e.g., sample date, time, location).
- Store the sample in a cooler or box along with a COC (i.e., minimize the exposure of the sample to light) until it can be analyzed.
- Samples must be analyzed within 24 hours of collection.

## 5.2 Shallow Soil Gas Sampling Methods

The methods that may be used for shallow soil gas sampling include:

- Slide hammer hole method;
- Hand auger hole method;
- Hand-driven probe method;
- Pneumatic probe method; and
- Hydraulic probe method.

Slide hammer, hand auger, and the hand-driven methods are best used for small site investigations where only a few samples are needed, or in remote areas where access for the equipment required for other methods is difficult. The pneumatic and hydraulic methods are designed for extensive soil gas investigations where 15 or more samples are required per day.

### 5.2.1 Shallow Soil Gas Equipment Decontamination Procedures

- Sampling equipment (slide hammer, hand auger sampling probes) is decontaminated by brushing soil from the equipment, washing with detergent, steam cleaning, and rinsing with potable and ASTM Type II water.
- Stainless steel or Teflon sampling tubing is decontaminated between uses by purging with ambient air for five minutes or until field FID/PID readings are at ambient levels, whichever is longer. The vacuum of the field instrument or the vacuum pump is used to purge the tubing. Daily equipment blanks are collected in syringes to verify that decontamination is effective (when a field GC is being used for the field effort). Teflon tubing is replaced after five uses, or as needed if blanks indicate contamination.
- Septa used for syringe sample collection are replaced daily, or more often if required.
- Glass sampling syringes, retractable probe tips, and stainless steel sampling manifold fittings are baked in an oven at least 2 hours at 120° to 160°C. Syringe blanks are

analyzed to ensure that bakeout has removed all volatiles.

### 5.2.2 Slide Hammer or Hand Auger Hole Method

Shallow soil gas may be sampled using a slide hammer to drive a rod into soil, providing a hole that will accept a sampling tube. The slide hammer is a steel rod with a weighted sliding handle used to drive the rod into the ground. The rod is three to six feet in length with a 5/8-inch diameter head. The weighted handle of the rod is used to drive the rod into the ground with repeated downward blows. Shallow soil gases may also be measured and collected from hand auger holes in conjunction with soil sampling. The field procedure is as follows:

- Initiate field data sheet, chain-of-custody form, and sampling log, following the procedures in the applicable SOPs.
- The slide hammer or hand auger is used to drive the rod to the desired depth.
- A 1/4-inch Teflon or stainless steel tube is inserted down the hole. Tube depth is measured relative to the depth of the auger stem or slide hammer to prevent soil clogging the end of the tube.
- Soil gas samples are drawn through 1/4-inch Teflon or stainless steel tubing connected to the field OVA or a vacuum pump.
- If a discrete sample is needed for laboratory analysis, disconnect field instrument and connect the sampling device to the tubing.
- Cover the boring opening with wood or plastic that has a hole for the sample tubing to pass through; this prevents soil gases from mixing with ambient air or escaping from the boring.
- Withdraw a sample through the tubing at a rate specified for the sampling apparatus and/or analytical method.
- To collect syringe samples for field GC analysis:
  1. Install a septum in the sampling line upstream of the field instrument. The field instrument is left in place during sampling to assure the continued flow of soil gases at the septum.
  2. Purge the syringe with soil gas three times.
  3. Collect a sample.
- To collect canister samples for off-site analysis:
  1. Disconnect the field instrument from sampling line.
  2. Connect the canister to the sampling line; a Swagelok tee fitting can be used to preconnect the sample container.

3. Collect the sample.

- To collect a sorbent tube or Tedlar bag sample:

  1 Disconnect the field instrument from the sampling line.

  2. Connect sorbent tube or Tedlar bag sampling train to sampling line. The sorbent tube sampling train will consist of a sorbent tube followed by a sampling pump and rotameter. The Tedlar bag sampling train will consist of an oilless vacuum pump and Tedlar bag.

  3. For sorbent tube—turn on sampling pump, observe rotameter for correct flow rate for type and size of sorbent tube used (adjust pumping rate as required), and let pump run for period needed to pass correct sample volume through tube.

  4. For Tedlar bag sample—turn on sampling pump and let run until bag is filled. Do not fill bag to above atmospheric pressure.

- Complete chain-of-custody form, if applicable, and field data sheet.
- Decontaminate the sampling tube and other equipment.
- Backfill the hand auger hole with native soil or grout as specified in the site specific SAP.

5.2.3 Document the sampling event on the Sample Collection Log or an equivalent form as specified in the project work plans. Note any pertinent field observations, conditions or problems on the Field Activity Daily Log. Any encountered problems or unusual conditions should also be immediately brought to the attention of the Sampling Team Leader.

5.2.4. Appropriately preserve, handle, package, and ship the samples per SOP 2.0 and the project work plans. The samples shall also be maintained under custody per SOP 1.1.

## *6.0 Required Forms*

6.1 Sample Collection Log
6.2 Field Activity Daily Log
6.3 Chain of Custody form

# CALIBRATION AND MAINTENANCE OF MEASURING AND TEST EQUIPMENT

**STANDARD OPERATING PROCEDURE**

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes the methods and responsibilities associated with the calibration, control, and maintenance of measuring and test equipment (M&TE). It applies to all tools, gauges, instruments, and other test equipment where the manufacturer requires or recommends equipment accuracy to be checked periodically. In the case of commercial devices such as rulers, tape measures, and levels calibration controls will not be required.

## 2.0 References

2.1 None

## 3.0 Responsibilities

3.1 The *Quality Assurance Officer (QAO)* or his/her designee is responsible for monitoring the effective implementation of this SOP and/or the M&TE manufacturer's recommendations.

3.2 The *Program Geologist and Sampling Team Leader(s)* are responsible for the selection of M&TE to be used in the field activity and to assure it is of the proper type, range, accuracy and tolerance required to meet project objectives. Additionally, he/she is responsible for storage and protection of M&TE.

3.3 The *field personnel* performing tests are responsible for assuring that all M&TE is properly calibrated prior to and during use, and for documenting the calibration or deficiencies of equipment.

## 4.0 Definitions

4.1 M&TE

Measuring and test equipment used to obtain data during the performance of tests or inspections.

4.2 Calibration

The comparison of a measurement standard or instrument of a known accuracy with another standard or instrument to detect, correlate, report, or eliminate by adjustment, any variation in the accuracy of the items being compared within allowable deviations.

4.3 Reference Standard

An item of known and verifiable value which is used to check or establish the basis for tests or inspections.

## *5.0 Procedure*

5.1 Equipment Identification and Control

5.1.1 M&TE that requires calibration will be uniquely identified by the manufacturer's serial number, or other suitable assigned number. If this should prove to be impractical, an identification label will be affixed using materials and methods which provide a clear and legible identification and do not detrimentally affect the function or service life of the M&TE. This identification will be replaced as needed to provide clear identification of the M&TE.

5.1.2 All M&TE and reference standards shall be stored between uses in a manner that will minimize damage or deterioration.

5.2 Calibration

5.2.1 Written and approved procedures will be used for calibration of M&TE. Calibration procedures that have been previously established and approved by the M&TE manufacturer or a nationally recognized authority (i.e., ASTM, EPA) will be used when available. If no preexisting procedure is available, procedures will be developed by qualified personnel familiar with the M&TE and approved by the TM and QAO. Development of procedures will take into consideration the intended use and objective of the resulting data, equipment characteristics, required accuracy and precision of data, location of examination, effects of climate or any other parameter which would adversely influence the calibration. The procedures will include, as applicable:

- Name/type of equipment to be calibrated
- Reference standards to be used
- Calibration method and sequential actions
- Acceptance criteria
- Frequency of calibrations/checks
- Data recording form/format
- Data processing methodology
- Any special instructions
- Operator training and qualification requirements.

5.2.2 Field M&TE will be calibrated prior to use. Calibrations of M&TE will be performed by trained and qualified personnel, approved external agencies or by the equipment manufacturer.

5.2.3 The following types of calibrations and checks will be performed by qualified personnel:

- Periodic calibrations - which are performed at prescribed intervals established for the M&TE to assure that the equipment is operating within its designed range and accuracy. These are usually performed by outside agencies or the M&TE manufacturer. A calibration certificate will be provided documenting the operational and functional acceptance of the M&TE.

- Specific calibrations - which are performed for specific measurements or tests and varies from instrument to instrument and from procedure to procedure. Specific calibrations are performed prior to start of each work shift.

5.3 Calibration Frequency

5.3.1 M&TE will be calibrated at prescribed intervals and before each specific use. The frequency of periodic calibrations will be based on manufacturer's recommendations, national standards of practice, equipment type and characteristics, and past experience.

5.3.2 Scheduled calibrations of M&TE does not relieve the user of the responsibility for selecting the appropriate and properly functioning equipment.

5.3.3 In the event that the calibration has expired, the M&TE will be removed from service and tagged as “out-of-service” to prevent inadvertent use until it has been appropriately recalibrated.

5.4 Reference Standards and Equipment

5.4.1 Calibration reference standards and equipment will have known relationships to the National Institute of Standards and Technology (NIST) or other nationally recognized standards. If a national standard does not exist, the basis for calibration will be fully documented by the Project Manager and approved by the QAO.

5.4.2 Physical and chemical standards will have certifications traceable to NIST, EPA or other recognized agencies. Standards that are repackaged or split will also have traceable lot or batch numbers transferred onto the new container.

5.4.3 It is the responsibility of the user to select, verify and use the correct standard in accordance with an approved procedure or established practice.

5.5 Calibration Failure

5.5.1 Each individual user of M&TE is responsible for checking the calibration status of equipment to be used and confirming the acceptable calibration status prior to use. Equipment for which the periodic calibration period has expired, equipment that fails calibration, or equipment that becomes inoperable during use will be removed from service and tagged as out-of-service.

5.5.2 Out-of-service M&TE will be segregated from operational M&TE when practical. The specific reason for removal from service and the date of removal will also be stated on the out-of-service tag. The M&TE will then be repaired and/or recalibrated by the appropriate vendor or manufacturer as deemed necessary by the PM. M&TE that cannot be repaired will be replaced, as necessary, to provide support to the project. Any M&TE consistently found to be out-of-calibration will be replaced.

5.5.3 Results of activities performed using equipment that has failed recalibration will be evaluated by the Project Manager and QAO. If the activity results are adversely affected, the results of the evaluation will be documented as a nonconformance.

5.6 Calibration Documentation

5.6.1 Specific calibration records will be prepared and documented for each calibrated M&TE used. Periodic calibration certificates will be maintained and available for review at the field office. Calibration data will be recorded on the Test Equipment List and Calibration Log form or other suitable form. The Project Manager will be responsible for reviewing the calibration data for appropriateness, accuracy, readability, and completeness.

5.6.2 Calibration records will include, as applicable, the following information:

- Equipment identification number
- Calibration procedure used
- Date/time of calibration
- Time of calibration checks (if required)
- Identification of reference standard(s) used
- Applicable responses or readings of calibration
- Name of individual performing calibration
- Item(s) that are being tested or inspected.

5.7 Preventive Maintenance

5.7.1 Preventive maintenance of M&TE will be performed in accordance with manufacturers recommendation to maintain proper M&TE performance, minimize equipment failure and to increase measurement reliability.

## *6.0 Required Forms*

6.1 Test Equipment List and Calibration Log

# FIELD INSTRUMENT QA/QC

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

The purpose of this Standard Operating Procedure (SOP) is to define field requirements for quality assurance/quality control (QA/QC), for equipment and instrument calibration, inspection, and maintenance. Instruments and equipment used to gather, generate, or measure environmental data must be calibrated to ensure that accuracy and reproducibility of results are consistent with the manufacturer's specifications. Equipment, instruments, tools, gauges, and other items requiring preventive maintenance must be serviced according to the manufacturer's specifications. Raw data from the field measurements and sample collection activities must be recorded in the appropriate logbook or field form, and standard reporting units must be used for comparability and consistency.

## 2.0 References

2.1 EPA, September 1987, EPA Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidelines for Conducting Remedial Investigation and Feasibility Studies under CERCLA, Interim Final OSWER Directive 9355.3-01.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Quality Assurance Officer (QAO)* has the responsibility for periodic review of procedures and documentation associated with the calibration of field instrumentaion. If perceived variances occur, the QAO is also responsible for issuing notices of nonconformances and requesting corrective actions.

3.3 The *Health and Safety Officer (HSO)* is responsible for ensuring that calibration is completed daily in accordance with this procedure, that equipment and instrument inspection and maintenance is conducted, that measurements are taken to the specified accuracy. The HSO is also responsible for validation of field data by:

- Conducting routine checks during the processing of data (e.g. errors in identification codes);
- Checking the consistency with parallel data sets obtained presumably from the same population (e.g., from the same portion of the aquifer or volume of soil).

3.4 The *Sampling Team Leader(s)* are responsible for calibrating, inspecting, and maintaining instruments, taking measurements to the specified precision.

## *4.0 Definitions/Materials*

4.1 Instruments (to be calibrated, and manufacturer's operating manual)

- pH Meter
- Conductivity meter
- Turbidity meter
- Photoionization detector
- Thermometer
- ¾ Water level measurement device
- Magnetometer
- Gas chromatographer, equipped with FID and PID (for soil sampling)

4.2 Other:

- Maintenance schedule.
- Field logbook.
- Indelible black ink pens.

## *5.0 Procedure*

5.1 Equipment and Instrument Calibration

The frequency of calibration for field instruments will be performed at the intervals specified by the manufacturer or more frequently as conditions dictate, but daily as a minimum. Field instruments will include a pH meter, thermometer, conductivity meter, organic vapor photoionization detector (PID), magnetometer, and a radioactivity meter. Calibration will be documented on the Equipment Calibration Form.

To ensure comparability between sample data of similar samples and sample conditions, standard solutions and material traceable to the National Institute of Standards and Technology or EPA-published standards/protocols will be used to calibrate the field instruments.

5.1.1 pH Calibration

The pH meter will be calibrated with standard buffer solutions prior to any field sampling event. In the field, the meter will be calibrated daily with two buffers before use. The general procedures for pH calibration are as follows:

- Temperature of sample and buffer should be the same;
- Connect the pH electrode into the pH meter and turn on the pH meter;
- Set temperature setting based on the temperature of buffer; place electrode in first buffer solution;
- After reading has stabilized, adjust the "CALIB" knob to display correct value;
- Repeat procedure for second buffer solution; and
- Remove pH electrode from sample and rinse off with potable water.

The pH meter will be recalibrated if results are suspect and a check with the buffer solution shows that the meter calibration is off.

### 5.1.2 Temperature

Hand-held, wide-range thermometers or digital thermometers specifically made for field use will be used to measure the temperature during the field sampling event. These instruments are calibrated by the manufacturer at the factory.

### 5.1.3 Conductivity Meter

The conductivity cells of the conductivity meter will be cleaned and checked against known conductivity standards before each field trip. In the field, the instrument will be checked daily with standards traceable to the National Institute of Standards and Technology or EPA when applicable. All calibrations will be recorded on the Equipment Calibration Log, and noted in the field log book. The general procedures for conductivity calibration are as follows:

- Place the probe in the conductivity standard solution;
- Set the temperature knob for temperature of standard solution;
- Turn to the appropriate scale and set the instrument for the value of calibration standard;
- Rinse off the electrode with potable water;
- Measure the conductivity for potable water to be used for a field blank, making sure that the temperature is set correctly for the temperature of the solution to be tested; and
- If the conductivity of the blank (potable water) is high, it must be discarded and a new blank sample procured.

### 5.1.4 Turbidity Meter

The turbidity meter will be checked and calibrated daily to a known standard of 5 nephelometric units (NTUs). The instrument will be checked in the field, before each test, for calibration using the standard. All instrument calibration checks and adjustments will be recorded on the Equipment Calibration Log and noted in the field log book. The general procedures for calibration of the turbidity meter are as follows:

- Turn the instrument power on.
- Check the instrument battery charge; if the meter reading is below the battery check line, recharge the battery.
- Remove the black sample chamber cover and remove any sample tube or standard from the chamber. Replace the black sample chamber cover without any sample tube or standard in the chamber.
- Put the "RANGE" selector switch to the "1" position.
- Press the "PUSH TO READ" switch and adjust the zero knob for a zero ("0") reading on the meter.
- Insert the turbidity standard into the sample chamber. Do not handle the surface (sides) of the standard. Oils from the fingers and hands will interfere with the calibration. If the standard vials need to be cleaned on the outside, use a good detergent and water.
- Replace the sample chamber cover. Press the "PUSH TO READ" switch and adjust the "STANDARDIZE" knob for a reading to correspond with the known standard.
- Replace the standard with a sample vial filled with a water sample (fill to over 80 percent capacity).
- Press the "PUSH TO READ" switch and read the water sample turbidity on the meter. If the meter reads over range, put the "RANGE" into the next higher range position.
- Record turbidity reading in the field logbook and on the appropriate field form.

### 5.1.5 PID

The PID will be calibrated daily with a gas of known concentration according to manufacturer instructions. The PID probe will be exposed to a volatile organic compound source prior to field use to determine if the instrument is working. All calibrations will be recorded on the Equipment Calibration Log.

5.1.6 Magnetometer

Calibration of the magnetometer will be according to manufacturer instructions. Record calibrations on the Equipment Calibration Log.

5.2 Equipment and Instrument Inspection and Maintenance

5.2.1 Equipment and Instrument Inspection

Equipment to be used during field sampling will be examined to ensure that it is in proper operating condition. This includes checking the manufacturer's operating manual and the instructions for each instrument to ensure that all maintenance requirements are being observed. Field notes for previous sampling trips will be reviewed so that the notations on any prior equipment problem are not overlooked and all necessary repairs to equipment have been carried out.

5.2.2 Equipment and Instrument Maintenance

Equipment, instruments, tools, gauges, and other items requiring preventive maintenance will be serviced in accordance with the manufacturer's recommendations.

Manufacturer's procedures identify the schedule for servicing critical items in order to minimize the downtime of the measurement system. It will be the responsibility of the operator to adhere to the maintenance schedule and to arrange any necessary and prompt service as required. Service to the equipment, instruments, tools, gauges, etc., will be performed by qualified personnel. In the absence of any manufacturer's recommended maintenance criteria, a maintenance procedure will be developed by the operator based upon experience and previous use of the equipment.

Logs will be established to record maintenance and service procedures and schedules. All maintenance records will be documented and traceable to the specific equipment, instruments, tools, and gauges.

5.3 Field Measurement Precision

For the pH meter and the conductivity meter, precision will be tested by multiple readings in the medium of concern. Consecutive readings should agree within ±0.1 standard units pH and ±0.01 ohms/cm conductivity. The thermometer will be visually inspected prior to each use. The photoionization detector probe will be exposed to a volatile organic compound source prior to field use in order to determine if the instrument is working. Water level indicator readings will be precise

within ±0.01 feet for duplicate measurements.

The following standard reporting units will be used during all phases of the project:

- Water levels measured in wells will be reported to the nearest 0.01 foot.
- Soil sampling depths will be reported to the nearest 0.1 foot.
- Soil gas results will be reported to two significant figures.

## *6.0 Required Forms*

6.1 Equipment Calibration Log

# *EQUIPMENT CALIBRATION LOG*

| Equipment Type | Serial No. | Date | Calibration Time | Calibration Gas | Calibration Gas Lot No. | Calibrated By: |
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# WATER LEVEL MEASUREMENTS IN MONITORING WELLS

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines for personnel to use in determining the depth to water in monitoring wells.

## 2.0 References

2.1 EPA, 1986, RCRA Groundwater Monitoring Technical Enforcement Guidance Document, OSWER-9950.1, U.S. Government Printing Office, Washington, D.C.

2.2 EPA, 1991, Environmental Compliance Branch, Standard Operating Procedures and Quality Assurance Manual, Region IV, Environmental Services Division, Athens, Georgia, U.S. Government Printing Office, Washington, D.C.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 *The Quality Assurance Officer (QAO)* is responsible for the periodic review of documentation generated as a result of this SOP and the periodic review and audit of field personnel as they perform the work. If problems arise, the QAO is also responsible for verifying implementation of corrective action(s) (i.e., retraining personnel, additional review of work plans and SOPs, variances to requirements, and issuing nonconformances) and assuring through monitoring the continued implementation of stated corrective actions.

3.3 The *Sampling Team Leader(s)* is responsible for ensuring that monitoring well water level measurements are properly collected and documented.

## 4.0 Definitions/Materials

A number of devices are available for the determination of water level measurements in monitoring wells. Those most commonly used and covered in this SOP include: steel tapes, electric sounders,

and petroleum product probes. The equipment must be capable of recording a measurement to the accuracy required by the project plans.

## *5.0 Procedure*

Water level measurements are commonly taken in each monitoring well immediately prior to, during, and following well development, and both before and after well purging and sampling. Water level measurements may also be taken where no development or purging is being conducted, strictly to monitor or generate water table or piezometric surfaces. When such measurements are made to monitor water table or piezometric surfaces, water levels in all wells at a given site should be measured within a 24-hour maximum period whenever possible. When measuring wells for water for water table or potentiometric surface analysis, and if the contaminant history is known for each of the wells, it is advisable to monitor water levels beginning with the least contaminated wells first and progressing to the most contaminated wells last.

### 5.1 Equipment Selection

Project data quality objectives and site characteristics must be taken into account when determining the water level measurement equipment to use. The total number of wells to be measured, weather, tidal influences, pumping, and construction can all affect water level measurements. The project-specific work plans will identify the specific equipment to be used.

### 5.2 Determining Water Level Measurements in Monitoring Wells

The standard procedure for determining depth to water is described below.

5.2.1 Calibrate all measuring devices according to the manufacturer's specifications. Measuring tapes should be checked a minimum of every six months against a surveyor's tape to determine if shrinking or stretching has occurred.

5.2.2 Prior to taking a water level measurement at each well, decontaminate the measuring device according to the procedures outlined in SOP 6.0. During decontamination, all measuring tapes should be inspected for kinks, cracks, or tears and, if present, repaired or replaced with undamaged equipment.

5.2.3 Visually inspect the well to ensure that it is undamaged, properly labelled and secured. Any damage or problems with the well head should be noted on the Field Activity Daily Log (FADL) and the site superintendent notified for repair or replacement of the equipment.

5.2.4 Uncap the well and monitor the air space immediately above the open casing per the project-specific health and safety plan. Observe if any air is flowing into or out of the casing. In the event such conditions are observed, they should be noted on the Water Level Measurement Form, Well Development Record, or Sampling Information Form as appropriate. Lower the electric sounder or equivalent (product probe or steel tape) into the well until the water surface is encountered. If air is observed to be entering flowing out of the casing, the sounder should not be placed inside the well until the air flow stops and pressure equalizes.

5.2.5 Measure the distance from the water surface to the permanent reference point. For aboveground "stickup" completions, the reference point is usually a groove cut into the north side of the casing. If no permanent reference point is available for an aboveground completion, measure from another permanently fixed structure or from ground level. The point of measurement should then be noted on the FADL and the appropriate form on which the water level is recorded. For flush mount completions, such as street boxes, the water level measurement should be referenced to a steel rate placed across the rim of the street box and over the casing. Any aboveground completions without permanent reference points or marks should be brought to the attention of the appropriate supervisory personnel per the project-specific work plans.

5.2.6 Collect measurements until two consecutive measurements are identical or within the specified tolerance of the project-specific work plans (usually 0.01 ft). Record all appropriate information on either the Water Level Measurement Form, Well Development Record, or the Sampling Information Form, depending upon the task being performed. At a minimum, the following information must be recorded:

- project name and number;
- unique well identification number;
- date and time of measurement collection;
- depth to water to the specified tolerance;
- weather conditions; and
- any problems encountered.

5.2.7 If product or other nonaqueous liquid is encountered, follow the procedures outlined in SOP 5.1.

5.2.8 Cap and relock the well.

## *6.0 Required Forms*

6.1 Field Activity Daily Log

6.2 Water Level Measurement Form

6.3 Well Development Record

6.4 Sampling Information Form

# NONAQUEOUS PHASE LIQUID MEASUREMENT IN MONITORING WELLS

**STANDARD OPERATING PROCEDURE**

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines for field personnel to use in determining the thickness of nonaqueous phase liquid in monitoring wells. The details within this SOP should also be used in conjunction with project work plans.

## 2.0 References

2.1 EPA, 1986, RCRA Groundwater Monitoring Technical Enforcement Guidance Document, OSWER-9950.1, U.S. Government Printing Office, Washington, D.C.

2.2 EPA, 1991, Environmental Compliance Branch, Standard Operating Procedures and Quality Assurance Manual, Region IV, Environmental Services Division, Athens, Georgia, U.S. Government Printing Office, Washington, D.C.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all nonaqueous phase liquid in monitoring wells is properly measured and documented in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Quality Assurance Officer (QAO)* is responsible for the periodic review of documentation associated with this SOP and the periodic review and audit of field personnel as they perform the work. If perceived variances occur, the QAO is also responsible for issuing notices of nonconformance and requests for corrective action.

3.3 The *Sampling Team Leader(s)* are responsible for the proper measurement and documentation of the nonaqueous phase liquid measurement in monitoring wells.

## 4.0 Definitions/Materials

4.1 Product - for the purposes of this procedure, product refers to liquid that is petroleum based (e.g., gasoline, diesel, or petroleum byproducts) or chlorinated hydrocarbon based (e.g., trichloroethene, tetrachloroethene, etc.).

4.2 Two types of equipment used to measure nonaqueous phase liquids (NAPLs) in monitoring wells: product probes and clear bailers. The type of equipment used will be determined on a project specific basis and identified in the Field Sampling Plan.

## 5.0 Procedure

5.1 Equipment Selection

5.1.1 This procedure addresses the operation of two types of equipment used to measure nonaqueous phase liquids (NAPLs) in monitoring wells: product probes and clear bailers. Clear bailers include both single- and double-check valve bailers. Single check valve bailers can only be used for measuring light nonaqueous phase liquids (LNAPLs) or floating products. Double check valve bailers can be used for measuring both LNAPls and dense nonaqueous phase liquids (DNAPLs) or sinking product. The equipment must be capable of recording a measurement to an accuracy of 0.01 foot.

5.1.2 Several problems can arise in measuring product thickness with either product probes or clear bailers. Product probes can malfunction, particularly when measuring degraded or weathered product that sticks to the probe sensors. When the thickness of the product layer in a well is greater than the length of the bailer, the product layer cannot be accurately measured with the bailer. Consequently, it is recommended that both methods be used (one to check the other) to measure product thicknesses in wells. The project work plans will identify the specific equipment to be used.

5.2 Product Probe Procedure

5.2.1 The product probe, sometimes called an immiscible layer probe, is a device that can detect the presence of both LNAPLs and DNAPLs (both “floating” and “sinking” layers) in water wells. The device detects the difference in conductivity or specific gravity between the aqueous and nonaqueous phases in the well. The device is generally a probe connected to a measuring tape with a reel. The device contains a receiver with an audio and/or visual signal that indicates when phase

changes occur. The standard procedure for using a petroleum product probe is described below.

5.2.2 Check the accuracy of the measuring tape of the petroleum product probe according to the manufacturer's specifications. Measuring tapes should be checked at least every six months against a surveyor's tape to determine if shrinking or stretching has occurred.

5.2.3 Prior to taking a measurement and between wells, decontaminate the probe and tape measure according to the procedures outlined in SOP 6.0. It is extremely important to conduct thorough decontamination to prevent cross-contamination between wells. During decontamination, all measuring tapes should be inspected for kinks, cracks, or tears and, if present, repaired or replaced with undamaged equipment.

5.2.4 Visually inspect the well to ensure that it is undamaged, properly labelled and secured. Any damage or problems with the well head should be noted on the Field Activity Daily Log (FADL) and notify the site superintendent per the project work plans.

5.2.5 Uncap the well and monitor the air space immediately above the open casing per the Project Health and Safety Plan. Observe if any air is flowing into or out of the casing. In the event such conditions are observed, they should be noted on the Water Level Measurement Form, Well Development Form, or Sampling Information Form as appropriate. If air is observed to be flowing into or out of the casing, the probe should not be placed inside the well until the air flow stops and pressure equalizes. Lower the probe into the well until the liquid surface is encountered. Continue lowering the probe, recording the depths at which any audio or visual changes in the device indicate a phase change. When measuring for DNAPL, continue lowering the probe to the bottom of the well. When measuring for LNAPL, there is no need to lower the probe further once the product/water interface is encountered and measured.

5.2.6 While lowering the probe, measure the distances to the encountered phase/phases from the permanent reference point. For aboveground “stick-up” completions, the reference point is usually a groove cut into the north side of the casing. If no permanent reference point is available for an aboveground completion, measure from another permanently fixed structure or from ground level. The point of measurement should then be noted on the FADL and the appropriate form on which the water level is recorded.

For flush mount completions, such as street boxes, the water level measurement should be referenced to a steel rule placed across the rim of the street box and over the casing. Any aboveground completions without permanent reference points or marks should be brought to the attention of the site supervisor per the project work plans.

5.2.7 Collect measurements until two consecutive measurements are identical or within tolerances specified in the project work plans. Record all appropriate information on either the Water Level Measurement Form, Well Development Record, or the Sampling Information Form, depending upon the task being performed. At a minimum, the following information must be recorded:

- project name and number;
- well identification number;
- date and time of measurement collection;
- depth to water to the specified tolerance;
- depth to and description of any nonaqueous phase liquid encountered;
- weather conditions; and
- comments, including any problems encountered.

5.2.8 Cap and relock the well.

5.3 Bailer Procedure

5.3.1 A single check-valve bailer is a cylindrical tube, open at the top and containing a floating ball at the bottom. Lowering the bailer into liquid allows the bottom ball to float, allowing floating product or water to enter the bailer. The design of this type of bailer only allows collection of a floating product (LNAPL) sample.

5.3.2 A double check-valve bailer is an enclosed cylindrical tube containing a floating ball at both the top and the bottom. Lowering the bailer into liquid causes both balls to float allowing water or product to enter the cylinder. Raising the bailer through the water causes both balls to settle, effectively trapping a discrete section of the water so that it can be brought to the surface. Since the double check-valve bailer is capable of collecting a discrete sample at any depth within the well, it can be used on both “floating” and “sinking” nonaqueous liquids.

5.3.3 The bailers must be constructed of clear material so that any product can be visibly measured. Some are also available with graduated markings on the side to allow easier measurement.

The standard procedure for using bailers to measure nonaqueous phase liquids in monitoring wells is described below.

Bailers are commonly used with a thin nylon line or “chord” made of similar material. Some are supplied with a connectable measuring tape.

5.3.4 Check the accuracy of the measuring tape to be used with the bailer according to the manufacturer’s specifications. Measuring tapes should be checked a minimum of every six months against a surveyor's tape to determine if shrinking or stretching has occurred.

5.3.5 Prior to taking a measurement and between wells, decontaminate the bailer and tape measure according to the procedures outlined in SOP 6.0, Sampling Equipment and Well Material Decontamination. If a bailer line is used, it is advised to slip, cut, and dispose of any. The run inside a previous well and then decontaminate the remaining line. Bailers used for product sampling should never be used for purging or collecting water samples.

5.3.6 If product probe measurements are to be used in conjunction with a bailer, the probe measurements should first be made, recorded, and noted by field personnel taking the measurements.

5.3.7 If bailer measurements are to be taken before or without product probe measurements, visually inspect and document well head conditions per 5.2.4 above. Uncap the well and monitor and observe the well head per 5.2.5 above.

5.3.8 Lower the bailer into the well until the liquid surface is encountered. Use the measuring tape if available to determine the depth to which the bailer should be lowered to recover either the LNAPL or DNAPL product.

If using bailer chord and attempting to recover DNAPL (“sticking”) product, a double check-valve bailer may simply be run to the bottom of the well. If attempting to recover LNAPL (“floating”) product using bailer chord, it is advisable to first note the depths to product and water made with the product probe and mark the depths on the bailer chord with a rubber band or twine. The bailer (either single or double check-valve) should then be lowered such that the bailer retrieves product and does not run completely through the product layer, thereby retrieving only water.

If no product probe measurements are available, the person attempting to retrieve the bailer product sample will then have to "feel" for first contact with the liquid while the bailer is descending inside the well. Once the contact is felt, the bailer descent should be halted. The bailer should then be slowly lowered no more than ¾ of its total length to avoid overtopping. Retrieve the bailer and visually inspect for product. Measure the amount of product contained in the bailer with the measuring tape. Note any appropriate conditions observed in the bailer such as:

- Color and clarity of the product
- Length of product column in bailer compared to overall length of bailer
- Evidence of any problems with the bailer valves
- Evidence of overtopping or complete run through the product column.

5.3.9 Record all appropriate information on either the Water Level Measurement Form, Well Development Record, or the Sampling Information Form, depending upon the task being performed. At a minimum, the following information must be recorded:

- project name and number;
- well identification number;
- date and time of measurement collection;
- depth to water if available to the appropriate tolerance specified in the project work plans;
- measurement and description of any nonaqueous phase liquid encountered;
- any observations made in 5.2.5 above; and
- comments, including any problems encountered.

5.3.10 Cap and relock the well.

## *6.0 Required Forms*

6.1 Field Activity Daily Log

6.2 Water Level Measurement Form

6.3 Well Development Record

6.4 Sampling Information Form

# FIELD EQUIPMENT DECONTAMINATION

## STANDARD OPERATING PROCEDURE

## *1.0 Purpose*

This Standard Operating Procedure (SOP) describes the procedures required for decontamination of field equipment. Decontamination of field equipment is necessary to ensure the quality of samples by preventing cross-contamination. Further, decontamination reduces health hazards and prevents the spread of contaminants off site.

## *2.0 References*

2.1 EPA, September 1987, EPA Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidelines for Conducting Remedial Investigation and Feasibility Studies under CERCLA, Interim Final OSWER Directive 9355.3-01.

## *3.0 Responsibilities*

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Program Chemist* are responsible for ensuring that field personnel are trained in the use of this procedure and that decontamination is conducted in accordance with this procedure.

3.3 The *Quality Assurance Officer (QAO)* has the responsibility for periodic review of procedures and documentation associated with the decontamination of drilling and heavy equipment. If perceived variances occur, the QAO is also responsible for issuing notices of nonconformances and requesting corrective actions. Additionally, he/she will perform the three phases of inspections and continuous monitoring of the decontamination activities.

3.5 The *Sampling Team Leader(s)* are responsible for verifying that this procedure is correctly implemented. The Sampling Team Leader may also be required to collect and document rinsate samples to provide quantitative verification that these procedures have been correctly implemented.

This SOP and the project work plans should be reviewed before implementing decontamination procedures at the project field area.

## *4.0 Definitions/Materials*

4.1 Deionized Analyte-Free Water

Ion-free, analyte-free water produced on site or purchased from a supplier with a deionization chamber equipped with a carbon filter.

4.2 Potable Water

Treated municipal water.

4.3 Laboratory Grade Detergent

A standard brand of laboratory-grade detergent, such as “Alconox” or “Liquinox”"

4.4 Methanol

Laboratory-grade methanol alcohol, CAS #67-56-1.

4.5 Hexane

Laboratory-grade hexane, CAS #110-54-3.

4.6 HPLC Water

High purity laboratory-grade water.

4.7 Nonsampling Equipment

Nonsampling equipment includes:

- Field logbook.
- Drilling rigs, backhoes, augers, drill pipe, bits, casing, and screen.
- High-pressure pump soap dispenser or steam-spray unit.
- 2- to 5-gal manual-pump sprayer (pump sprayer material must be compatible with the solution used).
- Stiff-bristle brushes.
- Gloves, goggles, boots, and other protective clothing as specified in the site-specific health and safety plan.

### 4.8 Small Equipment

Small equipment includes:

- Split spoons, bailers, bowls, and filtration equipment.
- 5-gal plastic buckets
- Laboratory-grade detergent (phosphate free).
- Stiff-bristle brushes.
- Nalgene**,** or Teflon**,** sprayers or wash bottles or 2- to 5-gal manual-pump sprayer (pump sprayer material must be compatible with the solution used).
- Plastic sheeting.
- Disposable wipes or rags.
- Potable water.
- Appropriate decontamination solutions.
- Gloves, goggles, and other protective clothing as specified in the site-specific health and safety plant.

### 4.9 Pumps and Pump Assemblies

The required pumps and pump assemblies include:

- Three or more empty 30-40 gallon containers
- Plastic sheeting.
- 5-gal (or larger) containers of potable water and other required decontamination solutions.
- Disposable wipes or rags.
- Gloves, goggles, and other protective clothing as specified in the site-specific health and safety plan.

## 5.0 Procedures

This section contains responsibilities, requirements, and procedures for sampling equipment and well material decontamination. The decontamination is required to maintain proper quality and integrity of collected samples.

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

- Types of equipment requiring decontamination under this SOP;
- pecific materials to be used for the decontamination; and
- Additional decontamination requirements and procedures beyond those covered in

this SOP, as necessary.

All field personnel associated with decontamination of sampling equipment or well materials must read both this SOP and the project work plans prior to implementation of related decontamination activities. Information and requirements for the decontamination of any and all drilling and heavy equipment is provided in SOP No. 6.1.

## 5.1 Decontamination Facility

If possible, sampling equipment decontamination will take place in an area designed exclusively for decontamination. This area will ideally be located within the contamination reduction zone on the project site. Well materials may be decontaminated at the facility set up for decontamination of drilling and heavy equipment (see SOP No. 6.1).

Each decontamination facility will be constructed so that the equipment, as well as all wastes generated during decontamination (e.g.: soil, rinsate, liquid spray, debris, etc.), are fully contained. In addition, chemical products used in the decontamination process must be properly containerized and labelled.

## 5.2 Decontamination of Nondedicated Sampling Equipment

Each piece of reusable, small or nondedicated sampling equipment will be decontaminated before mobilization to each site and before each sampling event. The standard procedure will be performed as described below.

5.2.1 Suitable personal protective equipment (specified by the project work plans) must be worn by all personnel involved with the task to reduce personal exposure.

5.2.2 Heavily caked soil and/or other material will be scraped or brushed from equipment. The scrapings will be placed into an appropriate container for disposal. Steam cleaning of equipment may be required to remove material from samplers.

5.2.3 Equipment that will not be damaged by water should be placed into a wash tub containing a laboratory-grade detergent solution and scrubbed with a brush or clean cloth. Rinsing will then be conducted with fresh, potable water, followed by deionized water.

5.2.4 Methanol, hexane, and HPLC water rinses may then follow for some sampler components when specified by the project work plans.

5.2.5 Any equipment that may be damaged by submersion into water will be wiped clean using a sponge and detergent solution. Cleaning will be followed by wiping the equipment with deionized water.

5.2.6 Air dry the rinsed equipment. Soil organic vapor (SOV) sampling equipment should be flushed dry with bottled air of known quality and/or as per the project work plans.

5.2.7 Place decontaminated equipment on clean plastic sheeting to prevent contact with contaminated soil. If equipment is not used immediately, cover or wrap the equipment in clean plastic sheeting to minimize airborne contamination.

5.2.8 Decontamination activities shall be documented on the Field Activity Daily Log (FADL) or other appropriate form(s), as specified by the project work plans.

5.3 Decontamination of Dedicated Sampling Equipment

Dedicated sampling equipment, such as submersible pumps, will be decontaminated prior to installation inside monitoring wells. At a minimum, the procedure outlined below must be performed. If factory-cleaned, hermetically sealed materials are used, no decontamination will be necessary, provided that laboratory certification of decontamination is submitted with the equipment.

5.3.1 Suitable personal protective equipment will be worn by all personnel involved in the task, in accordance with the project work plans.

5.3.2 Foot vale and pumping lines will be washed with a laboratory-grade detergent solution.

5.3.3 The equipment will then be rinsed twice with tap water, followed by a rinse with deionized water.

5.3.4 Air dry.

5.3.5 Place decontaminated equipment on clean plastic sheeting to prevent contact with contaminated soil. If equipment is not used immediately, cover or wrap the equipment in clean plastic sheeting to minimize airborne contamination.

5.3.6 Decontamination activities will be documented on the FADL or the appropriate form(s), as specified by the project work plans.

5.4 Decontamination of Well Materials

Well materials including well casing, well screens, centralizers, and end caps will be decontaminated prior to use in constructing monitoring wells. (If factory-cleaned, hermetically sealed material are used, no decontamination will be necessary provided that laboratory decontamination certification is submitted with the equipment.) The standard procedure outlined below must be performed when decontaminating well materials.

5.4.1 Appropriate personal protective equipment will be worn by all personnel involved in the task, in accordance with the project work plans.

5.4.2 Materials will be thoroughly sprayed and washed with water using a high pressure steam cleaner.

5.4.3 Air dry.

5.4.4 Decontaminated materials will be placed on clean metal racks or clean plastic sheeting. If equipment is not used immediately, cover or wrap the equipment in clean plastic sheeting to minimize airborne contamination.

5.4.5 Decontamination activities will be documented on the FADL or other appropriate form(s), as specified by the project work plans.

5.5 Pump Decontamination

The following steps must be followed when decontaminating pumps:

5.5.1 Set up decontamination area and separate clean storage area using plastic sheeting to cover the ground, tables, and other porous surfaces. Set up three 30-40 gallon containers in a triangle. The two containers at the base of the triangle will be used to contain dilute (nonfoaming) soapy water and potable water. The drum at the apex will receive wastewater. Place 5-gal cans of potable water adjacent to the water container on the same side as the potable water container.

5.5.2 Pump should be set up in the same configuration as for sampling. Submerge pump intake (or pump if submersible) and all downhole wetted parts (tubing, piping, foot valve) in soapy water of the first container. Place the discharge outlet in the waste container above the level of wastewater. Pump soapy water through the pump assembly until it discharges to the waste container.

5.5.3 Move pump assembly to the potable water container while leaving discharge outlet in the waste container. All downhole wetted parts must be immersed in the potable water rinse. Pump potable water through the pump assembly until it runs clear.

5.5.4 Decontaminate the discharge outlet by hand following the steps outlined in Sect. 5.2., part 2 of this SOP.

5.5.5 Remove the decontaminated pump assembly to the clean area and allow to air dry. Intake and outlet orifices should be covered with aluminum foil to prevent the entry of airborne contaminants and particles.

5.5.6 Record the equipment type and identification, and the date, time, and method of decontamination in the appropriate logbook.

5.6 Waste Disposal

The following steps must be followed when disposing of wastes:

5.6.1 All wash water and rinse water that have come in contact with contaminated equipment are to be handled, packaged, labeled, marked, stored, and disposed of as investigation-derived waste unless other arrangements are approved in advance.

5.6.2 Small quantities of decontamination solutions may be allowed to evaporate to dryness.

5.6.3 If large quantities of used decontamination solutions are generated, segregate each type of waste in separate containers. This may permit the disposal of wash water and rinse water in a sanitary sewage treatment plant rather than as a hazardous waste.

5.6.4 Unless required, plastic sheeting and disposable protective clothing may be treated as a solid nonhazardous waste.

## *6.0 Required Forms*

6.1 Field Activity Daily Log.

# DRILLING, DEVELOPMENT, AND HEAVY EQUIPMENT DECONTAMINATION

**STANDARD OPERATING PROCEDURE**

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines for use by field personnel in the decontamination of drilling, development, and heavy equipment. The details within this SOP are applicable as general requirements for drilling and heavy equipment decontamination, and should also be used in conjunction with project work plans.

## 2.0 References

2.1 EPA, September 1987, EPA Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidelines for Conducting Remedial Investigation and Feasibility Studies under CERCLA, Interim Final OSWER Directive 9355.3-01.

## 3.0 Responsibilities

3.1 The *Program Geologist* has the responsibility for ensuring that the decontamination of drilling and heavy equipment is properly performed through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Quality Assurance Officer (QAO)* has the responsibility for periodic review of procedures and documentation associated with the decontamination of drilling and heavy equipment. If perceived variances occur, the QAO is also responsible for issuing notices of nonconformances and requesting corrective actions. Additionally, he/she will perform the three phases of inspections and continuous monitoring of the decontamination activities.

3.3 The *Sampling Team Leader(s)* assigned to drilling, development, trenching, or construction activities are responsible for ensuring that subcontractors or equipment operators properly decontaminate the drilling, development, and heavy equipment associated with those tasks. The project staff are also responsible for documenting the decontamination activities on the Field Activity Daily Log (FADL) and/or appropriate form(s) as specified in the project work plans.

This SOP and the project work plans should be reviewed before implementing decontamination procedures at the project field area.

## *4.0 Definitions/Materials*

4.1 Laboratory Grade Detergent - A standard brand of laboratory-grade detergent, such as "Alconox" or "Liquinox".

4.2 Potable Water - Water dispensed from a municipal water system.

## *5.0 Procedure*

5.1 General

5.1.1 This section provides requirements for the set up of a decontamination facility for drilling, development, and heavy equipment and the decontamination procedures to be followed. The project work plans will provide specific information regarding:

- Types of equipment requiring decontamination under this SOP;
- Location of the decontamination station;
- Types and/or specifications on materials to be used in the fabrication of the decontamination station; and
- Types of materials and additional details on the procedures to be used in the decontamination process.

5.1.2 All field personnel associated with either the fabrication of the decontamination station or the decontamination of drilling or heavy equipment must read both this SOP and the project work plans prior to implementation of related decontamination activities. Information and requirements for the decontamination of any and all equipment used specifically for sampling is presented in SOP 6.0.

5.2 Decontamination Facility

5.2.1 A decontamination station will be set up in an area exclusively for decontamination of drilling, well development, and/or heavy equipment. The location of the decontamination station will be specified in the project work plans. All decontamination of drilling, development, and heavy equipment will be conducted within the station.

5.2.2 At a minimum, the station will be constructed such that all rinsates, liquid spray, soil, debris,

and other decontamination wastes are fully contained and may be collected for appropriate waste management and disposal. The station may be as simple as a bermed, impermeable polyethylene sheeting, of sufficient thickness, with an impermeable sump for collecting rinse water. More sophisticated designs involving self-contained metal decontamination pads in combination with bermed polyethylene sheeting may also be used, depending on project-specific requirements. These requirements along with specific equipment and construction specifications for the decontamination station will be provided in the project work plans.

5.3 Decontamination of Downhole Equipment

5.3.1 All downhole drilling and development equipment (including but not limited to drill pipe, drive casing, drill rods, bits, tools, bailers, etc.) will be thoroughly decontaminated before mobilization onto each site and between borings or wells at each site or as required in the project work plans. The standard procedure will be performed as described below. Decontamination will be performed in accordance with this SOP and the project work plans.

5.3.2 Appropriate personal protective equipment (as specified in the project work plans) must be worn by all personnel involved with the task to limit personal exposure.

5.3.3 Equipment caked with drill cuttings, soil, or other material will initially be scraped or brushed. The scrapings will be containerized and appropriately disposed.

5.3.4 Equipment will then be sprayed with potable water using a hot water, high pressure washer.

5.3.5 Washed equipment will then be rinsed with potable water.

5.3.6 Decontaminated downhole equipment (such as drill pipe, drive casing, bits, tools, bailers, etc.) will be placed on clean plastic sheeting to prevent contact with contaminated soil and allowed to air dry. If equipment is not used immediately, it will be covered or wrapped in plastic sheeting to minimize airborne contamination.

5.3.7 Decontamination activities will be documented by the Sampling Team Leader, lead geologist, or lead engineer on the FADL and/or appropriate form(s), as specified in the project work plans.

5.4 Decontamination of Heavy Equipment

5.4.1 Heavy equipment (e.g., drill rigs, development rigs, backhoes, and other earthmoving equipment) will be decontaminated between drilling sites or inside the contaminant reduction area prior to entering and leaving an exclusion zone. Decontamination will be performed in accordance with the project work plans. The standard procedure will be performed as described below.

5.4.1.1 Appropriate personal protective equipment (as specified in the project work plans) will be worn by all personnel involved in the task, in order to limit personal exposure.

5.4.1.2 Equipment caked with drill cuttings, soil, or other material will be initially scraped or brushed. The scrapings will be containerized and appropriately disposed.

5.4.1.3 Equipment will then be sprayed with potable water using a hot water, high pressure washer.

5.4.1.4 Clean equipment will then be rinsed with potable water.

5.4.2 During the decontamination effort, fluid systems should be inspected for any leaks or problems which might potentially result in an inadvertent release at the site, thereby contributing to the volume of waste or contamination. Any identified problems should be immediately repaired and documented on the FADL. Decontamination should then be completed before moving the equipment onto the site or exclusion zone.

5.4.3 Decontamination activities will be documented by the Sampling Team Leader, lead geologist, or lead engineer on the FADL and/or appropriate form(s), as specified in the project work plans.

5.4.4 Between boreholes at the same site, the back-end of the drilling rigs will be washed with potable water until surfaces are visibly free of soil buildup.

## *6.0 Required Forms*

6.1 Field Activity Daily Log.

# COMPACTION OF FILL MATERIAL

## STANDARD OPERATING PROCEDURE

## *1.0 Purpose*

This Standard Operating Procedure (SOP) establishes methods and responsibilities for compaction of earth fill for construction purposes to produce a soil that meets design specifications for strength, compressibility, stability against volume charge, and/or durability and safety against deterioration.

The purpose of this document is to provide general recommended methodologies for compaction of earth fill. This document does not include all methods, conditions, situations, or difficulties that may arise during compaction. For site specific information, an experienced and qualified engineer knowledgeable in earth fill compaction should be consulted.

## *2.0 References*

2.1 Essentials of Soil Mechanics, Third Edition, David F. McCarthy.

2.2 An Introduction to Geotechnical Engineering, Robert D. Holtz and William D. Kovacs.

2.3 ASTM D1557 (1994) - Moisture Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457 mm) Drop

2.4 ASTM D2922 (1994) - Density of Soil and Soil-Aggregate in Place by Nuclear Density Methods (Shallow Depth)

2.5 ASTM D3017 (1994) - Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

## *3.0 Responsibilities*

3.1 The *Program Environmental Engineer* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

The Program Environmental Engineer also has the responsibility to instruct his operators and technicians to implement compaction activities. The Program Engineer will insure that there is sufficient quantity of fill soil for the compaction operation, that the fill soil is suitable material, and that the fill soil has proper moisture content. The Program Engineer will insure that the height of each lift follows the design specifications, the number of passes by the compaction equipment is

sufficient to reach the design compaction specifications, the final grade is at the required design elevation, and that the compacted soil has reached the specified density.

The Program Engineer's *(or his/her designee)* duties will involve sampling the fill soil, obtaining a five point modified Proctor curve to determine maximum dry density of the soil and optimum moisture content, and using a device to determine in-place density. If the compacted soil does not meet the specified density, the Program Engineer has the responsibility to inform the Program Manager.

## *4.0 Definitions/Materials*

4.1 Expansive Clays

Expansive clays are clays that are susceptible to large volume changes that are directly related to changes in water content. The swelling forces of this clay can cause enough surcharge to lift pavements and light structures.

4.2 Cohesive Soil

Fine grained particles (i.e., silt and clay) that form clusters because each individual grain has high interparticle bonding properties.

4.3 Cohesionless Soil

Grains of soil (i.e., sands) that can settle out of a soil-fluid suspension independently of other grains.

4.4 Modified Proctor Test

The test produces a unique curve that relates a soil's water content to its maximum density. The test is used to determine the optimum moisture content for a soil so that maximum compaction can be achieved.

4.5 Backfill

Soil material placed back into an area that has been excavated.

## *5.0 Procedure*

The procedure will explain some acceptable methodologies to achieve design specified compaction.

5.1 Discussion

When soil is used for construction, it is normally placed in layers, the layer thickness determined by a qualified engineer. Each layer is compacted according to specifications before the next layer is

placed. The following sections will explain some acceptable methods to achieve soil compaction.

## 5.2 Preparation

### 5.2.1 Fill Soil

Fill soil is needed as compaction material for an excavation or trench. If the existing soil cannot be used as fill material, then fill soil must be imported from another source. Almost all soil can be used as fill soil provided it does not contain either organic material that can decompose, foreign material that can undergo changes after it is in place, or contaminated material. A qualified engineer will examine all fill soil before the soil is placed in the excavation.

### 5.2.2 Recommended Fill Soils

Granular soils are considered the easiest material to compact. This material can gain high strength with compaction. After the material is compacted, there will be minimal volume change.

Silty soils can gain reasonable strength with little propensity for volume change. Moisture control is important in the proper compaction of silty soils.

Compacted clay can gain relatively high strengths. Moisture control is important in the proper compaction of clay soils.

### 5.2.3 Soil Fill Placement

Fill soil is generally placed in an excavation with a self-propelled scraper or bull dozer. A bull dozer or grader is generally used in the fill area to maintain a uniform spread of fill soil.

The thickness of the soil placement will vary depending on the weight of the compaction equipment. Recommended thickness of soil layers is outlined in Section 5.2.4.1 and Section 5.2.4.2.

Fine grained silt and clay soils that appear too wet to compact should be substituted by a dryer soil. If it is not feasible to import soil, scarification and aeration can be utilized to reduce the existing soil moisture content. Water should be added to a soil that is too dry. The water should be evenly mixed into the soil.

### 5.2.4 Recommended Compaction Equipment/Methods

The type of compaction equipment and the method of compaction depends on the soil type and the soil conditions.

5.2.4.1 The “Sheepsfoot Roller”

The “sheepsfoot roller” or similar roller with projecting studs that compact through a combination of kneading and tamping is effective on cohesive soils like clay and silt-clay soils. The depth and compaction of a soil layer placed depends on the length of the studs, the weight of the roller, and the number of passes the equipment places on the soil layer. Generally, a large, heavy roller with long studs can compact a 12 inch soil layer in three to five passes. Small, light rollers with shorter studs should be limited to layers less than six inches thick.

5.2.4.2 Pneumatic Tire Roller

The pneumatic tire roller is effective for compacting both cohesive and cohesionless soils. It is the best compaction for general compaction use. Generally, a light pneumatic tire roller can properly compact a six inch soil layer with three to five passes. The heaviest pneumatic tire loader can typically compact an 18 inch soil layer with three to five passes.

5.2.4.3 Vibratory Compactors

Vibratory compactors are most effective on granular soils having a low to no silt/clay sized materials. Vibratory compactors can either be in the form of a "sheepsfoot roller" or a pneumatic tire roller. The thickness of the soil layer depends on the weight of the compactor (see Sections 5.2.4.1 and 5.2.4.2).

5.3 Compaction Implementation

After the soil is classified by a qualified engineer, the soil optimum moisture content and maximum dry density is determined through laboratory methods (ASTM D1557). This will enable the Environmental Engineer to determine whether the existing fill is suitable for compaction. If the material is not suitable, compactable fill soil must be imported. After the fill soil is approved, the compaction equipment is chosen and the site is prepared for compaction. The soil is placed in a series of layers. Each soil layer is compacted with the compaction equipment before the following layer is placed. Generally, the top few inches of the lift is scarified before the next life is placed. Soil layers are placed until the work area is flush with the existing ground surface or as dictated by the design specification. The final layer is not scarified.

5.3.1 Degree of Compaction

After the lift is thoroughly compacted, the Program Environmental Engineer verifies that the lift has met the compaction criteria. On structural earth fills, the job will normally specify the degree of compaction that must be achieved in order for the soil layer to be considered acceptable. This job specification is generally based on the results of laboratory compaction tests, such as a moisture-

density test, performed on a representative sample of fill soil. A recommended method to determine the moisture density relationship is the modified Proctor test (ASTM D1557). The Program Engineer must obtain at least five gallons of soil for the test. Additionally, it is recommended that two gallons of fill soil is obtained every 100 cubic yards for a one-point modified Proctor test. The one point test will help determine whether the soil conditions deviate from the conditions determined from the original Proctor test.

5.3.2 Field Density Tests

Field density tests are done using the results of the modified Proctor curve performed on the fill soil. The information obtained from the curve, both the optimum moisture content and the maximum dry density, is entered into a nuclear density gage. It is general practice to perform in-place density tests with a nuclear density gauge (ASTM D2922 and D3017). It is typical to test at several random locations after the soil layer is compacted. The elevation of the test location is also taken. The density of the compacted fill, the moisture of the fill soil, the percent compaction, and the elevation is recorded on a Nuclear Density/Moisture Log. It is recommended that the gauge reading and the elevation be recorded on a map of the work area. When the test results indicate that satisfactory compaction has been obtained, the Program Engineer will inform the Program Manager.

5.4 Compaction Difficulties

Compaction difficulties include underground buried structures and problem soils.

5.4.1 Buried Structures

If there are buried structures, the location and depth of the structure should first be determined. Work will not proceed until a qualified engineer determines the amount of backfill or a different compaction methodology required to prevent damage to the buried structure.

5.4.2 Problem Soils

Expansive clays, like those containing the montmorillonite mineral, are prone to large volume changes in the presence of water. The volume change could lift pavements and/or small structures. It is considered poor foundation material unless it can be protected from the effects of water.

## *6.0 Required Forms*

6.1 Nuclear Density/Moisture Log

# MONITORING WELL INSTALLATION

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) provides procedures and requirements for the installation of monitoring wells using rotary, dual-tube percussion, or hollow-stem auger drilling techniques. Monitoring wells are installed to provide access to groundwater for collecting samples, as well as for obtaining water-level and other data. Because monitoring wells are used to collect samples, it is important that construction materials not interfere with sample quality either by contributing contaminants or by sorbing contaminants already present. Further, construction materials must be compatible with (i.e., not degraded by) contaminants present in soils or groundwater.

Monitoring wells are potential contaminant migration routes between aquifers or from the surface to the subsurface. Construction procedures and standards must ensure that neither passive nor active introduction of contaminants can occur. Properly installed hydraulic seals and locking well covers reduce the potential for cross-contamination of monitoring wells The details within this SOP should be used in conjunction with specific project work plans.

## 2.0 References

2.1 U.S. Environmental Protection Agency (EPA), Manual of Water Well Construction Practices, U.S. Environmental Protection Agency, Office of Water Supply, U.S. Government Printing Office, Washington D.C.

2.2 U.S. Environmental Protection Agency (EPA), 1986, Resource Conservation and Recovery Act (RCRA) Ground Monitoring Technical Enforcement Guidance Document, OSWER-9950.1, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, U.S. Government Printing Office, Washington D.C.

2.3 U.S. Environmental Protection Agency (EPA), 1987, A Compendium of Superfund Field Operations Methods, EPA-500/P-87/001, U.S. Government Printing Office, Washington D.C.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all monitoring well installation activities are conducted and documented in accordance with this and any other appropriate procedures. This will be accomplished through staff training and by quality assurance/quality control

(QA/QC) monitoring activities.

3.2 The *Quality Assurance Officer (QAO)* is responsible for periodic review of well installation activities to assure implementation of this SOP. The QAO is also responsible for the review and approval of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to monitoring well installation requirements, issuing nonconformances, etc.) identified during the performance of these activities.

3.3 The *Sampling Team Leader(s)* assigned to monitoring well installation activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from the procedures to the Program Geologist.

## *4.0 Definitions/Materials*

4.1 Cuttings

Pieces of soil, sediment, or rock cut by a bit in the process of drilling borings.

4.2 Borehole

Any hole drilled into the subsurface for the purpose of identifying lithology, collecting soil samples, and/or installing groundwater wells.

4.3 Grout

For the purposes of this SOP, the term “grout” consists of a neat cement grout generally containing three to five percent bentonite powder to water by weight. The grout is emplaced as a slurry, and once properly set and cured, is capable of restricting movement of water.

4.4 Hollow-Stem Auger Drilling

A drilling method using augers with open centers. The augers are advanced with a screwing or rotating motion into the ground. Cuttings are brought to the surface by the rotating action of the augers, thereby clearing the borehole.

4.5 Air Rotary Casing Hammer Drilling

A drilling method using a nonrotating drive casing that is advanced simultaneously with a slightly smaller diameter rotary bit attached to a string of drill pipe. The drive casing is a heavy-walled, threaded pipe that allows for pass-through of the rotary drill bit inside the center of the casing. Air is forced down through the center drill pipe to the bit, and then upward through the space between

the drive casing and the drill pipe. The upward return stream removes cuttings from the bottom of the borehole.

4.6 Mud Rotary Drilling

For the purposes of this monitoring well installation SOP, the term "mud rotary drilling" refers to direct circulation (as opposed to reverse circulation) mud rotary drilling. Mud rotary drilling uses a rotating drill bit which is attached to the lower end of a string of drill pipe. Drilling mud is pumped down through the inside of the drill pipe and out through the bit. The mud then flows upward in the annular space between the borehole and the drill pipe, carrying the cuttings in suspension to the surface.

4.7 Dual-tube Percussion Drilling

A drilling method using nonrotating drive casing with a bit on the bottom of the casing string. A smaller diameter tube or drill pipe is positioned inside the drive casing. The drive casing is advanced by the use of a percussion hammer, thereby causing the bit to cut or break up the sediment or soil at the bottom of the boring. Air is forced down the annular space between the drive casing and inner drill pipe and cuttings are forced up the center of the inner drill pipe.

4.8 Monitoring Well

A well that provides for the collection of representative groundwater samples, the detection and collection of representative light and dense nonaqueous phase organic liquids, and the measurement of fluid levels.

4.9 Annular Space

The space between:

- Concentric drill pipes;
- An inner drill pipe and outer drive casing;
- Drill pipe or drive casing and the borehole wall; or
- Well screen or casing and the borehole wall.

4.10 Filter Pack

Granular filter material (sand, gravel, etc.) placed in the annular space between the well screen and the borehole to increase the effective diameter of the well and prevent fine-grained material from entering the well.

4.11 Well Screen

A perforated, wire wound, continuous wrap or slotted casing segment used in a well to maximize the entry of water from the producing zone and to minimize the entrance of sand.

4.12 Tremie

A tubular device or pipe used to place grout, bentonite, or filter pack in the annular space.

## *5.0 Procedures*

5.1 Well Installation Procedures

This section contains the procedures for monitoring well installation activities. The procedures described herein are applicable as requirements for monitoring well installations using mud rotary, air rotary, air rotary casing hammer, dual tube percussion, or hollow-stem auger drilling techniques. Site-specific factors need to be considered in the selection of well construction and completion materials, specification of well designs, and choosing well drilling methods. These factors will be incorporated in project planning activities and the compilation of specific project work plans. The project work plans will contain the following information related to monitoring well installation:

- Objectives of the monitoring well
- Specific location of the well to be installed
- Zone or depth well is to be installed
- Drilling method(s) to be used
- Well construction materials to be used
- Specification of well design(s) including Well Construction Diagrams.
- Additional procedures or requirements beyond this SOP.

5.1.1 Before mobilization of a rig to the well site, ensure that the monitoring well location has been appropriately cleared of all underground utilities, buried objects, and drill permits have been issued per the project work plans. Review all forms and diagrams documenting the location of the cleared monitoring well site and the location of any identified underground utility lines or other buried objects.

5.1.2 Decontaminate all downhole equipment and well construction materials before monitoring well installation, as described in SOP 6.0. Decontaminate the drilling rig and all drilling equipment before monitoring well installation per SOP 6.1.

5.1.3 Clear the work site of all brush and minor obstructions and then mobilize the rig to the

monitoring well location. The rig geologist or engineer should then review with the driller the proposed well design and details of the well installation including any anticipated potential drilling or completion problems.

5.1.4 Calibrate health and safety monitoring equipment according to the instrument manufacturer's specifications. Document the calibration results on the appropriate form(s). Instruments that cannot be calibrated according to the manufacturer's specifications will be removed from service and tagged.

5.1.5 Workers will be provided with, and don, the appropriate personal protective equipment as specified by the project work plans. Typically, the minimum personal protection will include a hard hat, safety glasses, gloves, steel-toed boots, hearing protection, and coveralls.

5.1.6 Commence drilling and advance the borehole while conducting health and safety monitoring according to the project work plans. Perform readings as often as necessary to ensure the safety of workers. Record all measurements on the Field Activity Daily Log (FADL) and/or other appropriate form(s) as specified in the project work plans. Record all other pertinent information (date, site, well or boring number, and location) on the FADL and/or on other appropriate form(s) as specified by the project work plans. Also note and record observed field conditions, any unusual circumstances, and weather conditions. Drilling of the borehole should be conducted in conformance with applicable SOPs, as appropriate.

5.1.7 During drilling, collect representative cutting and soil samples as required by the project work plans. Compile a boring or lithologic log from the cuttings and samples per SOP 10.0.

5.1.8 At total depth, remove soil cuttings through circulation or rapidly spinning the augers prior to constructing the well. Review logs and notes with the driller for any zones or depths exhibiting drilling problems which may affect the well installation. Condition the hole or take other actions mutually agreed upon by the rig geologist (or engineer), lead technical personnel, and the driller to ensure or aid in the well development.

5.1.9 Remove the drill pipe and bit if using rotary techniques, or remove the center bit boring if using the hollow-stem auger technique. The well construction materials will then be installed inside the open borehole or through the center of the drive casing or augers.

5.1.10 Measure the total depth of the completed boring using a weighted sounding line. The borehole depth is checked to assure that formation material has not heaved to fill the borehole. If heaving has taken place, options for cleaning, redrilling, or installation in the open section of the boring should be discussed with lead technical personnel.

5.1.11 In the event that the hole was over-drilled, grout, bentonite pellets, or bentonite chips (as specified in the project work plans) may be added to the bottom of the boring to raise the bottom of the hole to the desired depth. The grout should be pumped through a tremie pipe and fill from the bottom of the boring upward. During grouting, the tremie pipe should be submerged below the top of the grout column in the borehole to prevent free-fall and bridging. If bentonite is used, it should be added gradually to prevent bridging. Grout or bentonite addition will stop when its level has reached approximately one foot below the desired base of the well string (casing, screen, end plug or sump, etc.). The bentonite plug will be hydrated for at least one hour before installation of a filter pack.

5.1.12 Calculate volumes of filter pack, bentonite pellets/slurry, and grout required, based on borehole and well casing dimensions. If required by the project work plans, determine the filter pack and well screen slot size for the monitoring well.

5.1.13 Place a layer of filter pack (one to two feet, unless otherwise specified in the project-specific work plans) at the bottom of the borehole. The filter pack will be installed through the center of the drive casing/augers. Filter pack will be added slowly while withdrawing the drive casing/augers.

5.1.14 Inspect the casing, screen, and any other well construction materials prior to installation to assure that no damage has occurred during shipment and decontamination activities.

5.1.15 Connect and carefully lower the well string through the open borehole, drive casing, or inside of the augers until the well string is at the desired depth. The well string should be suspended by the installation rig and should not rest on the bottom of the boring. In the event the well string was dropped, lowered abruptly, or for any other reason suspected of being damaged during placement, the string should be removed from the boring and inspected. In certain instances, the well string may rise after being placed in the borehole due to heaving sands. If this occurs, the driller must not place any drilling equipment (drill pipe, hammers, etc.) to prevent the casing from rising. The amount of

rise should be noted by the rig geologist or engineer who should then consult lead technical personnel for an appropriate course of action.

5.1.16 Record the following information on the Well Completion Form and/or other appropriate forms per the project work plans:

- Length of well screen
- Total depth of well boring
- Depth from ground surface to top of grout or bentonite plug in bottom of borehole (if present)
- Depth to base of well string
- Depth to top and bottom of well screen.

5.1.17 When using the mud rotary drilling technique, tremie the filter pack into the annular space around the screen. Clean, potable water may be used to assist with the filter pack tremie operation. For all other drilling techniques, the filter pack may be allowed to free fall or be tremied per the project work plans. If using drive casing or augers, the drive casing or augers should be pulled slowly during filter pack installation in increments no greater than five feet.

5.1.18 Filter pack settlement should be monitored by initially measuring the sand level (before beginning to withdraw the drive casing/augers). In addition, depth soundings using a weighted tape shall be taken repeatedly to continually monitor the level of the sand. The top of the well casing shall also be monitored to detect any movement due to settlement or from drive casing/auger removal. If the top of the well casing moves upwards at any time during the well installation process, the driller should not be allowed to set drilling equipment (downhole hammers, drill pipe, etc.) on the top of the casing to prevent further movement.

5.1.19 Filter pack should be added until its height is approximately two feet above the top of the screen (unless otherwise specified in the project work plans), and verification of its placement (by sounding) should be conducted. The filter pack should then be gently surged using a surge block or swab in order to settle the pack material and reduce the possibility of bridging.

5.1.20 The height of the filter pack will then be re-sounded and additional filter pack placed as necessary. Once the placement of the filter pack is completed, the depth to the top of the pack is measured and recorded on the Well Completion Form or other appropriate forms per the project

work plans.

5.1.21 A three-foot thick (unless otherwise specified in the project work plans) bentonite seal is then installed on top of the filter pack. If pellets or chips are used, they should be added gradually to avoid bridging. Repeated depth soundings will be taken using a weighted tape to ascertain the top of the bentonite seal. The seal should be allowed to hydrate for at least one hour before proceeding with the grouting operation.

5.1.22 After hydration of the bentonite seal, grout is then pumped through a tremie pipe and filled from the top of the bentonite seal upward. The bottom of the tremie pipe should be maintained below the top of the grout to prevent free fall and bridging. When using drive casing or hollow-stem auger techniques, the drive casing/augers should be raised in incremental intervals, keeping the bottom of the drive casing/augers below the top of the grout. Grouting will cease when the grout level has risen to within approximately one to two feet of the ground surface, depending on the surface completion type (flush mount versus aboveground). Grout levels should be monitored to assure that grout taken into the formation is replaced by additional grout. If settling of the grout occurs, additional topping off of the grout may be necessary.

5.1.23 For aboveground completions, the protective steel casing will be centered on the well casing and inserted into the grouted annulus. Prior to installation, a 2-inch deep temporary spacer shall be placed between the PVC well cap and the bottom of the protective casing cover to keep the protective casing from settling onto the well cap.

5.1.24 After the protective casing has set, a drainage hole may be drilled into the protective casing if required by the project work plans. The drainage hole is positioned approximately two inches above ground surface. The protective casing will be painted with a rust-preventive colored paint.

5.1.25 The well head will be labeled to identify, at a minimum, the well number, depth, and date of installation.

5.1.26 A minimum of 24 hours after grouting should elapse before installation of the concrete pad and steel guard posts for aboveground completions, or street boxes or vaults for flush mount completions.

5.1.27 For aboveground completions, a concrete pad, usually 3-foot by 3-foot by 4-inch thick, is constructed at ground surface around the protective steel casing. The concrete is sloped away from the protective casing to promote surface drainage from the well.

5.1.28 For aboveground completions, where traffic conditions warrant extra protection, three steel bucking posts will be embedded to a depth approximately 1.5 feet below the top of the concrete pad. The posts will be installed in concrete filled post holes spaced equally around the well at a distance of approximately 1.5 feet from the protective steel casing. Where removal of bucking posts is required for well access, mounting sleeves should be imbedded into the concrete.

5.1.29 For flush mount (or subgrade) completions, a street box or vault is set and cemented in position. The top of the street box or vault will be raised slightly above grade and the cement sloped to grade to promote surface drainage away from the well.

5.1.30 Following well completion and demobilization of the rig, the well site should be cleared of all debris and trash and restored to a neat and clean appearance per the project work plans. All investigation-derived waste generated at the well site should be appropriately contained and managed per the project work plans.

## *6.0 Required Forms*

6.1 Well Construction Diagram
6.2 Field Activity Daily Log
6.3 Lithologic/Soil Boring Log
6.4 Well Completion Form

# MONITORING WELL DEVELOPMENT

## STANDARD OPERATING PROCEDURE

## *1.0 Purpose*

This Standard Operating Procedure (SOP) establishes guidelines for specifying, assessing and documenting the well development process. Additional specific well development procedures and requirements will be provided in the project work plans. Monitoring wells are developed to remove skin (i.e., near-well-bore formation damage), well drilling fluids, sediments, and to settle and remove fines from the filter pack. Wells should not be developed for 48 hours after completion when a cement bentonite grout is used to seal the annular space, nor after 7 calendar days beyond internal mortar collar placement.

## *2.0 References*

2.1 U.S. Environmental Protection Agency (EPA), August 1988, Guidance for Conducting Remedial Investigation and Feasibility Studies under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.2 U.S. Environmental Protection Agency (EPA), 1987, A Compendium of Superfund Field Operations Methods, EPA-540/P-87/001a, U.S. Government Printing Office, Washington D.C.

2.3 ASTM, 1988, Standards Technology Training Program - Groundwater and Vadose Zone Monitoring, Nielsen, et al.

## *3.0 Responsibilities*

3.1 The *Program Geologist* is responsible for ensuring that monitoring wells are properly developed and that the development process is properly documented. This will be accomplished by staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with well development. If deviations from project requirements occur, the QAO is also responsible for issuing notices of nonconformances and requests for corrective action.

3.3 The *Sampling Team Leader(s)* are responsible for conducting monitoring well development and documentation in accordance with the specifications outlined in this SOP and by the project work plans.

## *4.0 Definitions/Materials*

4.1 Well Development - The act of removing fine grained sediment and drilling fluids from the sand pack and formation in the immediate vicinity of the well, thus increasing the porosity and permeability of the materials surrounding the intake portion of the well.

4.2 Educator Pipe - The pipe used to transport well discharge water to the surface.

4.3 Materials

- Submersible pump or bailer.
- Power source (e.g., generator), if required.
- Electronic water level indicator and/or oil/water interface probe.
- Temperature, conductivity, pH, and turbidity meters.
- Personal protective equipment as specified in the project health and safety plan.
- Organic vapor meter (MicroTip, OVM, HNU, etc.).
- Teflon-coated stainless steel cable or acceptable material.
- Well development logs.

## *5.0 Procedure*

5.1 General

5.1.1 The most common methods used to develop monitoring wells consist of surging and bailing, surging and pumping, or combinations of all these.

5.1.2 The project work plans will identify the specific well development procedure to be followed. The standard procedure for field personnel to use in assessing and documenting well development is described below and is intended only for development methods listed above.

5.2 Well Development

5.2.1 Decontaminate the rig and development equipment in accordance with SOPs 6.0 and 6.1, respectively.

5.2.2 Calibrate all field analytical test equipment (pH, temperature, conductivity, turbidity) according to the instrument manufacturer's specifications and SOP 4.0. Specific test equipment to be used should be identified in the project-specific work plans. Instruments that cannot be calibrated according to the manufacturer's specifications will be removed from service, tagged with an out of calibration label, and segregated (when possible) from the calibrated equipment area.

An exception to the daily calibration requirements will be made in the case of the water level meters. The tape of these instruments will be checked prior to the beginning of the project and each succeeding six months using a steel surveyor's tape.

5.2.3 Visually inspect the well to ensure that it is undamaged, properly labeled and secured. Any observed problems with the well head should be noted in the Field Activity Daily Log and reported to the Sampling Team Leader(s).

5.2.4 Unlock the well and obtain a depth to water level measurement according to the procedures outlined in SOP 5.0. Calculate the volume of water in the well (cased well volume) as follows:

$$(\frac{d}{2})^2 \times (h_1 - h_2) \times 0.163 = \text{gallons per cased well volume}$$

where

d = inside diameter of well casing
$h_1$ = depth of well from top of casing
$h_2$ = depth to water from top of casing.

5.2.5 The depth to the bottom of the well should be sounded and then compared to the completion form or diagram for the well. If sand or sediment are present inside the well, it should first be removed by bailing. Do not insert bailers, pumps, or surge blocks into the well if obstructions, parting of the casing, or other damage to the well is suspected. Instead report the conditions to the

Site Superintendent and obtain approval to continue or cease well development activities.

5.2.6 Begin development by first gently surging followed by bailing or pumping. This is then continued with alternate surging and bailing or pumping. At no time should the surge block be forced down the well if excessive resistance is encountered. During development, the bailer should not be allowed to free-fall or descend rapidly such that it becomes lodged in the casing or damages the end cap or sediment trap at the bottom of the well.

5.2.7 While developing, take periodic water level measurements (at least one every five minutes) to determine if drawdown is occurring and record the measurements on the Well Development Record.

5.2.8 While developing, calculate the rate at which water is being removed from the well. Record the volume on the Well Development Record.

5.2.9 While developing, water is also periodically collected directly from the eductor pipe or bailer discharge and readings taken of the indicator parameters: pH, specific conductance, and temperature. Development is considered complete when the indicator parameters have stabilized (i.e., three consecutive pH, specific conductance, and temperature readings are within tolerances specified in the project work plans) and a minimum of three well volumes of water have been removed. In certain instances, for slow recharging wells, the parameters may not stabilize. In this case, well development is considered complete upon removal of the minimum of three well volumes. In some cases, the project work plans may also specify a maximum turbidity requirement for completion of development.

5.2.10 Obtain a water level and turbidity measurement at the completion of development.

5.2.11 Complete documentation of the well development event on the Well Development Record form. At a minimum this record must contain:

- Project name and number
- Well identification number
- Well depth, casing size, and completion date
- Method of development
- Volume of water removed

- Water levels (including the time of measurement)
- Physical description of the water (e.g., discoloration, turbidity, odor, etc.) and solids removed from the well
- Test equipment readings for pH, conductivity, temperature and turbidity (including the time of collection)
- Signature of the well development observer.

5.2.12 Collect and appropriately transport and dispose of water removed from the well in accordance with criteria listed in the project-specific work plans and regulatory requirements.

5.2.13 Allow the well to recover for at least 24 hours prior to sampling.

## *6.0 Required Forms*

6.1 Well Development Record Form

# GROUNDWATER SAMPLING

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for use by field personnel in the collection and documentation of groundwater samples for chemical analysis. Proper collection procedures are necessary to assure the quality and integrity of all groundwater samples. Additional specific procedures and requirements will be provided in the project work plans, as necessary.

## 2.0 References

2.1 EPA, September 1987, Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.3 ASTM, 1988, Standards Technology Training Program - Groundwater and Vadose Zone Monitoring, Nielsen, et al.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QC/QC).

3.2 The Quality Assurance Officer (QAO) is responsible for periodic review of field generated documentation associated with this SOP. The QAO is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

3.3 The *Sampling Team Leader(s)* assigned to surface and shallow subsurface soil sampling activities is responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Program Geologist.

## *4.0 Definitions/Materials*

4.1 Bladder Pump

A bladder pump is an enclosed cylindrical tube containing a flexible membrane bladder. Well water enters the bladder through a one-way check-valve at the bottom. Gas is forced into the annular space (positive displacement) surrounding the bladder through a gas supply line. The gas displaces the well water through a one-way check-value at the top. The water is brought to the surface through a water discharge line. Gas (air or nitrogen) is provided by compressors or cylinders.

4.2 Peristaltic Pump

A peristaltic pump is a self-priming, low volume pump consisting of a rotor and ball bearing rollers. Tubing placed around the rotors is squeezed by the rotors as they revolve. The squeezing produces a wavelike contractual movement which causes water to be drawn through the tubing. The peristaltic pump is limited to sampling at depths of less than 25 feet.

4.3 Electric Submersible Pump

An electric submersible pump is an enclosed cylindrical tube containing a motor with rotary attachments. Well water enters the cylinder through a one-way check valve. Electrical power to the motor causes rotors or impellers to turn and displace the groundwater.

4.4 Bailer

A bailer is an enclosed cylindrical tube containing a floating ball check-valve at the bottom. Lowering the bailer into water causes the ball to float allowing water to enter the cylinder. Raising the bailer through the water causes the ball to settle, creating a seal to trap the water so that it can be brought to the surface.

4.5 Dedicated Groundwater Monitoring Equipment

Dedicated groundwater monitoring equipment is used to purge and sample only one well. The equipment is installed and remains in the well for the duration of the monitoring program. Dedicated equipment does not need to be decontaminated between sampling events.

4.6 Materials:

- Clean rope or wire line of sufficient length for conditions.
- Appropriate sample containers with labels and preservatives, as required.
- Hard plastic or steel cooler with cold packs (or ice) for samples.
- Temperature, pH, conductivity, and turbidity meters.

- Equipment calibration standards.
- Electronic water level indicator.
- Organic vapor meters.
- Plastic sheeting, if needed.
- 55-gallon drums for purge water.
- Decontamination supplies, as required.
- Personal protective clothing and equipment, if required by the project health and safety plan.
- Field logbook and monitoring well purge and sample forms

## *5.0 Procedure*

This section contains the procedures involved with groundwater sampling. Proper groundwater sampling procedures are necessary to insure the quality and integrity of the samples. The details within this SOP should be used in conjunction with project work plans. The project work plans will generally provide the following information:

- Sample collection objectives
- Locations of groundwater samples to be collected
- Numbers and volumes of samples to be collected
- Types of chemical analyses to be conducted for the samples
- Specific quality control (QC) procedures and sampling required
- Any additional groundwater sampling requirements or procedures beyond those covered in this SOP, as necessary.

At a minimum, the procedures outlined in this SOP for groundwater sampling will be followed.

### 5.1 Groundwater Sampling Requirements

#### 5.1.1 Equipment Selection and Sampling Considerations

Purging and sampling equipment is constructed from a variety of materials. The most inert material (e.g., Teflon, stainless steel), with respect to known or anticipated contaminants in the well(s), should be used whenever possible. The project work plans will describe the type of equipment to be used.

If non-dedicated sampling is to be used and the contaminant histories of the wells are known, it is advisable to establish a sampling order starting with the least contaminated well and progressing to the most contaminated last.

5.1.2 Groundwater Purging and Sampling with a Bladder Pump

Pre-sample purging and sampling should be conducted in accordance with the project work plans. The standard procedure for purging and sampling using a bladder pump will be conducted as described below.

5.1.2.1 Inspect the equipment to ensure that it is in good working order.

5.1.2.2 Calibrate all field analytical test equipment (e.g., pH, temperature, conductivity) according to the instrument manufacturer's specifications. Calibration results will be recorded on the appropriate form(s) as specified by the project work plans. Instruments that cannot be calibrated according to the manufacturer's specifications will be removed from service and tagged.

An exception to the daily calibration requirements will be made in the case of the water level meters. These instruments will be calibrated at the beginning of the project and then every six months using a steel surveyors tape.

5.1.2.3 If non-dedicated equipment is being used, decontaminate according to SOP 6.0. During decontamination, the equipment should again be inspected for damage and, if present, repaired or replaced with undamaged equipment.

5.1.2.4 Visually inspect the well to ensure that it is undamaged, properly labelled and secured. Damage or other conditions that may affect the integrity of the well will be recorded on the Field Activity Daily Log and brought to the attention of the Sampling Team Leader.

5.1.2.5 Uncap the well and monitor the air space immediately above the open casing per the health and safety plan. Observe if any air is flowing into or out of the casing. In the event such conditions are observed, they should be noted on the Sampling Information Form.

5.1.2.6 Obtain a depth to water level measurement according to the procedures outlined in SOP 5.0. Calculate the volume of water in the well (cased well volume) as follows:

$$\pi \times \left(\frac{d}{2}\right)^2 \times (h_1 - h_2) \times 7.48 = \textit{cased well volume (in gallons)}$$

where

d = inside diameter of well casing (in feet)
$h_1$ = depth of well from top of casing (in feet)
$h_2$ = depth to water from top of casing (in feet)

Record static water level measurement and calculations on the Sampling Information Form.

5.1.2.7 If using non-dedicated equipment, lower the pump and associated tubing and/or lines into the well.

5.1.2.8 Attach the compressor or cylinder to the controller and the controller to the gas supply line, making sure that the compressor is downwind of the monitoring well. Attach the sampling tube to the discharge supply line. Adjust the pressure/discharge cycle on the controller.

5.1.2.9 Begin purging. Collect, transport, and dispose of purge water in accordance with the criteria specified by the project work plans.

5.1.2.10 Physical parameters (pH, specific conductance, and temperature) of the purge water will be measured when purging begins and then periodically throughout the purging procedure. These measurements will be recorded on Sampling Information Form. Purging is considered complete when a minimum of three casing volumes have been removed and pH, specific conductivity, and temperature measurements have stabilized (i.e., three consecutive pH, specific conductance, and temperature readings are within tolerances specified in the project work plans). If stability is not reached within the removal of three well volumes then purging is continued until a maximum of five cased well volumes have been removed.

For slowly recharging wells, the parameters may not stabilize. In this case, purging will be considered complete upon removal of a minimum three well volumes.

5.1.2.11 Allow the well to recover to at least 80 percent of the initial cased well volume prior to sampling.

5.1.2.12 Inspect the sampling bottles (obtained from the analytical laboratory prior to the sampling

event) to be used to ensure that they are appropriate for the samples being collected, are undamaged, and have had the appropriate types and volumes of preservatives added. The types of sample containers to be used and sample preservation requirements will be provided in the project work plans.

5.1.2.13 Turn on the pump and adjust the pressure/discharge cycle on the pump controller so that the water will flow smoothly and without agitation into the sample containers.

5.1.2.14 Collect the sample directly into the provided sample bottle (container), allowing the discharge to flow gently down the inside of the bottle, minimizing aeration of the sample. Completely fill the bottle; however, samples collected for metals and general water chemistry analysis should be filled to the base of the bottle neck.

5.1.2.15 The samples should be collected in the order of volatility, collecting the most volatile samples first, followed by the least volatile samples. The volatile samples should be collected during one full discharge cycle. Do not partially fill a volatile sample during one cycle and complete the filling during the next cycle.

5.1.2.16 Samples that require filtering should be collected last. The samples should preferably be filtered using a disposable vacuum filterization unit. The required filter mesh should be stipulated in the project work plans.

5.1.2.17 Cap the bottle and attach custody tape across the cap so that any attempt to remove the sample or open the sample bottle will be evident. Fill out and attach the sample label to the bottle per SOP 2.1. The sample will be assigned a sample number per SOP 2.2.

5.1.2.18 Document the sampling event on the Sample Collection Log.

5.1.2.19 As soon as possible after sample collection, place the sample in a separate, appropriately sized, airtight, seam sealing, polyethylene bag (i.e., Ziplock™ or equivalent). Seal the bag, removing any excess air. Place the bagged sample inside the shipping container.

5.1.2.20 Handle and ship the sample according to the procedures outlined in SOP 2.1, following

appropriate custody procedures described in SOP 1.1. Samples stored temporarily on site will be maintained per SOP 2.3.

5.2 Groundwater Purging and Sampling with a Peristaltic Pump

Purging and sampling will be conducted per the project work plans. The standard procedure for groundwater purging and sampling using a peristaltic pump will be conducted as described below.

5.2.1 Inspect the equipment to ensure that it is in good working order.

5.2.2 Conduct all field analytical test equipment (pH, temperature, conductivity) calibration as discussed in Section 5.1.2.2.

5.2.3 Conduct equipment decontamination as described in Section 5.1.2.3. However, the old Tygon™ tubing should not be decontaminated. New tubing should be used for each well.

5.2.4 Conduct wellhead inspection and air space monitoring as discussed in Sections 5.1.2.4 and 5.1.2.5.

5.2.5 Obtain a water level measurement and calculate the cased well volume per Section 5.1.6.

5.2.6 Connect new Tygon™ tubing to the rotor head of the pump motor and tighten until snug.

5.2.7 Run a short section of the tubing from the discharge side of the pump head to a collection vessel.

5.2.8 Insert the free end of the influent tubing into the well and lower it to the middle of the well screen.

5.2.9 Begin and conduct purging as described in Sections 5.1.2.9 and 5.1.2.10.

5.2.10 Purging will be considered complete per Section 5.1.2.10. Once purging is completed, allow the well to recover to at least 80 percent of the initial cased well volume prior to sampling.

5.2.11 Inspect the sampling bottles to be used per Section 5.1.2.12.

5.2.12 Turn on and adjust the rotor speed of the pump so that the water will flow smoothly and without agitation into the sample bottles.

5.2.13 Collect the sample directly into the provided sample bottle (container), allowing the discharge to flow gently down the inside of the bottle, minimizing aeration of the sample. Completely fill the bottle; however, samples collected for metals and general water chemistry analyses should be filled to the base of the bottle neck.

5.2.14 The samples should be collected in the order of volatility as described in Section 5.1.2.15. VOC samples should not be collected with a Peristaltic Pump.

5.2.15 Samples that require filtering should be collected last. The samples should preferably be filtered using a disposable vacuum filterization unit. The required filter mesh should be stipulated in the project work plans.

5.2.16 Appropriately cap, label, and number the samples as discussed in Section 5.1.2.17.

5.2.17 Document the sampling event on the Sample Collection Log.

5.2.18 Appropriately seal, store, handle, and ship the samples per Sections 5.1.2.19 and 5.1.2.20.

5.3 Groundwater Purging and Sampling with an Electric Submersible Pump

Purging and sampling will be conducted in accordance with the project work plans. The standard procedure for purging and sampling using a submersible pump is described below.

5.3.1 Inspect the equipment to ensure that it is in good working order.

5.3.2 Conduct field analytical test equipment (pH, temperature, conductivity) calibration as discussed in Section 5.1.2.2.

5.3.3 Conduct equipment decontamination as described in Section 5.1.2.3.

5.3.4 Conduct wellhead inspection and air space monitoring as discussed in Sections 5.1.4 and

5.1.5.

5.3.5 Obtain a water level measurement and calculate the cased well volume per Section 5.1.6.

5.3.6 If using non-dedicated equipment, lower the pump and associated lines into the well.

5.3.7 Place the generator downwind of the well. Start the generator, and then plug the pump into the generator.

5.3.8 Begin and conduct purging as described in Sections 5.1.2.9 and 5.1.2.10.

5.3.9 Purging will be considered complete per Section 5.1.2.10. Once purging is completed, allow the well to recover to at least 80% of the initial cased well volume prior to sampling.

5.3.10 Inspect the sampling bottles to be used per Section 5.1.2.12.

5.3.11 Turn on and adjust the flow rate of the pump by using the check-valve on the discharge line so that the water will flow smoothly and without agitation into the sample bottles.

5.3.12 Collect the sample directly into the provided sample bottle (container), allowing the discharge to flow gently down the inside of the bottle, minimizing aeration of the sample. Completely fill the bottle; however, samples collected for metals and general water chemistry analyses should be filled to the base of the bottle neck.

5.3.13 The samples should be collected in the order of volatility, as described in Section 5.1.2.15. An electric submersible pump is not recommended for collecting volatile organic samples.

5.3.14 Samples that require filtering should be collected last. The samples should preferably be filtered using a disposable vacuum filterization unit. The required filter mesh should be stipulated in the project work plans.

5.3.15 Appropriately cap, label, and number the samples as discussed in Section 5.1.2.17.

5.3.16 Document the sampling event on the Sample Collection Log (Attachment 6.3).

5.3.17 Appropriately seal, store, handle and ship the samples per Sections 5.1.2.19 and 5.1.2.20.

5.4 Groundwater Purging and Sampling with a Bailer

Purging and sampling will be conducted in accordance with the project work plans. The standard procedure for purging and sampling with a bailer is described below.

5.4.1 Inspect the equipment to ensure that it is in good working order.

5.4.2 Conduct field analytical test equipment (pH, temperature, conductivity) calibration as discussed in Section 5.1.2.1.

5.4.3 Decontaminate purging and sampling equipment according to SOP 6.0.

5.4.4 Conduct wellhead inspection and air space monitoring as discussed in Sections 5.1.2.4 and 5.1.2.5.

5.4.5 Obtain a water level measurement and calculate the cased well volume per Section 5.1.2.6.

5.4.6 Secure the bailer to a five foot length of Teflon™ coated stainless bailer wire with a bowline knot or clip. Attach the bailer wire to bailing line or chain.

5.4.7 Begin purging by slowly lowering the bailer into the groundwater. Allow the floating ball valve to seat, and slowly retrieve the bailer. Repeat this procedure to purge the well. Collect, transport, and dispose of purge water in accordance with the criteria specified in the project work plans.

During purging, the descent of the bailer should be controlled to prevent freefall inside the well. In the event the bailer encounters an obstruction inside the well, no attempts may be made to push the bailer beyond the obstruction. If the bailer becomes lodged in the well, the line should not be pulled with such force that it would part from the bailer. Such conditions should also be noted in the Field Activity Daily Log and brought to the immediate attention of the Project Geologist.

5.4.8 Purging will be considered complete per Section 5.1.2.10. Once purging is completed, allow the well to recover to at least 80% of the initial cased well volume prior to sampling.

5.4.9 Inspect the sampling bottles to be used per Section 5.1.2.12.

5.4.10 Lower the sample collection bailer and submerge into the water column as above. Retrieve the bailer and insert a bottom emptying device into the bailer so that the water will flow smoothly and without agitation into the sample bottles.

5.4.11 Collect the sample water directly into the provided sample bottles (containers), allowing the discharge to flow gently down the inside of the bottles, minimizing aeration of the sample. Completely fill the bottles; however, samples collected for metals and general water chemistry analyses should be filled to the base of the bottle neck.

5.4.12 The samples should be collected in the order of volatility as described in Section 5.1.2.15.

5.4.13 Samples that require filtering should be collected last. The samples should preferably be filtered using a disposable vacuum filterization unit. The required filter mesh should be stipulated in the project work plans.

5.4.14 Appropriately cap, label, and number the samples as discussed in Section 5.1.2.17.

5.4.15 Document the sampling event on the Sample Collection Log.

5.4.16 Appropriately seal, store, handle, and ship the samples per Sections 5.1.2.19 and 5.1.2.20.

## *6.0 Required Forms*

6.1 Field Activity Daily Log
6.2 Sampling Information Form
6.3 Sample Collection Log

# PASSIVE DIFFUSION BAG SAMPLING FOR VOCS IN GROUNDWATER

## STANDARD OPERATING PROCEDURE

### *1.0 Purpose*

This Standard Operating Procedure (SOP) establishes guidelines and procedures for use by field personnel in the collection and documentation of ground water samples for volatile organics by passive diffusion bag (PDB) samplers. Proper collection procedures are necessary to assure the quality and integrity of all volatile organic samples regardless of sampling method. Any variants to these specific procedures and requirements will be provided in the approved project work plans.

PDB technology uses natural molecular diffusion to cause the molecules from volatile organic compounds to pass from the groundwater through the semi-permeable sampler that is suspended in the screened interval of the well. PDB samplers eliminate the need for purging and disposal, and they can be left in targeted areas for a period of time that enables collection of a more representative sample.

Although the samplers vary slightly in specific construction, a typical PDB sampler consists of a one to two foot long low density polyethylene (LDPE) tube closed at both ends and containing laboratory grade water that has been tested to be free of the volatile organics. The outside of the PDB sampler is covered with a LDPE mesh for protection of the sampler against the abrasive sides of the well or borehole encountered during lowering and raising of the sampler. The PDB is positioned through use of a weighted line that allows the sampler to be positioned in the screened interval at a location optimized for each individual well. #

### *2.0 References*

2.1 Vroblesky, D.A., User's *Guide for Polyethlene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic CompoundsConcentrations in Wells,* U.S. Geological Survey Water-Resources Investigations Report 01-4060, Part 1, 2001.

### *3.0 Responsibilities*

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 *The Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with this SOP. The QAO is also responsible for implementation of

corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

3.3 The *Sampling Team Leader(s)* assigned to ground water sampling activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Program Geologist or QAO as appropriate.

## *4.0 Definitions/Materials*

4.1 Sampling Equipment and Materials:

- PDB samplers filled with volatile free laboratory-grade water
- Weighted line, stainless steal or Teflon-coated stainless steel
- Sample discharge tubes
- Pre-preserved VOA sample containers with labels
- Solvent resistant disposable gloves
- Water level and organic vapor meters as necessary
- Decontamination supplies, as required
- Sample shipping supplies as per SOP 2.0
- Personal protective clothing and equipment, if required by the health and safety plan.
- Field logbook and monitoring well sampling forms

## *5.0 Procedure*

This section contains procedures involved with PDB sampling. Proper sampling procedures are necessary to insure the quality and integrity of the samples. The details within this SOP should be used in conjunction with project work plans or current scopes of work (SOW) if applicable. The project work plans or SOW will generally provide the following information:

- Sample collection objectives
- Locations of samples to be collected
- Numbers of samples to be collected
- Specific quality control (QC) procedures and sampling required
- Any additional sampling requirements or procedures beyond those covered in this SOP, as necessary.

At a minimum, the procedures outlined below for PDB sampling will be followed.

5.1 SAMPLE COLLECTION PROCEDURES

5.1.1 Prior to sampling and between sampling locations, decontaminate reusable sample equipment according to SOP 6.0 and any specific procedures outlined in the project work plans.

5.1.2 Handle all sample collection equipment and containers with gloved hands.

5.1.3 Calculate the distance from the bottom of the well up to the point where the PDS are to be placed. For any initial sampling of a well not previously sampled by PDB, a sampling bag will be placed every five feet of screen interval for th e length of the well screen. For each subsequent sampling from that well, a PDB sam pler will be pl aced in the zone of highest concentration as determined from the original sampling event.

5.1.4 Attach the PDB sampler(s) to a weighted line, sufficient weight should be added to counter balance the buoyancy of the PDB sampler(s). Attach each end of the PDB samplers to a knot/loop in the weighted line at the appropriate locations by using cable ties or other break-resistant fastener. Alternatively, the weight can be attached to the bottom of the sampling bag on the loop specifically provided for the weight. The sampler is then attached at the appropriate pre-determined depth on the line. For multiple bag deployments (optimization procedures) attach the weight to the lowest PDB in the series.

5.1.5 Once the PDB sampler(s) and weighted line have been assembled, lower the weighted line assembly until the weight rests on the bottom of the well and the line above the weight is taught. The PDB sam pler(s) should now be positioned at the expected depth interval(s).

5.1.6 Secure the assembly in this position by attaching the weighted line to a hook inside the well cap. Reattach the well cap. Allow the PDB assembly to remain undisturbed for the PDB sampler(s) to equilibrate. This should be a minimum of two weeks.

5.1.7 After the sampling equilibration period, remove the PDB sampler(s) from the well by using the attached line. The sampler(s) should not be exposed to heat or agitated.

5.1.8 Examine the surface of the samplers for evidence of alga, iron, or other coatings. Note any observations in the field book. If there are tears noted in the bag membrane than that sample should be rejected. Detach and remove the PDB sampler(s) from the weighted line.

5.1.9 Pierce the sampler at the bottom with the discharge tube and empty the sampler into the pre-preserved VOA vials controlling flow with the sampling bag so as to minimize any sample agitation. Alternatively the PDB sampler can be cut open at one end using decontaminated scissors or other cutting device. The water can then be gently transferred to the VOA vials in a m anner that minimizes sample agitation.

5.2. SAMPLE HANDLING AND SHIPPING

5.2.1 Appropriately label and number the sample containers per SOPs 2.1 and 2.2, respectively, and the project work plans. The label will be filled out with waterproof ink and will contain, at a minimum, the following information:

- Project number
- Sample number
- Sample location
- Sample type

- Date and time of collection
- Methods for analysis
- Sampler's initials.

5.2.2 Document the sampling event on the Sample Collection Log or an equivalent form as specified in the project work plans. Note any pertinent field observations, conditions or problems on the Field Activity Daily Log. Any encountered problems or unusual conditions should also be immediately brought to the attention of the Sampling Team Leader.

5.2.3 Appropriately temperature preserve, package, and ship the samples per SOP 2.0 and the specific project work plans. The samples shall also be maintained under custody per SOP 1.1.

## *6.0 Required Forms*

6.1 Sample Collection Log
6.2 Field Activity Daily Log
6.3 Chain of Custody Form

# CONE PENETRATION TESTING (CPT) AND HYDROPUNCH® GROUNDWATER SAMPLING

**STANDARD OPERATING PROCEDURE**

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines for conducting cone penetration testing (CPT), soil sampling using a CPT rig, and Hydropunch® groundwater sampling. The details within this SOP should also be used in conjunction with project work plans.#

## 2.0 References

2.1 ASTM, 1988, Standard Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil , Designation: D 3441-86, Volume 4.08 Soil and Rock, Building Stones: Geotextiles, pp.409-414.

2.2 Manchon, B., 1992, Introduction to Cone Penetrometer Testing and Groundwater Samplers, Sixth National Outdoor Action Conference on Aquifer Restoration, Groundwater Monitoring and Geophysical Methods, May 1992.

## 3.0 Responsibilities

3.1 The *Program Geologist* or delegated representative is responsible for ensuring that all CPT, soil sampling, and Hydropunch® activities are conducted and documented in accordance with this and any other appropriate procedures. This will be accomplished by staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Quality Assurance Officer (QAO)* is responsible for periodic review of field activities and documentation associated with this SOP. The QAO is also responsible for the implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, generation of variances to CPT and sampling requirements, issuing nonconformances, etc.) if problems occur.

3.3 The *Sampling Team Leader(s)* and sampling personnel assigned to CPT, soil sampling, and Hydropunch® activities are responsible for completing their tasks according to this and other appropriate procedures. All staff are responsible for reporting deviations from the procedure to the Program Geologist.

## 4.0 Definitions/Materials

4.1 Cone - the cone-shaped point of the penetrometer tip, upon which the end-bearing resistance develops.

4.2 Cone penetrometer - an instrument in the form of a cylindrical rod with a conical point, designed for penetrating soil and soft rock and for measuring the end-bearing component of penetration resistance.

4.3 Cone resistance or end-bearing resistance - the resistance to penetration developed by the cone, equal to the vertical force applied to the cone divided by its horizontally projected area.

4.4 Hydropunch® - A device used to collect groundwater samples using CPT or drill rig technology. Various forms of the Hydropunch® exist; they vary in the method used for sample collection. Hydropunch I® uses the body of the hydropunch to collect and retrieve the sample. Hydropunch II® allows for the collection of water samples using a bailer lowered within the CPT rods or drill stem.

4.5 Sounding - the entire series of penetration tests performed at one location.

4.6 Friction Ratio - the ratio of friction resistance to cone resistance, expressed in percent.

4.7 Friction Resistance - the resistance to penetration developed by the friction sleeve, equal to the vertical force applied to the sleeve divided by its surface area. This resistance consists of the sum of friction and adhesion.

4.8 Differential Pore Pressure Ratio - A calculated parameter equal to the excess pore pressure measured behind the tip divided by the sum of the tip resistance (corrected for pore pressure effects and the total overburden stress). Used in combination with the end-bearing resistance to infer lithology.

4.9 Pore Pressure - Water pressure in the formation.

4.10 Push Rods - The thick-walled tubes, or other suitable rods, used for advancing the penetrometer tip or Hydropunch® to the required test depth.

## 5.0 Procedure

Depending on the sampling activities to be performed, CPT/Hydropunch® testing may require multiple runs to complete the desired tests. The first run is generally conducted to generate stratigraphic or hydrogeologic information. The stratigraphic or hydrogeologic data is then evaluated to determine optimum depth intervals to obtain soil and groundwater samples, which will be collected in subsequent runs.

CPT soundings, and soil and groundwater sampling will be performed by an experienced contractor under the direction of the prime contractor or their subcontractors. All CPT, soil sampling, and Hydropunch® techniques covered in this SOP will be performed in accordance with the project work plans. The project work plans will identify the following:

- Testing and sampling objectives
- Locations and depths of CPT and sampling points
- Numbers and volumes of soil or groundwater samples to be collected
- Types of chemical analyses to be conducted for the samples
- Specific quality control (QC) procedures and sampling required
- Specific procedures to be performed in addition to those covered in this SOP.

At a minimum, the procedures outlined below for CPT, soil sampling, and Hydropunch® groundwater sampling will be followed.

5.1 Preparation Procedures

5.1.1 Prior to commencement of CPT activities, ensure that all CPT, soil sampling, and Hydropunch® locations have been appropriately cleared of all underground utilities and buried objects per the project work plans. Review all forms and diagrams documenting the location of the cleared sampling and CPT locations, as well as that of any underground utility lines or other buried objects.

5.1.2 Perform a specific calibration of air monitoring equipment required for air space monitoring according to the instrument manufacturer's specifications. Calibration results will be recorded on the appropriate form(s), as specified in the project work plans. Instruments that can not be calibrated according to the manufacturer's specifications will be removed from service and tagged.

5.1.3 Don the appropriate personal protection equipment specified in the project-specific work

plans.

5.2 Cone Penetration Testing

In general, the CPT is the first run to be conducted. The CPT rig is normally truck-mounted and contains a hydraulic push system (20 ton is typical). The depth of investigation will typically be less than 100 feet below ground surface (bgs). Lighter weight rigs can be utilized for shallow surveys up to approximately 15 feet bgs.

Some CPT rigs are equipped with an automatic decontamination system featuring an enclosed chamber that may be mounted beneath the CPT rig (project-specific decontamination requirements are specified in the project work plans). This chamber contains scrubbers and spray nozzles for pressure washing of the CPT probe as it is retrieved from the ground. In this type of system, all activities are conducted within the enclosed CPT rig.

The standard procedure for conducting stratigraphic and hydrogeologic investigations is described below.

5.2.1 Obtain specifications on the type and dimensions of the probes and equipment, along with the results of current shop calibrations from the CPT subcontractor.

5.2.2 With the CPT subcontractor, inspect all equipment to ensure that it is in proper working order.

5.2.3 Examine data from adjacent soil borings, if available. Initial correlation of the CPT data with site lithologies will be accomplished by comparison with existing boring logs, geophysical logs, and CPT logs.

5.2.4 Before moving onto the site, decontaminate the outside of the rig per SOP 6.1 and the project work plans. For those rigs that do not have an automatic decontamination system, the CPT probe and rods should also be decontaminated per SOP 6.1.

5.2.5 Calibrate the CPT cones at zero load reading in air and water, shielding the cone from direct sunlight before commencement of testing at each location.

5.2.6 Commence the test and advance the CPT probe into the subsurface at a consistent, controlled

rate of 0.03 to 0.07 feet per second (1 to 2 centimeter per second), unless conditions prevent that rate.

5.2.7 Record real-time field plots consisting of depth, cone tip resistance, sleeve friction resistance, and friction ratio. Pore pressure and differential pore pressure ratio may be included in some cases.

5.2.8 Pore pressure dissipation tests may be conducted to determine relative flow rates at specific depths. The CPT probe is held stationary at a given depth and data are recorded for a set time interval. The time interval is dependent on the lithology of the zone being tested.

5.2.9 Once the CPT is pushed to the maximum desired depth, data collection is terminated. The CPT is retracted from the hole and the tip and rods are wiped down during extraction.

5.2.10 Upon completion of a test, calibrate the piezocone again to zero load reading and compare this to the initial reading.

5.2.11 Abandon the hole in accordance with the project work plans.

5.2.12 All pertinent information observed during the investigations will be recorded by the rig geologist or engineer. Information will be recorded on the Field Activity Daily Log (FADL) and/or appropriate form(s) as specified in the project work plans. Any and all problems or unusual conditions encountered should also be noted on the above forms and brought to the attention of the site superintendent.

5.3 Soil Samples

If required, soil sampling will follow the CPT analysis run. Soil sampling locations will be placed updip relative to the location of the previous CPT testing run. The standard procedure is described below.

5.3.1 Assemble and check the necessary sampling equipment before soil sampling. Decontaminate all downhole sampling equipment before sampling, as described in SOP 6.0. The rig should also be decontaminated per SOP 6.1.

5.3.2 Deploy and advance the soil sampling probes with the CPT rods to collect soil samples at the

sample intervals specified in the project work plans. The sample intervals may be identified from the adjacent CPT data and any other subsurface data available. The sampling device contains removable liners that fit inside the drive tip mechanism.

5.3.3 Retrieve the sampler and remove the liners containing the soil. Cover the ends of each liner to be submitted for chemical analysis with Teflon™ film and then cap with plastic end caps.

5.3.4 Each liner to be submitted for analysis will beappropriately labeled. The label will be filled out using waterproof ink and will contain, at a minimum, the following information:

- Project number
- Sample point (or boring) number
- Bottom depth of liner
- Date and time of sample collection
- Parameters for analysis
- Sampler's initials.

5.3.5 As soon as possible after sample collection, place the sample in an appropriately sized, airtight, seam-sealing polyethylene bag (e.g.,Ziploc™ or equivalent). Seal the bag, removing any excess air, and tape the bag with custody tape so that any attempt to remove the sample will cause the tape to be broken.

5.3.6 Document the sampling event on the Sample Collection Log or an equivalent form as specified in the project work plans.

5.3.7 Handle the sample according to the procedures outlined in SOP 2.1. For samples submitted to a laboratory for analysis, an Analysis Requestand Chain-of-Custody Record shall be completed and maintained per SOP 1.1 and the project work plans.

5.3.8 Abandon the hole following the procedure outlined in the project work plans.

5.4 Hydropunch® Groundwater Samples

The Hydropunch® sample locations, if conducted in conjunction with CPT data collection, will be located a few feet in the estimated upgradient direction from the previous CPT location. Hydropunch® sampling will be conducted in accordance withthe project work plans. The standard

procedure for Hydropunch® sampling is described below.

5.4.1 Decontaminate the Hydropunch® probe and push/drive rods in accordance with SOP 6.0. If the Hydropunch® model is being used with a small diameter bailer, the bailer and associated equipment must also be decontaminated in accordance with SOP 6.0.

5.4.2 Advance the probe to the target depth, which will commonly be a permeable layer as defined from the adjacent CPT or other stratigraphic information. Depth control is maintained by counting the number of whole and partial push or drive rods used. The Hydropunch® is measured at the tip of the tool and zeroed at the ground surface.

5.4.3 To obtain a groundwater sample, retract the outer jacket of the Hydropunch® probe to allow groundwater inflow into the sample chamber. An optional technique, used to determine when the sample chamber is full as follows:

- Place a surgical glove over the end of the push rod before the outer jacket of the sampler is retracted.
- As water enters the sample chamber and displaces air, the glove will inflate.
- Once the glove stops inflating, water has ceased flowing into the chamber and the sample may be retrieved.

The length of time required for the sample chamber to fill is a function of the relative permeability of the formation and the presence or absence of materials which may clog the filter screen, thereby inhibiting the flow of water.

5.4.4 Retract the probe from the hole, disconnect the push rods from the Hydropunch®, and remove the upper valve. Replace the upper valve with a Teflon™ stop cock valve and a disposable tube (Hydropunch® I). Turn the sampler upside down, open the cock valve and decant the sample into the sample container.

5.4.5 If using the Hydropunch® II model with a small diameter bailer, the water sample is retrieved by lowering the bailer through the inside of the push rod into the sample chamber. The water

recovered in the bailer is then decanted directly into the appropriate sample containers.

5.4.6 If collecting samples for analysis of volatile organic compounds (VOCs), first completely fill the VOC sample vials. Each filled, capped vial will be inverted to ensure no air bubbles are present. If an air bubble is present, the vial will be opened and refilled with an additional sample. The vial will be immediately capped and checked again for bubbles. If air bubbles are still present, the VOC sample vial will be discarded and a new vial used. The VOC sample vial filling procedure is then repeated until no air bubbles are present.

5.4.7 If other sample analyses are required, fill the other sample containers after the VOC sample vials are filled. Samples collected for metals and general minerals analysis will be filled to the base of the bottle neck. Care will be taken not to aerate the sample during transfer from the bailer to the sample bottles and not to overfill bottles containing preservatives. All samples shall be appropriately preserved per the project work plans.

5.4.8 Each sample container to be submitted for analysis will be appropriately labeled. The label will be filled out using waterproof ink and will contain, at a minimum, the following information:

- date and time sample was collected
- sample location
- the initials of the individual conducting the sampling
- any additional required information.

5.4.9 Document the sampling event on the Sample Collection Log or an equivalent form as specified in the project work plans.

5.4.10 Place the labeled vials in seam-sealing plastic bags (i.e., ziplock or equivalent). Seal the bag, removing any excess air, and tape the bag with custody tape so that removal of the sample will cause the tape to be broken.

5.4.11 Conduct a visual inspection of the turbidity of samples and record on the FADL and on the Sample Collection Log to provide a qualitative record of results.

5.4.12 Handle the samples according to procedures outlined in SOP 2.1. For samples submitted to a laboratory for analysis, an Analysis Request and Chain-of-Custody Record shall be completed and

maintained per SOP 1.1 and the project work plans.

5.4.13 After samples are collected, water levels may be measured. For water level measurements using the Hydropunch®, allow enough time for groundwater to fill the sample chamber and the push rods. After static water level conditions are achieved, an electric tape is lowered through the push rods and the water level is measured. Document results on the appropriate form, as specified by the project-specific work plans.

5.4.14 Abandon the hole following the procedure outlined in the project work plans.

5.5 Reporting

The CPT contractor should provide a field survey report of the test data before demobilizing from each location. The CPT contractor should record on the survey report the operator's name, date of the survey, and the CPT location number. The report should include the following:

- descriptions of the various probes and equipment, and the results of calibrations performed;
- profiles of cone tip resistance, sleeve friction resistance, friction ratio, inclination, pore pressures, and differential pore pressure ratio versus depth; and
- a list of the derived geotechnical parameters related to the subsurface conditions, including soil types, standard penetration test blow counts, relative density, and shear strengths.

The report should then be reviewed, approved, and signed by the Program Geologist as identified in the project work plans.

## *6.0 Required Forms*

6.1 Field Activity Daily Log

6.2 Sample Collection Log

6.3 Analysis Request and Chain-of-Custody Record

# HYDRASLEEVE™ SAMPLING OF GROUNDWATER

## STANDARD OPERATING PROCEDURE

### *1.0 Purpose*

This Standard Operating Procedure (SOP) establishes guidelines and procedures for use by field personnel in the collection and documentation of ground water samples by HydraSleeve samplers. Proper collection procedures are necessary to assure the quality and integrity of samples regardless of sampling method. Any variants to these specific procedures and requirements will be provided in the approved project work plans.

HydraSleeve groundwater samplers are considered instantaneous grab-sampling devices designed to collect water samples from groundwater wells without purging or mixing fluid from other intervals. HydraSleeve samplers can be used to sample for most groundwater analytes (e.g., VOCs, SVOCs, and metals) as long as an adequate volume of sample is recovered for analysis. HydraSleeve samplers eliminate the need for purging and disposal of purge water.

HydraSleeve samplers cause no well drawdown and minimal agitation of the water column. The samplers are made from a collapsible tube of polyethylene or other flexible material, sealed at the bottom end, and built with a self-sealing reed-valve at the top end. The HydraSleeve sampler is installed empty into the water column where hydrostatic pressure keeps the device closed except during sample collection. One or more samplers can be suspended on a weighted line and positioned in a well at the desired screen sampling intervals or target horizons. Following sampler deployment, the samplers are left in place long enough for the well water, contaminant distribution, and flow dynamics to restabilize after the minor vertical mixing caused by the installation of the sampler. To obtain a water sample, the HydraSleeve is pulled upward on the suspension line through the zone of interest, which causes water to enter the one-way reed-valve and fill the sampler. The sampler is deployed through use of a weighted line that allows the sampler to be positioned in the screened interval at a location optimized for each individual well.

### *2.0 References*

2.1 ITRC (Interstate Technology & Regulatory Council). 2007. *Protocol for Use of Five Passive Samplers to Sample for a Variety of Contaminants in Groundwater*. DSP-5. Washington, D.C.: Interstate Technology & Regulatory Council, Diffusion/Passive Sampler Team.

2.2 Cordry, K. E. 2006. *HydraSleeve Field Manual*. Las Cruces, N.M.: GeoInsight, Inc.

### *3.0 Responsibilities*

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be

accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 *The Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with this SOP. The QAO is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

3.3 The *Sampling Team Leader(s)* assigned to ground water sampling activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Program Geologist or QAO as appropriate.

## *4.0 Definitions/Materials*

4.1 Sampling Equipment and Materials:

- HydraSleeve sampler(s)
- Sampler weights and measured line,
- Pre-preserved sample containers with labels
- Solvent resistant disposable gloves
- Water level and organic vapor meters as necessary
- Decontamination supplies, as required
- Sample shipping supplies as per SOP 2.0
- Personal protective clothing and equipment, if required by the health and safety plan.
- Field logbook and monitoring well sampling forms

## *5.0 Procedure*

This section contains procedures involved with HydraSleeve sampling. Proper sampling procedures are necessary to insure the quality and integrity of the samples. The details within this SOP should be used in conjunction with project work plans or current scopes of work (SOW) if applicable. The project work plans or SOW will generally provide the following information:

- Sample collection objectives
- Locations of samples to be collected
- Numbers of samples to be collected
- Sample containers and preservation required for each sample type
- Specific quality control (QC) procedures and sampling required
- Any additional sampling requirements or procedures beyond those covered in this SOP, as necessary.

At a minimum, the procedures outlined below for HydraSleeve sampling will be followed.

5.1 SAMPLE COLLECTION PROCEDURES

5.1.1 Prior to sampling and between sampling locations, decontaminate reusable sample equipment, if any, according to SOP 6.0 and any specific procedures outlined in the project work plans.

5.1.2 Handle all sample collection equipment and containers with gloved hands.

5.1.3 For any initial sampling of a well not previously sampled by HydraSleeve, a sampling bag may be placed every five feet of screen interval for the length of the well screen. For each subsequent sampling from that well, a HydraSleeve sampler will be placed in the zone of highest concentration, if any stratification is present, as determined from the original sampling event.

5.1.4 HydraSleeve samplers are deployed by attaching a suspension line to the top and a weight to the bottom of an empty HydraSleeve sampler and lowering the assembly into the well. Attach the HydraSleeve(s) to a deployment line, as indicated in the *HydraSleeve Field Manual* attached to this SOP. For multiple bag deployments (optimization procedures) attach the weight to the lowest HydraSleeve in the series. See Figure 4 under Multiple Interval Deployment in the *HydraSleeve Field Manual*.

5.1.5 Once the HydraSleeve(s) and weight(s) have been assembled, measure the correct amount of line needed to hang the top of the HydraSleeve(s) at the desired sampling depth (in most cases, this will be at the bottom of the sampling zone). It is critical to place the sampler in the same location or depth during each sampling event to maintain sample consistency and data comparability over time. Dedicating the deployment line to the well assures the samples will be collected within the same sampling interval for each event. The upper end of the line can be connected to the well cap to suspend the HydraSleeve at the correct measured depth until activated for sampling.

5.1.6 To collect a groundwater sample without purging, the well must be allowed time to restabilize after placement of the sampler. When any device is lowered into a well, some mixing of the water column occurs. The diameter of the device and its shape affect the degree of mixing. The flat cross section of the empty HydraSleeve minimizes the disturbance to the water column as the sampler is lowered into position, reducing the time needed for the well to restabilize. An empty 2" HydraSleeve with 8 oz. weight displaces ~75 ml, or less than two VOA vials. Mixing of stagnant casing water has been shown to be confined to the top foot of the well screen, which is above the zone being sampled. Restabilization time, if any, will be consistent with the Work Plan for the sampling event.

5.1.7 For sample recovery, the HydraSleeve must move upward at a rate of 1 foot per second or faster (about the speed a bailer is usually pulled upward) for water to pass through the reed-valve into the sample sleeve. The reed-valve must travel about 1–1.5 times the length of the sampler to fill the sleeve. For example, a 30-inch HydraSleeve needs a total upward movement of 30 to no more than 45 inches to fill. The upward motion can be accomplished using one long, continuous pull that moves the reed valve the required distance in the open position. A special technique can be used for sampling low-yield wells. Figures 8 and 9 in the *HydraSleeve Field Manual* depict sample collection with the HydraSleeve and a method for sample collection in low-yield wells.

5.1.8 Detach and remove the HydraSleeve sampler(s) from the weighted line. To transfer a sample

from the HydraSleeve with the least amount of aeration and agitation, use the short discharge tube included with the sampler. First, squeeze the full sampler just below the top to expel water resting above the flexible reed-valve. Then push the pointed discharge tube through the outer polyethylene sleeve about 3-4 inches below the white reinforcing strips. Discharge the sample into the pre-preserved sample containers filling from the most volatile (VOA vials) to the least volatile samples. Raising and lowering the bottom of the sampler or pinching the sample sleeve just below the discharge tube will control the flow of the sample. The sample sleeve can also be squeezed, forcing fluid up through the discharge tube, similar to squeezing a tube of toothpaste.

5.2. SAMPLE HANDLING AND SHIPPING

5.2.1 Appropriately label and number the sample containers per SOPs 2.1 and 2.2, respectively, and the project work plans. The label will be filled out with waterproof ink and will contain, at a minimum, the following information:

- Project number
- Sample number
- Sample location
- Sample type
- Date and time of collection
- Methods for analysis
- Sampler's initials.

5.2.2 Document the sampling event on the Sample Collection Log or an equivalent form as specified in the project work plans. Note any pertinent field observations, conditions or problems on the Field Activity Daily Log. Any encountered problems or unusual conditions should also be immediately brought to the attention of the Sampling Team Leader.

5.2.3 Appropriately temperature preserve, package, and ship the samples per SOP 2.0 and the specific project work plans. The samples shall also be maintained under custody per SOP 1.1.

## *6.0 Required Forms*

6.1 Sample Collection Log

6.2 Field Activity Daily Log

6.3 Chain of Custody Form

Attachment 1

# HydraSleeve Field Manual

# HYDRASleeve

Simple by Design

US Patents No. 6,481,300; No. 6,837,120; others pending

# Field Manual

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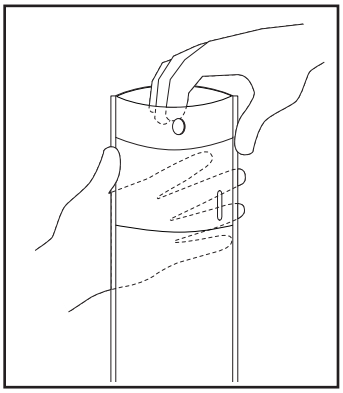
# Introduction

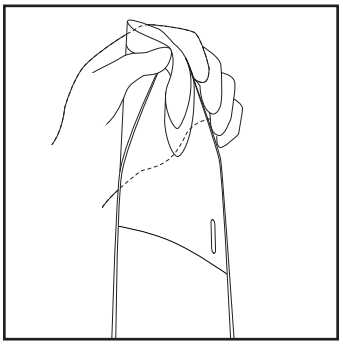
The HydraSleeve groundwater sampler can be used to collect a representative sample for most physical and chemical parameters without purging the well. It collects a whole water sample from a user-defined interval (typically within the well screen), without mixing fluid from other intervals. One or more HydraSleeves are placed within the screened interval of the monitoring well, and a period of time is allocated for the well to re-equilibrate. Hours to months later, the sealed HydraSleeve can be activated for sample collection. When activated, HydraSleeve collects a sample with no drawdown and minimal agitation or displacement of the water column. Once the sampler is full, the one-way reed valve collapses, preventing mixing of extraneous, non-representative fluid during recovery.

# Assembly

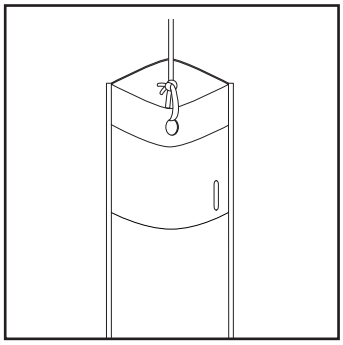
Assembling the HydraSleeve is simple, and can be done by one person in the field, taking only a minute or two.



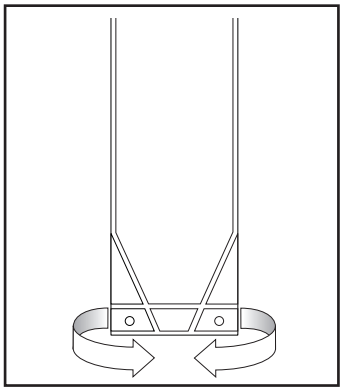
**1** Remove HydraSleeve from package and grasp top to "pop" open.



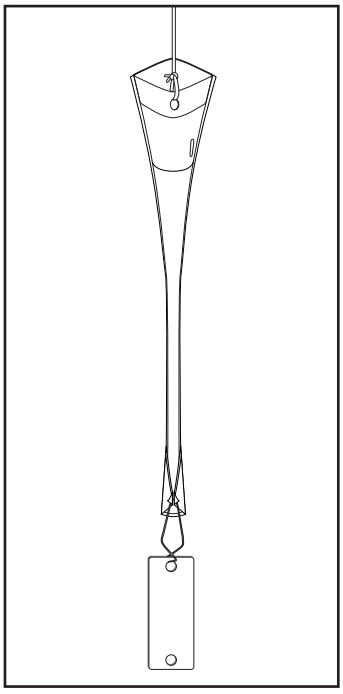
**2** Squeeze side fins together at top to bend reinforcing strips outward.



**3** Attach line to hole at top of HydraSleeve.



**4** Fold the two holes at bottom of HydraSleeve together and attach weight



**5** Sampler is ready to insert into the well.

# Placing the HydraSleeve(s)

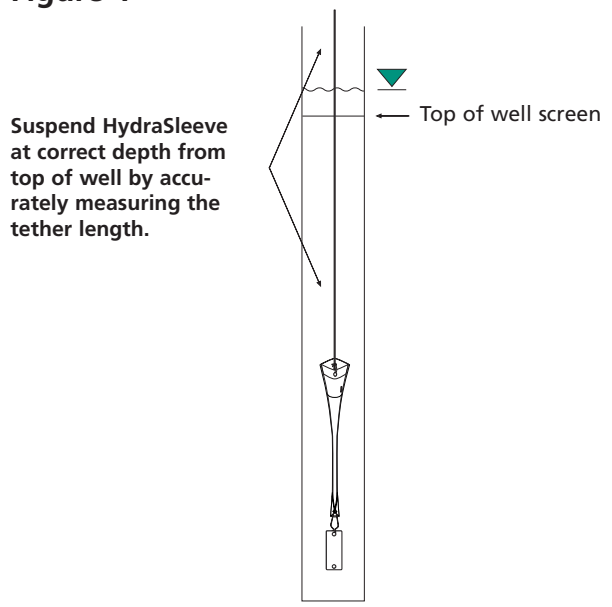
To collect a representative groundwater sample without purging, the well must be allowed time to re-equilibrate after placement of the sampler. When any device is lowered into a well, some mixing of the water column occurs. The diameter of the device and its shape greatly affect the degree of mixing. The flat cross-section of the empty HydraSleeve minimizes the disturbance to the water column as the sampler is lowered into position, reducing the time needed for the well to return to equilibrium.

There are three basic methods for holding a HydraSleeve in position as the well equilibrates.

**TOP DOWN DEPLOYMENT (Figure 1)**
Measure the correct amount of suspension line needed to "hang" the top of the HydraSleeve(s) at the desired sampling depth (in most cases, this will be at the bottom of the sampling zone). The upper end of the tether can be connected to the well cap to suspend the HydraSleeve at the correct depth until activated for sampling.

Note: For deep settings, it may be difficult to accurately measure long segments of suspension line in the field. Factory prepared, custom suspension line and attachment points can be provided.

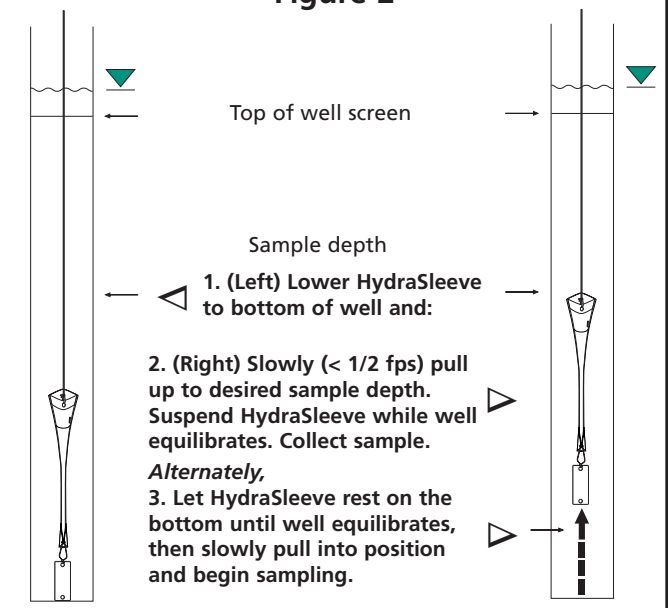
**Figure 1**




**BOTTOM DEPLOYMENT (Figure 2)**
Sound the well to determine the exact depth. Lower the weighted HydraSleeve into the well and let it touch the bottom. Very slowly (less than 1/2 foot per second) raise the sampler to the point where the check valve is at the depth the sample is to be collected. Attach the suspension line to the top of the well to suspend it at this depth. (It is often easier to measure a few feet from the bottom of the well up to the sample point, than it is to measure many feet from the top of the well down.)

Alternately, the sampler can be left on the bottom until the well re-equilibrates. For sampling, it can be very slowly pulled (< 1/2 fps) to sampling depth, then activated (see "Sample Collection," p. 6) to collect the sample, and retrieved to the surface.

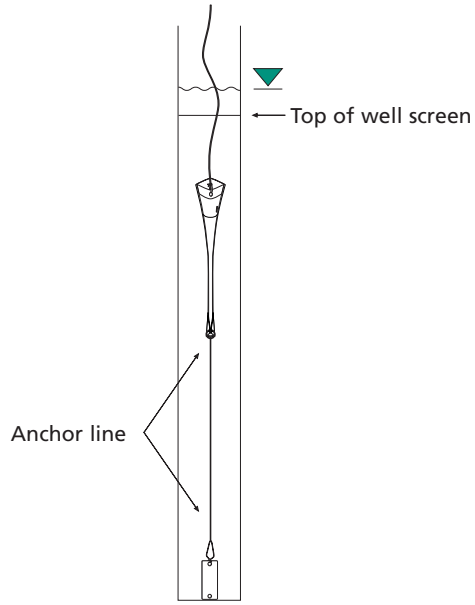
**Figure 2**



**BOTTOM ANCHOR (Figure 3)**

Determine the exact depth of the well. Calculate the distance from the bottom of the well to the desired sampling depth. Attach an appropriate length anchor line between the weight and the bottom of the sampler and lower the assembly until the weight rests on the bottom of the well, allowing the top of the sampler to float at the correct sampling depth.

**Figure 3**



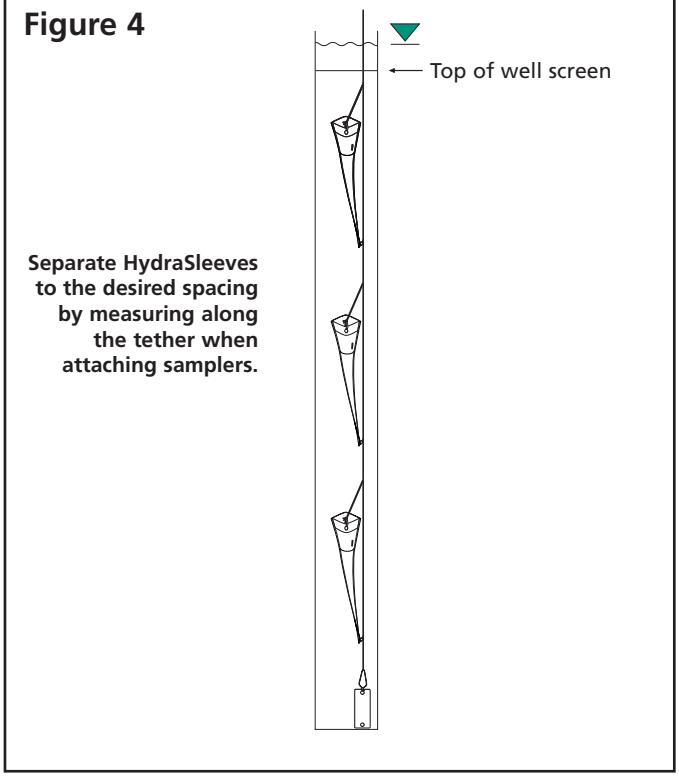
# Multiple Interval Deployment

There are two basic methods for placing multiple HydraSleeves in a well to collect samples from different levels simultaneously.

### ATTACHED TO A SINGLE TETHER (Figure 4)

To use 3 or more samplers simultaneously, we recommend attaching them all to a tether for support to prevent the sampling string from pulling apart. The weight is attached to a single length of suspension line and allowed to rest on the bottom of the well. The top and bottom of each HydraSleeve are attached to the tether at the desired sample intervals. Cable tie or stainless steel clips (supplied) work well for attaching the HydraSleeves to the line. Simply push one end of the clip between strands of the rope at the desired point before attaching the clip to the HydraSleeve.

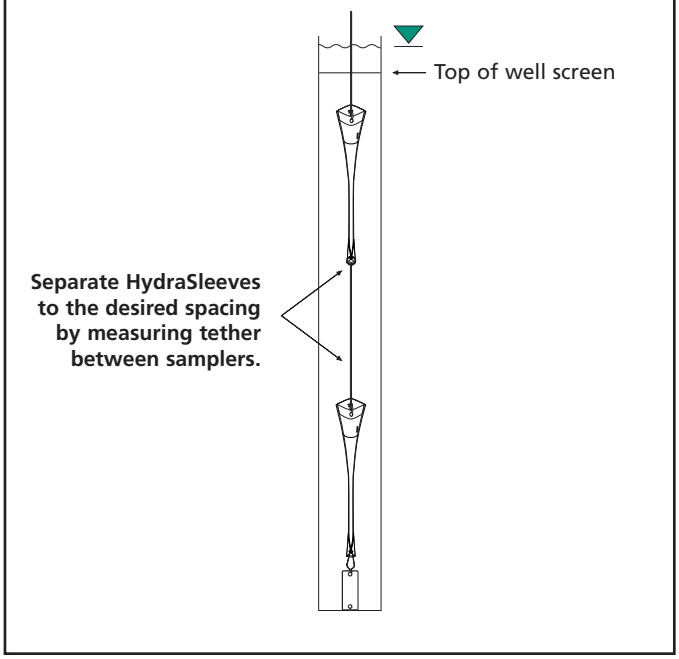
**Figure 4**




### ATTACHED END TO END (Figure 5)

To place 2 or 3 stacked HydraSleeves for vertical profiling, use one of the methods described above to locate the bottom sampler. Attach the bottom of the top sampler to the top of the following HydraSleeve(s) with a carefully measured length of suspension cable. Connect the weight to the bottom sampler. Note: if many HydraSleeves are attached to a tether, more weight may be required than with a single sampler.

**Figure 5**



# Sample Collection

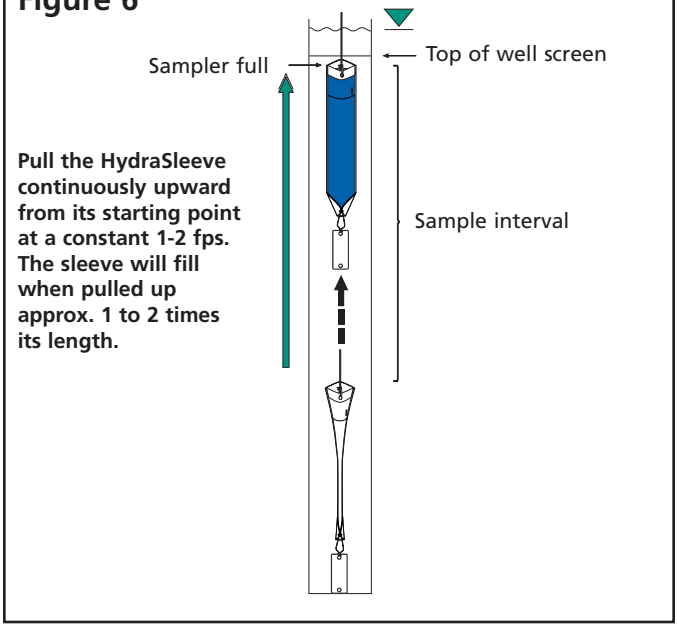
The HydraSleeve must move upward at a rate of one foot per second or faster (about the speed a bailer is usually pulled upward) for water to pass through the check valve into the sample sleeve. The total upward distance the check valve must travel to fill the sample sleeve is about 1 to 2 times the length of the sampler. For example, a 24-inch HydraSleeve needs a total upward movement of 24 to no more than 48 inches to fill. The upward motion can be accomplished using one long continuous pull, several short strokes, or any combination that moves the check valve the required distance in the open position. A special technique is used for sampling low-yield wells.

**CONTINUOUS PULL (Figure 6)**

Pull the HydraSleeve continuously upward from its starting point at a constant 1 to 2 feet per second until full. This method usually provides the least turbid samples and is analogous to coring the water column from the bottom up.

*Note: When using this method, the screen interval should be long enough so the sampler fills before exiting the top of the screen.*

**Figure 6**

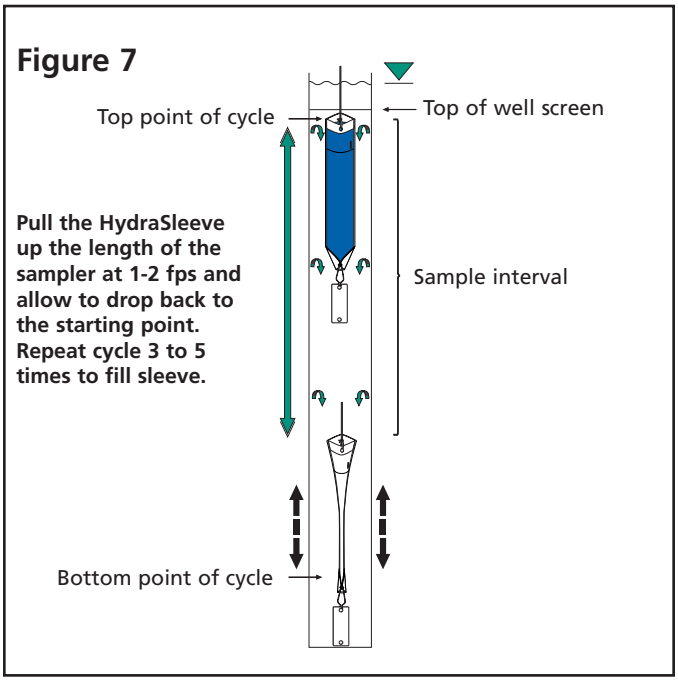



**SHORT STROKES (Figure 7)**

Pull the sampler upward at about 1 to 2 feet per second for the length of the sampler and let it drop back to the starting point. Repeat the cycle 3 to 5 times.

This method provides a shorter sampling interval than the continuous pull method (above), and usually reduces the turbidity levels of the sample below that of numerous rapid, short cycles (below). The sample comes from between the top of the cycle and the bottom of the sampler at its lowest point.

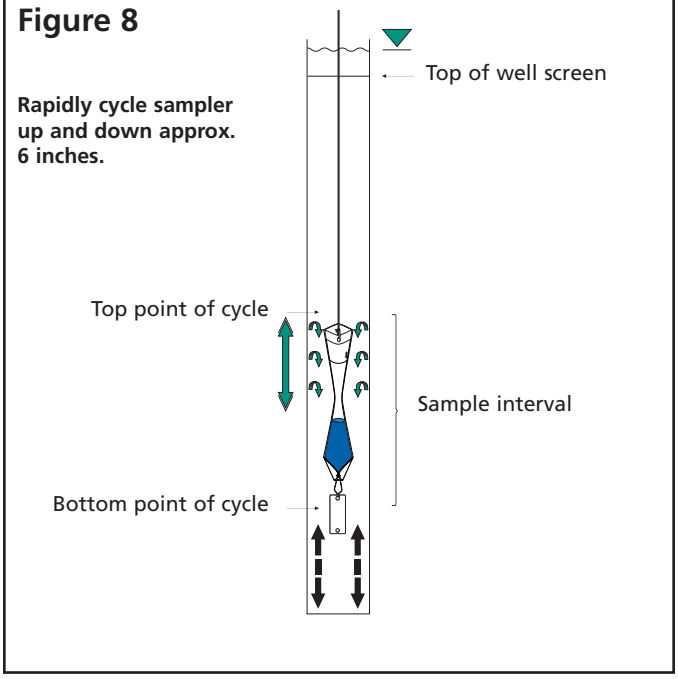
**Figure 7**



## RAPID, SHORT CYCLES (Figure 8)

Cycle the HydraSleeve up and down using rapid, short strokes (6-inch cycle at a minimum of 1 cycle per second) 5 to 8 times. This method provides the shortest sampling interval. Dye studies have shown that when using this method the sample flows into the check valve from along the length of the sampler and immediately above the check valve. The sample interval is from the bottom the sampler at its lowest point in the cycle to the top of the check valve at the peak of the cycle.

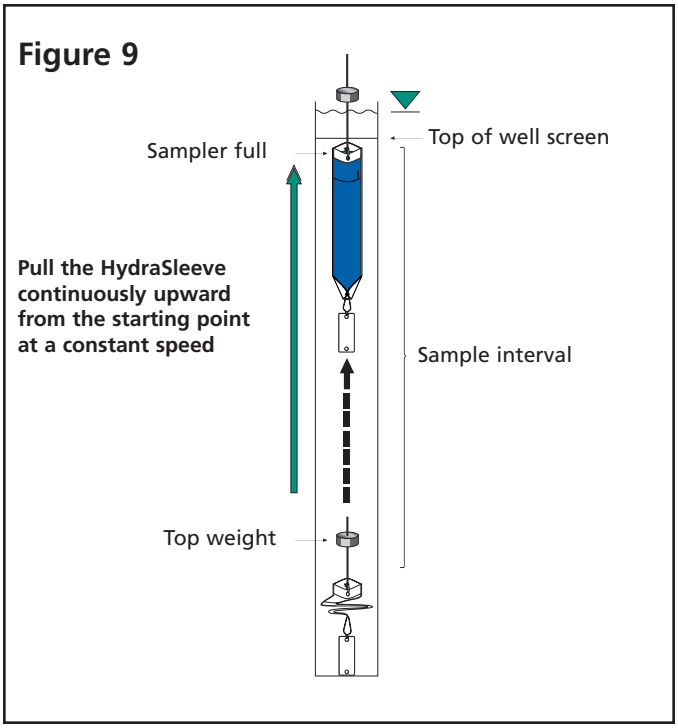
**Figure 8**




## SAMPLING LOW-YIELD WELLS (Figure 9)

HydraSleeve provides the best available technology for sampling low yield wells. When pulled upward after the well re-equilibrates, the HydraSleeve will collect a water core from the top of the sampler to about its own length above that point. The sample is collected with no drawdown in the well and minimal sample agitation. An optional top weight can be attached to compress the sampler in the bottom of the well if needed for an extremely short water column. With a top weight, the check valve is pushed down to within a foot of the bottom of the well.

**Figure 9**



# Sample Discharge

The best way to remove a sample from the HydraSleeve with the least amount of aeration and agitation is with the short plastic discharge tube (included).


First, squeeze the full sampler just below the top to expel water resting above the flexible check valve. (Photo 1, top left)


Then, push the pointed discharge tube through the outer polyethylene sleeve about 3-4 inches below the white reinforcing strips. (Photo 2, middle left)


Discharge the sample into the desired container. (Photo 3, bottom left)

Raising and lowering the bottom of the sampler or pinching the sample sleeve just below the discharge tube will control the flow of the sample. The sample sleeve can also be squeezed, forcing fluid up through the discharge tube, similar to squeezing a tube of toothpaste. With a little practice, and using a flat surface to set the sample containers on, HydraSleeve sampling becomes a one-person operation.

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# LITHOLOGIC LOGGING

## STANDARD OPERATING PROCEDURE

## 1.0 Objective

The objective of this procedure is to define the requirements necessary for borehole and sample logging. The major objective of this procedure is to provide a uniform set of guidelines that will aid in developing consistency among sample descriptions and sample techniques. The importance of accurate, complete, clear, and concise logs cannot be overemphasized.

## 2.0 Background

Borehole logging is used to determine the geologic relationships of subsurface soil and rock formations. The relationship of geologic formations and features is important in describing groundwater flow and in determining probable contaminant migration pathways.

## 3.0 Responsibilities

*Field Geologist*: The Field Geologist is responsible for on-site monitoring of drilling and soil sampling operations, for recording (logging) pertinent information regarding the geologic materials penetrated during the operations, and that the well and sample numbering system is consistant with the site specific SAP.

## 4.0 Required Equipment

1. Clipboard
2. Drilling record forms
3. Portable organic vapor detector
4. Field book, straight edge and black permanent ink
5. Foot engineer's tape (weighted)
6. Folding rule or tape measure
7. Sand gauge
8. Color chart
9. Acid bottle
10. Water level indicator
11. Site map
12. Copy of drilling contract

13. Waterproof marking pen
14. Sample jars or bags

4.1 Optional Equipment

1. Hand lens
2. Brunton compass
3. Pocket penetrometer
4. Equipment pouch
5. Flagging tape
6. Cooler and water bottles
7. Flashlight
8. Rock hammer

## *5.0 Procedure for Filling out Soil Boring/Well Log*

This form is intended for use in the field during the drilling, sampling, and logging process for soil borings and wells. Most of the items can be neatly and legibly included in the field; however, some items, such as the graphic log column, may be reserved for completion in the office. The purpose of the log is to clearly document the events and findings of the drilling activity. All pertinent data related to boring/drilling operations must be concisely recorded as objectively as possible. The subcontractor has the option to resubmit this form in a deliverable as a completely redrafted/typed form, or as a combination of information applied in the field and in the office. Regardless, the original field log should be retained in the permanent file. Any alterations or changes between the office copy and the original should be justified. To complete the boring or well logs:

- Fill out information on header of the log noting either boring or well number, if well is to be installed. Use the sampling site identification number.
- Note number under "Location".
- Note start and end date of boring or well installation under "Date", use MM/DD/YY format.
- Briefly describe wind direction, speed, and temperature under "Weather".
- The logging geologist or engineer should include his name under "Logged by", include three initials.
- The driller's name and drilling company should be included under "Drilled by", include three initials for the driller’s name.

- "Drilling method" should contain information such as hollow-stem auger and auger inside diameter. If using rotary methods, include size of bit and rotary method used.
- "Sampling method" should be described as length of sampler and type, i.e., 2.5´ split spoon. The sampling method should be described such that it is easily translatable to one of the following codes at time of data entry:

| | | |
|---|---|---|
| ___ | B | Bail |
| ___ | C | Composite grab |
| ___ | G | Single grab |
| ___ | P | Pump |
| ___ | S | Split-spoon core sampling |
| ___ | T | Shelby tube core sampling |
| ___ | U | Soil auger |
| ___ | X | Composite core sample |
| ___ | Z | Scraping from physical surface |
| ___ | 1 | Magnetometer (UXO survey) |
| ___ | 2 | Well sampler |
| ___ | 9 | Trip and rinse blanks |

- "Gravel pack" should include the depth interval of gravel pack installation, sieve filter size, and type, i.e., 50´-39´, 20-40 Colorado silica.
- "Seal" The seal should describe the depth interval of seal above the gravel pack and type. The seal should also describe the depth interval of grout slurry, e.g.,

___ 39´ - 34´ - Bentonite pellets

___ 34´ - 0´ - Bentonite/grout slurry

Under the header of casing, the casing description will require the following:

- "Type" Schedule 40 polyvinyl chloride (PVC), stainless steel etc.
- "Diameter" The information supplied here will bereported in inches (usually 4 inch).
- "Length" The length of casing or riser should include stick-up at the surface.

Under the heading of screen, the well screen will require the following information:

- "Type" Same as in type above.
- "Slot" The screen slot size. For silts and fine-grained sands, the slot size will be 0.01 inch. For sands medium to coarse grained, the slot size will be 0.02 inch.
- "Diameter" The diameter for well screens reported in inches (usually will be 4 inch).
- "Length" The length of the well screen in reported feet.
- "Hole Diameter" The diameter of hole cut by either a rotating bit or auger cutting head. Reported in inches.
- "Total Depth" The total depth drilled (in feet). If sampled deeper than depth drilled, this should be noted at the bottom of the log.
- "Location Map" A sketch of the boring location should be constructed in this corner.
- Topographical setting will be one of the following:

  ___ DEPR Local depression

  ___ DTCH Drainage ditch

  ___ DUNE Dunes (mound, ridge, or hill of windblown sand; bare or covered with vegetation)

  ___ FLAT Flat surface

  ___ HLSD Hillside slope

  ___ HLTP Hilltop

  ___ PDMT Pediment (broad, gently sloping erosion surface or plain of low relief, typically developed by running water, in an arid or semiarid region at the base of an abrupt and receding mountain front, often mantled with a thin discontinuous veneer of alluvium)

  ___ TRCH Trench (a long, narrow excavation, natural or artificial)

  ___ VALY Valley - flat valleys of all sizes
- "Surface cover" will be bare, wooded, or grassy.

Below the header are lithology/remarks and sample classifications. The following sample classifications should be described as follows:

- "Moisture Content" (Clays and Sands)

  ___ Dry
  ___ Damp
  ___ Moist (compactable)
  ___ Wet (not Compactable)
  ___ Saturated

- "Sorting" (Sands only)

  ___ Very well
  ___ Well
  ___ Moderately
  ___ Poorly
  ___ Very poorly

- "Density" or consistency (CONSS) (Sands and Clay) Density is described by the number of drops required by a 140 lb. hammer over 30 inches to drive a 2-inch outside diameter, 1 3/8 inch inside diameter, split-spoon 6 inches. The following is a description of soil consistency (density):

| Sand or Gravel | (Blows/ft.) | Silt or Clay | (Blows/ft.) | Thumb Penetration |
|---|---|---|---|---|
| VL (Very Loose) | 0-4 | VSO (Very Soft) | 0-2 | Very easy-inches |
| L (Loose) | 4-10 | SO (Soft) | 2-4 | Easily inches |
| MD (Medium Dense) | 10-30 | M (Medium Soft) | 4-8 | Moderate effort-inches |
| D (Dense) | 30-50 | ST (Stiff) | 8-15 | Indented easily |
| VD ( Very Dense | > 50 | VST (Very Stiff) | 15-30 | Indented by nail |
| | | H (Hard) | > 30 | Difficult by nail |

- Other descriptions may include:

  ___ NC (Noncemented)
  ___ PC (Poorly cemented)

- "`Plasticity" Plasticity refers to the case in which cohesive soils are molded. The following describes the plasticity terms.

___ EXTREMELY HARD, resistant to pressure, not broken by hand
___ NONPLASTIC, not wire formable
___ SLIGHTLY PLASTIC, wire formable but soil remains easily deformed
___ PLASTIC, wire formable, moderate pressure required
___ VERY PLASTIC, wire formable, much pressure required

- "Sample Number" In this column, record the number order that the sample was taken.
- "TIP Reading" Refers to "Total Ionizables Present". Record the headspace reading here and the type of instrument used, i.e., HNU, OVM, etc.
- "Sample Recovery" After obtaining a split-spoon sample or Shelby sample, measure the length of recovered sample to the nearest 0.01´ and record level.
- "Penetration Resistance" The blow counts for every 6 inches of driving the sample are to be recorded under this heading.
- "Color" The Munsell soil color or Geological Society of America soil color codes (COLOR) are a combination of the hues, values, and colors listed below:
  ___ - Hue: 2Y, 2YR, 5B, 5BG, 5G, 5GY, 5P, 5PB, 5R, 5RP, 5Y, 5YR, 7R, 7YR, 10G, 10GY, 10R, 10Y, 10YR, N
  ___ - Value: 0 - 9
  ___ - Color: 0 - 8 (not used when hue is "N")

A Munsell color chart will be available for color determination.

- "USCS Classification/Lithology/Grain Size, Modifications/Remarks" The predominant lithology or lithologies should be identified first in capital letters, followed by qualifying adjectives that define grain size, color (using a Munsell chart), mineralogy, structural/textural features, bedding and laminations. For mixed lithologies within a common interval, provide relative percentages of the two or more lithologies within parenthesis following the lithologic name. For example, Sand (fine-medium [60%]) brownish yellow (10 yr. 6/6), and Gravel coarse (40%) very pale brown (10 yr. 7/3). Any obvious features related to evidence for contamination, such as odor or staining, should be documented. Drilling comments and occurrences should also be noted under this section. The acceptable codes, based on Unified Soil Classification System (USCS) augmented by lithology and special codes, are identified in Table 1. Codes for grain size (soil) are listed below:

| Action or Measurement | | Acceptable Entries | |
|---|---|---|---|
| **Code** | **Description** | **Code** | **Description** |
| GRAIN | Grain size (soil) | For soils: | |
| | | C | Coarse |
| | | CF | Coarse to fine |
| | | F | Fine |
| | | FM | Fine to medium |
| | | LG | Large |
| | | vM | Medium |
| | | MC | Medium to coarse |
| | | SMALL | Small |
| | | VC | Very coarse |
| | | VF | Very fine |

Rock texture codes are available, but have not been included here since they are not expected.

## Table 1

## Soil Classification and Lithology

| Action or Measurement | | Acceptable Entries | |
|---|---|---|---|
| **Code** | **Description** | **Code** | **Description** |
| USCS | Unified Soil Classification System augmented by lithology and special codes | | Separate dual USCS codes by a hyphen. |
| | | USCS Codes: | |
| | | CH | Fat clay, inorganic clay of high plasticity |
| | | CL | Lean clay, sandy clay, silty clay, or low to medium plasticity |
| | | GC | Clayey gravel, gravel-sand-clay mixtures |
| | | GM | Silty gravel, gravel-sand-silt mixtures |
| | | GP | Gravel, poorly graded, gravel-sand mixtures, little or no fines |
| | | GW | Well graded gravel-sand mixture, little or no fines |
| | | MH | Silt, fine sandy or silty soil with high plasticity |
| | | ML | Silty and very fine sand, silty or clayey fine sand or clayey silt with slight plasticity |
| | | OH | Organic clays of medium to high plasticity, organic silts |
| | | OL | Organic silts and organic silty clays of low plasticity |
| | | PT | Peat or other highly organic soil |
| | | SC | Clayey sand, sand-clay mixtures |
| | | SI | Shells |
| | | SM | Silty-sand, sand-silt mixtures |
| | | SP | Sand, poorly-graded, gravelly sands |
| | | SW | Sand, well-graded, gravelly sands |
| | | WD | Wood |
| | | Special Codes: | |
| | | ASH | Ash |
| | | ASPHLT | Asphalt (road material) |
| | | CONC | Concrete |
| | | CRLMSN | Crushed limestone |
| | | FILL | Unknown man-made landfill material |
| | | LC | Lost core |
| | | NR | No recovery |
| | | NTLOGD | Not logged |

| | |
|---|---|
| RUBBLE | Construction debris rubble or demolition fill |

## Table 1
## Soil Classification and Lithology
## (continued)

| Action or Measurement | | Acceptable Entries | |
|---|---|---|---|
| **Code** | **Description** | **Code** | **Description** |
| USCS (continued) | Unified Soil Classification System augmented by lithology and special codes | VOID | Void or cavity |
| WSTAT | Final status of the well | CB | Well filled with grout: cement-bentonite |
| | | FB | Well filled with bentonite |
| | | FC | Well filled with concrete |
| | | FG | Well filled with gravel |
| | | FS | Well filled with soil |
| | | NC | Well filled with grout: neat cement |
| | | O | Open well |
| | | OP | Open well with piezometer or observation well installed |
| | | WD | Well damaged |
| MODIF | Lithology modifications | B | Boulders |
| | | BDWX | Badly weathered |
| | | CAL | Calcareous |
| | | CARB | Carbonaceous |
| | | CC | Concretions |
| | | CEM | Cemented |
| | | CHE | With chemicals (based on headspace reading) |
| | | CL | Clayey |
| | | CS | Clay strata or lenses |
| | | DCOLOR | Discolored |
| | | FAULT | Faulted |
| | | FECC | Iron concentrations |
| | | FILL | Disturbed soil |
| | | FRACT | Fractured |
| | | FRIA | Friable |
| | | G | Gravelly |
| | | HPL | Highly plastic |
| | | IRNST | Ironstained |
| | | LIG | Lignite fragments |
| | | MICA | Micaceous |
| | | ML | Silty |

**Table 1**
**Soil Classification and Lithology**
**(continued)**

| Action or Measurement | | Acceptable Entries | |
|---|---|---|---|
| **Code** | **Description** | **Code** | **Description** |
| MODIF (continued) | Lithology modifications | SH | Shale fragments |
| | | MOT | Mottled |
| | | O | Organic matter |
| | | ODOR | Odiferous |
| | | OX | Oxidized |
| | | PL | Plastic |
| | | ROUND | Rounded |
| | | RT | Rootlets |
| | | S | Sandy |
| | | SDL | Sandstone lenses |
| | | SDS | Sandstone fragments |
| | | SHLN | Shale lenses |
| | | SHLY | Shaly |
| | | SIS | Silt strata or lenses |
| | | SL | Slickensides |
| | | SLF | Shell fragments |
| | | SLWX | Slightly weathered |
| | | SO | Solid |
| | | THSK | Thin streaks |
| | | TR | Trace |
| | | TRCL | Trace of clay |
| | | TRG | Trace of gravel |
| | | TRML | Trace of silt |
| | | TRMN | Trace of manganese |
| | | TRS | Trace of sand |
| | | WCL | With clay |
| | | WFE | With iron oxide |
| | | WG | With gravel |
| | | WGML | With gravel and silt |
| | | WLAM | With laminations |
| | | WML | With silt |
| | | WS | With sand |
| | | WX | Weathered |

## *6.0 Required Forms*

6.1 Soil Boring Log Forms

# AQUIFER TESTING

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for conducting aquifer testing. Proper testing guidelines and procedures are necessary to ensure effective evaluation of aquifer parameters and characteristics. Additional specific aquifer testing procedures and requirements will be provided in the project work plans.

## 2.0 References

2.1 F.G. Driscoll, 1986, Groundwater and Wells, Johnson Filtration Systems Inc., St. Paul, Minnesota.

2.2 C.W. Fetter, 1988, Applied Hydrogeology, Second Edition, Merrill Publishing Co., Columbus, Ohio.

2.3 R.C. Heath, 1987, Basic Ground-Water Hydrology, U.S. Geological Survey Water-Supply Paper 2220, Denver, Colorado, pp 34-50.

2.4 S.W. Lohman, 1979, Ground-Water Hydraulics, U.S. Geological Survey Professional Paper 708, Denver, Colorado, pp 11-56.

2.5 U.S. Department of the Interior Water and Power Resources Service, 1981, Ground Water Manual, New York, New York, pp 225-246.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all aquifer testing activities are conducted and documented in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with this SOP. The QAO is also responsible for the implementation of corrective action (i.e., retaining personnel, additional review of work plans and SOPs, variances to aquifer testing requirements, issuing nonconformances, etc.) if problems occur.

3.3 *The Sampling Team Leader(s)* and assigned to aquifer testing activities are responsible for

completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from the procedures to the Program Geologist.

## *4.0 Definitions/Materials*

4.1 Aquifer Testing - Refers to physical testing methods used to determine the hydrologic characteristics of confined or unconfined aquifers. Slug, specific capacity, step-drawdown and constant rate pump tests are commonly used testing methods. Slug tests are conducted by instantaneously changing the water level in a well by adding, removing or displacing a known volume of water and then monitoring the water level recovery in the well.

Specific capacity tests are short-term single-well pump tests that are useful in highly transmissive units which preclude slug testing. The method consists of measuring the stabilized drawdown in the well while pumping at a constant discharge. Specific capacity tests can be conducted immediately after well development, utilizing the pump used for the development. While less accurate than long-term multi-well pumping tests, the tests provide fast and easy to interpret data for estimating hydraulic conductivity and transmissivity.

Step-drawdown tests are used to estimate well performance, determine a sustainable optimum pumping rate for the well, and estimate aquifer properties. The test is conducted by pumping the well at several successively higher rates and measuring the corresponding water level drawdown.

The constant rate pump test method involves discharging water at a constant rate from a well by pumping and monitoring the corresponding water level drawdown. The recovery of water levels in the well may also be monitored after pumping is terminated (recovery test). Water level monitoring during a pumping and recovery test commonly includes the pumping well and one or more nearby observation wells. In certain instances, observation wells are not available and water level monitoring is limited to only the pumping well.

4.2 Cone of Depression - A depression in the groundwater table or potentiometric surface that has the shape of an inverted cone around a well from which water is being withdrawn.

4.3 Confined or Artesian Aquifer - An aquifer that is overlain and underlain by confining layers of lower hydraulic conductivity and, at a given point, the total head of the aquifer is higher than the base of the upper confining layer.

4.4 Drawdown (s) - The difference between the height of the static water level and that of the water level in a well during pumping or water withdrawal. Or, in a confined aquifer, the reduction of the pressure head as a result of the withdrawal of free water.

4.5 Discharge (Q) - Volume of water removed per unit of time ($l^3/t$).

4.6 Electric Well Tape or Electric Tape - A water level measuring device that uses a light, or sounds a buzzer, to show that the end of the tape has entered the water. The water in the well completes an electric circuit that turns on the light or sounds a buzzer. The tape is graduated to show the depth.

4.7 Flow Regulator - Flow regulators (flow controllers) are used to control the discharge rate (in volume/time) of water from the well while pumping. The discharge from the mechanical pump is normally set at a constant rate.

4.8 Hydraulic Conductivity (k) - A quantitative measure of the ability of a porous material to transmit a fluid. Also defined as the volume of water that will flow through a unit cross-sectional area of porous material per unit time under a unit hydraulic gradient (l/t). Hydraulic conductivity is dependent upon properties of the material and fluid.

4.9 Measuring Point - A fixed and clearly identified point of reference from which water levels in a monitoring well may be measured. It is generally established on the upper rim of the outer protective well casing and has a surveyed location and elevation.

4.10 Mechanical Pump - An electric-powered water pump used to withdraw water from the well during a pumping test.

4.11 Observation Well - A non-pumping well used to observe the groundwater levels during pump testing.

4.12 Potentiometric Surface - The surface defined by water levels from multiple tightly cased wells that penetrate an aquifer or hydrogeologic unit. Also, a map of the hydraulic head of an aquifer.

4.13 Pressure Transducer and Data Logger - An electric sensor that can accurately measure hydrostatic pressure. By relating hydrostatic pressure to depth below the water level, the water level

can be electronically measured as the transducer is held in the water. Periodic water level measurements can be stored by the data logger for later recall and data evaluation.

4.14 Recovery - The time rate of return to the static water level during a slug test or after cessation of pumping. This is related to the aquifer's response to the change in water level during the aquifer test. After the water level has been raised or lowered by raising or lowering the slugging rod, or after the pump is turned off during a pumping test, the water will return to static conditions (static water level).

4.15 Saturated Thickness (b) - For unconfined aquifers, the interval between the water table and base of the unconfined water bearing unit. For confined aquifers, the interval between the base of the upper confining unit and the top of the lower confining unit.

4.16 Slugging Rod - A large metallic or PVC rod (or cylinder) of known volume that is lowered into the well to displace the water during a slug test. Sometimes called a "pig".

4.17 Specific Capacity (C) - Discharge per unit of drawdown in a pumping well (Q/s).

4.18 Specific Yield (Sy) - The ratio of the volume of water that saturated soil or rock will yield under the influence of gravity, per unit volume of the saturated soil or rock. Specific yield is dimensionless.

4.19 Storage Coefficient or Storativity (S) - The volume of water that an aquifer releases from, or takes into storage per unit area of aquifer, per unit change in head. Storage coefficient is dimensionless.

4.20 Transmissivity (T) - A quantitative measure of the ability of an aquifer to transmit water. It is the product of the hydraulic conductivity and saturated thickness ($k \bullet b$) ($l^2/t$).

4.21 Unconfined Aquifer - An aquifer in which the water table forms the upper boundary.

4.22 Water Level - The position of the air-water interface in a well. The water level is usually measured as the depth to the water from a measuring point (such as the top of the outer protective well casing) by the use of a weighted measuring tape or electric sounder. Changes in the water level over time may also be monitored by a pressure transducer installed at a known depth within the water column inside the well. The water level is called the static water level when it is not

influenced by well drilling activities, aquifer testing, well development, or groundwater sampling.

4.23 Water Table - The saturated zone surface at which the pore water pressure is equal to atmospheric pressure. The water table is the potentiometric surface for an unconfined aquifer.

4.24 Wellhead Flow Meter - A meter installed in the water discharge line near the well head to measure the discharge (in volume/time) of water by the mechanical pump and controlled by the flow regulator.

## *5.0 Procedure*

This section contains requirements and procedures for conducting aquifer testing. Slug, specific capacity, and pump tests are commonly used testing methods to determine the hydrologic characteristics of confined and unconfined aquifers. Consequently, these methods are covered in this section.

All aquifer testing to be conducted at a site must incorporate and be tailored to:

- Known or expected site-specific conditions
- Targeted parameters to be evaluated
- Analysis methodology(ies) to be conducted with the test data

Consequently these factors must be considered and the tests designed well before generation of the project work plans and implementation in the field. The project work plans will specify all necessary details to complete the aquifer testing at the particular site. Aquifer testing information and specifications to be included in the project work plans will include at a minimum the following:

- Objectives of the aquifer testing
- Aquifer parameters to be evaluated
- Type(s) of aquifer tests to be conducted
- Exact wells to be used for aquifer testing
- Equipment to be used
- Type, duration and frequency of measurements to be made
- Additional procedures or requirements beyond those covered in this SOP

At a minimum the following requirements and procedures described in the following section must

be incorporated into the aquifer testing to be conducted at each site.

5.1 Slug Test Method

A slug test is an aquifer test in which the water level in a well is instantaneously changed by removing, adding, or displacing a known volume of water. The water level response is monitored over a period of time in the slugged well. The water level response is generally proportional to aquifer transmissivity and hydraulic conductivity.

A known volume of water can be removed relatively rapidly from the well with a submersible pump or bailer. Potable water can be added rapidly to a well by directly dumping from barrels or Baker™ tanks. However, the most common method used in environmental projects involves the insertion and removal of a solid slugging rod (or pig) which instantaneously displaces the water level inside the well.

During testing, water levels may be measured with an electric tape if the wells recharge slowly. However, pressure transducers (with associated data loggers) are more commonly used to measure water levels as they can record a large number of measurements on a more rapid basis. Many brands of transducer/data logger packages have the ability to pre-program the rate of measurement, obtaining frequent measurements during the initial portions of the test and less frequent measurements near the end of the test as the water level slowly stabilizes.

The procedures described below are written for use with a slugging rod and pressure transducer/data logger during slug testing. The procedures also cover both slug insertion and slug withdrawal portions of slug testing. In certain instances only the slug withdrawal test data are used for analysis. However, it is advisable to still conduct the slug insertion test even if only using the withdrawal test data for evaluation of aquifer parameters. The slug insertion test can provide information to make necessary adjustments to the withdrawal test in the field.

The procedures described below are readily adaptable for the other slug testing methods. The project work plans will outline specific slug testing methods and procedures to be used.

5.1.1 Any newly installed wells to be slug tested must be developed before commencement of slug testing activities.

5.1.2 Inspect the equipment to ensure that it is in good working order. Aquifer slug test equipment will vary widely depending on the formation, other site conditions, the diameter and depth of the

wells, and the number of the wells to be tested. The project work plans will outline the type of equipment to be used.

5.1.3 All measuring and testing equipment (M&TE) used for field activities will be calibrated by the equipment manufacturer or an approved calibration laboratory using standards which are traceable to the National Institute of Standards and Technology (NIST). Certificates of calibration for M&TE will be obtained from the M&TE supplier and kept in the project files. No M&TE will be utilized without verification of calibration certification.

5.1.4 Decontaminate all downhole equipment according to SOP No. 6.0. In the event that the contaminant histories of the wells to be tested are known or anticipated, the slug tests should be performed starting with the least contaminated well and ending with the most contaminated. Also, it is recommended to cut and remove braided rope or line that has been submerged during slug testing of one well before moving on to another well. These practices will reduce the potential for cross-contamination between wells.

5.1.5 Visually inspect and access the wellhead per SOP No. 5.0.

5.1.6 Obtain a water level depth measurement and sound the bottom of the well according to the procedures outlined in SOP No. 5.0. Compare the measured total depth to the bottom of the well with the well construction diagram to determine if sediment is in the bottom of the well. It is important not to set the pressure transducer in the sediment.

5.1.7 Calculate the height of the water column in the well as follows:

$(h_1 - h_2)$ = height of water column in well

where

$h_1$ = total depth of well from top of casing (in feet)
$h_2$ = depth to water from top of casing (in feet)

The height of the water column should be sufficient to totally immerse the slugging rod and also allow concurrent use of a pressure transducer or other measuring equipment during the testing.

5.1.8 Connect the pressure transducer to the data logger. Install the pressure transducer in the

water column to a depth that will not interfere with the insertion or withdrawal of the slugging rod during testing, but also not exceed the maximum head limitation of the transducer.

5.1.9 Obtain a barometric pressure measurement if testing (recovery of water level) is expected to take longer than 30 minutes. Station barometric pressure may be recorded from on-site equipment or obtained from a local weather station.

5.1.10 Turn on the pressure transducer/data logger and set the recording frequency (frequency that recorder stores data measured from the transducer and displays a reading) for pre-test monitoring to that specified by the project work plans.

5.1.11 Measure the water level with an electric tape (or equivalent) and record along with the measurement time. Commence pre-test monitoring with the pressure transducer/data logger. The total length of time over which the pre-test measurements are made will be specified in the project work plans. In general, the total time should be roughly equal to or greater than twice the length of time expected to run the slug test.

5.1.12 Once the pre-test monitoring period is ended, remeasure the water level using the electric tape and record along with the measurement time.

5.1.13 Change the recording frequency on the data logger for the slug-in test as specified in the project work plans. Lower the slugging rod to just above the static water level. Concurrently start the data logger and lower the slugging rod as quickly as possible to a depth below the static water level. Record the time of initiation of the test on the appropriate form as outlined in the project work plans.

The slugging rod should be completely submerged. However, it is best to lower the rod only enough to make sure it is submerged and not more. This will reduce the chance of pinching the transducer cables, dragging the transducer, or sticking the rod.

5.1.14 Continue to monitor water level decline with the pressure transducer/data logger, taking periodic water level measurements with the electric tape. Data logger and tape readings should be conducted in accordance with the schedule outlined in the project work plans.

5.1.15 The slug-in test may be terminated once the water level has declined to within 90 percent of the pre-test static, or as specified in the project work plans. Once the slug-in test is terminated, take a physical water level measurement with the electric tape. Record the measurement and time on the appropriate form. Continue on to the slug withdrawal ("slug-out") test.

5.1.16 The slug withdrawal test should not be initiated until the water level has recovered to within 90 percent of static or as specified in the project work plans.

5.1.17 Remeasure the water level using the electric tape and record along with the time.

5.1.18 Change the recording frequency on the data logger to the appropriate frequency of data recording for the slug withdrawal test. The recording frequency will be specified in the project work plans, but may be modified based upon a review of the slug-in test data. Concurrently with starting the data logger, immediately raise the slugging rod as quickly as possible such that the rod is completely out of the water column and above the static water level. Record the test initiation time on the appropriate form as outlined in the project work plans.

5.1.19 Continue to monitor water level rise with the pressure transducer/data logger, taking periodic water level measurements with the electric tape. Data logger and tape readings should be conducted in accordance with the schedule outlined in the project work plans and/or based upon a review of the slug-in test data.

5.1.20 The slug-out test may be terminated once the water level has risen to within 90 percent of the pre-test static or as specified in the project work plans. Once the slug-out test is terminated, take a physical water level measurement with the electric tape. Record the measurement and time on the appropriate form.

5.1.21 The data should be reviewed in the field to help ensure the validity of the test. Complete all documentation on the appropriate form as outlined in the project work plans.

5.1.22 The slug-in and slug-out tests may be repeated as necessary, and as required by the project work plans.

5.1.23 Once all tests are satisfactorily completed for the well, all downhole equipment may be removed and the wellhead secured.

5.2 Specific Capacity Testing

Specific capacity tests are short-term single-well aquifer tests that are useful in highly transmissive units which preclude slug testing. The method consists of measuring the stabilized drawdown in the well while pumping at a uniform rate. The tests may be conducted in monitoring, extraction and injection wells. Specific capacity tests can be conducted at the end of well development, using the pump utilized for development. While less accurate than long-term multiple well pumping tests, specific capacity tests provide fast and easy to interpret data for estimating hydraulic conductivity and transmissivity in the immediate vicinity of the well being tested.

5.2.1 Newly installed wells to be specific capacity tested must be developed before commencement of testing activities.

5.2.2 Inspect the equipment to ensure that it is in good working order. Specific capacity test equipment may vary widely depending on the formation and site conditions, the diameter and depth of the wells, and the number of the wells to be tested. The project work plans will outline the type of equipment to be used. This step may be skipped if the specific capacity testing is to be conducted immediately after development, using the development equipment.

5.2.3 All measuring and testing equipment (M&TE) used for field activities will be calibrated by the equipment manufacturer or an approved calibration laboratory using standards which are traceable to the National Institute of Standards and Technology (NIST). Certificates of calibration for M&TE will be obtained from the M&TE supplier and kept in the project files. No M&TE will be utilized without verification of calibration certification.

5.2.4 Decontaminate all downhole equipment according to SOP No. 6.1. If specific capacity testing is to be conducted immediately after development using the same equipment, and the equipment has not been removed from the well site, then the equipment may not have to be decontaminated for the testing.

In the event that the contaminant histories are known or suspected for the wells to be tested, the tests

may then be performed starting with the least contaminated and ending with the most contaminated. This will reduce the potential for cross-contamination between wells.

5.2.5 Visually inspect and access the well per SOP No. 5.0.

5.2.6 Obtain a water level depth measurement and sound the bottom of the well according to the procedures outlined in SOP No. 5.0. Compare the measured total depth to the bottom of the well to the well construction diagram to determine if sediment is in the bottom of the well.

5.2.7 Install the mechanical pump in the well using the manufacturer's instructions. Place the pump in the well so that the pump intake is near the bottom of the well screen or location of water entry into the well. Note the height of the water column from the static water level to the pump motor housing and intake. Record all information on the appropriate form as specified by the project work plans. During testing, the drawdown should not be so great as to cause the pump to cavitate.

5.2.8 Immediately prior to turning on the pump, physically measure the water level in the well. Start the mechanical pump and adjust the valve or flow regulator to maintain a constant discharge specified by the project work plan, or as determined from the well development records (see SOP No. 8.2). It is advisable that the discharge rate be sufficient to maintain a stabilized sustainable drawdown of at least 0.1 feet. Record the time of the start of the specific capacity test on forms specified in the project work plans.

5.2.9 Once pumping starts, physically measure the water level decline with the electric well tape (or equivalent) as directed at time intervals specified by the project work plans. Observe and record the wellhead flow meter readings at intervals specified by the project work plan. Record these measurements and the time on the appropriate form.

5.2.10 Once the drawdown appears to stabilize (i.e., the water level under pumping is relatively stable), continue pumping for a sufficient length of time as specified in the project work plans. The criterion for stabilization of water levels and drawdown will be specified in the project work plans. During this time period, continue to physically measure and record the water levels at intervals stated in the project work plans.

5.2.11 Once the specified time period has elapsed, take a physical water level measurement with the electric tape and shut the pump down. Record the measurement and time on the appropriate form.

5.2.12 The data should be reviewed in the field to ensure that the valid data have been collected. This includes verification that discharge was maintained at a constant rate, and the drawdown stabilized at the minimum required magnitude. Complete all documentation on the appropriate form as outlined in the project work plans.

5.2.13 The specific capacity tests may be repeated as necessary, and as required by the project work plans.

5.2.14 Once all tests are satisfactorily completed for the well, all downhole equipment may then be removed and the wellhead secured.

## 5.3 Aquifer Pump Test Methods

The pump test methods covered in this section include step-drawdown tests and constant rate pump tests. A step-drawdown test is conducted for the pumping well and is recommended prior to initiation of any constant rate pump test. The data provided by the step drawdown test is used to evaluate well performance and determine the optimum discharge for the subsequent constant rate test. The step drawdown test entails conducting three or more steps of increased discharge while monitoring water level drawdown. This effectively produces successive stepped drawdown curves. Aquifer testing may potentially be discontinued at a well after the step-drawdown pumping test if: 1) only a single well pumping test is planned; and 2) the step-drawdown test provides all the necessary data of a single well pumping test.

The constant rate pump test method involves the pumping of water from a well at a constant rate, and monitoring the water level drawdown in response to the pumping. Water level recovery may also be monitored after the pumping is discontinued.

Water level monitoring may be limited to the pumping well (single well pumping test) or include one or more nearby observation wells (multiple well pumping test). The single well pumping test utilizes a single well (the pumped well) and a mechanical pump to remove water at a constant rate from the water bearing unit. The same well is used to measure water level drawdown and recovery

in the formation.

The multiple well test utilizes one or more observation wells at selected distances and locations relative to the pumping well. Water levels are monitored in the pumping and observation wells throughout the duration of the test.

The remaining discussion provides the requirements and procedures for step-drawdown tests and single and multiple well constant rate pump tests. These represent minimum requirements as site- and project-specific information and criteria must be incorporated in planning and conducting pump tests. The project work plans will provide the necessary additional requirements and procedures for the specific pump tests to be conducted.

The procedures below describe the use of pressure transducers/data loggers to monitor water levels during the pump testing. However, other water level measurement techniques may be substituted and the procedures may be modified as appropriate in the project work plans.

5.3.1 Step-Drawdown Testing

Step-drawdown testing should be conducted before other pump testing. All newly installed wells should be developed before conducting step-drawdown tests.

5.3.1.1 Inspect the equipment to be used to ensure that it is in good working order. Equipment used for the step-drawdown testing will vary widely based upon site-specific conditions. The project work plans will outline the type of equipment to be used.

5.3.1.2 Measuring and test equipment (M&TE) used for field activities will be calibrated by the equipment manufacturer or an approved calibration laboratory using standards that are traceable to the National Institute of Standards and Technology (NIST). Certificates of calibration for M&TE will be obtained from the M&TE supplier and kept in the project files. No M&TE will be utilized without verification of calibration certification.

5.3.1.3 Decontaminate all downhole equipment according to SOP No. 6.0.

5.3.1.4 Visually inspect and access the well per SOP No. 5.0.

5.3.1.5 Obtain a depth to water level measurement and sound the bottom of the well with the electric tape according to the procedures outlined in SOP No. 5.0. Compare the measured total depth to the bottom of the well to the well construction diagram to determine if sediment is in the bottom of the well.

5.3.1.6 Install the mechanical pump in the well using the manufacturer's instructions. The position of the pump intake inside the well should be based upon well construction and site specific factors stipulated in the project work plans. The criteria for placement of the pump in the well should also be contained on the project work plans. Note the height of the water column from the static water level to the pump intake. Record all information on the appropriate form as specified by the project work plans. During testing, the drawdown should not be so great as to cause the pump to cavitate.

5.3.1.7 Connect the pressure transducer to the data logger. Lower the pressure transducer inside the pumping well to a depth below the bottom of the anticipated drawdown. The transducer should be installed at a level that: 1) eliminates effects from the pump intake; 2) is below the anticipated water level during maximum drawdown; and 3) does not exceed the maximum transducer head limitation. In addition, the transducer must be secured inside the pumping well in such a manner that the transducer will not be effected by turbulence from the pump. Record the depth of the transducer.

5.3.1.8 Turn on the pressure transducer/data logger, set the recording frequency for pre-test monitoring to that specified by the project work plans. (Data loggers should be placed in a secure location to prevent tampering.)

5.3.1.9 Physically measure the water level with the electric tape and record along with the time. Commence pre-test monitoring with the pressure transducer/data logger. The total length of time over which the pre-test measurements are made will be provided in the project work plans. Generally water levels are recorded for a period before the step-drawdown test that is at least twice as long as the time expected for the step-drawdown test and the recovery period. Record the information, including times of measurements, on the appropriate form as specified by the project work plans.

5.3.1.10 Once the pre-test monitoring period is ended, remeasure the water level using the electric tape and record along with the time.

5.3.1.11 Change the recording frequency on the data logger to the appropriate frequency of step-drawdown data entry as required by the project work plans. Begin recording water level measurements with pressure transducer/data logger as required by the project work plans for the initial pumping phase of the step-drawdown test. Start the mechanical pump and adjust the valve or flow regulator to maintain the constant rate of discharge specified by the project-specific work plan. This rate will be the first step in the step-drawdown test. Record the time of the start of the step-drawdown test as specified in the project work plans.

5.3.1.12 Continue to monitor water level decline during the first step with the pressure transducer/data logger, taking periodic water level measurements with the electric tape. Data logger and tape readings should be conducted in accordance with the schedule outlined in the project work plans. As the first step continues, review the water level data and, if necessary, adjust the recording frequency of the data logger. Observe and record the wellhead flow meter readings as required by the project work plans.

5.3.1.13 Continue pumping and recording water levels and flow meter readings in the first step as long as required by the project work plans.

5.3.1.14 Once the first step is ended, measure the water level with the electric tape and record depth and time. Adjust the data logger as necessary (based upon review of data from the first step) or specified in the project work plans for commencement of the second step of the test.

5.3.1.15 Without turning the mechanical pump off, initiate the second step of the test by changing the pumping rate with the valve or flow regulator to the rate specified by the project work plans.

5.3.1.16 Monitor the water levels and flow meter readings and continue the second step as described in 5.3.1.13 and 5.3.1.14 above.

5.3.1.17 Repeat the cycles of changing pumping rate and recording depth of water as often as is required (for each step of the step-drawdown test) by the project work plans and as described in 5.3.1.15 and 5.3.1.16 above.

5.3.1.18 Once the last step is completed, re-set the data logger for the recovery period measurement

duration and frequency as specified in the project work plans. Obtain a water level measurement with the electric well tape and record the measurement and time. Shut down the mechanical pump. Record the time (to the nearest 10 sec) that the pump was shut down on the appropriate form.

5.3.1.19 Continue to measure and record the water level recovery with the pressure transducer/data logger as long as is required by the project work plans or until the water level has recovered to within 90 percent of the level expected from the pretest trends. Also, continue to take physical water level measurements periodically during recovery. Once the recovery period is ended, take a physical water level measurement at the end of the test. Record the measurement and time on the appropriate form.

5.3.1.20 The data should be reviewed in the field to help ensure the validity of the test. The field data review may also be used to determine the discharge rate to be used during the subsequent single or multiple well pump testing. Complete all documentation on the appropriate form as outlined in the project work plans.

5.3.1.21 Once the step-drawdown test is satisfactorily completed for the well, the equipment may be left in the well for subsequent single or multiple well pump testing. If the subsequent testing will not be conducted then all downhole equipment may be removed and the wellhead secured.

5.3.2 Single and Multiple Well Constant Rate Pump Testing

The procedures in this section are written as if multiple well pump test is being conducted. However, these procedures are directly applicable to single well testing. The only difference is that testing and measuring equipment are installed only in the pumping well, and water level measurements are also only collected from this well.

5.3.2.1 Inspect the equipment to be used to ensure that it is in good working order. Equipment used for the pump testing will vary widely based upon site-specific conditions. The project work plans will outline the type of equipment to be used.

5.3.2.2 Measuring and test equipment (M&TE) used for field activities will be calibrated by the equipment manufacturer or an approved calibration laboratory using standards that are traceable to the National Institute of Standards and Technology (NIST). Certificates of calibration for M&TE

will be obtained from the M&TE supplier and kept in the project files. No M&TE will be utilized without verification of calibration certification.

5.3.2.3 Decontaminate all downhole equipment according to SOP No. 6.1. Equipment maintained inside the pumping well from the step-drawdown test and to be used directly for the subsequent pumping test does not need to be re-decontaminated.

5.3.2.4 Visually inspect and access the wells to be used during the pumping test per SOP No. 5.0.

5.3.2.5 Obtain a depth to water level measurement and sound the bottom of each well to be used with the electric tape according to the procedures outlined in SOP No. 5.0. Compare the measured total depths to the bottom of the wells to their respective construction diagrams to determine if sediment is in the bottom of the wells.

5.3.2.6 If necessary, install the mechanical pump in the pumping well as described in Section 5.3.1.6.

5.3.2.7 If a multiple well test is being conducted, connect the pressure transducers to their respective data loggers. Install the transducers inside the observation wells at this time. The transducers should be installed at a position inside each well that is below the anticipated water level during maximum drawdown, and does not exceed the maximum head limitation. Set up another pressure transducer in an outlying well (outside of the suspected influence of the pumping well) to record station barometric effects, if required. If not already installed from the step-drawdown test, set the pressure transducer inside the pumping well as described in Section 5.3.1.7. Record the depth(s) of the transducer(s).

5.3.2.8 If any transducer cables are run across traffic areas, they must be appropriately protected. Data loggers should also be placed in a secure location to prevent tampering.

5.3.2.9 Turn on the pressure transducers/data loggers, set the recording frequencies for pre-test monitoring to that specified by the project work plans. It is also important before initiating pre-test monitoring for the pumping test to ensure that water levels from any previous step-drawdown testing have completely recovered.

5.3.2.10 Physically measure the water levels in the pumping and observation wells with the electric tape and record along with the time. Separate data sheets should be used for each well.

5.3.2.11 Commence pre-test monitoring with the pressure transducers/data loggers. The total length of time over which the pre-test measurements are made will be provided in the project work plans. Generally water levels are recorded for a period before the pumping test that is at least as long as the time expected for the pumping and recovery period. Record the information, including times of measurements, on the appropriate form as specified by the project work plans.

5.3.2.12 Once the pre-test monitoring period is ended, remeasure the water levels in the wells using the electric tape and record along with time.

5.3.2.13 Change the recording frequencies in the data loggers for the pumping test as required by the project work plans. Just before starting the pump, begin recording the pressure transducer measurements.

5.3.2.14 Start the mechanical pump and adjust the valve or flow regulator to maintain a constant rate of discharge as determined from the step-drawdown test and/or specified by the project work plans. Record pump start time on the appropriate form.

5.3.2.15 Continue to monitor water levels during pumping with the pressure transducers/data loggers, taking periodic water level measurements in each of the wells with the electric tape. Data logger and tape readings should be conducted in accordance with the schedule outlined in the project work plans. However, the water level data should be evaluated during the test and, if necessary, the recording frequencies of the data loggers adjusted.

5.3.2.16 Observe and record the wellhead flow meter readings as required by the project work plans.

5.3.2.17 The Program Geologist or designee will determine the time that the mechanical pump should be shut down as specified in the project work plans and/or based on review of field generated drawdown versus time plots from the pumping and observation wells.

5.3.2.18 Once the pumping phase is completed, re-set the data loggers for the recovery period

recording duration and frequencies as specified in the project work plans. Obtain a water level measurement in each of the wells with the electric well tape and record the measurements and times. Shut down the mechanical pump. Record the time (to the nearest 10 sec) that the pump was shut down on the appropriate form.

5.3.2.19 Continue to record the water level recovery in the wells with the pressure transducers/data loggers as long as is required by the project work plans or until the water levels have recovered to within 90 percent of the level expected from the pretest trends. Also, continue to take physical water level measurements periodically during recovery. Once the recovery period is ended, take a physical water level measurement in each well at the end of the test. Enter the measurements and times on the appropriate form.

5.3.2.20 The project work plans may require additional depth to water measurements to be physically taken following complete well recovery in order to monitor post test trends in water level. The project work plans will specify the frequency of measurements, and the length of time that the measurements must be taken.

5.3.2.21 The data should be reviewed in the field to help ensure the validity of the test. Complete all documentation on the appropriate form as outlined in the project work plans.

5.3.2.22 Once the pump test is satisfactorily completed for the wells, all downhole equipment may be removed and the wellheads secured.

## *6.0 Required Forms*

6.1 None

# SOIL STOCKPILING

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines for stockpiling of excavated soils. The details within this SOP should be used in conjunction with project work plans. The work plans may present additional project-specific requirements and procedures for soil stockpiling.

## 2.0 References

2.1 None.

## 3.0 Responsibilities

3.1 The *Program Environmental Engineer* is responsible for assigning project staff to complete soil stockpiling activities, and for ensuring that this and any other appropriate procedures are implemented by project personnel. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Quality Assurance Officer (QAO)* is responsible for the periodic review of field generated documentation associated with soil stockpiling. If perceived variances occur, the QAO is also responsible for issuing notices of nonconformance and requests for corrective action.

3.3 The *Sampling Team Leader(s)* assigned to this task are responsible for performing the task according to this SOP and other appropriate procedures identified in the project work plans. All staff are responsible for reporting deviations from the procedures to the Program Environmental Engineer.

## 4.0 Definitions/Materials

4.1 None.

## 5.0 Procedure

5.1 General

5.1.1 Stockpiling of soils is overseen by various regulatory agencies. Prior to initiating excavation activities, ensure that the procedures and requirements for compliance with applicable federal, state, and local regulations regarding stockpiling of soils have been reviewed and understood. The

standard procedures for short-term and long-term stockpiling are described below. The project work plans will also present the following information pertaining to soil stockpiling:

- Any additional requirements or procedures to be followed
- Equipment to be used
- Stockpile locations.

5.2 Short-term Stockpiling

5.2.1 Upon initiation of excavation activities, soil will be segregated on a site-specific basis. Potentially clean soils will be stored in a separate short-term stockpile at the site. Soil that is suspected or known to be contaminated will be short-term stockpiled at the site separately from the clean soil.

5.2.2 The short-term stockpiles will be placed upon two layers of impermeable sheeting (such as polyvinyl chloride, polyethylene, etc.). For short-term storage, the separated soils may also be placed in bins or drums for subsequent transport to long-term stockpiles, per the project work plans.

5.2.3 Each pile will be covered with impermeable sheeting at the end of each work day. The covering will be secured at both the top and base of the stockpile. Plastic sheeting will be utilized to limit soil aeration and the release of windborne dust and particulates. The cover will also limit access by rainwater, resulting in possible contamination of surface water runoff from the stockpile. If bins or drums are used for short-term storage, impermeable sheeting should be used to cover the bins and the covers to the drums should be secured and seated at the end of each work day.

5.2.4 Short-term stockpiling activities will be documented by the Program Environmental Engineer on the Field Activity Daily Log (FADL) and/or other appropriate form, as specified by the project work plans.

5.3 Long-term Soil Stockpiling

5.3.1 When space and logistics allow, long-term stockpiles will be constructed on a concrete or asphalt base. Two layers of impermeable sheeting will be placed on top of the concrete or asphalt. All sheeting will be folded at joining edges with a three-foot overlap to prevent seepage.

5.3.2 A berm will be erected around each stockpile. Boards or hay bales can be used to construct the berm. The material used to construct the berm will be placed under the two layers of impermeable sheeting to provide containment of any liquids that might leach from the soil.

5.3.3 Soil will be segregated by contaminant type (i.e., separate stockpiles for storage of soils impacted by gasoline, diesel, halogenated hydrocarbons, metals, etc.).

5.3.4 Each stockpile will be visibly labeled.

5.3.5 Covering of each pile with impermeable sheeting will be completed at the end of each work day. The covering will be secured at both the top and base of the stockpile. The sheeting will be utilized to limit soil aeration and the release of windborne dust and particulates. This cover will also limit access by rainwater, resulting in possible contamination of surface water runoff from the stockpile.

5.3.6 Long-term stockpiling activities will be documented by the program Environmental Engineer on the FADL and/or other appropriate form, as specified by the project work plans.

## *6.0 Required Forms*

6.1 Field Activity Daily Log

# HOLLOW STEM AUGER DRILLING

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for field personnel to use during the supervision of drilling operations involving hollow stem auger techniques. Additional specific hollow stem auger drilling procedures and requirements will be provided in the project work plans.

## 2.0 References

2.1 None

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all hollow stem auger drilling activities are conducted and documented in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with this SOP. The QAO is also responsible for the implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to hollow stem auger drilling requirements, issuing nonconformances, etc.) if problems occur.

3.3 The *Sampling Team Leader(s)* assigned to hollow stem auger drilling activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff responsible for reporting deviations from the procedures to the Program Geologist.

## 4.0 Definitions/Materials

4.1 Hollow Stem Auger Drilling

A drilling method using rotating auger flights (typically in 5 foot joints) with a bit on the bottom of the lead flight (sometimes called the "lead auger"). The flights consist of a hollow pipe and an outer spiral plate, which when rotated, forces soil cuttings upward along the borehole wall to the surface. The auger string is advanced by rotation, with pressure exerted by the rig, forcing the bit to cut the soil at the bottom and direct cuttings to the augers.

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

This method is commonly used for drilling and sampling of soil borings, collection of soil gas and screening-level water samples, and installation of some smaller diameter wells. The well casing string may be placed through the hollow stem.

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

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

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

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

Additional disadvantages of the hollow stem auger method include a typical maximum depth of 100 to 200 feet (may be less depending on soil conditions). Hard soil horizons or very coarse gravel

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(cobbles and boulders) may be impenetrable with this method.

## *5.0 Procedure*#

This section contains procedures and requirements for hollow stem auger drilling. The selection and implementation of hollow stem auger drilling techniques must incorporate site specific conditions and requirements. Consequently, the project work plans will identify the following:

- The purpose of each borehole (e.g., to install monitoring well, soil sampling, well abandonment, etc.)
- Specific methodology for drilling, including equipment and cuttings/fluid containment
- Specific locations, depths, and diameters of boreholes
- Objectives and types of sampling and/or logging of borehole
- Details of mobilization/demobilization and decontamination of equipment
- Appropriate health and safety guidelines and personnel protective equipment
- Additional procedures or requirements beyond those covered in this SOP

5.1 Drilling Site Mobilization

5.1.1 Rig Decontamination and Preparation

5.1.1.1 All drilling and sampling equipment should be decontaminated before drilling as per SOPs 6.0 and 6.1, and the project work plans.

5.1.1.2 The driller and rig geologist/engineer should inspect the drilling equipment for proper maintenance and appropriate decontamination prior to each time the rig is mobilized to a site. All clutches, brakes and drive heads should be in proper working order. All cables and hydraulic hoses should be in good condition. All auger joints and bits should also be in good condition (e.g., no cracked or bent blades, bits are not excessively worn, etc.).

5.1.1.3 Any observed leakage of fluids from the rig should be immediately repaired and the rig decontaminated again before it is allowed to mobilize.

5.1.2 Site Preparation

5.1.2.1 The logistics of drilling, logging, sampling, cuttings/fluid containment, and/or well construction should be determined before mobilizing. The site should be prepared as per the project work plans.

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5.1.2.2 Before mobilization, the Program Geologist should assess the drilling site with the driller. This assessment should identify potential hazards (slip/trip/fall, overhead power lines, etc.), and determine how drilling operations may impact the environment (dust, debris, noise). Potential hazards should be evaluated and corrected, or the borehole location changed or shifted, as per the project work plans.

5.1.2.3 The Program Geologist or appropriate designee should ensure that all identifiable underground utilities around the drilling location have been marked, and the borehole location appropriately cleared per the project work plans. At a minimum, copies of the site clearance documents should be kept on-site.

5.1.3 Mobilization and Set-Up

5.1.3.1 Once the site is prepared, the rig is mobilized to the site and located over the borehole location. The rig is leveled with a set of hydraulic pads attached to the front and rear of the rig. The driller should always raise the mast slowly and carefully to prevent tipping or damaging the rig, and avoiding obstructions or hazards.

5.1.3.2 Appropriate barriers and markers should be in place prior to drilling, as per the site health and safety plan. Visqueen (plastic) may be required beneath the rig.

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

5.1.4 Health and Safety Requirements

5.1.4.1 Tailgate Safety Meetings should be held in the manner and frequency stated in the health and safety plan. All personnel at the site should have appropriate training and qualifications as per the health and safety plan.

5.1.4.2 During drilling all personnel within the exclusion zone should pay close attention to rig operations. The rotating auger blades can snag or catch loose clothing and literally screw someone into the ground.

5.1.4.3 Establishing clear communication signals with the drilling crew is mandatory since verbal signals may not be heard during the drilling process. The entire crew should be made aware to inform the rig geologist/engineer of any unforeseen hazard, or when anyone is approaching the exclusion zone.

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5.2 Drilling Procedures

5.2.1 Breaking Ground

5.2.1.1 Prior to the commencement of drilling, all safety sampling and monitoring equipment will be appropriately calibrated per the project work plans.

5.2.1.2 The Program Geologist should inform the driller of the appropriate equipment (e.g., cookie cutter, etc.) to be used for penetration of the surface cover (e.g., asphalt, concrete, cement, etc.). In the event of breaking ground where a shallow subsurface hazard may exist (unidentifiable utility, trapped vapors, etc.), the driller should be in formed of the potential hazard and drilling should commence slowly to allow continuous visual inspection and/or monitoring, and if necessary, stop for probing.

5.2.2 Borehole Drilling

During drilling operations, and as the borehole is advanced, the rig geologist/engineer will generally:

- Observe and monitor rig operations;
- Conduct all health and safety m onitoring and sampling, and supervise health and safety compliance;
- Prepare a lithologic log from soil samples or cuttings; and
- Supervise the collection of, and prepare soil, soil vapor, and groundwater samples.

5.2.2.1 As drilling progresses the rig geologist/engi neer should observe and be in frequent communication with the driller regarding drilling conditions. This includes relative rates of penetration (indicative of f ast or slow drilling) and chattering or bucking of the rig. These conditions, including the relative drilling rate, shoul d be recorded on the boring log per SOP No, 10.0. Drilling should not be allowed to progress faster than the rig geologist/engineer can adequately observe conditions, compile boring logs, and supervise safety and sampling activities.

The Program Geologist should also observe the rig operations, including the make-up and tightening of connections as additional auger joints are a dded to the auger string. Any observed problem s, including significant down tim e, and their causes are recorded on the Field Activity Daily Log (FADL).

5.2.2.2 Cuttings and fluids containment during drilling should be observed and supervised by the Program Geologist, as per specifications in the project work plans.

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5.2.2.3 The Program Geologist will oversee or conductappropriate health and safety sampling and monitoring. If any potentially unsafe conditions are evident from the above drilling observations and the health and safety sam pling and monitoring, the Program Geologist may suspend drilling operations at any time and take appropriate actions as per the health and safety plan. In the event suspension of drilling activities occur:

- The Program Manager must be informed of the situation;
- Appropriate corrective action m ust be im plemented bef ore drilling m ay be continued; and
- The observed problem, suspension, and corrective action are entered on the FADL.

5.2.2.4 During drilling the rig geologist/engineer w ill compile a boring log as per SOP No. 10.0. The log will be compiled preferably from soil samples recovered while drilling. Logs should only be compiled from cuttings if this is the only op tion. Observations of drilling conditions are also entered on the log as discussed above and in SOPNo. 10.0. If total depth was reached prematurely due to refusal, the cause of refusal should be noted on the boring log and the FADL.

5.2.2.5 Subsurface soil samples may be collected with a split spoon sampler or Shelby tube during drilling per SOP No. 3.1. The sampling will be supervised by the Program Geologist. Soil samples (drive samples) can be readily obtained at discrete intervals with these methods.

5.2.2.6 Soil organic vapor (SOV) sam pling may be conducted at discrete intervals during hollow stem auger drilling. This is done by stopping at the desired depth and driving a sam ple probe through the hollow stem into the soil ahead of th e bit and then collecting a vapor sam ple. The sampling should be supervised by the rig geologist/engineer.

5.2.2.7 Groundwater screening (grab) samples can be obtained at discrete intervals during drilling. One method is to auger to the bottomof the selected interval or zone and pull the auger back to the top of the interval, allowing groundwater through the open borehole. A water sam ple is then collected with a bailer run through the inside of the augers. Another method is to stop the augers at a selected interval or zone and advance a hydropunch sampler beyond the lead auger to retrieve a water sample.

5.2.3 Borehole Abandonment

If the borehole is to be abandoned once drilling is com pleted, the abandonm ent will follow procedures outlined in the project work plan The abandonm ent will be supervised by the rig

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geologist/engineer.

5.2.4 Monitoring Well Completion
If a monitoring well is to be installed in the borehole, the well completion will follow procedures outlined in SOP No. 8.1. The well installation activities will be supervised by the rig Program Geologist..

5.3 Dem obilization/Site Restoration
After drilling, sampling, well installation or borehole abandonment is completed the hollow stem rig is rigged down and removed from the borehole location. The demobilization/site restoration will be supervised by the rig geologist/engineer or appropriate designee.

5.3.1 All debris generated by the drilling operation will be removed and appropriately disposed.

5.3.2 The site should be cleaned (ground washed if necessary) and surface conditions restored as per the project work plans.

5.3.3 All abandoned borings should be topped off and completed as per the project work plans. All monitoring wells will also have their surface completions finished as per the project work plans.

5.3.4 Any remaining hazards as a result of drilli ng activities will be identified and appropriate barriers and markers put in place, as per the health and safety plan.

5.3.5 All soil cuttings and fluids will be properly contained, clearly labeled, and maintained as per the project work plans.

5.3.6 The Program Geologist or appropriate designee should inspect the site to m ake sure that post-drilling site conditions are in compliance with the project work plans.

## *6.0 Required Forms*

6.1 Field Activity Daily Log
6.2 Boring Log

# FIELD QC SAMPLING

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for conducting field quality control (QC) sampling. Field QC sampling is required to assist in verifying the quality and integrity of samples collected during a given sampling event. Additional specific field QC sampling procedures and requirements will be provided in the project work plans.

## 2.0 References

2.1 EPA, September 1987, Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final OSWER Directive 9355.3-01.

## 3.0 Responsibilities

3.1 The *Program Geologist* is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

3.2 The *Quality Assurance Officer (QAO)* is responsible for periodic review of field generated documentation associated with this SOP. The QAO is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

3.3 The *Sampling Team Leader(s)* assigned to environmental and QC sampling activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Program Geologist.

## 4.0 Definitions/Materials

4.1 Field QC Sample

A field QC sample is a physical sample collected during or for a specific sampling event. The purpose of this sample is to evaluate the quality and integrity of original samples collected during

the specific sampling event.

## *5.0 Procedure*

This section contains the requirements for field QC sampling. Field QC sampling is required to provide data to verify the quality and integrity of environmental samples collected during a given sampling event.

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

- Sample collection objectives
- Numbers, types and locations of environmental (non-QC) samples to be collected
- Numbers and types of supportive QC samples to be collected
- Any additional QC sampling requirements or procedures beyond those covered in this SOP, as necessary.

5.1 Quality Control Sampling Requirements

5.1.1 Field QC samples may consist of different media. Typical QC samples are as follows:

- Trip blank (TB)
- Equipment rinsate (ER)
- Field blank (FB)
- Field duplicate (FD)

5.1.1.1 Trip blanks are analyte-free water, shipped from and returned unopened to the laboratory in the same shipping containers for volatile organic, and at times gasoline hydrocarbons. The blanks are prepared at the laboratory using ASTM Type II DI Water, sent to the project location, carried with the sampling team(s) during sampling, and shipped to the laboratory for analysis with the environmental samples.

Trip blank samples are commonly collected and analyzed at a rate of one per sample cooler containing samples for volatile organic analyses or the gasoline fraction of petroleum hydrocarbons. The number or rate of trip blanks to be collected and the specific analyses to be conducted for the trip blanks will be provided in the project work plans.

5.1.1.2 Equipment rinsate samples are collected from the final rinse water during decontamination

of groundwater, soil, or waste sampling equipment. This type of equipment includes bailers, splitspoon samplers, soil sample sleeves, hand augering equipment, surface soil sampling equipment, purge and sample pumps, etc.

Rinsate samples are generally collected at a rate of one per day per sampling team during the sampling event. Equipment rinsates are usually collected from dedicated sampling equipment only upon installation. The number or rate of equipment rinsate samples to be collected for a particular project will be specifically developed and documented in the project work plans. The specific chemical analyses to be conducted for the rinsate samples will also be developed and documented in the project work plans.

5.1.1.3 Field blanks are prepared from the water which is used for decontamination. One sample from each sampling event and each water source or lot number is generally collected and analyzed for all parameters of interest for the project. Upon collection, a description of the water source for the field blank sample should be documented in the Sample Collection Log.

The number or rate of field blank samples to be collected for a particular project will be specifically developed and documented in the project work plans. The specific chemical analyses to be conducted for the field blank samples will also be developed and documented in the project work plans.

5.1.1.4 For soils, field duplicate samples are generally collected by co-located sampling (e.g., using successive sample tubes from the same split spoon sampling run) or by splitting samples. Field duplicate water samples are commonly collected by retaining consecutive samples from the sampling device (e.g., bailer or sample pump discharge line). Field duplicate water samples may also be generated by splitting a collected volume; however, this practice may lead to a loss in volatile organic compounds and is not common practice for volatile analyses.

Field duplicate samples are commonly collected at a rate of 10 percent per media sampled. However, the number or rate of field duplicate samples to be collected for a particular project will be specifically developed and documented in the project work plans. The specific chemical analyses to be conducted for the field duplicates will also be developed and documented in the project work plans.

5.1.2 The type and number of QC samples collected for a particular project is based on specifications provided in project specific documents, i.e., the project work plans. Field QC samples are to be collected at appropriate times during a sampling event.

5.1.3 All field QC samples will be collected in proper containers with appropriate preservation per the project work plans.

5.1.4 The collection of field QC samples consisting of various media (e.g., soil, groundwater, etc.) will follow procedures in sample collection SOPs for the respective media and any other applicable procedures in the project work plans. For example, the collection of a groundwater field duplicate QC sample will follow procedures specified in the groundwater sampling SOP (SOP 9.0). Equipment rinsate samples are collected directly while rinsing the sampling equipment following appropriate procedures in SOP 9.0 and the project work plans. Field blank samples are collected by pouring decontamination water directly into sample containers following appropriate protocol in SOP 9.0 and the project work plans.

5.1.5 Field QC samples will be labeled and numbered as described in SOPs 2.1 and 2.2 respectively and the project work plans.

5.1.6 The field QC samples will also be maintained under custody per SOP 1.1, and be appropriately stored, handled and shipped per SOPs 2.0 and 2.3.

## *6.0 Required Forms*

6.1 Sample Collection Log

6.2 Chain of Custody Form

# MANAGEMENT OF INVESTIGATION-DERIVED WASTE

## STANDARD OPERATING PROCEDURE

## 1.0 Objective

Wastes covered by this policy statement include wastes generated from the investigation and remediation of sites contaminated by past operations at Tooele Army Depot (TEAD). Analysis of waste performed using this SOP are to determine the proper hazardous waste characterization and insure the waste is disposed of consistent with all applicable Solid and Hazardous Waste Regulations. Prior to disposal, the wastes will be collected, transferred and stored in accordance with all applicable regulations. This IDW SOP applies to the sampling activities specified in the work plans conducted under the TEAD CDQMP.

## 2.0 Background

During environmental investigations at TEAD, sampling crews may generate potentially contaminated Investigation-Derived Waste, including but not limited to the following types of materials:

- Saturated and unsaturated soil
- Groundwater
- Decontamination water
- Personal Protective Equipment (PPE) and miscellaneous refuse

## 3.0 Reference

*ENVIRONMENTAL OFFICE POLICY STATEMENT #EO-05* – Handling, Characterization, and Disposal of Investigation/Remediation Derived Wastes, Tooele Army Depot, 1 January 2004.

## 4.0 Responsibilities

*Investigation Contractor* - This is any contractor completing an environmental investigation at TEAD. Examples of such investigations would include RCRA Facility Investigations, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) assessments and investigations, and groundwater monitoring programs under the direction of either EPA or the State of Utah.

The contractor(s) are tasked with the collection, on-site storage, transportation and disposal of solid and hazardous waste generated from the site investigation and remediation work in accordance with all applicable regulations. This includes the proper containerization and labeling of wastes; safe movement of waste containers; characterization of the waste; temporary storage of the waste; and the preparation of the hazardous waste manifests and the notifications required under the Land Disposal Restrictions (LDR). While Tooele Army Depot (TEAD) has the ultimate responsibility as the property owner, the contractor will bear full responsibility for any violations or fines resulting from their actions.

Unless the waste has been previously characterized, all containers will be sampled within 10 days of being filled. The sample will be analyzed, as discussed in the paragraphs below, and characterized for proper disposal within 30 days of being sampled. The waste will then be disposed of accordingly within 30 days of completing the characterization. If the waste is generated off-site and will be transferred via hazardous waste manifest to the TEAD 90-day area prior to performing the characterization identified below, then the waste will be characterized using generator knowledge. Once an analysis has been completed, the waste will be characterized and disposed of based on the results of that analysis.

It will not always be practical to transfer waste to the TEAD 90-day storage facilities from some remediation activities. In that case, the contractor will establish a 90-day storage facility in accordance with 40 CFR 262.34(a); Subpart I of 40 CFR 265; and 40 CFR 265.16, 265.111 and 265.114. All plans (Training, Inspection and Contingency) and procedures required to operate the facility in accordance with the regulations will be incorporated into the applicable work plan.

## *5.0 Procedures*

5.1 Waste Minimization Procedures

To the extent that it is practical, the Investigation Contractor will follow waste minimization procedures during environmental investigations. Guidelines for waste minimization are:

- Minimize materials which are introduced into any exclusion zone in an investigation area.
- Combine similar wastes throughout an investigation area in a single container wherever possible.
- Combine decontamination water from multiple sites in one container.
- Use a container of the appropriate size (e.g., use a 5-gallon drum for a small amounts of waste unless a 55-gallon drum is needed to hold all the waste).

- Decontaminate and reuse material and equipment whenever practical. Minimize the volume of decontamination water generated.
- With solid environmental media and materials, ensure that waste is tightly packed to minimize the number of containers.
- Use less hazardous substances whenever possible.

5.2 Waste Containerization and Labeling

Investigation or remediation derived waste, which are known or suspected to be hazardous waste, will be placed in appropriate DOT containers, supplied by the contractor, and labeled as hazardous waste.

5.2.1 Labels for **tracking wastes on depot** will be obtained in advance from the Environmental Office (EO).

5.2.2 Labels for **shipping waste on public roads** will be supplied by the contractor. Upon filling of a container, the start accumulation date will be annotated on the label and the container will be transferred off-site or to the TEAD 90-day storage facility within **3 days**.

5.3 Waste Management and Sampling Procedures

Wastes are either managed in open top, or closed top drums, gondolas, or in some instances discharged to a bulk tanker for transport to a Treatment Storage and Disposal Facility (TSDF).

The sampling method selected for a given waste stream is based on the physical properties the waste exhibits. Liquids will be sampled with a coliwasa or glass tube; dry powder, sludges, and moist granules will be sampled with a trier; and packed powder will be sampled with an auger.

Each sample will be taken using a sampling tool that will insure the most representative sample. When more than one container is generated per waste stream, the sample to be analyzed will be a composite sample comprised of equal amounts taken from all the containers filled with that waste stream. For example, the drill cuttings from a single well would be composited into one sample. However, if information pertaining to the waste stream indicates the contamination may vary significantly, then composites would only be utilized for those portions of the waste stream with similar characteristics or each container would be sampled.

5.4. Waste Characterization

Unless the waste has been previously characterized, all containers will be sampled within 10 days of being filled. The sample will be analyzed, as discussed in the paragraphs below, and characterized for proper disposal within 30 days of being sampled. The waste will then be disposed of accordingly within 30 days of completing the characterization. If the waste is generated off-site and

will be transferred via hazardous waste manifest to the TEAD 90-day area prior to performing the characterization identified below, then the waste will be characterized using generator knowledge. Once an analysis has been completed, the waste will be characterized and disposed of based on the results of that analysis.

## 5.5 Parameter Test Methods

The type of analysis of each waste will depend upon the operations previously conducted at the site and information gained from previous investigative or remedial work performed. The parameters of analysis that normally will be considered include the characteristics of Ignitability, Corrosivity, Reactivity, Toxicity Characteristic Leaching Procedure (TCLP) Metals, TCLP Pesticides/Herbicides and TCLP Organics. Parameters for F and K listed hazardous wastes will only be analyzed for if information specific to the site indicates their possible presence.

Parameters will be eliminated when previously gathered information for a site or the physical state of the waste generated would so justify. For example, if the waste were a solid, then the parameters of ignitability and corrosivity would be eliminated.

Table 1 below contains the EPA waste codes and the applicable SW-846 analytical method(s). In addition, the EPA waste numbers have been grouped into analyte groups.

# TABLE 1
# SW-846 APPROVED ANALYTICAL METHODOLOGIES

| CHARACTERISTIC | WASTE CODE | CONSTITUENT OF CONCERN | ANALYTICAL METHOD(S)* |
|---|---|---|---|
| Ignitability | D001 | Flash Point less than 140 °F | 1010 or 1020 |
| Corrosivity | D002 | pH less than or equal to 2<br>or greater or equal to 12.5 | 9040 or 9045 |
| Reactivity | D003 | Total Cyanide greater than 590 mg/kg<br>Total Sulfide greater than 500 mg/kg | 9010 or 9012<br>9030 |
| Toxicity (Metals) | D004 | Arsenic | 6010,7060, or 7061 |
| | D005 | Barium | 6010, 7080, or 7081 |
| | D006 | Cadmium | 6010, 7130, or 7131 |
| | D007 | Chromium | 6010, 7190, or 7191 |
| | D008 | Lead | 6010, 7420, or 7421 |
| | D009 | Mercury | 7470, or 7471 |
| | D011 | Sliver | 6010, 7760, or 7761 |
| Toxicity (Organics) | D018 | Benzene | 8021, or 8260 |
| | D019 | Carbon Tetrachloride | 8021, or 8260 |
| | D020 | Chlorodane | 8021, or 8260 |
| | D023 | o-Cresols | 8041, or 8270 |
| | D025 | p-Cresol | 8041, or 8270 |
| | D026 | Cresol (Total) | 8041, or 8270 |
| | D028 | 1,2 Dichloroethane | 8021, or 8260 |
| | D029 | 1,1 Dichloroethylene | 8021, or 8260 |
| | D030 | 2,4 Dinitrotoluene | 8091, or 8270 |
| | D032 | Hexachlorobenzene | 8121, or 8270 |
| | D033 | Hexachloro 1,3 butadiene | 8121, or 8270 |
| | D035 | Methyl Ethyl Ketone | 8015, or 8260 |
| | D036 | Nitrobenzene | 8121, or 8270 |
| | D037 | Pentachlorophenol | 8041, or 8270 |
| | D039 | Tetrachloroethylene | 8021, or 8260 |
| | D040 | Trichloroethylene | 8021, or 8260 |
| | D042 | 2,4,6 Thichlorophenol | 8041, or 8270 |
| | D043 | Vinyl Chloride | 8021, or 8260 |
| Spent Halogenated Solvents used in Degreasing | F001 | Carbon Tetrachloride | 8021, or 8260 |
| | | Methylene Chloride | 8021, or 8260 |
| | | 1,1,1 Trichloroethane | 8021, or 8260 |
| | | Tetrachloroethylene | 8021, or 8260 |
| | | Trichloroethylene | 8021, or 8260 |
| | | Chlorinated Fluorocarbons | 8021, or 8260 |

| CHARACTERISTIC | WASTE CODE | CONSTITUENT OF CONCERN | ANALYTICAL METHOD(S)* |
|---|---|---|---|
| Spent Halogenated Solvents | F002 | Chlorobenzene | 8021, or 8260 |
| | | Methylene Chloride | 8021, or 8260 |
| | | Ortho-Dichlorobenzene | 8121, or 8270 |
| | | Tetrachloroethylene | 8021, or 8260 |
| | | 1,1,1 Trichloroethane | 8021, or 8260 |
| | | Trichloroethylene | 8021, or 8260 |
| | | Trichlorofluromethane | 8021, or 8260 |
| | | 1,1,2 Trichloroethane | 8021, or 8260 |
| | | 1,1,2 Trichloro-1,2,2 trifluoroethane | 8021, or 8260 |
| Spent Nonhalogenated Solvents | F003 | Acetone | 8015, or 8260 |
| | | n-Butyl Alcohol | 8015, or 8260 |
| | | Cyclohexanone | 8091, or 8270 |
| | | Ethyl acetate | 8015, or 8260 |
| | | Ethyl Benzene | 8021, or 8260 |
| | | Ethyl Ether | 8015, or 8260 |
| | | Methonol | 8015, or 8260 |
| | | Methyl Isobutyl Ketone | 8015, or 8260 |
| | | Xylene | 8021, or 8260 |
| Spent nonhalogenated Solvents | F004 | Cresols | 8041, or 8270 |
| | | Cresylic Acid | 8041, or 8270 |
| | | Nitrobenzene | 8091, or 8270 |
| Spent nonhalogenated Solvents | F005 | Carbon Disulfide | 8015, or 8260 |
| | | Isobutanol | 8015, or 8260 |
| | | Methyl Ethyl Ketone | 8015, or 8260 |
| | | Pyridine | 8091, or 8270 |
| | | Toluene | 8021, or 8260 |
| | | Benzene | 8021, or 8260 |
| | | 2 Ethoxy ethanol | 8031, or 8260 |
| | | 2 Nitropropane | 8015, or 8260 |
| California List Land Ban Restrictions | TOX | Total Organic Halides | 9020, or 9022 |
| | TOC | Total Organic Carbon | 9060 |

* Most Current Published EPA SW-846 Version

## 5.6 Off-site Transportation and Disposal of Hazardous Waste

Prior to transporting or offering a container of hazardous waste for transport off-site, the contractor must label each container in accordance with Department of Transportation regulations for hazardous materials under 49 CFR Part 172. In addition, each container of 110 gallons or less must be labeled with the following words and displayed in accordance with 49 CFR 172.304:

> HAZARDOUS WASTE – Federal Law Prohibits Improper Disposal. If found, contact the nearest police or public safety authority or the U.S. Environmental Protection Agency.
>
> Generator's Name and Address _____.
>
> Manifest Document Number _____.

Any hazardous wastes shipped from to TEAD from off-site or from TEAD to a disposal facility off-site will be accompanied with a hazardous waste manifest prepared by the contractor in accordance with 40 CFR 262.20. Acquisition, copies and use of the manifest will be in accordance with 40 CFR 262.21 through 23. A representative from the TEAD EO will sign the manifest as the generator.

# PREPARATION, REVISION, AND APPROVAL OF PLANS AND PROCEDURES

**STANDARD OPERATING PROCEDURE**

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes the methods and responsibilities associated with the preparation, revision, and approval of quality-affecting documents.

## 2.0 References

2.1 None.

## 3.0 Responsibilities

3.1 The *Program Manager* has the responsibility to assure that the QCP is implemented effectively by delivery order personnel. Further, he/she is responsible to ensure that SOP's which are required for delivery order performance are prepared by qualified personnel and are reviewed and approved by authorized personnel, prior to the implementation of delivery order activities.

3.2 The *Quality Assurance Officer (QAO)* is responsible for the preparation and maintenance of the QCP and SQPs. He reviews and approves SOPs to assure compliance with the requirements of the QCP and that they constitute an acceptable approach to meeting QA objectives. He is also a part of the approval cycle for the technical planning documents (e.g., Work Plan, Sampling and Analysis Plan, etc.).

## 4.0 Definitions

4.1 Quality Control Plan (QCP)

A plan describing the quality control requirements to be applied, as applicable, to the delivery order requirements, which includes the methods and responsibilities established to meet hose requirements specified.

4.2 Standard Operation Procedures (SOP)

A set of implementing procedures which prescribe the actions necessary to complete a work operation in accordance with accepted practices for quality and safety.

## *5.0 Procedure*

5.1 Discussion

5.1.1 The QCP is established and maintained as the documented basis for compliance with the projects QC requirements. The QCP emphasizes TEAD's commitment to meeting those requirements. The associated SOPs establish methods for complying with those commitments.

5.2 Preparation

5.2.1 The Program Manager determines the need for establishing a procedure describing how to perform quality-affecting activities. He also initiates revisions to these documents due to programmatic requirement changes, audit findings, or corrective actions, as applicable.

5.2.2 Procedures, field work variance (FWV), and drawings will include appropriate qualitative and quantitative acceptance criteria for determining satisfactory work performance and quality compliance.

5.3 Format

5.3.1 The SOPs will adhere to a consistent format in accordance with the following guidelines.

5.3.2 Revision Block - This area will contain the document identification, section or procedure number, revision number, date, and pages. This information will appear consistently on each page of the document in the upper right-hand corner.

5.3.3 Title Block - This area will contain the title of the SQP or SOP and will appear on the first page only.

5.4 Contents

5.4.1 Procedures required to implement delivery order activities will include the information listed below. When any of these items are not required or are inappropriate to the SOP, they will be noted by the word "none".

1.0 Purpose - Describe the purpose of the SOP. Be as specific as possible; do not generalize.

2.0 References - Identify pertinent documents or procedures that interface with the SOP being prepared. Reference to specific documents that are directly applicable to the SOP (e.g., Chemical Data Quality Management Plan (CDQMP), Sampling and

Analysis Plan (SAP), Field Sampling Plan (FSP), Health and Safety Plan (HSP) etc.) is acceptable.

3.0 Responsibilities - Assign responsibility for accomplishing activities, be specific in context. Include appropriate reporting requirements for assuring that important activities have been satisfactorily accomplished.

4.0 Definitions/Materials - Define words and phrases having a special meaning of application within the SOP. Definitions must be consistent with the glossary of terms located within the CDQMP. List materials and equipment required for the procedure(s) being performed.

5.0 Procedure - Identify the sequence of activities to be followed for accomplishing activities, be specific in context. Incorporate examples of forms or documents which are required to be completed as a result of the procedure implementation.

6.0 Required Forms - List all forms that are required for the successful implementation of the specific SOP.

5.5 Approval

5.5.1 The signature of the Program Manager (PM), Quality Assurance Officer (QAO) and others as deemed necessary on the Table of Contents/Log of Revisions or cover page will signify the documents and revisions listed are authorized for use. For SOPs, the PM and QAO will sign the Table of Contents/Log of Revisions Page of the procedure manual indicating their approval.

5.6 Manual Change Requests

5.6.1 Personnel responsible for complying or interfacing with the requirements of the approved plans, SOPs may request revisions to these documents via a Manual Change Request (MCR) memo. Manual Change Requests are different from field work modifications, as they are used to suggest improvements to existing processes or systems and are not structured to adjust the plans and procedures based on changing site conditions.

5.6.2 Originators of MCRs are responsible for forwarding a MCR to the PM for dispositioning.

5.6.3 The PM is responsible for reviewing all MCRs and either accepting or rejecting them. If an MCR is accepted, the PM will indicate this acceptance by signing and dating the MCR. He/she will forward a copy of the signed MCR to the originator for their files. A copy of accepted MCRs will be maintained by the PM for logging and revision inclusion.

5.6.4 If an MCR is not accepted, the PM will indicate this by marking, signing and dating the MCR. Nonaccepted MCRs will be maintained in the project files.

5.7 Revisions

5.7.1 Revisions to an approved plans will be documented and will receive the same level of review, approval, and control as the original document.

5.7.2 Field Work Variances will be issued by the PM using the FWV form. When twelve (12) months have elapsed for a Field Work Modification Form or six (6) have been issued, whichever comes first, the PM will issue new revisions to the affected documents to incorporate the FWV.

## *6.0 Required Forms*

6.1 Manual Change Requests

# QUALITY INSPECTIONS AND INSPECTION RECORDS

## STANDARD OPERATING PROCEDURE

## 1.0 Purpose

This Standard Operating Procedure (SOP) establishes the methods and responsibilities for the performance and documentation of Quality Control inspection of activities performed during delivery order activities to ensure compliance with established requirements.

## 2.0 References

2.1 None.

## 3.0 Responsibilities

3.1 The *Program Manager and the Quality Assurrance Officer (QAO)* will select the most qualified individual(s) to perform the QC inspection. This determination will be made based on the nature of QC inspection.

## 4.0 Definitions

4.1 Inspection

Examination or measurement to verify whether an item or activity conforms to a specified requirement(s).

## 5.0 Procedure

5.1 Qualification of Inspectors

5.1.1 Personnel performing inspection activities will have the necessary expertise in the area to be inspected, but will be sufficiently independent of the activity performed.

5.1.2 Prior to performance of inspection activities, personnel designated for that responsibility will review and be thoroughly familiar with the procedures, regulations, etc., governing the activities to be inspected.

5.2 Field Inspection Plans and Reports

5.2.1 Activities requiring inspection (i.e., Preparatory Phase, initial Phase and Follow-up Phase) will have a definable features of work matrix prepared for that activity. Inspection(s) will be performed for definable features of work which are identified for each delivery order and will be performed consistent with ongoing delivery order activities.

5.2.1.1 The definable features of work matrix will identify the items and activities to be inspected and will provide or reference the specification section and paragraph which specifies the requirements for each activity or item.

If a Nonconformance Report is required for activities being inspected, a reference will be provided on the Daily QC Report.

5.2.2 The Daily QC Reports will be issued identifying inspections performed. The report will be completed by the QAO (or designee) and will address each inspection performed during the course of the daily activities and submitted to the Program Manager (PM).

5.2.3 Items or activities not conforming to inspection acceptance criteria will be resolved and when determined necessary documented on a Nonconformance Report. Daily QC Reports will be logged and sequentially numbered. Each Daily QC Report will be signed by the inspector certifying that the activities listed within the report have been completed in accordance with the project planning documents to the best of his/her knowledge, and submitted for review by the PM.

## *6.0 Required Forms*

6.1 Definable Features of Work Matrix

6.2 Daily QC Report

*Appendix D*

# *EXAMPLE FIELD FORMS*

# DAILY QUALITY CONTROL REPORT

| | |
|---|---|
| CONTRACTOR | REPORT NO. |
| | DATE |
| PROJECT & LOCATION | CONTRACT NO. |
| | WEATHER |

DESCRIPTION & LOCATION OF WORK PERFORMED *(INCLUDE PROGRESS & DELAYS)*

DECONTAMINATION PROCEDURES

CONTRACTOR'S QUALITY CONTROL

SAMPLING *(INCLUDE TYPES OF SAMPLES AND DEPTHS)*

MATERIALS RECEIVED AT SITE TODAY

CESPK FORM 86
1 APR 92

*(Replaces SPD Form 9, which is obsolete; and CESPK Form 86, 1 Apr 91, which will be used)*

**Example Daily Quality Control Report**

DISCUSSIONS WITH CONTRACTOR *(INCLUDE NAME OF CONTRACTOR'S REPRESENTATIVE*

SAFETY VIOLATIONS & ACCIDENTS OBSERVED AND ACTION TAKEN

REMARKS *(INCLUDE VISITORS)*

| PAY ITEM NO. | DESCRIPTION | QUANT. TODAY | TOTAL TO DATE | PAY ITEM NO. | DESCRIPTION | QUANT. TODAY | TOTAL TO DATE |
|---|---|---|---|---|---|---|---|
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*By signing this document, the Contractor acknowledges agreement with the items and totals to date noted above.*

SIGNATURE OF CONTRACTOR

*I CERTIFY that the work inspected or checked by me or members of my party on this date and covered by this report is in strick accordance with the provisions of the contract specifications with the exceptions indicated above.*

SIGNATURE OF INSPECTOR _____

CESPK FORM 86 *(Reverse)*
1 APR 92

**Example Daily Quality Control Report (cont.)**

0007

# CHAIN OF CUSTODY RECORD

Page ___ of ___

US ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
Engineering Division
SPK-ED-GB
1325 "J" Street
Sacramento, California
95814

| | | |
|---|---|---|
| Project Name: | | Laboratory: |
| Project Location: | | Address: |
| Project Coordinator: | | |
| Phone: | FAX: | Contact: |
| Sampler: | Phone: | Phone: |

**ANALYSIS REQUESTED ➤**

| SAMPLE IDENTIFICATION Field | Laboratory | GRAB | COMP | DATE | TIME | TURN AROUND TIME (DAYS) | MATRIX CODE | NUMBER OF CONTAINERS PLASTIC | GLASS | VOA | SLEEVE | FIELD FILTERED | PRESERVATIVE CODE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
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COMMENTS/SPECIAL INSTRUCTIONS:

CHECKED BY:

**PRESERVATIVE CODES:**
C = HCl N = $HNO_3$ S = $H_2SO_4$

**SAMPLE DISPOSAL:**
☐ Hold ☐ Dispose ☐ Return

| RELINQUISHED BY | DATE/TIME | RECEIVED BY | DATE/TIME |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

**MATRIX CODES:**
W = Water Sl = Sludge SP = Solid Product
S = Soil A = Air LP = Liquid Product
Sd = Sediment

**SHIPPING:**
☐ Fed Ex ☐ Courier ☐ Hand Deliver
Airbill Number:

CESPK FORM 111
1 DEC 94

DISTRIBUTION: WHITE and YELLOW - send to testing laboratory; PINK - send to QA laboratory; GOLD - retained by originator

# COOLER RECEIPT REPORT
## South Pacific Division Laboratory

**Project ID:** _____ **Project No.:** _____ **1st Sample No.:** _____
**(Cost Code)**

**Shipping Container(s)**

Container(s) Received On: _____ Inspected By: _____

Temperature (°C): _____ Thermometer ID : _____

Samples received in good condition: yes ☐ no ☐ (if no check the appropriate variance items)

☐ Custody seals not intact ☐ No Custody Form with samples

☐ Condition of samples affected (proceed to next section)

**Samples**

| Samples Affected | Method | Variance No. | Samples Affected | Method | Variance No. |
|---|---|---|---|---|---|
| | | | | | |
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**Variances**

1. Not enough sample received for proper analysis.
2. Sample received broken/leaking.
3. Sample received without proper preservative.
4. Sample received in improper container.
5. Sample received without paperwork.
6. Paperwork received without sample(s).
7. Sample ID on container does not match sample ID on paperwork. Explain briefly:

_____
_____
_____

8. No sample ID on container.
9. Holding time exceeded at receipt.
10. Sample received out of temperature.
11. Custody seal broken.
12. Custody form not properly relinguished.
13. Headspace in VOA samples.
14. Sample bottles not shipped in separate plastic bags.
15. Other: _____

_____
_____
_____

**Corrective Action**

Client informed ☐ verbally ☐ in writing on _____ by _____
Client : _____

☐ Sample(s) processed "as is." Comments: _____
_____

☐ Sample(s) on hold until _____. If released, notify: _____

# FIELD BORING LOG

| | | |
|---|---|---|
| AGENCY | | HOLE NO. |
| PROJECT | INSTALLATION | SHEET OF SHEETS |
| DRILLING CONTRACTOR | NAME OF DRILLER | NAME OF LOGGER |
| TYPES OF DRILL RIG, AUGER, BIT, SAMPLER, HAMMER | LOCATION | |
| | NORTHING / EASTING / SURFACE ELEVATION | |
| | DATE STARTED / DATE COMPLETED | |
| TOTAL DEPTH OF HOLE | DEPTH WATER ENCOUNTERED | DEPTH TO WATER TABLE/DATE |
| | | SOIL BORING BACKFILL |
| MONITORING WELL | CASING / SLOT SIZE / FILTER PACK / GROUT | SURFACE PROTECTION / TOP OF CASING ELEVATION |

| SAMPLE NUMBER | DEPTH (FEET) | SAMPLE | BLOW COUNTS | PID (PPM) | DESCRIPTION OF MATERIALS | WELL DETAILS | DRILLING REMARKS |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

C:\AC12\USPA\HTP\LOG2.DWG

| AGENCY | FIELD BORING LOG (CONTINUATION) | HOLE NO. |
|---|---|---|
| PROJECT | INSTALLATION | SHEET OF SHEETS |

| SAMPLE NUMBER | DEPTH (FEET) | SAMPLE | BLOW COUNTS | PID (PPM) | DESCRIPTION OF MATERIALS | WELL DETAILS | DRILLING REMARKS |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

C:\AC12\USR\HTRWLOG1.DWG

# MONITORING WELL MEASUREMENT LOG

Project _____ Date _____

Site _____ Sampler _____

Instrument _____ Checked by _____

| Well Number | Ref. Pt. Elev. (ft) | Water Depth (ft) | Time | Well Depth (ft) | Source | Water Elev. (ft) | Remarks |
|---|---|---|---|---|---|---|---|
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Water Elevation = Ref. Pt. Elev. - Water Depth

Source of well depth - (Log or Measured)

# *FIELD TEST EQUIPMENT CALIBRATION LOG*

| Equipment Type | Serial No. | Date | Calibration Time | Calibration Gas | Calibration Gas Lot No. | Calibrated By: |
|---|---|---|---|---|---|---|
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Revision 2
June 1999

# *MONITORING WELL PURGE AND SAMPLE LOG*

| | | |
|---|---|---|
| Project No.: | Site ID: | |
| Installation: | Log Book No. | Pages: |
| Contractor: | Sampler(s) | |
| Purge Start Date: / / Time: | Purge End Date: / / Time: | |
| Weather: ind mph | Precipitation: | Air Temperature: °F |
| Well Labeled: Y/N [ ] Well Secure: Y/N [ ] | Comments: | |
| PID SN: | Well Headspace (PID mu) | Odor |
| Explosimeter SN: | Reading: | %LEL |
| Water Level Instrument: | Serial No.: | |
| SWL (BTOC) | Total Well Depth (BTOC) | |
| Well Casing 2" 4" 6" Other: | Borehold diameter: | |
| Water Column: Gals/ft | Total Purge Vol. | Gallons |
| Purge Method: | Purge Equipment: | |

**Purge Data:**

Total depth _____ - Depth to water _____ = Column Height (Ht.)_____

Gal/ft *_____ x Ht _____ = Well volume _____ x No. of Volumes to be purged _____ =

Required purge volume _____ Actual purge Volume _____

* 2-inch ID well = 0.163, 4-inch ID well = 0.653, 6-inch ID well = 1.472, 4-inch ID well with 10-inch bore = 1.66

**PURGE CYCLE**

| Actual Time | Elapsed Time | Volume Purged (gals) | Depth to Water (ft) | Depth of Pump Intake (ft) | Temp (°F) | pH | Conductivity ($\mu$mhos/cm) | Turbidity (NTU) | Comments |
|---|---|---|---|---|---|---|---|---|---|
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|---|---|---|
| Sample Type(s): | **Sample No(s).** | |
| **Sample Equipment** | **Sample Filtered Y/N [ ]** | **Filter Type/Size:** |
| **Equipment Rinsate Sample No.:** | **Sample Equip Decon:** | **by:** |
| **Comments:** | | |
| **Prepared by:** **Date: / /** | **Reviewed by:** | **Date: / /** |

TOC - Top of Casing SWL - Static Water Level

*Appendix E*

# *Electronic Data Deliverable (EDD)*

# Enhanced ERPIMS Electronic Data Specification

## Draft Final

This specification provides for delivery of electronic data in a single file that is consistent with the latest Environmental Resources Program Information Management System (ERPIMS) format. The *ERPIMS '98 Data Loading Handbook, Version 4.0* (October 1997) is incorporated by reference. This specification also allows for the capture of additional quality control data, such as instrument calibration, internal standards, instrument tune, etc. Depending on project requirements, the laboratory will be provided with a software application that will screen all submissions for format compliance and accuracy prior to submission.

All fields in the EDD that also appear in the printed hardcopy must be exactly the same. Data that is physically the same but reported in more than one EDD (i.e. lab QC), must have all fields reported exactly the same in all EDDs. Care should be taken to ensure that values for all fields within a record are in agreement; for example, a PARVQ of "TR" would necessitate a PARVAL between the RL and MDL, and a QAPP_FLAG of "J".

### 1. Data Structure

The following list of fields is a compilation of all fields normally included in the SAMPLE, TEST, and RESULT ERPIMS tables (with the exception of REMARKS, which has been removed in the interest of brevity). Standard ERPIMS valid value lists should be used for all applicable entries. The submission is to be a fixed width file; data types and field lengths are those specified in the *Data Loading Handbook*, with modifications to Start and End values as listed below. Any additions to the descriptions contained in the *Data Loading Handbook* have been italicized. The columns "Field", "Lab" and "Val" have been included to designate either field, laboratory or data validation personnel as responsible for generating values for each field.

| Short Name | VVL | Field | Lab | Val | Start End | Description |
|---|---|---|---|---|---|---|
| AFIID | Yes | **Req** | | | 1-5 | INSTALLATION CODE [C5] Unique code used to represent an installation, base, or plant. These coded values usually represent Air Force installations. |
| LOCID | | Req | | | 7-21 | LOCATION NAME [C15] Unique identifier assigned to a location within a USAF installation where measurements or samples are taken. This is typically synonymous with monitoring well, borehole, *etc.* (*e.g.,* "MW-06.") |
| LOGDATE | | **Req** | | | 23-33 | SAMPLE DATE [DD-MMM-YYYY] Date that a sample is collected or a field test is performed. For Trip Blanks, LOGDATE should record when the sample was placed into the cooler. The LOGDATE for other Field QC samples is the date the sample was created. For Lab QC samples, LOGDATE relates to the earlier of ANADATE and EXTDATE *for each set of LB, BS and BD samples.* |
| LOGTIME | | **Req** | | | 35-38 | SAMPLE TIME [C4] Time of day (HHMM) that a sample is collected or a field measurement is made. For Trip Blanks, LOGTIME should record when the sample was placed into the cooler. For |

| Short Name | VVL | Field | Lab | Val | Start End | Description |
|---|---|---|---|---|---|---|
| | | | | | | Lab QC samples, LOGTIME relates to the earlier of ANADATE and EXTDATE *for each set of LB, BS and BD samples.* All times are reported using a 24-hour clock without a colon. |
| MATRIX | Yes | **Req** | | | 40-41 | Sampling Matrix. [C2] Coded value identifying the sample medium collected for analysis, *e.g.,* soil, water, air, *etc.* For QC blanks and reference materials, use the codes WQ, SQ, and AQ as specified in the valid value list. Since QC replicates and matrix spikes are in effect the same as the original sample, use the actual matrix of the original sample (see section 1 of Appendix B). |
| SBD | | Req | | | 43-50 | SAMPLE BEGINNING DEPTH [N7,2] [XXXXX.XX] The upper depth in feet from the ground surface or the water surface at which a sample is collected. Zero should be entered when depth is not used to identify where the sample was taken, *e.g.*, for QC blanks and most water samples. A value greater than zero should be entered for groundwater samples if depth is required to identify where the sample was taken, *e.g.*, for a well with multiple screened intervals where samples are taken at several different depths. |
| SED | | Req | | | 52-59 | SAMPLE ENDING DEPTH [N7,2] [XXXXX.XX] Lower depth in feet at which a soil sample is collected for analysis, relative to the ground surface. IMPORTANT: Water or field QC samples should have a zero in this field, not space characters. Zero should be entered when depth is not used to identify where the sample was taken. Sample ending depth (SED) if greater than zero should never be a smaller value than the sample beginning depth (SBD). |
| SACODE | Yes | Req | Cond | | 61-62 | SAMPLE TYPE [C2] A coded value indicating the type of sample collected (*e.g.,* normal, equipment blank, lab replicate, blank spike, *etc.).* See Section 1 of Appendix B for further discussion of sample types. *Field personnel are responsible for assigning this value for samples originating in the field; the laboratory assigns this value only for samples originating in the laboratory.* |
| SAMPNO | | Req | Cond | | 64-65 | SAMPLE NUMBER [N2] This number is sequentially assigned to samples of a given Sample Type collected at the same location on the same day. *Field personnel are responsible for assigning this value for samples originating in the field; the laboratory assigns this value only for samples originating in the laboratory. SAMPNO should be 1 in almost all circumstances.* |
| LOGCODE | Yes | Req | | | 67-70 | LOGGING COMPANY CODE [C4] Coded value identifying the company collecting samples or performing field tests. Report NA for LAB QC samples. |

| Short Name | VVL | Field | Lab | Val | Start End | Description |
|---|---|---|---|---|---|---|
| SMCODE | Yes | Req | | | 72-73 | SAMPLING METHOD CODE [C2] Coded value identifying the sampling method used to collect a sample. For QC blanks (or other samples where sampling method is not applicable) use the code NA. |
| FLDSAMPID | | **Req** | | | 75-104 | FIELD SAMPLE ID [C30] Unique number assigned to the sample in the field. |
| COCID | | **Opt** | | | 106-117 | CHAIN OF CUSTODY [C12] Unique identification reference to the chain of custody describing the transport of the sample to the laboratory. |
| COOLER | | Req | | | 119-120 | FIELD COOLER ID [C2] The unique number assigned to the cooler used to transport the sample. If a sample is split, enter the ID for the cooler containing the VOCs. Coolers with VOC samples must contain an associated trip blank. |
| ABLOT | | Req | | | 122-129 | AB FIELD LOT ID [C8][DDMMYYNN] Ambient Blank Field Lot Identifier. This field should only be filled-in for environmental samples with associated ABs and should never be filled-in for blank samples themselves. |
| EBLOT | | Req | | | 131-138 | EB FIELD LOT ID [C8][DDMMYYNN] Equipment Blank Field Lot Identifier. This field should only be filled-in for environmental samples with associated EBs and should never be filled-in for blank samples. |
| TBLOT | | Req | | | 140-147 | TB FIELD LOT ID [C8][DDMMYYNN] Trip Blank Field Lot Identifier. This field should only be filled-in for environmental samples with associated TBs and should never be filled-in for blank samples |
| LABCODE | Yes | | Req | | 149-152 | ANALYTICAL LABORATORY CODE [C4] Coded value identifying the actual laboratory that performed the analysis of a sample. |
| ANMCODE | Yes | | Req | | 154-160 | ANALYTICAL METHOD CODE [C7] Coded value representing the method of analysis (analytical method) used to perform laboratory testing. |
| EXMCODE | Yes | | Req | | 162-168 | PREPARATION METHOD [C7] Coded value representing the method used to extract or prepare a sample for a particular analysis. |
| LCHMETH | Yes | | Req | | 170-176 | LEACHATE METHOD [C7] Coded value representing the method used to derive leachate from a given sample. |
| RUN_NUMBER | | | Req | | 178-179 | RUN NUMBER [N2] This field permits the numerical coding of multiple or repeat analyses of a sample by the same analytical method on the same day. |
| LABSAMPID | | | Req | | 181-192 | LABORATORY SAMPLE IDENTIFICATION [C12] *Unique* identifier assigned to a sample by the laboratory and included in the reporting of results. |
| EXTDATE | | | Req | | 194-204 | PREPARATION DATE [DD-MMM-YYYY] Date that an extraction or some other preparation is made from a sample. |
| EXTTIME | | | Req | | 206-209 | PREPARATION TIME [C4] Time of day, using the 24 hour clock (HHMM), that an extraction or other preparation is made from a sample. |

| Short Name | VVL | Field | Lab | Val | Start End | Description |
|---|---|---|---|---|---|---|
| LCHDATE | | | Cond | | 211-221 | LEACHATE DATE [DD-MMM-YYYY] Date that leachate was derived from the sample. |
| LCHTIME | | | Cond | | 223-226 | LEACHATE TIME [C4] Time of day, using the 24 hour clock (HHMM), that the leachate was derived from the sample. |
| LCHLOT | | | Cond | | 228-237 | LEACHATE LOT [C10] The *unique* batch designator of an autonomous group of environmental samples and associated QC samples leached together. |
| ANADATE | | | Req | | 239-249 | ANALYSIS DATE [DD-MMM-YYYY] Date that the sample or extract was analyzed in a laboratory. |
| ANATIME | | | Req | | 251-254 | ANALYSIS TIME [C4] Time of day, using the 24 hour clock (HHMM), that a laboratory analysis was performed on a sample or extract. |
| ANALOT | | | Req | | 256-265 | ANALYTICAL LOT [C10] The *unique* batch designator of an autonomous group of environmental samples and associated QC samples analyzed together. |
| LABLOTCTL | | | Req | | 267-276 | PREPARATION LOT [C10] The *unique* batch designator of an autonomous group of environmental samples and associated QC samples prepared together. |
| CALREFID | | | Opt | | 278-287 | CALIBRATION REFERENCE [C10] A *unique* coded value which establishes a reference link between environmental and QC samples and their corresponding calibration records. |
| RTTYPE | Yes | Opt | | | 289-293 | REMEDIATION TECHNOLOGY TYPE [C5] Type of remediation technology (*e.g.,* slurry wall*, in-situ* vitrification, bio-reactor). |
| BASIS | Yes | | Req | | 295 | BASIS [C1] For tissue or solid samples enter whether results are reported on a wet (W) or dry (D) basis. Enter an X for samples of water, air, and gas matrix Field QC and Lab QC samples. |
| PARLABEL | Yes | | Req | | 297-308 | ANALYTE [C12] A coded value that must be selected from the PAR Valid Value List, that represents a particular analyte or parameter. |
| PRCCODE | Yes | | Req | | 310-312 | ANALYTE TYPE [C3] Coded value identifying a class or group that a parameter is associated with (*e.g.* ORG, MET, STD, *etc.*). |
| PARVQ | Yes | | Req | | 314-315 | PARAMETER VALUE QUALIFIER [C2] Coded value qualifying the analytical results field (PARVAL). This field must be filled in every result record. *Note that "%" is no longer a valid PARVQ.* |
| PARVAL | | | Req | | 317-331 | PARAMETER VALUE [N14,4] [XXXXXXXXXX.XXXX] The actual numeric value of the calculated or measured parameter being reported. This value is expressed in terms of the units of measure reported in the UNITS field. This field also captures the primary value for Gas Chromatography (GC) and High Performance Liquid Chromatography (HPLC) analyses. |
| PARUN | | | Cond | | 333-345 | PARAMETER VALUE UNCERTAINTY [N12,4] [XXXXXXXX.XXXX] A value that expresses the uncertainty of measured values inherent in the |

| Short Name | VVL | Field | Lab | Val | Start End | Description |
|---|---|---|---|---|---|---|
| | | | | | | measuring technique (expressed as + or - some value). Radiochemistry Only. |
| PRECISION | | | Req | | 347 | PRIMARY VALUE PRECISION [N1] Number indicating the precision (number of digits after the decimal point) that applies to the reported PARVAL, PARUN, EXPECTED, MDL, and RL fields. |
| EXPECTED | | | Cond | | 349-363 | EXPECTED VALUE [N14,4] [XXXXXXXXXX.XXXX] The target result for a spiked sample (*e.g.,* Matrix Spike, Matrix Spike Duplicate, surrogate, *etc.*). |
| EVPREC | | | Cond | | 365 | EXPECTED VALUE PRECISION [N1] Number indicating the precision (number of digits after the decimal point) that applies to the reported value for EXPECTED. |
| MDL | | | Req | | 367-381 | METHOD DETECTION LIMIT [N14,4] [XXXXXXXXXX.XXXX] The smallest quantity of analyte that can be detected from a prepared sample subject to the applied analytical method. |
| RL | | | Req | | 383-397 | REPORTING LIMIT [N14,4] [XXXXXXXXXX.XXXX] The applicable reporting limit for the project. If the project is following the AFCEE QAPP, the QAPP will give the AFCEE reporting limit or there will be an AFCEE approved, project-specific reporting limit. |
| UNITS | Yes | | Req | | 399-408 | UNITS [C10] Units of measure applied to the parameter value (PARVAL). If VAL_1C or VAL_CONFIRM are reported, the same UNITS must apply to them. |
| VQ_1C | Yes | | Cond | | 410-411 | FIRST COLUMN VALUE QUALIFIER [C2] Coded value qualifying the reported VAL_1C. VQ_1C relates to VAL_1C in the same way as PARVQ relates to PARVAL. |
| VAL_1C | | | Cond | | 413-427 | FIRST COLUMN VALUE [N14,4] [XXXXXXXXXX.XXXX] The primary value result for an analyte, from a Gas Chromatography (GC) or High Performance Liquid Chromatography (HPLC) analysis. |
| FCVALPREC | | | Cond | | 429 | FIRST COLUMN PRECISION [N1] Number indicating the precision (number of digits after the decimal point) that applies to the reported VAL_1C. |
| VQ_CONFIRM | Yes | | Cond | | 431-432 | CONFIRMING VALUE QUALIFIER [C2] Coded value qualifying the reported VQ_CONFIRM. VQ_CONFIRM relates to VAL_CONFIRM in the same way as PARVQ relates to PARVAL. |
| VAL_CONFIRM | | | Cond | | 434-448 | CONFIRMING VALUE [N14,4] [XXXXXXXXXX.XXXX] The confirming value for an analyte, from a GC or HPLC analysis that requires second column confirmation. |
| CNFVALPREC | | | Cond | | 450 | CONFIRMING VALUE PRECISION [N1] Number indicating the precision (number of digits after the decimal point) that applies to the reported VAL_CONFIRM. |

| Short Name | VVL | Field | Lab | Val | Start End | Description |
|---|---|---|---|---|---|---|
| DILUTION | | | Req | | 452-459 | DILUTION FACTOR [N8] Numeric expression of the amount of dilution required to bring the analyte concentration in the sample into analysis range. |
| DQTYPE | Yes | | | Cond | 461-462 | DATA QUALIFIER TYPE [C2] A code identifying the type of data qualifier. |
| EPA_FLAGS | | | | Cond | 464-469 | DATA QUALIFIER [C6] EPA qualifier codes that are assigned during chemistry data validation. |
| QAPPFLAGS | Yes | | Cond | | 471-472 | QAPP FLAGS [C2] A coded value assigned to analytical results during laboratory or validation review. Flags are set in accordance with the AFCEE Quality Assurance Project Plan (QAPP). |
| *VALCODE* | *Yes* | | | *Req* | *474-477* | *DATA VALIDATOR CODE [C4] Coded value identifying the company validating analytical results.* |
| *DQREASON* | | | | *Cond* | *479-484* | *DATA QUALIFIER REASON CODE [C6] A code identifying the reason associated with the applied data qualifier.* |
| *DQBIAS* | *Yes* | | | *Cond* | *486* | *DATA QUALIFIER BIAS CODE [C1] A code identifying the bias associated with the applied data qualifier.* |

Fields in **bold** are provided to the laboratory via the chain of custody, and must be included in the electronic data submitted by the laboratory.

## 2. Data Submissions

Data will be reported in sample delivery groups (SDGs). The SDG will be identified using the first eight characters of the lowest field sample ID within the group, considering both alpha and numeric designations. This SDG identifier will also be used as the file name of the electronic deliverable, followed by an extension of ".XXn" where "XX" is either "LB" or "VL", representing the party submitting the deliverable, and n is incremented to reflect the submission number. For instance, "{SDG}.LB1" for the initial laboratory submittal; if necessary, data would be resubmitted with the file names "{SDG}.LB2", "{SDG}.LB3", etc. The corresponding validator electronic data submittals would be "{SDG}.VL2 "{SDG}.VL2", "{SDG}.VL3", etc.

Should field personnel provide electronic chain of custody information to the laboratory, one file will be provided for each chain of custody document, with the file name {COCID}.FLn, where {COCID} is the last eight characters (unique) of the chain of custody ID number, and n is incremented to reflect the submission number.

## 3. Additional QC Data

Based on the needs of the project, additional QC data may be reported using the following guidelines. QC data not included in the ERPIMS specification is to be reported as follows:

Calibration verification standards, interference check samples, and internal standards shall be expressed as percent recovery and reported in units of "PERCENT"; the fields RL and MDL should be left blank.

Multipoint calibration standards shall be expressed as 'response factor' with units of "RF"; the fields RL and MDL should be left blank.

Instrument tune data shall be expressed as 'abundance' with units of "ABD"; the fields RL and MDL should be left blank.

Calibration blanks shall be reported in the same manner as laboratory blanks.

## 4. Valid Value Additions

In order to accommodate the delivery of additional QC elements, the following valid values have been added:

| Table | Description | Code | Name |
|---|---|---|---|
| VVLSA | Sample Type | CV | Calibration Verification Standard |
| | | CB | Calibration Blank |
| | | MC | Multipoint Calibration |
| | | IA | Interference Check Sample-A |
| | | IB | Interference Check Sample-AB |
| | | TU | Instrument Tune |
| VVLUTM | Units of Measure | RF | Response Factor |
| | | ABD | Abundance |
| VVLPRC | Analytic Classification) | IS | Internal Standard |

*Appendix F*

# *DOD QSM SW-846 METHOD QUALITY REQUIREMENTS*

# Appendix F – SW-846 Quality Control Requirements

In many cases, SW-846 methods are ambiguous or provide insufficient detail in regards to Quality Control (QC) requirements. The specific manner in which methods commonly used by DoD should be implemented is detailed in the following tables. Modifications to the following requirements need project-specific approval by DoD personnel.

**SW-846 Methods**
This appendix is based on all method versions available at the time of publication, regardless of status (promulgated, draft, or proposed). The requirements in this appendix represent the minimum requirements for DoD regardless of method version. If there is a contradiction between the method and the following tables, the requirements specified in the tables shall be followed unless project- specific or regulatory approval is required.

The tables describe specific quality assurance and quality control requirements for SW-846 analytical methods commonly used when investigating DoD sites. The tables specify the minimum DoD requirements, as well as additional clarification. If possible, the actual requirement from the method is listed, although in some cases the description in the method is so lengthy that only a reference to the method is made. DoD has done its best to interpret the methods, providing clarification where there are inconsistencies between existing guidance documents, and stating minimum DoD requirements when multiple options are acceptable. If there is a contradiction between the method and the following tables, the requirements specified in the tables shall be followed unless project-specific or regulatory approval is required.

Table F-1 below presents a summary of the definition, purpose, and evaluation of the major SW-846 QC checks required in the subsequent QC tables (F-2 through F-12) for the various methods. The definition column describes what the QC check is and how it is performed. The purpose column describes why the check is important for assessing and measuring the quality of the data being generated. The evaluation column describes how to interpret the results of the QC check, particularly in the context of the results of other QC checks. This table should be used in conjunction with the instrument- and method-specific requirement tables to properly implement the methods for DoD projects. In addition, a supplementary list of acronyms relevant to this appendix follows Table F-12.

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| Table F-1. Summary of Quality Control Check Definitions, Purpose, and Evaluation | | | |
|---|---|---|---|
| **QC Check** | **Definition** | **Purpose** | **Evaluation** |
| **Breakdown check (Endrin and DDT – Method 8081, DDT – Method 8270)** | Analysis of a standard solution containing Endrin and DDT. Area counts of these compounds and their breakdown products are evaluated to assess instrument conditions. | To verify the inertness of the injection port because DDT and Endrin are easily degraded in the injection port. | If degradation of either DDT or Endrin exceeds method-specified criteria, corrective action must be taken before proceeding with calibration. |
| **Calibration blank** | Reagent water containing no analytes of interest. | To determine the zero point of the calibration curve for all initial and continuing calibrations. | This is a required QC procedure. Continuing calibration blank responses above the LOD require corrective action. |
| **Confirmation of positive results (organics only)** | Use of alternative analytical techniques (another method, dissimilar column, or different detector such as MS detector) to validate the presence of target analytes identified. | To verify the identification of an analyte. | All positive results must be confirmed. |
| **Continuing calibration verification (CCV)** | The verification of the ICAL that is required during the course of analysis at periodic intervals. Continuing calibration verification applies to both external standard and internal standard calibration techniques, as well as to linear and non-linear calibration models. | To verify that instrument response is reliable, and has not changed significantly from the current ICAL curve. | If the values for the analytes are outside the acceptance criteria, the ICAL may not be stable. Results associated with out-of-control CCV results require reanalysis or flagging. |
| **Demonstrate acceptable analytical capability** | QC samples are analyzed in series to verify ability to produce data of acceptable precision and bias. | To verify the ability to produce data of acceptable precision and bias for a specific instrument type, matrix, method, and analyst. | The average recovery of the spikes and standard deviation of the replicates must be within designated acceptance criteria.<br><br>Analysis of field samples may not be conducted until this check is successful. |
| **Dilution test (metals only)** | Analysis of a positive sample, which has been diluted to a concentration one-fifth of the original, to confirm that there is no interference in the original sample analysis. (Modified COE) | To assess matrix interference. | Agreement within 10% between the concentration for the undiluted sample and five times the concentration for the diluted sample indicates the absence of interferences, and such samples may be analyzed without using the method of standard additions. Results outside acceptance limits indicate a possible matrix effect. For ICP, a post-digestion spike must be run; for GFAA, a recovery test must be run. |

**Table F-1. Summary of Quality Control Check Definitions, Purpose, and Evaluation (continued)**

| QC Check | Definition | Purpose | Evaluation |
|---|---|---|---|
| **Duplicate sample (replicate)** | Two identical portions of material collected for chemical analysis, and identified by unique alphanumeric codes. The duplicate may be portioned from the same sample, or may be two identical samples taken from the same site. The two portions are prepared and analyzed identically. (Modified QSM) | To provide information on the heterogeneity of the sample matrix or to determine the precision of the intralaboratory analytical process for a specific sample matrix. | A duplicate sample will provide information on the heterogeneity of the sample matrix. The greater the heterogeneity of the matrix, the greater the relative percent difference between the sample and the sample duplicate.<br><br>If the sample matrix is homogeneous (such as with drinking water) and the relative percent difference is high, this could indicate a problem in the analytical system. |
| **GC column performance check (Methods 8280 and 8290 only)** | Analysis of method-specified compounds to verify chromatographic separation of dioxin isomers. (Method) | To evaluate the performance of the analytical system and establish retention time window markers for dioxin isomers. | Sample analysis may not begin until method-specified criteria are met. |
| **Initial calibration for all analytes (ICAL)** | Analysis of analytical standards at different concentrations that are used to determine and calibrate the quantitation range of the response of the analytical detector or method. | To establish a calibration curve for the quantification of the analytes of interest. | Statistical procedures are used to determine the relationship between the signal response and the known concentration of analytes of interest. The ICAL must be successful before any samples or other QC check samples can be analyzed. |
| **Instrument detection limit (IDL) study (Methods 6010 and 6020 only)** | The process to determine the minimum concentration of a substance (analyte) that an instrument can differentiate from noise. The procedure for calculating varies by method. | To provide an evaluation of instrument sensitivity. | IDLs must be established before samples can be analyzed. |
| **Interference check solutions (ICP and ICP/MS only)** | A pair of solutions containing interfering elements that are used to verify the correction factors of analytes of concern. | To verify the established correction factors by analyzing the interference check solution at the beginning of the analytical sequence. | No samples can be run if this check does not pass acceptance criteria. |
| **Internal standards** | A substance that is introduced in known amount into each calibration standard and field and QC sample of the analyte. | The ratio of the analyte signal to the internal standard signal is then used to determine the analyte concentration. | Any samples associated with out-of-control results must be reanalyzed. |

**Table F-1. Summary of Quality Control Check Definitions, Purpose, and Evaluation (continued)**

| QC Check | Definition | Purpose | Evaluation |
|---|---|---|---|
| **Laboratory control sample (LCS) containing all analytes to be reported** | A sample matrix, free from the analytes of interest, spiked with known amounts of analytes or a material containing known and verified amounts of analytes. | Used to evaluate the performance of the total analytical system, including all preparation and analysis steps. Assesses the ability of the laboratory/analyst to successfully recover the target analytes from a control (clean) matrix.<br><br>Control limits for LCS recovery, typically expressed as percent recovery, are used for the development of statistical control limits and serve as acceptance criteria for determining whether an analytical run is in control (batch acceptance). | This is a required QC check. The inability to achieve acceptable recoveries in the LCS indicates problems with the precision and bias of the measurement system.<br><br>Failure to achieve acceptable recoveries in a "clean" matrix is an indicator of possible problems achieving acceptable recoveries in field samples. |
| **Linear dynamic range or high-level check standards (ICP and ICP/MS only)** | High-level check standard periodically analyzed to verify the linearity of the calibration curve at the upper end. | To verify quantitative accuracy of data up to the high-level standard. | This QC check establishes the upper linear range of the calibration. |
| **Low-level calibration check standard (ICP only)** | A reference standard that contains a quantity of analyte equal to or less than the reporting limit. | To confirm the accuracy of measurements at or near the RL. | This QC check must be within acceptance criteria before any samples are analyzed. |
| **Matrix spike (MS)** | A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available. | To assess the performance of the method as applied to a particular matrix.<br><br>Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency.<br><br>The recovery of target analytes from the matrix spike sample is used to determine the bias of the method in the specific sample matrix. | The lack of acceptable recoveries in the matrix spike often points to problems with the sample matrix. One test of this is a comparison to the LCS recoveries. If the corresponding LCS recoveries are within acceptable limits, a matrix effect is likely. The laboratory should not correct for recovery; only report the results of the analyses and the associated matrix spike results and indicate that the results from these analyses have increased uncertainty. |

**Table F-1. Summary of Quality Control Check Definitions, Purpose, and Evaluation (continued)**

| QC Check | Definition | Purpose | Evaluation |
|---|---|---|---|
| **Matrix spike duplicate (MSD)** | A second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of recovery for each analyte. | To assess the performance of the method as applied to a particular matrix and provide information on the homogeneity of the matrix.<br><br>Also used to determine the precision of the intralaboratory analytical process for a specific sample matrix. | When compared with the MS, the MSD will provide information on the heterogeneity of the sample matrix. The greater the heterogeneity of the matrix, the greater the RPD between the matrix spike and the matrix spike duplicate.<br><br>If the sample matrix is homogeneous, such as with drinking water, and the RPD is high, this could indicate a problem in the analytical system. |
| **Matrix verification sample (hexavalent chromium only)** | A pH-adjusted filtrate that has been spiked with hexavalent chromium to ensure that the sample matrix does not have a reducing condition or other interferents that could affect color development. (Modified Method) | To ensure that the sample matrix does not have a reducing condition or other interferents that affect color development. | To verify the absence of an interference, the spike recovery must be between 85% and 115%. If the result of verification indicates a suppressive interference, the sample should be diluted and reanalyzed. If the interference persists after sample dilution, an alternative method (Method 7195, Coprecipitation, or Method 7197, Chelation/Extraction) should be used. |
| **Method blank** | A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses. | To assess background interference or contamination in the analytical system that might lead to high bias or false positive data. Results of method blanks provide an estimate of the within-batch variability of the blank response and an indication of bias introduced by the preparation and analytical procedure. | This is one of the QC samples used to measure laboratory accuracy/bias. This sample could indicate whether contamination is occurring during sample preparation and analysis. If analytes are detected > ½ RL, reanalyze or qualify (B-flag) all results for the specific analyte(s) in all samples in the associated preparatory batch, as appropriate. For common laboratory contaminants, no analytes detected > the RL. See Section D.1.1.1 and Box D-1. |
| **Method of standard additions (ICP/GFAA only)** | A set of procedures adding one or more increments of a standard solution to sample aliquots of the same size in order to overcome inherent matrix effects. The procedures encompass the extrapolation back to obtain the sample concentration. (This process is also called spiking the sample.) | To compensate for a sample constituent that enhances or depresses the analyte signal, thus producing a different slope from that of the calibration standards. It will not correct for additive interferences that cause a baseline shift. | This is the method used when matrix interferences are present and do not allow determination of accurate sample results. |

**Table F-1. Summary of Quality Control Check Definitions, Purpose, and Evaluation (continued)**

| QC Check | Definition | Purpose | Evaluation |
|---|---|---|---|
| **Post digestion spike addition (ICP and ICP/MS only)** | An analyte spike added to a portion of prepared sample to verify absence or presence of matrix effects. | To confirm the presence of a matrix interference. Assess matrix effects based on, (1) the occurrence of new and unusual matrices included within the batch, or (2) contingency analysis based on serial dilution or matrix spike failures. | To verify the absence of an interference, the spike recovery must be between 75% and 125%. Results outside the acceptance limits require a method of standard additions (MSA) for all samples within the batch. |
| **Recovery test (GFAA only)** | An analyte spike added to a portion of prepared sample to verify absence or presence of matrix effects. | To confirm the presence of a matrix interference. Assess matrix effects based on, (1) the occurrence of new and unusual matrices included within the batch, or (2) contingency analysis based on serial dilution or matrix spike failures. | To verify the absence of an interference, the spike recovery must be between 85% and 115%. Results outside the acceptance limits require a MSA for all samples within the batch. |
| **Retention time window position establishment for each analyte (and surrogate) (all chromatographic methods only)** | Determination of the placement of the retention time window (i.e., start/stop time) of each analyte or group of analytes as it elutes through the chromatographic column so that analyte identification can be made during sample analysis. This is done during the ICAL. | To identify analytes of interest. | Incorrect window position may result in false negatives, require additional manual integrations, or cause unnecessary reanalysis of samples when surrogates or spiked compounds are erroneously not identified. |
| **Retention time window width calculated for each analyte (and surrogate) (non-MS chromatographic methods only)** | Determination of the length of time between sample injection and the appearance of a peak at the detector. The total length of time (window) is established for each analyte or group of analytes and is set for complete elution of analyte peaks. It is based upon a series of analyses and statistical calculations that establish the measured band on the chromatogram that can be associated with a specific analyte or group of analytes. | To ensure that the chromatographic system is operating reliably and that the system conditions have been optimized for the target analytes and surrogates in the standards and sample matrix to be analyzed. It is done to minimize the occurrence of both false positive and false negative results. | Used to evaluate continued system performance. Tight retention time windows may result in false negatives or may cause unnecessary reanalysis of samples when surrogates or spiked compounds are erroneously not identified. Overly wide retention time windows may result in false positive results that cannot be confirmed upon further analysis. |
| **Second source calibration verification (ICV)** | A standard obtained or prepared from a source independent of the source of standards for the ICAL. Its concentration should be at or near the middle of the calibration range. It is done after the ICAL. | To verify the accuracy of the ICAL. | The concentration of the second-source calibration verification, determined from the analysis, is compared with the known value of the standard to determine the accuracy of the ICAL. This independent verification of the ICAL must be acceptable before sample analysis can begin. |

**Table F-1. Summary of Quality Control Check Definitions, Purpose, and Evaluation (continued)**

| QC Check | Definition | Purpose | Evaluation |
|---|---|---|---|
| **Surrogate spike (organic analysis only)** | A substance with properties that mimic the analyte of interest. It is unlikely to be found in environment samples and is added to them for quality control purposes. | To assess the ability of the method to successfully recover specific non-target analytes from an actual matrix.<br><br>Because surrogates are generally added to each sample in a batch, they can be used to monitor recovery on a sample-specific, rather than batch-specific basis. | Whereas the matrix spike is normally done on a batch-specific basis, the surrogate spike is done on a sample-specific basis. Taken with the information derived from other spikes (LCS, matrix spike), the bias in the analytical system can be determined. |
| **Tuning (mass spectrometer methods only)** | The analysis of a standard compound to verify that the mass spectrometer meets standard mass spectra abundance criteria prior to sample analysis. (COE) | To verify the proper working of the mass spectrometer. | Proper tuning of the mass spectrometer must be verified prior to sample analysis. |

As always, project-specific requirements identified by the client supersede any requirements listed in the following tables. The requirements are meant to be the default, to be used when project-specific direction based on DQOs is not included.

Tables F-2 through F-10 are organized in most cases by instrument type. The applicable methods are specified in the table title. When there are exceptions (i.e., the QC check does not apply to all methods or instrument types in the table), they are noted in the first column of the table ("QC Check"). Each table contains the following fields (or columns):

**QC Check:** The name of the QC measure that is required. If the check is only applicable to certain methods from the table, they will be noted in parentheses in this field.

**Minimum Frequency:** Describes how often the QC check must be performed and, if relevant, at what point in the process (for example, prior to sample analysis). Some QC checks are only performed when another QC check fails. This will be noted in the minimum frequency field.

**Acceptance Criteria:** The standard that the QC check must satisfy in order to proceed without performing corrective action. In some cases there are multiple options, all equivalently acceptable by DoD, for acceptance of a single QC check. These options will be listed and the appropriate option should be applied. There may be references to acceptance criteria published by DoD. The LCS control limits for certain methods can be found in Appendix G.

**Corrective Action:** If a QC check does not meet the acceptance criteria specified in the preceding field, the corrective action field identifies what steps must be taken to ensure that the results will be valid. Requirements usually include finding the cause of failure of the acceptance criteria and rerunning the QC check. The corrective action field will also specify which other QC checks must be rerun to ensure valid data.

**Flagging Criteria:** Where flagging is appropriate, the qualifier flag is listed in this field along with the criteria for using the flag. Flagging should only be used as a last resort. Data should only be flagged once corrective action has been performed. In many cases the field states "Flagging criteria is not appropriate." This means that corrective action must continue until the problem is solved and the QC check satisfies its acceptance criteria. Samples will not be accepted without successful completion of this QC check. Flagging is only appropriate in cases where the samples cannot be reanalyzed. This field will also specify when additional information should be detailed in the case narrative.

**Comments:** This field contains further clarification of any of the previous five fields.

The following tables detail DoD-specific QC requirements for SW-846 methods, organized by instrument type:

**Table F-2:** Organic Analysis by Gas Chromatography and High-Performance Liquid Chromatography (Methods 8011, 8015, 8021, 8070, 8081, 8082, 8121, 8141, 8151, 8310, 8330, and 8330A)

**Table F-3:** Nitroaromatics, Nitramines, and Nitrate Esters Analysis by High-Performance Liquid Chromatography (Method 8330B)

**Table F-4:** Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 8260 and 8270)

**Table F-5:** Dioxin/Furan Analysis by High-Resolution Gas Chromatography/Low-Resolution Mass Spectrometry (Method 8280)

**Table F-6:** Dioxin/Furan Analysis by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (Method 8290)

**Table F-7:** Inorganic Analysis by Inductively Coupled Plasma (ICP) Atomic Emission Spectrometry and Atomic Absorption Spectrophotometry (AA) (Methods 6010 and 7000 series)

**Table F-8:** Trace Metals Analysis by Inductively Coupled Plasma/Mass Spectrometry (ICP/MS) (Method 6020)

**Table F-2. Organic Analysis by Gas Chromatography and High-Performance Liquid Chromatography (Methods 8011, 8015, 8021, 8070, 8081, 8082, 8121, 8141, 8151, 8310, 8330, and 8330A)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Demonstrate acceptable analytical capability** | Prior to using any test method and at any time there is a significant change in instrument type, personnel, test method, or sample matrix. | QC acceptance criteria published by DoD, if available; otherwise, method-specified criteria. | Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f). | Not Applicable (NA). | This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete. |
| **LOD determination and verification (See Box D-13)** | | | | | |
| **LOQ establishment and verification (See Box D-14)** | | | | | |
| **Retention time (RT) window width calculated for each analyte and surrogate** | At method set-up and after major maintenance (e.g., column change). | RT width is ± 3 times standard deviation for each analyte RT from a 72-hour study. | NA. | NA. | |
| **Breakdown check (Endrin / DDT Method 8081 only)** | At the beginning of each 12-hour period, prior to analysis of samples. | Degradation ≤ 15% for both DDT and Endrin. | Correct problem then repeat breakdown check. | Flagging criteria are not appropriate. | No samples shall be run until degradation ≤ 15% for both DDT and Endrin. |

**Table F-2. Organic Analysis by Gas Chromatography and High-Performance Liquid Chromatography (Methods 8011, 8015, 8021, 8070, 8081, 8082, 8121, 8141, 8151, 8310, 8330, and 8330A) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Minimum five-point initial calibration (ICAL) for all analytes** | ICAL prior to sample analysis. | One of the options below:<br><br>Option 1: RSD for each analyte ≤ 20%;<br><br>Option 2: linear least squares regression: r ≥ 0.995;<br><br>Option 3: non-linear regression: coefficient of determination (COD) $r^2 \geq$ 0.99 (6 points shall be used for second order, 7 points shall be used for third order). | Correct problem then repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until ICAL has passed.<br><br>Calibration may not be forced through the origin.<br><br>Quantitation for multicomponent analytes such as chlordane, toxaphene, and Aroclors must be performed using a 5-point calibration. Results may not be quantitated using a single point. |
| **Retention time window position establishment for each analyte and surrogate** | Once per ICAL and at the beginning of the analytical shift. | Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used. | NA. | NA. | |
| **Second source calibration verification (ICV)** | Immediately following ICAL. | All project analytes within established retention time windows.<br><br>GC methods: All project analytes within ± 20% of expected value from the ICAL;<br><br>HPLC methods: All project analytes within ± 15% of expected value from the ICAL. | Correct problem, rerun ICV. If that fails, repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until calibration has been verified. |

**Table F-2. Organic Analysis by Gas Chromatography and High-Performance Liquid Chromatography (Methods 8011, 8015, 8021, 8070, 8081, 8082, 8121, 8141, 8151, 8310, 8330, and 8330A) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Continuing calibration verification (CCV)** | Prior to sample analysis, after every 10 field samples, and at the end of the analysis sequence. | All project analytes within established retention time windows.<br><br>GC methods: All project analytes within ± 20% of expected value from the ICAL;<br><br>HPLC methods: All project analytes within ± 15% of expected value from the ICAL. | Correct problem, then rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable calibration verification. | Problem must be corrected. Results may not be reported without a valid CCV. Flagging is only appropriate in cases where the samples cannot be reanalyzed.<br><br>Retention time windows are updated per the method. |
| **Method blank** | One per preparatory batch. | No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results (see Box D-1). | Correct problem, then see criteria in Box D-1. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Laboratory control sample (LCS) containing all analytes to be reported, including surrogates** | One per preparatory batch. | QC acceptance criteria specified by DoD, if available. Otherwise, use in-house control limits. In-house control limits may not be greater than ± 3 times the standard deviation of the mean LCS recovery. See Box D-3 and Appendix G. | Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available (see full explanation in Appendix G). | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Matrix spike (MS)** | One per preparatory batch per matrix (see Box D-7). | For matrix evaluation, use LCS acceptance criteria specified by DoD, if available. Otherwise, use in-house LCS control limits. | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | For matrix evaluation only. If MS results are outside the LCS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error. |

**Table F-2. Organic Analysis by Gas Chromatography and High-Performance Liquid Chromatography (Methods 8011, 8015, 8021, 8070, 8081, 8082, 8121, 8141, 8151, 8310, 8330, and 8330A) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Matrix spike duplicate (MSD) or sample duplicate** | One per preparatory batch per matrix (see Box D-7). | MSD: For matrix evaluation, use LCS acceptance criteria specified by DoD, if available. Otherwise, use in-house LCS control limits.<br><br>MSD or sample duplicate: RPD ≤ 30% (between MS and MSD or sample and sample duplicate). | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | The data shall be evaluated to determine the source of difference. |
| **Surrogate spike** | All field and QC samples. | QC acceptance criteria specified by DoD, if available. Otherwise, use in-house control limits. | For QC and field samples, correct problem then reprep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary. | Apply Q-flag to all associated analytes if acceptance criteria are not met. | Alternative surrogates are recommended when there is obvious chromatographic interference. |
| **Confirmation of positive results (second column or second detector)** | All positive results must be confirmed (with the exception of Method 8015). | Calibration and QC criteria same as for initial or primary column analysis. Results between primary and second column RPD ≤ 40%. | NA. | Apply J-flag if RPD > 40%. Discuss in the case narrative. | Use project-specific reporting requirements if available; otherwise, use method reporting requirements; otherwise, report the result from the primary column (see Box D-16). |
| **Results reported between DL and LOQ** | NA. | NA. | NA. | Apply J-flag to all results between DL and LOQ. | |

| Table F-3. Nitroaromatics, Nitramines, and Nitrate Esters Analysis by High-Performance Liquid Chromatography (Method 8330B) | | | | | |
|---|---|---|---|---|---|
| **QC Check** | **Minimum Frequency** | **Acceptance Criteria** | **Corrective Action** | **Flagging Criteria** | **Comments** |
| **Demonstrate acceptable analytical capability** | Prior to using any test method and at any time there is a significant change in instrument type, personnel, test method, or sample matrix. | QC acceptance criteria published by DoD, if available; otherwise, method-specified criteria. | Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f). | Flagging criteria are not appropriate. | This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete. |
| **LOD determination and verification (See Box D-13)** | | | | | |
| **LOQ establishment and verification (See Box D-14)** | | | | | |
| **Soil drying procedure** | Each sample and batch LCS. | Laboratory must have a procedure to determine when the sample is dry to constant weight. Record date, time, and ambient temperature on a daily basis while drying samples. | NA. | Flagging criteria are not appropriate. | |
| **Soil sieving procedure** | Each sample and batch LCS. | Weigh entire sample. Sieve entire sample with a 10 mesh sieve. Breakup pieces of soil (especially clay) with gloved hands. Do not intentionally include vegetation in the portion of the sample that passes through the sieve unless this is a project specific requirement. Collect and weigh any portion unable to pass through the sieve. | NA. | Flagging criteria are not appropriate. | |

**Table F-3. Nitroaromatics, Nitramines, and Nitrate Esters Analysis by High-Performance Liquid Chromatography (Method 8330B) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Soil grinding procedure** | Initial demonstration. | The laboratory must initially demonstrate that the grinding procedure is capable of reducing the particle size to < 75 µm by passing representative portions of ground sample through a 200 mesh sieve (ASTM E11). | NA. | Flagging criteria are not appropriate. | |
| **Soil grinding blank** | Between each sample. | A grinding blank using clean solid matrix (such as Ottawa sand) must be prepared (e.g., ground and subsampled) and analyzed in the same manner as a field sample. Grinding blanks can be analyzed individually or composited. No target analytes detected greater than 1/2 Reporting Limit (RL). | All blank results must be reported and the affected samples must be flagged accordingly if blank criteria is not met. | If the composite grinding blank exceeds the acceptance criteria, apply B-flag to all samples associated with the grinding composite. If any individual grinding blank is found to exceed the acceptance criteria, apply B-flag to the sample following that blank. | |
| **Soil subsampling process** | Each sample, duplicate, and batch LCS. | Entire ground sample is mixed, spread out on a large flat surface (e.g., baking tray), and 30 or more randomly located increments are removed from the entire depth to sum a ~10 g subsample. | NA. | Flagging criteria are not appropriate. | |
| **Soil sample triplicate** | At the subsampling step, one sample per batch. Cannot be performed on any type of blank sample. | Three 10 g subsamples are taken from a sample expected to contain the highest levels of explosives within the Quantitation Range of the method.<br><br>The RSD for results above the RL must not exceed 20%. | Corrective action must be taken if this criterion is not met (e.g., the grinding process should be investigated to ensure that the samples are being reduced to a sufficiently small particle size). | Apply J-flag if corrective action does not solve problem and no sample available. | |

**Table F-3. Nitroaromatics, Nitramines, and Nitrate Esters Analysis by High-Performance Liquid Chromatography (Method 8330B) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Aqueous sample preparation** | Each sample. | Solid phase extraction (SPE) using resin-based solid phase disks or cartridges is required. The salting-out procedure is not permitted. | NA. | Flagging criteria are not appropriate. | |
| **Initial calibration (ICAL)** | Minimum of 5 calibration standards with the lowest standard concentration at or below the RL. Once calibration curve or line is generated, the lowest calibration standard must be re-analyzed. | The apparent signal-to-noise ratio at the RL must be at least 5:1. If linear regression is used, $r \geq 0.995$. If using Internal Standardization, RSD ≤ 15%. | Correct problem, then repeat ICAL. | Flagging criteria are not appropriate. | No samples can be run without a valid ICAL. Analysis by HPLC UV, LC/MS, or LC/MS/MS is allowed. |
| **Second source calibration verification (ICV)** | Immediately following ICAL. | All analyte(s) and surrogates within ± 20% of true value. | Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until calibration has been verified. |
| **Continuing calibration verification (CCV)** | Prior to sample analysis, after every 10 field samples, and at the end of the analysis sequence. | All target analytes and surrogates within ± 20% of the expected value from the ICAL. | Correct problem, rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable calibration verification. | Problem must be corrected. Results may not be reported without a valid CCV. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Method blank** | One per preparatory batch. | No analytes detected > ½ RL and greater than 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. | Correct problem, then see criteria in Box D-1. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |

**Table F-3. Nitroaromatics, Nitramines, and Nitrate Esters Analysis by High-Performance Liquid Chromatography (Method 8330B) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **LCS containing all analytes to be reported** | One per preparatory batch. | A solid reference material containing all reported analytes must be prepared (e.g., ground and subsampled) and analyzed in exactly the same manner as a field sample. In-house laboratory control limits for the LCS must demonstrate the laboratory's ability to meet the project's MQOs. | Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available (see full explanation in Appendix G). | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Matrix Spike (MS)** | One per preparatory batch per matrix (see Box D-7). | For matrix evaluation only, therefore is taken post grinding from same ground sample as parent subsample is taken. Percent recovery must meet LCS limits. | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | For matrix evaluation only. If MS results are outside the LCS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error. |
| **Matrix spike duplicate (MSD) or sample duplicate** | One per preparatory batch per matrix (see Box D-7). | For matrix evaluation only, therefore is taken post grinding from same ground sample as parent subsample is taken. Percent recovery must meet LCS limits and relative percent difference (RPD) < 20%. | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | The data shall be evaluated to determine the source of difference. |

**Table F-3. Nitroaromatics, Nitramines, and Nitrate Esters Analysis by High-Performance Liquid Chromatography (Method 8330B) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Confirmation analysis** | When target analytes are detected on the primary column using the UV Detector (HPLC) at concentrations exceeding the Limit of Detection (LOD). | Calibration and QC criteria are the same as for initial or primary column analysis. Results between primary and second column RPD ≤ 40%. | Report from both columns. | If there is a > 40% RPD between the two column results, data must be J-flagged accordingly. | Confirmation analysis is not needed if LC/MS or LC/MS/MS was used for the primary analysis. Secondary column – Must be capable of resolving (separating) all of the analytes of interest and must have a different retention time order relative to the primary column. Any HPLC column used for confirmation analysis must be able to resolve and quantify all project analytes. Detection by HPLC UV, LC/MS or LC/MS/MS. Calibration and calibration verification acceptance criteria is the same as for the primary analysis. |
| **Results reported between DL and LOQ** | NA. | NA. | NA. | Apply J-flag to all results between DL and LOQ. | |

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| Table F-4. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 8260 and 8270) | | | | | |
|---|---|---|---|---|---|
| **QC Check** | **Minimum Frequency** | **Acceptance Criteria** | **Corrective Action** | **Flagging Criteria** | **Comments** |
| **Demonstrate acceptable analytical capability** | Prior to using any test method and at any time there is a significant change in instrument type, personnel, test method, or sample matrix. | QC acceptance criteria published by DoD, if available; otherwise, method-specific criteria. | Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f). | NA. | This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete. |
| **LOD determination and verification (See Box D-13)** | | | | | |
| **LOQ establishment and verification (See Box D-14)** | | | | | |
| **Tuning** | Prior to ICAL and at the beginning of each 12-hour period. | Refer to method for specific ion criteria. | Retune instrument and verify. Rerun affected samples. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be accepted without a valid tune. |
| **Breakdown check (DDT Method 8270 only)** | At the beginning of each 12-hour period, prior to analysis of samples. | Degradation ≤ 20% for DDT. Benzidine and pentachlorophenol should be present at their normal responses, and should not exceed a tailing factor of 2. | Correct problem then repeat breakdown check. | Flagging criteria are not appropriate. | No samples shall be run until degradation ≤ 20%. |

**Table F-4. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 8260 and 8270) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Minimum five-point initial calibration (ICAL) for all analytes** | ICAL prior to sample analysis. | 1. Average response factor (RF) for SPCCs:<br>VOCs ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachlorolethane; ≥ 0.1 for chloromethane, bromoform, and 1,1-dichloroethane.<br><br>SVOCs ≥ 0.050.<br><br>2. RSD for RFs for CCCs:<br>VOCs and SVOCs ≤ 30% and one option below:<br><br>Option 1: RSD for each analyte ≤ 15%;<br><br>Option 2: linear least squares regression r ≥ 0.995;<br><br>Option 3: non-linear regression–coefficient of determination (COD) $r^2$ ≥ 0.99 (6 points shall be used for second order, 7 points shall be used for third order). | Correct problem then repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until ICAL has passed. Calibration may not be forced through the origin. |
| **Second source calibration verification (ICV)** | Once after each ICAL. | All project analytes within ± 20% of true value. | Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until calibration has been verified. |
| **Retention time window position establishment for each analyte and surrogate** | Once per ICAL. | Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used. | NA. | NA. | |

**Table F-4. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 8260 and 8270) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Evaluation of relative retention times (RRT)** | With each sample. | RRT of each target analyte within ± 0.06 RRT units. | Correct problem, then rerun ICAL. | Flagging criteria are not appropriate. | Laboratories may update the retention times based on the CCV to account for minor performance fluctuations or after routine system maintenance (such as column clipping).<br><br>With each sample, the RRT shall be compared with the most recently updated RRT. If the RRT has changed by more than ±0.06 RRT units since the last update, this indicates a significant change in system performance and the laboratory must take appropriate corrective actions as required by the method and rerun the ICAL to reestablish the retention times. |
| **Continuing calibration verification (CCV)** | Daily before sample analysis and every 12 hours of analysis time. | 1. Average RF for SPCCs: VOCs ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachlorolethane; ≥ 0.1 for chloromethane, bromoform, and 1,1-dichloroethane.<br><br>SVOCs ≥ 0.050.<br><br>2. %Difference/Drift for all target compounds and surrogates: VOCs and SVOCs ≤ 20%D (Note: D = difference when using RFs or drift when using least squares regression or non-linear calibration). | DoD project level approval must be obtained for each of the failed analytes or corrective action must be taken.<br><br>Correct problem, then rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since last acceptable CCV. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since last acceptable CCV. | Problem must be corrected. Results may not be reported without a valid CCV. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |

**Table F-4. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 8260 and 8270) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Internal standards verification** | Every field sample, standard, and QC sample. | Retention time ± 30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard. | Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory. | If corrective action fails in field samples, apply Q-flag to analytes associated with the non-compliant IS. Flagging criteria are not appropriate for failed standards. | Sample results are not acceptable without a valid IS verification. |
| **Method blank** | One per preparatory batch. | No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL (see Box D-1). | Correct problem, then see criteria in Box D-1. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **LCS containing all analytes to be reported, including surrogates** | One per preparatory batch. | QC acceptance criteria specified by DoD, if available. Otherwise, use in-house control limits. In-house control limits may not be greater than ± 3 times the standard deviation of the mean LCS recovery. See Box D-3 and Appendix G. | Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available (see full explanation in Appendix G). | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Matrix Spike (MS)** | One per preparatory batch per matrix (see Box D-7). | For matrix evaluation, use LCS acceptance criteria specified by DoD, if available. Otherwise, use in-house LCS control limits. | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | For matrix evaluation only. If MS results are outside the LCS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error. |

**Table F-4. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 8260 and 8270) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Matrix spike duplicate (MSD) or sample duplicate** | One per preparatory batch per matrix (see Box D-7). | MSD: For matrix evaluation, use LCS acceptance criteria specified by DoD, if available. Otherwise, use in-house LCS control limits.<br><br>MSD or sample duplicate: RPD ≤ 30% (between MS and MSD or sample and sample duplicate). | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | The data shall be evaluated to determine the source of difference. |
| **Surrogate spike** | All field and QC samples. | QC acceptance criteria specified by DoD, if available. Otherwise, use in-house control limits. | For QC and field samples, correct problem then reprep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary. | Apply Q-flag to all associated analytes if acceptance criteria are not met. | Alternative surrogates are recommended when there is obvious chromatographic interference. |
| **Results reported between DL and LOQ** | NA. | NA. | NA. | Apply J-flag to all results between DL and LOQ. | |

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| Table F-5. Dioxin/Furan Analysis by High-Resolution Gas Chromatography/Low-Resolution Mass Spectrometry (Method 8280) | | | | | |
|---|---|---|---|---|---|
| **QC Check** | **Minimum Frequency** | **Acceptance Criteria** | **Corrective Action** | **Flagging Criteria** | **Comments** |
| **Demonstrate acceptable analytical capability** | Prior to using any test method and at any time there is a significant change in instrument type, personnel, test method, or sample matrix. | QC acceptance criteria published by DoD, if available; otherwise, method-specified criteria. | Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f). | NA. | This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete. |
| **LOD determination and verification (See Box D-13)** | | | | | |
| **LOQ establishment and verification (See Box D-14)** | | | | | |
| **Tuning** | Prior to analyzing calibration standards. | Verify MS calibration per the method. | Retune instrument and verify. Rerun affected samples. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be accepted without a valid tune. |
| **Retention time window defining mix** | At method set-up and prior to analyzing calibration standards. | Verify descriptor switching times per method. | Correct problem then repeat retention time window defining mix. | Flagging criteria are not appropriate. | |
| **GC column performance check (for SP-2331 column or equivalent)** | Prior to ICAL or calibration verification standards and for each 12-hour period of sample analysis. | Peak separation between 2,3,7,8-TCDD and other TCDD isomers: Resolved with a valley of ≤ 25%, per method; For calibration verification standard only: Peak separation between 1,2,3,4,7,8-HxCDD and 1,2,3,6,7,8-HxCDD must be resolved with a valley of ≤ 50%, per method. | Correct problem then repeat column performance check. | Flagging criteria are not appropriate. | Needed only if using a column other than DB-5 or equivalent. |

**Table F-5. Dioxin/Furan Analysis by High-Resolution Gas Chromatography/Low-Resolution Mass Spectrometry (Method 8280) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **GC Column performance check (for DB-5 column or equivalent)** | Included with the ICAL standard (CC3) or the calibration verification standard. | Peak separation of standard CC3: Peak between the 2,3,7,8-TCDD and 1,2,3,4-TCDD must be resolved with a valley of ≤ 25%, per method;<br><br>For calibration verification standard only: Peak separation between 1,2,3,4,7,8-HxCDD and 1,2,3,6,7,8-HxCDD must be resolved with a valley of ≤ 50%, per method. | Correct problem then repeat column performance check. | Flagging criteria are not appropriate. | |
| **Initial calibration (ICAL) for all analytes identified in method** | ICAL prior to sample analysis and as needed by the failure of calibration verification standard. | Ion abundance ratios in accordance with the method;<br>and RSD of the RFs ≤ 15% for labeled IS and unlabeled PCDD/PCDF per method. | Correct problem then repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until ICAL has passed.<br><br>Calibration may not be forced through the origin. |
| **Calibration verification** | At the beginning of each 12-hour period of sample analysis, after successful GC and MS resolution checks. | Ion abundance specified in the method must be met for all PCDD/PCDF peaks, including labeled internal and recovery standards; and Sensitivity criteria of an S/N ratio > 2.5 for unlabeled PCDD/PCDF ions and > 10 for labeled internal and recovery standards per method; and RF for each analyte and IS within ± 20% (% difference) of RF established in ICAL. | Correct problem, then rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples analyzed since the last successful calibration verification. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last successful calibration verification. | Problem must be corrected. Results may not be reported without a valid calibration verification. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Sensitivity check** | At the end of 12-hour sample analysis period or at the end of analysis (whichever comes first) (Injection must be done within the 12-hour period.). | See criteria for retention time check, ion abundances, and S/N ratios noted above for calibration and response verification standard per method. | Correct problem, then repeat calibration and reanalyze samples indicating a presence of PCDD/PCDF less than LOQ or when maximum possible concentration is reported. | Flagging criteria are not appropriate. | |

**Table F-5. Dioxin/Furan Analysis by High-Resolution Gas Chromatography/Low-Resolution Mass Spectrometry (Method 8280) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Method blank** | One per preparatory batch. | Use project-specific criteria, if available. Otherwise, no analytes detected ≥ LOD for the analyte or ≥ 5% of the associated regulatory limit for the analyte or ≥ 5% of the sample result for the analyte, whichever is greater, per method. | Correct problem, then see criteria in Box D-1. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Laboratory control sample (LCS)** | One per preparatory batch. | QC acceptance criteria specified by DoD, if available. Otherwise, use in-house control limits. In-house control limits may not be greater than ± 3 times the standard deviation of the mean LCS recovery. See Box D-3 and Appendix G. | Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available (see full explanation in Appendix G). | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Matrix spike (MS)** | One per preparatory batch per matrix (see Box D-7). | For matrix evaluation, use LCS acceptance criteria specified by DoD, if available. Otherwise, use in-house LCS control limits. | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | For matrix evaluation only. If MS results are outside the LCS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error. |
| **Matrix spike duplicate (MSD) or sample duplicate** | One per preparatory batch per matrix (see Box D-7). | MSD: For matrix evaluation, use LCS acceptance criteria specified by DoD, if available. Otherwise, use in-house LCS control limits.<br><br>MSD or sample duplicate: RPD ≤ 20% (between MS and MSD or sample and sample duplicate). | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if criteria are not met. | The data shall be evaluated to determine the source of difference. |

**Table F-5. Dioxin/Furan Analysis by High-Resolution Gas Chromatography/Low-Resolution Mass Spectrometry (Method 8280) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Internal standards (IS)** | Every field sample, standard, and QC sample. | % recovery for each IS in the original sample (prior to any dilutions) must be within 25-150%, per method. | Correct problem, then reprep and reanalyze the sample(s) with failed IS. | Apply Q-flag to results of all affected samples. | |
| **Sample PCDD/PCDF identification** | Identify all positive sample detections per method. | Verify that absolute RT at maximum height is within -1 to +3 secs. of that for corresponding labeled standard, or the RRT of analytes is within 0.05 RRT units of that for unlabeled standard in the calibration verification standard, or RT for non-2,3,7,8-substituted isomers within the RT window established by the window defining mix for the corresponding homologue per method; and Absolute RTs of the recovery standards must be within ±10 sec. of those in the calibration verification standard; and All ions listed in Table 8 of the method must be present in the SICP, must maximize simultaneously (±2 sec.), and must have not saturated the detector; and S/N ratio of ISs ≥ 10 times background noise. Remaining ions in Table 8 of the method must have an S/N ratio ≥ 2.5 times the background noise and Ion abundance in Table 9 of the method must be met for all analytes, internal, and recovery standards. | Correct problem, then reprep and reanalyze the sample(s) with failed criteria for any of the internal, recovery, or cleanup standards. If PCDPE is detected or if sample peaks present do not meet all identification criteria, calculate the EMPC (estimated maximum possible concentration) according to the method. | Flagging criteria are not appropriate. | Positive identification of 2,3,7,8-TCDF on the DB-5 or equivalent column must be reanalyzed on a column capable of isomer specificity (DB-225) (see method). |

**Table F-5. Dioxin/Furan Analysis by High-Resolution Gas Chromatography/Low-Resolution Mass Spectrometry (Method 8280) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Sample specific estimated detection limit / estimated quantitation limit (EDL / EQL)** | Calculated for each 2,3,7,8-substituted isomer that was not identified. | Per method. | NA. | Flagging criteria are not appropriate. | |
| **Sample estimated maximum possible concentration (EMPC)** | Determined for each 2,3,7,8-substituted isomer that did not meet ion abundance ratio criteria (Table 9 of the method) or PCDFs where peak representing a corresponding PCDPE was detected. | Response for both quantitation ions must be ≥ 2.5 times S/N ratio of background; all other criteria from sample PCDD/PCDF identification above; PCDE peak at the same RT (± 2 sec.) must have S/N < 2.5. | NA. | Flag as appropriate. | |
| **Sample 2,3,7,8-TCDD toxicity equivalents (TE) concentration** | All positive detections. | If the TEQ is greater than 0.7 ppb for soil/sediment or fly ash, 7 ppb for chemical waste, or 7 ppt for an aqueous sample; and 2,3,7,8-TCDF is either detected or reported as an EMPC, then better isomer specificity may be required than can be achieved on the DB-5 column or equivalent. | NA. | Flagging criteria are not appropriate. | Recommended reporting convention by the EPA and CDC for positive detections in terms of toxicity of 2,3,7,8-TCDD. |
| **Results reported between DL and LOQ** | Positive detections calculated per method. | NA. | NA. | Apply J-flag to all results between DL and LOQ. | |

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| Table F-6. Dioxin/Furan Analysis by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (Method 8290) | | | | | |
|---|---|---|---|---|---|
| **QC Check** | **Minimum Frequency** | **Acceptance Criteria** | **Corrective Action** | **Flagging Criteria** | **Comments** |
| **Demonstrate acceptable analytical capability** | Prior to using any test method and at any time there is a significant change in instrument type, personnel, test method, or sample matrix. | QC acceptance criteria published by DoD, if available; otherwise, method-specified criteria. | Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f). | NA. | This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete. |
| **LOD determination and verification (See Box D-13)** | | | | | |
| **LOQ establishment and verification (See Box D-14)** | | | | | |
| **Tuning** | At the beginning and the end of each 12-hour period of analysis. | Static resolving power ≥ 10,000 (10% valley) for identified masses per method,<br>and lock-mass ion between lowest and highest masses for each descriptor and level of reference compound ≤ 10% full-scale deflection, per method. | Retune instrument and verify. Rerun affected samples. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be accepted without a valid tune. |

**Table F-6. Dioxin/Furan Analysis by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (Method 8290) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **GC column performance check** | Prior to ICAL or calibration verification. Use GC performance check solution per method. | Peak separation between 2,3,7,8-TCDD and other TCDD isomers result in a valley of ≤ 25%, per method; and Identification of all first and last eluters of the eight homologue retention time windows and documentation by labeling (F/L) on the chromatogram; and Absolute retention times for switching from one homologous series to the next ≥ 10 sec. for all components of the mixture. | Correct problem then repeat column performance check. | Flagging criteria are not appropriate. | |
| **Initial calibration (ICAL) for all analytes identified in method** | ICAL prior to sample analysis, as needed by the failure of calibration verification standard, and when a new lot is used as standard source for HRCC-3, sample fortification (IS), or recovery solutions. | Ion abundance ratios in accordance with criteria in Table 8 of the method; and S/N ratio ≥ 10 for all target analyte ions; and RSD ≤ 20% for the response factors (RF) for all 17 unlabeled standards and RSD ≤ 20% for the RFs for the 9 labeled IS. | Correct problem, then repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until ICAL has passed.<br><br>Calibration may not be forced through origin. |

**Table F-6. Dioxin/Furan Analysis by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (Method 8290) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Calibration verification** | At the beginning of each 12-hour period, and at the end of each analytical sequence. | Ion abundance ratios in accordance with criteria in Table 8 of the method; and For unlabeled standards, RF within ± 20% D of RF established in ICAL; and For labeled standards, RF within ± 30% D of RF established in ICAL. | Correct problem, repeat calibration verification standard. If that fails, repeat ICAL and reanalyze all samples analyzed since the last successful CCV. End-of-run CCV: If the RF for unlabeled standards ≤ 25% RPD and the RF for labeled standards ≤ 35% RPD (relative to the RF established in the ICAL), the mean RF from the two daily CCVs must be used for quantitation of impacted samples instead of the ICAL mean RF value. If the starting and ending CCV RFs differ by more than 25% RPD for unlabeled compounds or 35% RPD for labeled compounds, the sample may be quantitated against a new initial calibration if it is analyzed within two hours. Otherwise reanalyze samples with positive detections if necessary. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last successful calibration verification. | Problem must be corrected. Results may not be reported without a valid calibration verification. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |

**Table F-6. Dioxin/Furan Analysis by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (Method 8290) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Method blank** | One per preparatory batch, run after calibration standards and before samples. | Use project-specific criteria, if available. Otherwise, no analytes detected ≥ LOD for the analyte or ≥ 5% of the associated regulatory limit for the analyte or ≥ 5% of the sample result for the analyte, whichever is greater, per method. | Correct problem, then see criteria in Box D-1. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **LCS (or fortified field blank)** | One per preparatory batch. | QC acceptance criteria specified by DoD, if available. Otherwise, use in-house control limits. In-house control limits may not be greater than ± 3 times the standard deviation of the mean LCS recovery. See Box D-3 and Appendix G. | Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available (see full explanation in Appendix G). | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Sample duplicate** | One per preparatory batch per matrix (see Box D-7). | RPD ≤ 25% (between sample and sample duplicate), per method. | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | |
| **Matrix spike (MS)** | One per preparatory batch per matrix (see Box D-7). | For matrix evaluation, use LCS acceptance criteria specified by DoD, if available. Otherwise, use in-house LCS control limits. | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | For matrix evaluation only. If MS results are outside the LCS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error. |

**Table F-6. Dioxin/Furan Analysis by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (Method 8290) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Matrix spike duplicate (MSD)** | One per preparatory batch per matrix (see Box D-7). | For matrix evaluation, use LCS acceptance criteria specified by DoD, if available. Otherwise, use in-house LCS control limits.<br><br>RPD ≤ 20% (between MS and MSD) per method. | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | The data shall be evaluated to determine the source of difference. |
| **Internal standards (IS)** | Every field sample, standard, and QC sample. | % recovery for each IS in the original sample (prior to dilutions) must be within 40-135%, per method. | Correct problem, then reprep and reanalyze the samples with failed IS. | Apply Q-flag to results of all affected samples. | |

**Table F-6. Dioxin/Furan Analysis by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (Method 8290) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Sample PCDD/PCDF identification** | Identify all positive sample detections per method. | 2,3,7,8-substituted isomers with labeled standards: Absolute RT at maximum height within -1 to +3 seconds of that for corresponding labeled standard; 2,3,7,8-substituted isomers with unlabeled standards: RRT within 0.005 RRT units of that in calibration verification standard; Non-2,3,7,8-substituted isomers: RT within RT window established by column performance check solution for corresponding homologue, per method; and Ions for quantitation must maximize simultaneously (± 2 sec.); and Ion abundance ratios in accordance with criteria in Table 8 of the method; and S/N ratio of ISs ≥ 10 times background noise; and S/N ratio of all remaining ions for unlabeled analytes ≥ 2.5 times background noise; and For PCDF: No signal present having a S/N ratio ≥ 2.5 for the corresponding ether (PCDPE) detected at the same retention time (± 2 sec). | Correct problem, then reprep and reanalyze the samples with failed criteria for any of the internal, recovery, or cleanup standards. If PCDPE is detected or if sample peaks present do not meet ion abundance ratio criteria, calculate the EMPC (estimated maximum possible concentration) according to method. | Flagging criteria are not appropriate. | Positive identification of 2,3,7,8-TCDF on the DB-5 or equivalent column must be reanalyzed on a column capable of isomer specificity (DB-225) (see method). |

**Table F-6. Dioxin/Furan Analysis by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (Method 8290) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Sample specific estimated detection limit / estimated quantitation limit (EDL / EQL)** | Calculated for each 2,3,7,8-substituted isomer that is not identified. | Per method. | NA. | Flagging criteria are not appropriate. | |
| **Sample estimated maximum possible concentration (EMPC)** | Every sample that indicates a detection ≥ 2.5 times S/N response. | Identification criteria per method must be met, and response for both quantitation ions must be ≥ 2.5 times S/N ratio for background. | NA. | Flag as appropriate. | |
| **Sample 2,3,7,8-TCDD toxicity equivalents (TE) concentration** | All positive detections, as required. | Per method. | NA. | Flagging criteria are not appropriate. | Recommended reporting convention by the EPA and CDC for positive detections in terms of toxicity of 2,3,7,8-TCDD. |
| **Results reported between DL and LOQ** | Positive detections calculated per method. | NA. | NA. | Apply J-flag to all results between DL and LOQ. | |

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**Table F-7. Inorganic Analysis by Inductively Coupled Plasma (ICP) Atomic Emission Spectrometry and Atomic Absorption Spectrophotometry (AA) (Methods 6010 and 7000 Series)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Demonstrate acceptable analytical capability** | Prior to using any test method and at any time there is a significant change in instrument type, personnel, test method, or sample matrix. | QC acceptance criteria published by DoD, if available; otherwise, method-specified criteria. | Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f). | NA. | This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete. |
| **LOD determination and verification (See Box D-13)** | | | | | |
| **LOQ establishment and verification (See Box D-14)** | | | | | |
| **Instrument detection limit (IDL) study (ICP only)** | At initial set-up and after significant change in instrument type, personnel, test method, or sample matrix. | IDLs shall be ≤ LOD. | NA. | NA. | Samples may not be analyzed without a valid IDL. |
| **Linear dynamic range or high-level check standard (ICP only)** | Every 6 months. | Within ± 10% of true value. | NA. | NA. | |

**Table F-7. Inorganic Analysis by Inductively Coupled Plasma (ICP) Atomic Emission Spectrometry and Atomic Absorption Spectrophotometry (AA) (Methods 6010 and 7000 Series) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Initial calibration (ICAL) for all analytes**<br>**ICP: minimum one high standard and a calibration blank;**<br>**GFAA: minimum three standards and a calibration blank;**<br>**CVAA: minimum 5 standards and a calibration blank** | Daily ICAL prior to sample analysis. | If more than one calibration standard is used, $r \geq 0.995$. | Correct problem, then repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until ICAL has passed. |
| **Second source calibration verification (ICV)** | Once after each ICAL, prior to beginning a sample run. | Value of second source for all analyte(s) within ± 10% of true value. | Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until calibration has been verified. |
| **Continuing calibration verification (CCV)** | After every 10 field samples and at the end of the analysis sequence. | ICP: within ± 10% of true value;<br>GFAA: within ± 20% of true value;<br>CVAA: within ± 20% of true value. | Correct problem, rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable calibration verification. | Problem must be corrected. Results may not be reported without a valid CCV. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Low-level calibration check standard (ICP only)** | Daily, after one-point ICAL. | Within ± 20% of true value. | Correct problem, then reanalyze. | Flagging criteria are not appropriate. | No samples may be analyzed without a valid low-level calibration check standard. Low-level calibration check standard should be less than or equal to the reporting limit. |

**Table F-7. Inorganic Analysis by Inductively Coupled Plasma (ICP) Atomic Emission Spectrometry and Atomic Absorption Spectrophotometry (AA) (Methods 6010 and 7000 Series) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Method blank** | One per preparatory batch. | No analytes detected > ½ RL and greater than 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL (see Box D-1). | Correct problem, then see criteria in Box D-1. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Calibration blank** | Before beginning a sample run, after every 10 samples, and at end of the analysis sequence. | No analytes detected > LOD. | Correct problem. Re-prep and reanalyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed. | Apply B-flag to all results for specific analyte(s) in all samples associated with the blank. | |
| **Interference check solutions (ICS) (ICP only)** | At the beginning of an analytical run. | ICS-A: Absolute value of concentration for all non-spiked analytes < LOD (unless they are a verified trace impurity from one of the spiked analytes);<br><br>ICS-AB: Within ± 20% of true value. | Terminate analysis; locate and correct problem; reanalyze ICS, reanalyze all samples. | If corrective action fails, apply Q-flag to all results for specific analyte(s) in all samples associated with the ICS. | |
| **LCS containing all analytes to be reported** | One per preparatory batch. | QC acceptance criteria specified by DoD, if available; see Box D-3 and Appendix G. | Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available (see full explanation in Appendix G). | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |

**Table F-7. Inorganic Analysis by Inductively Coupled Plasma (ICP) Atomic Emission Spectrometry and Atomic Absorption Spectrophotometry (AA) (Methods 6010 and 7000 Series) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Matrix spike (MS)** | One per preparatory batch per matrix (see Box D-7). | For matrix evaluation, use QC acceptance criteria specified by DoD for LCS. | Examine the project-specific DQOs. If the matrix spike falls outside of DoD criteria, additional quality control tests are required to evaluate matrix effects. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | For matrix evaluation only. If MS results are outside the LCS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error. |
| **Matrix spike duplicate (MSD) or sample duplicate** | One per preparatory batch per matrix (see Box D-7). | MSD: For matrix evaluation use QC acceptance criteria specified by DoD for LCS.<br>MSD or sample duplicate: RPD ≤ 20% (between MS and MSD or sample and sample duplicate). | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | The data shall be evaluated to determine the source of difference. |
| **Dilution test (ICP and GFAA only)** | One per preparatory batch. | Five-fold dilution must agree within ± 10% of the original measurement. | ICP: Perform post-digestion spike (PDS) addition;<br>GFAA: Perform recovery test. | Flagging criteria are not appropriate. | Only applicable for samples with concentrations > 50 x LOQ. |
| **Post-digestion spike (PDS) addition (ICP only)** | When dilution test fails or analyte concentration in all samples < 50 x LOD. | Recovery within 75-125% (see Table B-1). | Run all associated samples in the preparatory batch by method of standard additions (MSA) or see flagging criteria. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | Spike addition should produce a concentration of 10 – 100 x LOQ. |
| **Recovery test (GFAA only)** | When dilution test fails or analyte concentration in all samples < 25 x LOD. | Recovery within 85-115%. | Run all associated samples in the preparatory batch by method of standard additions (MSA) or see flagging criteria. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | |
| **Method of standard additions (MSA)** | When matrix interference is confirmed. | NA. | NA. | NA. | Document use of MSA in the case narrative. |
| **Results reported between DL and LOQ** | NA. | NA. | NA. | Apply J-flag to all results between DL and LOQ. | |

| Table F-8. Trace Metals Analysis by Inductively Coupled Plasma/Mass Spectrometry (ICP/MS) (Method 6020) | | | | | |
|---|---|---|---|---|---|
| **QC Check** | **Minimum Frequency** | **Acceptance Criteria** | **Corrective Action** | **Flagging Criteria** | **Comments** |
| **Demonstrate acceptable analytical capability** | Prior to using any test method and at any time there is a change in instrument type, personnel, test method, or sample matrix. | QC acceptance criteria published by DoD, if available; otherwise method-specified criteria. | Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f). | NA. | This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete. |
| **LOD determination and verification (See Box D-13)** | | | | | |
| **LOQ establishment and verification (See Box D-14)** | | | | | |
| **Instrument detection limit (IDL) study** | At initial set-up and after significant change in instrument type, personnel, test method, or sample matrix. | IDLs shall be ≤ LOD. | NA. | NA. | Samples may not be analyzed without a valid IDL. |
| **Tuning** | Prior to ICAL. | Mass calibration ≤ 0.1 amu from the true value; Resolution < 0.9 amu full width at 10% peak height; For stability, RSD ≤ 5% for at least four replicate analyses. | Retune instrument then reanalyze tuning solutions. | Flagging criteria are not appropriate. | No analysis shall be performed without a valid MS tune. |
| **Initial calibration (ICAL) for all analytes (minimum one high standard and a calibration blank)** | Daily ICAL prior to sample analysis. | If more than one calibration standard is used, r ≥ 0.995. | Correct problem, then repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until ICAL has passed. |

**Table F-8. Trace Metals Analysis by Inductively Coupled Plasma/Mass Spectrometry (ICP/MS) (Method 6020) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Second source calibration verification** | Once after each ICAL, prior to beginning a sample run. | Value of second source for all analytes within ± 10% of true value. | Verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until calibration has been verified. |
| **Continuing calibration verification (CCV)** | After every 10 field samples and at the end of the analysis sequence. | All analytes within ± 10% of true value. | Correct problem, rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable calibration verification. | Problem must be corrected. Results may not be reported without a valid CCV. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Low-level calibration check standard** | Daily, after one-point ICAL. | Within ± 20% of true value. | Correct problem, then reanalyze. | Flagging criteria are not appropriate. | No samples may be analyzed without a valid low-level calibration check standard. Low-level calibration check standard should be less than or equal to the reporting limit. |
| **Linear dynamic range or high-level check standard** | Every 6 months. | Within ±10% of true value. | NA. | NA. | |
| **Method blank** | One per preparatory batch. | No analytes detected > ½ RL and greater than 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL (see Box D-1). | Correct problem, then see criteria in Box D-1. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |

**Table F-8. Trace Metals Analysis by Inductively Coupled Plasma/Mass Spectrometry (ICP/MS) (Method 6020) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Calibration blank** | Before beginning a sample run, after every 10 samples, and at end of the analysis sequence. | No analytes detected > LOD. | Correct problem. Re-prep and reanalyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed. | Apply B-flag to all results for specific analyte(s) in all samples associated with the blank. | |
| **Interference check solutions (ICS-A and ICS-AB)** | At the beginning of an analytical run and every 12 hours. | ICS-A: Absolute value of concentration for all non-spiked analytes < LOD (unless they are a verified trace impurity from one of the spiked analytes);<br><br>ICS-AB: Within ± 20% of true value. | Terminate analysis, locate and correct problem, reanalyze ICS, reanalyze all samples. | If corrective action fails, apply Q-flag to all results for specific analyte(s) in all samples associated with the ICS. | |
| **LCS containing all analytes to be reported** | One per preparatory batch. | QC acceptance criteria specified by DoD, if available; see Box D-3 and Appendix G. | Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available (see full explanation in Appendix G). | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Matrix spike (MS)** | One per preparatory batch per matrix (see Box D-7). | For matrix evaluation, use QC acceptance criteria specified by DoD for LCS. | Examine the project-specific DQOs. If the matrix spike falls outside of DoD criteria, additional quality control tests (dilution test and post-digestion spike addition) are required to evaluate matrix effects. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | For matrix evaluation only. If MS results are outside the LCS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error. |
| **Matrix spike duplicate (MSD) or sample duplicate** | One per preparatory batch per matrix (see Box D-7). | MSD: For matrix evaluation use QC acceptance criteria specified by DoD for LCS.<br><br>MSD or sample duplicate: RPD < 20% (between MS and MSD or sample and sample duplicate). | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | The data shall be evaluated to determine the source of difference. |

| Table F-8. Trace Metals Analysis by Inductively Coupled Plasma/Mass Spectrometry (ICP/MS) (Method 6020) (continued) | | | | | |
|---|---|---|---|---|---|
| **QC Check** | **Minimum Frequency** | **Acceptance Criteria** | **Corrective Action** | **Flagging Criteria** | **Comments** |
| **Dilution test** | One per preparatory batch. | Five-fold dilution must agree within ± 10% of the original measurement. | Perform post-digestion spike addition. | Flagging criteria are not appropriate. | Only applicable for samples with concentrations > 50 x LOQ. |
| **Post digestion spike addition** | When dilution test fails or analyte concentration for all samples < 50 x LOD. | Recovery within 75-125% (see Table B-1). | Run all associated samples in the preparatory batch by method of standard additions (MSA) or see flagging criteria. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | Spike addition should produce a concentration of 10 – 100 x LOQ. |
| **Method of standard additions (MSA)** | When matrix interference is confirmed. | NA. | NA. | NA. | Document use of MSA in the case narrative. |
| **Internal standards (IS)** | Every sample. | IS intensity within 30-120% of intensity of the IS in the ICAL. | Reanalyze sample at 5-fold dilution with addition of appropriate amounts of internal standards. | Flagging criteria are not appropriate. | |
| **Results reported between DL and LOQ** | NA. | NA. | NA. | Apply J-flag to all results between DL and LOQ. | |

| Table F-9. Inorganic Analysis by Colorimetric Hexavalent Chromium (Method 7196) | | | | | |
|---|---|---|---|---|---|
| **QC Check** | **Minimum Frequency** | **Acceptance Criteria** | **Corrective Action** | **Flagging Criteria** | **Comments** |
| **Demonstrate acceptable analytical capability** | Prior to using any test method and at any time there is a change in instrument type, personnel, test method, or sample matrix. | QC acceptance criteria published in method; otherwise QC acceptance criteria established in-house by laboratory. | Recalculate results; locate and fix problem, then rerun demonstration for the analyte that did not meet criteria (see Section C.1 f). | NA. | This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete. |
| **LOD determination and verification (See Box D-13)** | | | | | |
| **LOQ establishment and verification (See Box D-14)** | | | | | |
| **Reference blank (reagent water)** | Before beginning standards or sample analysis. | NA. | NA. | NA. | Used for blank subtraction of standards, field and QC samples. For turbid field samples, a turbidity blank must be used instead of the reference blank (using a sample aliquot prepped in accordance with Method 7196A (Section 7.1)). |
| **Initial calibration (ICAL) (minimum three standards and a calibration blank)** | Daily ICAL prior to sample analysis. | $r \geq 0.995$. | Correct problem and repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until ICAL has passed. |
| **Second source calibration verification (ICV) (also known as independently prepared check standard)** | Before beginning a sample run. | Value of second source within ± 10% of true value. | Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat calibration. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until calibration has been verified. |

| Table F-9. Inorganic Analysis by Colorimetric Hexavalent Chromium (Method 7196) (continued) | | | | | |
|---|---|---|---|---|---|
| **QC Check** | **Minimum Frequency** | **Acceptance Criteria** | **Corrective Action** | **Flagging Criteria** | **Comments** |
| **Continuing calibration verification (CCV)** | After every 15 field samples and at the end of the analysis sequence. | Value of CCV within ± 10% of true value. | Correct problem then repeat CCV and reanalyze all samples since last successful calibration verification. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable calibration verification. | Problem must be corrected. No samples may be run until calibration has been verified. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Method blank** | One per preparatory batch. | No analyte detected > 1/2 the reporting limit and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results (see Box D-1). | Correct problem then see criteria in Box D-1. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **LCS** | One per preparatory batch. | QC acceptance criteria specified by DoD; see Box D-3 and Appendix G. | Correct problem, then reprep and reanalyze the LCS and all samples in the associated batch for the failed analyte in all samples in the associated preparatory batch, if sufficient sample material is available (see full explanation in Appendix G). | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Sample matrix verification (also known as matrix spike)** | Once for every sample matrix analyzed. | Spike recovery within 85–115%. | If check indicates interference, dilute and reanalyze sample; persistent interference indicates the need to use alternative method or analytical conditions, or to use method of standard additions. | Flagging criteria are not appropriate. | Verification check ensures lack of reducing condition or interference from matrix. Additional corrective actions are identified in Method 7196A (Sections 7.4 and 7.5). |

**Table F-9. Inorganic Analysis by Colorimetric Hexavalent Chromium (Method 7196) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Matrix spike duplicate (MSD) or sample duplicate** | Aqueous matrix: One per every 10 project samples per matrix.<br><br>Solid matrix: One per preparatory batch per matrix. | Aqueous matrix: RPD ≤ 20% (between MS and MSD or sample and sample duplicate).<br><br>Solid matrix: RPD ≤ 30%. | Examine project-specific DQOs. Contact the client as to additional measures to be taken. | Flagging criteria are not appropriate. | Refer to sample matrix verification sample for MS data evaluation. |
| **Pre-digestion matrix spikes (solid matrix samples only, Method 3060)** | One soluble and insoluble pre-digestion MS analyzed per preparatory batch prior to analysis. | MS recoveries within 75–125%. | Correct problem and rehomogenize, redigest, and reanalyze samples. If that fails, evaluate against LCS results. | If corrective action fails, apply J-flag to the analyte in all samples in the associated preparatory batch. | |
| **Post-digestion matrix spike** | One per preparatory batch. | Recovery between 85–115%. | Correct problem and rehomogenize, redigest, and reanalyze samples. Persistent interference indicates the need to use an alternative method or analytical conditions, or to use method of standard additions. | NA. | |
| **Results reported between DL and LOQ** | NA. | NA. | NA. | Apply J-flag to all results between DL and LOQ. | |

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| Table F-10. Cyanide Analysis (Methods 9010, 9012, and 9014) | | | | | |
|---|---|---|---|---|---|
| **QC Check** | **Minimum Frequency** | **Acceptance Criteria** | **Corrective Action** | **Flagging Criteria** | **Comments** |
| **Demonstrate acceptable analytical capability** | Prior to using any test method and at any time there is a significant change in instrument type, personnel, test method, or sample matrix. | QC acceptance criteria published by DoD, if available; otherwise use method-specified criteria. | Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f). | NA. | This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete. |
| **LOD determination and verification (See Box D-13)** | | | | | |
| **LOQ establishment and verification (See Box D-14)** | | | | | |
| **Initial calibration (ICAL) (six standards and a calibration blank)** | Daily ICAL prior to sample analysis. | $r \geq 0.995$. | Correct problem, then repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until calibration has passed.<br><br>All calibration standards must be distilled if samples are expected to contain sulfides. |
| **Distilled standards (one high and one low)** | Once per multipoint calibration. | Within ± 15% of true value. | Correct problem, then repeat distilled standards. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until distilled standards have passed. |
| **Second source calibration verification (ICV)** | Once after each ICAL, prior to beginning a sample run. | Within ± 15% of true value. | Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until calibration has been verified. |

| Table F-10. Cyanide Analysis (Methods 9010, 9012, and 9014) (continued) | | | | | |
|---|---|---|---|---|---|
| **QC Check** | **Minimum Frequency** | **Acceptance Criteria** | **Corrective Action** | **Flagging Criteria** | **Comments** |
| **Method blank** | One per preparatory batch. | No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL (see Box D-1). | Correct problem, then see criteria in Box D-1. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **LCS** | One per preparatory batch. | QC acceptance criteria specified by DoD, if available; see Box D-3 and Appendix G. | Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available (see full explanation in Appendix G). | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Matrix spike (MS)** | One per preparatory batch per matrix (see Box D-7). | For matrix evaluation, use QC acceptance criteria specified by DoD for LCS. | Examine the project-specific DQOs. If the matrix spike falls outside of DoD criteria, the method of standard additions shall be used for the analysis. | For the specific analyte in the parent sample, apply J-flag if acceptance criteria are not met. | If MS results are outside the LCS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error. |
| **Matrix spike duplicate (MSD) or sample duplicate (replicate)** | One per preparatory batch per matrix (see Box D-7). | MSD: For matrix evaluation use QC acceptance criteria specified by DoD for LCS.<br><br>MSD or sample duplicate: RPD ≤ 20% (between MS and MSD or sample and sample duplicate). | Correct problem and reanalyze sample and duplicate. | Apply J-flag if sample cannot be rerun or reanalysis does not correct problem. | The data shall be evaluated to determine the source of difference. |
| **Results reported between DL and LOQ** | NA. | NA. | NA. | Apply J-flag to all results between DL and LOQ. | |

| Table F-11. Common Anions Analysis (Method 9056) | | | | | |
|---|---|---|---|---|---|
| **QC Check** | **Minimum Frequency** | **Acceptance Criteria** | **Corrective Action** | **Flagging Criteria** | **Comments** |
| **Demonstrate acceptable analytical capability** | Prior to using any test method and at any time there is a significant change in instrument type, personnel, test method, or sample matrix. | QC acceptance criteria published by DoD, if available; otherwise, method-specified criteria. | Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f). | NA. | This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete. |
| **LOD determination and verification (See Box D-13)** | | | | | |
| **LOQ establishment and verification (See Box D-14)** | | | | | |
| **Retention time (RT) window width calculated for each analyte** | After method set-up and after major maintenance (e.g., column change). | RT width is ± 3 times standard deviation for each analyte RT over a 24-hour period. | NA. | NA. | |
| **Initial calibration (ICAL) for all analytes (minimum three standards and one calibration blank)** | ICAL prior to sample analysis. | $r \geq 0.995$. | Correct problem, then repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until ICAL has passed. |
| **Initial calibration verification (ICV) (second source)** | Once after each ICAL, prior to beginning a sample run. | All analytes within ± 10% of true value and retention times within appropriate windows. | Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until calibration has been verified. |
| **Retention time window position establishment for each analyte** | Once per multipoint calibration. | Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used. | NA. | NA. | |

**Table F-11. Common Anions Analysis (Method 9056) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Midrange continuing calibration verification (CCV)** | After every 10 field samples and at the end of the analysis sequence. | All project analytes within established retention time windows.<br><br>Within ± 10% of true value. | Correct problem, then rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable calibration verification. | Problem must be corrected. Results may not be reported without a valid CCV. Flagging is only appropriate in cases where the samples cannot be reanalyzed.<br><br>Retention time windows are updated per the method. |
| **Method blank** | One per preparatory batch. | No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results (see Box D-1). | Correct problem, then see criteria in Box D-1. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **LCS containing all analytes to be reported** | One per preparatory batch. | Laboratory in-house limits not to exceed ± 20%. Control limits may be not greater than ± 3 times the standard deviation of the mean LCS recovery. See Box D-3. | Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available (see full explanation in Appendix G). | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Matrix Spike (MS)** | One per preparatory batch per matrix (see Box D-7). | For matrix evaluation, use laboratory in-house LCS limits (not to exceed ± 20%). | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | For matrix evaluation only. If MS results are outside the LCS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error. |

| Table F-11. Common Anions Analysis (Method 9056) (continued) | | | | | |
|---|---|---|---|---|---|
| **QC Check** | **Minimum Frequency** | **Acceptance Criteria** | **Corrective Action** | **Flagging Criteria** | **Comments** |
| **Matrix spike duplicate (MSD)** | One per preparatory batch per matrix (see Box D-7). | For matrix evaluation, use laboratory in-house LCS limits (not to exceed ± 20%).<br><br>RPD ≤ 15% (between MS and MSD). | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | The data shall be evaluated to determine the source of difference. |
| **Sample duplicate (replicate)** | One per every 10 samples. | %D ≤ 10% (between sample and sample duplicate). | Correct problem and reanalyze sample and duplicate. | Apply J-flag if sample cannot be rerun or reanalysis does not correct problem. | The data shall be evaluated to determine the source of difference. |
| **Results reported between DL and LOQ** | NA. | NA. | NA. | Apply J-flag to all results between DL and LOQ. | |

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| Table F-12. Perchlorate Analysis (Methods 6850 and 6860) | | | | | |
|---|---|---|---|---|---|
| **QC Check** | **Minimum Frequency** | **Acceptance Criteria** | **Corrective Action** | **Flagging Criteria** | **Comments** |
| **Demonstrate acceptable analytical capability** | Prior to using any test method and at any time there is a significant change in instrument type, personnel, test method, or sample matrix. | QC acceptance criteria published by DoD, if available; otherwise, method-specified criteria. | Recalculate results; locate and fix problem, then rerun demonstration for the analyte that did not meet criteria (see Section C.1.f). | Flagging criteria are not appropriate. | This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete. |
| **LOD determination and verification (See Box D-13)** | | | | | |
| **LOQ establishment and verification (See Box D-14)** | | | | | |
| **Initial calibration (ICAL)** | Minimum of 5 calibration standards to establish linearity at method set-up and after major maintenance. | $r \geq 0.995$ or RSD $\leq 20\%$.<br><br>The concentration corresponding to the absolute value of the calibration curve's Y-intercept must be $\leq$ LOD. | Correct problem, then repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until ICAL has passed.<br><br>The calibration is linear and shall not be forced through the origin. |
| **Initial calibration verification (ICV)** | Once after each ICAL, analysis of a second source standard at the midpoint of the calibration. | Within ± 15% of true value. | Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be run until calibration has been verified. |
| **Continuing calibration verification (CCV)** | Analysis of mid-level standard after every 10 field samples. All samples must be bracketed by the analysis of a standard demonstrating that the system was capable of accurately detecting and quantifying perchlorate. | Within ± 15% of true value. | Correct problem, rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable calibration verification. | Problem must be corrected. Results may not be reported without a valid CCV. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |

**Table F-12. Perchlorate Analysis (Methods 6850 and 6860) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Limit of detection verification (LODV) (per batch)** | Prior to sample analysis and at the end of the analysis sequence. It can be analyzed after every 10 samples in order to reduce the reanalysis rate. | Within ± 30% of true value. | Correct problem and rerun LODV and all samples analyzed since last successful LODV.<br><br>If a sample with perchlorate concentration at or between the LOD and RL is bracketed by a failing LODV, it must be reanalyzed. A sample with concentration above the RL can be reported. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable LODV. | Problem must be corrected. Results may not be reported without a valid LODV. Flagging is only appropriate in cases where the samples cannot be reanalyzed.<br><br>Perchlorate spike concentration is approximately 2 times the limit of detection. |
| **Isotope ratio $^{35}Cl/^{37}Cl$** | Every sample, batch QC sample, and standard. | Monitor for either the parent ion at masses 99/101 or the daughter ion at masses 83/85 depending on which ions are quantitated. Theoretical ratio ~ 3.06. Must fall within 2.3 to 3.8. | If criteria are not met, the sample must be rerun. If the sample was not pretreated, the sample should be reextracted using cleanup procedures. If, after cleanup, the ratio still fails, use alternative techniques to confirm presence of perchlorate (i.e., a post spike sample, dilution to reduce any interference, etc.). | Apply J-flag if acceptance criteria are not met. | Decision to report data failing ratio check should be thoroughly documented in case narrative. |
| **Internal standard (IS)** | Addition of $^{18}O$-labeled perchlorate to every sample, batch QC sample, standard, instrument blank, and method blank. | Measured $^{18}O$ IS area within ± 50% of the value from the average of the IS area counts of the ICAL.<br><br>RRT of the perchlorate ion must be 1.0 ± 2% (0.98 – 1.02). | Rerun the sample at increasing dilutions until the ± 50% acceptance criteria are met. If criteria cannot be met with dilution, the interference are suspected and the sample must be reprepped using additional pretreatment steps. | Apply Q-flag and discuss in the case narrative. | If peak is not within retention time window, presence is not confirmed. Use for quantitation and to ensure identification. Failing internal standard should be thoroughly documented in the case narrative. |

**Table F-12. Perchlorate Analysis (Methods 6850 and 6860) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Interference check sample (ICS)** | One ICS is prepared with every batch of 20 samples and must undergo the same preparation and pretreatment steps as the samples in the batch. It verifies the method performance at the matrix conductivity threshold (MCT). At least one ICS must be analyzed daily. | Within ± 30% of true value. | Correct problem and then reanalyze all samples in that batch. If poor recovery from the cleanup filters is suspected, a different lot of filters must be used to reextract all samples in the batch. If column degradation is suspected, a new column must be calibrated before the samples can be reanalyzed. | Flagging criteria are not appropriate. | Analysis of a standard containing perchlorate at the RL and interfering anions at the concentration determined by the interference threshold study. Monitor recovery of perchlorate and retention time.<br><br>No samples may be reported that are associated with a failing ICS. |
| **Laboratory reagent blank** | Prior to calibration, after samples with overrange concentration of perchlorate, and at the end of the analytical sequence. | No perchlorate detected > ½ RL. | Reanalyze reagent blank (until no carryover is observed) and all samples processed since the contaminated blank. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated batch. | Problem must be corrected. Results may not be reported without a valid reagent blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed. |
| **Tuning** | Prior to ICAL and after any mass calibration or maintenance is performed. | Tuning standards must contain the analytes of interest and meet acceptance criteria outlined in the laboratory SOP. | Retune instrument. If the tuning will not meet acceptance criteria, an instrument mass calibration must be performed and the tuning redone. | Flagging criteria are not appropriate. | Problem must be corrected. Sample analysis shall not proceed without acceptable tuning. |

**Table F-12. Perchlorate Analysis (Methods 6850 and 6860) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Mass calibration** | Instrument must have a valid mass calibration prior to any sample analysis. The mass calibration is updated on an as-needed basis (e.g., QC failures, ion masses show large deviations from known masses, major instrument maintenance is performed, or the instrument is moved). | Mass calibration range must bracket the ion masses of interest without greatly exceeding the range. The most recent mass calibration must be used for an analytical run, and the same mass calibration must be used for all data files in an analytical run. Mass calibration must be verified by acquiring a full scan continuum mass spectrum of a perchlorate stock standard. Perchlorate ions should be within ± 0.3 *m/z* of mass 99, 101, and 107 or their respective daughter ion masses (83, 85, and 89), depending on which ions are quantitated. | If the mass calibration fails, recalibrate. If it still fails, consult manufacturer instructions on corrective maintenance. | Flagging criteria are not appropriate. | Problem must be corrected. No samples may be analyzed under a failing mass calibration. |
| **Interference threshold study** | At initial setup and when major changes occur in the method's operating procedures (e.g., addition of cleanup procedures, column changes, mobile phase changes). | Measure the threshold of common suppressors (chloride, sulfate, carbonate, bicarbonate) that can be present in the system without affecting the quantitation of perchlorate. The threshold is the concentration of the common suppressors where perchlorate recovery falls outside an 85-115% window. | NA. | Flagging criteria are not appropriate. | This study and site history will determine the concentration at which the ICS suppressors should be set. |

**Table F-12. Perchlorate Analysis (Methods 6850 and 6860) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Method blank (MB)** | One per preparatory batch. | No perchlorate detected > ½ RL and greater than 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. | Correct problem, then see criteria in Box D-1. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank. | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed.<br><br>Method blank must undergo the same preparation and pretreatment steps as the samples in the batch. |
| **Laboratory control sample (LCS)** | One per preparatory batch. LCS must be spiked at the RL. | Recovery within method requirements, laboratory-generated limits, or 80-120% (whichever is more stringent) to verify calibration and to check method performance. | Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available (see full explanation in Appendix G). | If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch. | Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed.<br><br>LCS must undergo the same preparation and pretreatment steps as the samples in the batch. |
| **Matrix spike (MS)** | One per preparatory batch per matrix (see Box D-7). The MS must be spiked at the RL. | Recovery within 80-120% or within laboratory generated limits, whichever is more stringent. | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | For matrix evaluation only. If MS results are outside the limits, the data must be evaluated to determine the source of the difference and to determine if there is a matrix effect or analytical error.<br><br>MS must undergo the same preparation and pretreatment steps as the samples in the batch. |

**Table F-12. Perchlorate Analysis (Methods 6850 and 6860) (continued)**

| QC Check | Minimum Frequency | Acceptance Criteria | Corrective Action | Flagging Criteria | Comments |
|---|---|---|---|---|---|
| **Matrix spike duplicate (MSD) or laboratory duplicate (LD)** | One per preparatory batch per matrix (see Box D-7). The MSD must be spiked at the RL. | MSD: Recovery within 80-120% or within laboratory generated limits, whichever is more stringent.<br><br>MSD or laboratory duplicate: RPD < 15%. | Examine the project-specific DQOs. Contact the client as to additional measures to be taken. | For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met. | The data shall be evaluated to determine the source of difference. |
| **Results reported between DL and LOQ** | Positive detections calculated per method. | NA. | NA. | Apply J-flag to all results between DL and LOQ. | |

# List of Acronyms for Appendix F

**C**

| | |
|---|---|
| **CC3** | The third of five solutions for instrument calibration used in Method 8280 |
| **CCC** | Calibration check compounds |
| **CCV** | Continuing calibration verification |
| **CFR** | Code of Federal Regulations |
| **COD** | Coefficient of determination |
| **CV** | Calibration verification |
| **CV-IS** | Calibration verification of internal standards |

**D**

| | |
|---|---|
| **D** | Difference or drift |
| **DDT** | 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane/dichlorodiphenyl-trichloroethane/p,p'-DDT |
| **DoD** | Department of Defense |
| **DQO** | Data quality objective |
| **DRO** | Diesel range organics |

**E**

| | |
|---|---|
| **EDL** | Estimated detection limit |
| **EQL** | Estimated quantitation limit |
| **EMPC** | Estimated maximum possible concentration |
| **EICP** | Extracted ion current profile |

**G**

| | |
|---|---|
| **GC** | Gas chromatography |
| **GC/MS** | Gas chromatography/mass spectrometry |
| **GFAA** | Graphite furnace atomic absorption spectrophotometry |
| **GRO** | Gasoline range organics |

**H**

| | |
|---|---|
| **HPLC** | High performance liquid chromatography |
| **HxCDD** | Hexachlorodibenzo-p-dioxin (solution used for calibration verification) |

**I**

| | |
|---|---|
| **ICAL** | Initial calibration |
| **ICP** | Inductively coupled plasma atomic emission spectrometry |
| **ICP/MS** | Inductively coupled plasma/mass spectrometry |
| **ICS** | Interference check solution |
| **ICV** | Initial calibration verification |
| **IS** | Internal standard |
| **IDL** | Instrument detection limit |

**L**

| | |
|---|---|
| **LCS** | Laboratory control sample |
| **LOD** | Limit of detection |
| **LOQ** | Limit of quantitation |

**M**

| | |
|---|---|
| **MS** | Mass spectrometry |
| **MS** | Matrix spike |

| | |
|---|---|
| **MSA** | Method of standard additions |
| **MSD** | Matrix spike duplicate |
| **P** | |
| **PCB** | Polychlorinated biphenyl |
| **PCDD** | Polychlorinated dibenzodioxin |
| **PCDF** | Polychlorinated dibenzofuran |
| **PDS** | Post-digestion spike |
| **PE** | Performance evaluation |
| **PT** | Proficiency testing |
| **Q** | |
| **QC** | Quality control |
| **QSM** | DoD Quality Systems Manual for Environmental Laboratories |
| **R** | |
| **RF** | Response factor |
| **RL** | Reporting limit |
| **RPD** | Relative percent difference |
| **RRO** | Residual range organics |
| **RRT** | Relative retention time |
| **RSD** | Relative standard deviation |
| **RT** | Retention time |
| **S** | |
| **SICP** | Selected ion current profile |
| **S/N** | Signal to noise ratio |
| **SPCC** | System performance check compound |
| **SVOC** | Semivolatile organic compound |
| **T** | |
| **TCDD** | Tetrachlorodibenzo-p-dioxin |
| **TCDF** | Tetrachlorodibenzofuran |
| **V** | |
| **VOC** | Volatile organic compound |

# Appendix G – SW-846 LCS Control Limits

DoD conducted a study to establish control limits for laboratory control samples (LCS) using data collected from DoD-approved environmental laboratories. LCS recoveries for all the analytes on the target analyte lists were pooled, and statistical analyses (such as outlier tests and analysis of variance) were performed on the data before generating the final LCS control limits (LCS-CLs). A complete description of the methodology and findings for Method 8270 can be found in the Laboratory Control Sample Pilot Study (DoD, 2000).

Environmental testing laboratories that perform work for DoD must utilize the DoD-specified LCS-CLs when assessing batch acceptance whenever they are available. This appendix presents the control limits generated by the LCS study and the methodology for applying the limits to LCS data. All analytes spiked in the LCS shall meet the DoD-generated LCS control limits. As described in Section D.1.1.2.1.e of NELAC Appendix D, a number of sporadic marginal exceedances are allowed. Depending on the length of the list of analytes, a specified small number of analytes may exceed the generated control limit. Upper and lower marginal exceedance (ME) limits, calculated at 4 standard deviations around the mean, are established to mark the boundaries of marginal exceedances. If more analytes exceed the LCS-CLs than are allowed, or if any one analyte exceeds the ME limits, then the LCS has failed.

**DoD LCS Control Limits Policy**

- The laboratory shall use project-specific control limits based on data quality objectives (DQOs), if available. If not, DoD-generated LCS-CLs shall be used, if available. Otherwise, the laboratory's own in-house control limits shall be used.
- The LCS-CLs are based on the promulgated versions of SW-846 methods at the time of the study (2000). They should be used as a benchmark to evaluate acceptability even as methods are updated or alternative methods for the same class of compounds become available.
- The fact that the LCS-CLs are based on certain SW-846 methods should not limit the use of alternative analytical methods, if appropriate. If an alternative method is used, however, it should be capable of producing LCS recoveries that are at least as good as the DoD-generated LCS-CLs, unless project-specific DQOs allow less stringent criteria.
- The LCS study shows that preparatory methods may have a significant influence on a laboratory's ability to achieve certain LCS-CLs. If a laboratory is unable to achieve the LCS-CLs presented in this appendix, it should investigate the use of alternative preparatory methods as a means to improve precision and accuracy.

## G.1 Generated LCS Control Limits

As mentioned above, DoD compiled LCS data from multiple laboratories, performing statistical analyses on the data sets before generating control limits. The control limits were set at 3 standard deviations around the mean for all methods except 8151 (see below for further explanation). Limits were then rounded to the nearest 5 for ease of use. The ME limits were set at 4 standard deviations around the mean. The lower ME limit was then raised to 10% for those analytes in which 4 standard deviations falls below that level. Tables G -4 through G -19 at the end of this appendix present the mean or median, standard deviation, lower control limit, upper control limit, lower ME limit, and upper ME limit, as applicable, for each analyte in Methods 8260, 8270, 8151, 8310, 8330, 8081, 8082, 6010, and 7470/7471, for the water and solid matrices. The lower and upper ME limits are not presented for Methods 8151, 8082, and 7470/7471, since those methods have fewer than 11 analytes and are not capable of utilizing the sporadic marginal exceedance allowance. The analytes for Method 8270 are grouped by compound class.

The control limits for explosives Method 8330 in the water matrix were generated using data that were extracted with solid phase extraction (SPE) using acetonitrile only. Analysis of the data received from the LCS study showed that the extraction method produced recoveries with higher means and lower

standard deviations than the salting out extraction method. This results in significantly narrower control limits. Since SPE/acetonitrile is less expensive, cumbersome, and time and labor intensive, the LCS control limits for Method 8330 in water were set with data using only that method. A limited amount of data were received that used SPE/acetonitrile, therefore, no outliers were removed during the statistical analysis. This ensures that a representative data set was used to generate the control limits (see Table G -12).

***Note:*** Laboratories may use any extraction method they feel is appropriate; however, the LCS recoveries must fall within the LCS-CLs presented in Table G-12.

Control limits for chlorinated herbicides Method 8151 were generated using a non-parametric statistical approach. This is a different approach than for the other methods in the LCS study due to the large amount of intralaboratory variability in recoveries for all analytes in the method. The control limits for Method 8151, both solid and water matrices, were set at the 5$^{th}$ and 95$^{th}$ percentile of all data received in the study (no outliers were removed). Tables G -8 and G -9 present the median, lower control limit, and upper control limit for each analyte. LCS failure is assessed and corrective action applied the same way for all methods with control limits in this appendix (see Sections G.3 and G.4).

***Note:*** These data represent the current capability of the SW-846 analytical and preparatory methods. Use of alternative preparatory procedures and/or improvements through PBMS is encouraged. Project-specific control limits can supersede these DoD limits.

If limits are not available for a project-specific analyte, the laboratory shall discuss with the client appropriate limits considering the project-specific DQOs.

Control limits for metals Method 6010, and mercury Method 7470/7471 were set at 80 – 120% even though generated limits were within these numbers. This reflects the allowable uncertainty in the calibration of the instrument. In one case the generated limit (silver in solid) was outside 80 – 120%, and therefore the generated limit was used.

## G.2 Marginal Exceedance

As described in Section D.1.1.2.1.e of NELAC Appendix D, a number of sporadic marginal exceedances of the LCS-CLs will be allowed. The number of exceedances is based on the total number of analytes spiked in the LCS. As the number of analytes in the LCS increases, more marginal exceedances are allowed. Table G-1 presents the allowable number of marginal exceedances for a given number of analytes in the LCS (as presented in NELAC Appendix D).

**Table G-1. Number of Marginal Exceedances**

| Number of Analytes in LCS | Allowable Number of Marginal Exceedances of LCS-CLs |
|---|---|
| > 90 | 5 |
| 71 – 90 | 4 |
| 51 – 70 | 3 |
| 31 – 50 | 2 |
| 11 – 30 | 1 |
| < 11 | 0 |

A *marginal* exceedance is defined as beyond the LCS-CL but still within the marginal exceedance limits (set at 4 standard deviations around the mean). This outside boundary prevents a grossly out-of-control LCS from passing.

NELAC requires that the marginal exceedances be sporadic, i.e., random. As defined by DoD, if the same analyte exceeds the LCS-CLs repeatedly (e.g., two out of three consecutive LCS), that is an indication that the problem is systematic and something is wrong with the measurement system. The source of error should be located and the appropriate corrective action taken. Laboratories must monitor the application of the sporadic marginal exceedance allowance to the LCS results through QA

channels to ensure random behavior. Effective implementation of the marginal exceedance allowance requires cooperation from the laboratory. If the laboratory fails to implement the policy properly, the privilege of using the marginal exceedance option will be revoked. Oversight and appropriate corrective action will be a focus of DoD laboratory assessments in the future.

## G.3 LCS Failure

Each LCS must be evaluated against the appropriate control limits and ME limits before being accepted. The laboratory shall use project-specific control limits, if available. If not, DoD generated LCS-CLs shall be used, if available (see Tables G-4 through G-19). Otherwise, the laboratory's own in-house control limits shall be used. First, the recoveries for the analytes spiked in the LCS should be compared with the LCS control limits. If a recovery is less than the lower control limit or greater than the upper control limit, that is an exceedance. The laboratory should note which analytes exceeded the control limits and make a comparison to the list of project-specific analytes of concern. **If a project-specific analyte of concern exceeds its LCS-CLs, the LCS has failed.** Next, the laboratory should add up the total number of exceedances for the LCS. Based on the number of analytes spiked in the LCS, the total number of exceedances should be compared with the allowable number from Table G-1. (The allowable number of marginal exceedances depends on the total number of analytes spiked in the LCS, even if DoD-generated control limits are not available for all analytes.) **If a LCS has more than the allowable number of marginal exceedances, the LCS has failed.** Finally, the recoveries for those analytes that exceeded the LCS-CLs should be compared with the ME limits from Tables G-4 to G-7, G-10 to G-15, or G-18 to G-19. **If a single analyte exceeds its marginal exceedance limit, the LCS has failed.** (This applies only to methods with greater than 10 analytes.)

In summary, failure of the LCS can occur several ways:

- Exceedance of a LCS-CL by any project-specific analyte of concern
- Marginal exceedance of the LCS-CLs by more than the allowable number of analytes
- Exceedance of the ME limits by one or more analytes

Once a LCS has failed, corrective action is required, see section D.4.

## G.4 Corrective Action

If a sample fails based on any of the criteria in section G.3, corrective action is required. The corrective action requirement applies to all analytes that exceeded the LCS-CLs, even if one specific analyte's exceedance was not the trigger of LCS failure (see example below). **All exceedances of the LCS-CLs, marginal or otherwise, are subject to corrective action.**

**Example of Applying Corrective Action**

- In a single LCS, anthracene has a recovery of 30%.
- The lower ME limit for anthracene is 45, therefore the LCS has failed.
- In the same LCS three other analytes exceeded their LCS-CLs but were within their ME limits.
- The LCS was spiked with 74 analytes; therefore, according to Table G-1, four marginal exceedances are allowed.
- The four total exceedances (anthracene plus the three other analytes) are within the allowable number for that analyte list size.

*Corrective action is triggered for the LCS because the anthracene recovery exceeded its ME limit, but it is required for all four analytes that exceeded the LCS-CLs.*

If a LCS fails, an attempt must be made to determine the source of error and find a solution. All the findings and corrective action should be documented. DoD requires that the analytes subject to corrective action in the LCS and all the samples in the batch be reprepped and reanalyzed or the batch rerun with a new LCS. The corrective action applied shall be based on professional judgment in the review of other QC measures (i.e., surrogates). If an analyte falls outside the LCS-CLs a second time or

if there is not sufficient sample material available to be reanalyzed, then all the results in the associated batch for that analyte must be flagged with a Q (see DoD Gray Box 47). The recoveries of those analytes subject to corrective action must be documented in the case narrative, whether flagging is needed or not.

## G.5 Poor Performing Analytes

On the basis of results from the LCS study, DoD identified certain compounds that do not perform well with specific methods. These compounds produce low mean recoveries and high standard deviations, resulting in wide LCS control limits with particularly low lower control limits (sometimes negative values). The performance of these compounds reflects routine implementation of the method in many laboratories. DoD has defined a poor performing analyte as having a lower control limit of 10% or less. DoD does not feel it is appropriate to control batch acceptance on these compounds because there is a high level of uncertainty in their recovery. The data may be used; however, routine performance of the method on these compounds can result in being able to identify only a small percentage of the analyte.

The laboratory should include all target analytes in the calibration standard, including the poor performing analytes. If one of the poor performing analytes identified below is a project-specific analyte of concern *or* if it is detected in the project samples, the laboratory should contact the client (DoD), who will then work with the laboratory on an appropriate course of action. Ideally DoD and the laboratory would use an alternative method to test for the analyte (one that is known to produce higher recoveries) or else modify the original method to optimize conditions for the poor performing analyte.

Poor performing analytes were only identified in SW-846 Methods 8270, 8151, and 8330. These analytes, along with the mean, standard deviation, lower control limit, upper control limit, lower ME limit, and upper ME limit (as generated by the LCS study) are presented in Table G-2.

**Table G-2. Poor Performing Analytes**[1]

| Analyte | Mean/ Median | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| **8270 Water:** | | | | | | |
| 4-Nitrophenol | 54 | 23 | 0 | 125 | 0 | 145 |
| Benzoic acid | 54 | 24 | 0 | 125 | 0 | 150 |
| Phenol | 55 | 19 | 0 | 115 | 0 | 135 |
| Phenol-$d_5$/$d_6$ (surrogate) | 62 | 18 | 10 | 115 | 0 | 135 |
| **8270 Solid:** | | | | | | |
| 3,3'Dichlorobenzidine | 68 | 19 | 10 | 130 | 0 | 145 |
| 4-Chloroaniline | 51 | 14 | 10 | 100 | 0 | 110 |
| Benzoic acid | 55 | 18 | 0 | 110 | 0 | 130 |
| **8151 Solid:** | | | | | | |
| Dinoseb | 72 | | 5 | 130 | | |
| **8330 and 8330A Solid:** | | | | | | |
| Methyl-2,4,6-trinitrophenylnitramine (Tetryl) | 80 | 23 | 10 | 150 | 0 | 172 |

***Note:*** Lower limits calculated as negative values were raised to zero.

The LCS control limits generated by the study for the poor performing analytes are provided as a benchmark against which laboratories can measure the effectiveness of alternative methods or modifications to the current methods. Batch acceptance should not be evaluated using these limits. When choosing alternative or modified methods, laboratories should strive to raise the mean recoveries and lower the standard deviations in comparison with the performance of the analytes

[1]Control limits for Method 8151 were generated using non-parametric statistics; therefore, the median is presented without standard deviation (see section G.1 for further explanation). ME limits are not used for Method 8151 since the target analyte list has fewer than 11 analytes.

presented in Table G-2. The lower control limit generated for alternative or modified methods must be greater than 10% to be considered acceptable.

## G.6 Surrogates

The surrogate compounds for each method are added to all samples, standards, and blanks to assess the ability of the method to recover specific non-target analytes from a given matrix and to monitor sample-specific recovery. Control limits for these compounds were calculated in the same study as the other analytes on the target analyte lists. Below are the limits for some of the surrogates of Methods 8260, 8270, 8081, and 8082, based on 3 standard deviations around the mean (Table G-3). Sufficient data were not received for those analytes during the LCS study to perform statistically significant analyses. No ME limits are presented as marginal exceedances are not acceptable for surrogate spikes.

*Note:* DoD prefers the use of those surrogates not identified as poor performing analytes in Table G-2 above.

**Table G-3. Surrogates**

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit |
|---|---|---|---|---|
| **8260 Water:** | | | | |
| 1,2-Dichloroethane-$d_4$ | 95 | 8 | 70 | 120 |
| 4-Bromofluorobenzene | 98 | 7 | 75 | 120 |
| Dibromofluoromethane | 100 | 5 | 85 | 115 |
| Toluene-$d_8$ | 102 | 6 | 85 | 120 |
| **8260 Solid:** | | | | |
| 4-Bromofluorobenzene | 101 | 6 | 85 | 120 |
| Toluene-$d_8$ | 100 | 5 | 85 | 115 |
| **8270 Water:** | | | | |
| 2-Fluorobiphenyl | 79 | 10 | 50 | 110 |
| Terphenyl-$d_{14}$ | 92 | 14 | 50 | 135 |
| 2,4,6-Tribromophenol | 82 | 13 | 40 | 125 |
| 2-Fluorophenol | 63 | 14 | 20 | 110 |
| Nitrobenzene-$d_5$ | 76 | 11 | 40 | 110 |
| **8270 Solid:** | | | | |
| 2-Fluorobiphenyl | 72 | 10 | 45 | 105 |
| Terphenyl-$d_{14}$ | 78 | 15 | 30 | 125 |
| 2,4,6-Tribromophenol | 80 | 15 | 35 | 125 |
| 2-Fluorophenol | 70 | 11 | 35 | 105 |
| Phenol-$d_5$/$d_6$ | 71 | 10 | 40 | 100 |
| Nitrobenzene-$d_5$ | 69 | 10 | 35 | 100 |
| **8081 Water:** | | | | |
| Decachlorobiphenyl | 83 | 17 | 30 | 135 |
| TCMX | 81 | 19 | 25 | 140 |
| **8081 Solid:** | | | | |
| Decachlorobiphenyl | 94 | 13 | 55 | 130 |
| TCMX | 97 | 9 | 70 | 125 |
| **8082 Water:** | | | | |
| Decachlorobiphenyl | 88 | 15 | 40 | 135 |
| **8082 Solid:** | | | | |
| Decachlorobiphenyl | 91 | 11 | 60 | 125 |

## G.7 In-House LCS Control Limits

The acceptability of LCS results within any preparatory batch shall be based on project-specified limits or the following DoD-specified LCS control limits, if project-specific limits are not available. If DoD limits are not available, the laboratory must use its in-house limits for batch acceptance.

DoD strongly believes that it is important for laboratories to maintain their own in-house LCS limits. These in-house limits must be consistent with (i.e., within) the DoD limits (project-specific, if available; otherwise the following LCS-CLs). The laboratory in-house limits shall be calculated from the laboratory's historical LCS data in accordance with a documented procedure (e.g., SOP) that is consistent with good laboratory practice. That document must describe the process for establishing and maintaining LCS limits and the use of control charts.

The laboratory in-house limits are to be used for several purposes:

- Laboratories are expected to utilize their in-house limits as part of their quality control system, and to evaluate trends and monitor and improve performance.
- When a laboratory's in-house limits are outside the DoD control limits (upper and/or lower), they must report their in-house limits in the laboratory report (see Appendix E) even if the LCS associated with the batch fell within the DoD limits. Using this information, DoD will be able to determine how laboratory performance affects the quality of the environmental data.
- DoD may review the laboratory in-house limits and associated trends, as reflected in control charts, to determine whether the laboratory's overall performance is acceptable. If deemed unacceptable, this can allow DoD to decide not to use the laboratory again until substantial improvement has occurred.

**Table G-4. LCS Control Limits for Volatile Organic Compounds SW-846 Method 8260 Water Matrix**[2]

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| 1,1,1,2-Tetrachloroethane | 105 | 8 | 80 | 130 | 75 | 135 |
| 1,1,1-Trichloroethane | 100 | 11 | 65 | 130 | 55 | 145 |
| 1,1,2,2-Tetrachloroethane | 96 | 11 | 65 | 130 | 55 | 140 |
| 1,1,2-Trichloroethane | 100 | 8 | 75 | 125 | 65 | 135 |
| 1,1-Dichloroethane | 101 | 11 | 70 | 135 | 60 | 145 |
| 1,1-Dichloroethene | 99 | 10 | 70 | 130 | 55 | 140 |
| 1,1-Dichloropropene | 102 | 10 | 75 | 130 | 65 | 140 |
| 1,2,3-Trichlorobenzene | 99 | 14 | 55 | 140 | 45 | 155 |
| 1,2,3-Trichloropropane | 98 | 9 | 75 | 125 | 65 | 130 |
| 1,2,4-Trichlorobenzene | 100 | 11 | 65 | 135 | 55 | 145 |
| 1,2,4-Trimethylbenzene | 103 | 10 | 75 | 130 | 65 | 140 |
| 1,2-Dibromo-3-chloropropane | 91 | 14 | 50 | 130 | 35 | 145 |
| 1,2-Dibromoethane | 100 | 7 | 80 | 120 | 75 | 125 |
| 1,2-Dichlorobenzene | 96 | 9 | 70 | 120 | 60 | 130 |
| 1,2-Dichloroethane | 100 | 10 | 70 | 130 | 60 | 140 |
| 1,2-Dichloropropane | 100 | 8 | 75 | 125 | 65 | 135 |
| 1,3,5-Trimethylbenzene | 102 | 10 | 75 | 130 | 65 | 140 |
| 1,3-Dichlorobenzene | 100 | 8 | 75 | 125 | 65 | 130 |
| 1,3-Dichloropropane | 100 | 9 | 75 | 125 | 65 | 135 |
| 1,4-Dichlorobenzene | 99 | 8 | 75 | 125 | 65 | 130 |
| 2,2-Dichloropropane | 103 | 11 | 70 | 135 | 60 | 150 |
| 2-Butanone | 91 | 20 | 30 | 150 | 10 | 170 |

[2] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. LCS control limits are not available for Total Xylene. Xylene may be reported on a project-specific basis as a total number; however, for the purposes of the DoD QSM, it will be analyzed and reported as m,p-Xylene and o-Xylene. Additional limits for poor performing compounds can be found in section G.5 and for surrogate compounds in section G.6.

**Table G-4. LCS Control Limits for Volatile Organic Compounds SW-846 Method 8260 Water Matrix[2]** (continued)

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| 2-Chlorotoluene | 100 | 9 | 75 | 125 | 65 | 135 |
| 2-Hexanone | 92 | 12 | 55 | 130 | 45 | 140 |
| 4-Chlorotoluene | 101 | 9 | 75 | 130 | 65 | 135 |
| 4-Methyl-2-pentanone | 96 | 13 | 60 | 135 | 45 | 145 |
| Acetone | 91 | 17 | 40 | 140 | 20 | 160 |
| Benzene | 102 | 7 | 80 | 120 | 75 | 130 |
| Bromobenzene | 100 | 8 | 75 | 125 | 70 | 130 |
| Bromochloromethane | 97 | 11 | 65 | 130 | 55 | 140 |
| Bromodichloromethane | 98 | 8 | 75 | 120 | 70 | 130 |
| Bromoform | 99 | 10 | 70 | 130 | 60 | 140 |
| Bromomethane | 88 | 19 | 30 | 145 | 10 | 165 |
| Carbon disulfide | 100 | 21 | 35 | 160 | 15 | 185 |
| Carbon tetrachloride | 102 | 12 | 65 | 140 | 55 | 150 |
| Chlorobenzene | 102 | 7 | 80 | 120 | 75 | 130 |
| Chlorodibromomethane | 96 | 13 | 60 | 135 | 45 | 145 |
| Chloroethane | 99 | 12 | 60 | 135 | 50 | 145 |
| Chloroform | 100 | 12 | 65 | 135 | 50 | 150 |
| Chloromethane | 83 | 15 | 40 | 125 | 25 | 140 |
| cis-1,2-Dichloroethene | 99 | 9 | 70 | 125 | 60 | 135 |
| cis-1,3-Dichloropropene | 100 | 10 | 70 | 130 | 60 | 140 |
| Dibromomethane | 101 | 8 | 75 | 125 | 65 | 135 |
| Dichlorodifluoromethane | 93 | 21 | 30 | 155 | 10 | 175 |
| Ethylbenzene | 100 | 9 | 75 | 125 | 65 | 135 |
| Hexachlorobutadiene | 97 | 15 | 50 | 140 | 35 | 160 |
| Isopropylbenzene | 101 | 9 | 75 | 125 | 65 | 135 |
| m,p-Xylene | 102 | 9 | 75 | 130 | 65 | 135 |
| Methyl tert-butyl ether | 94 | 10 | 65 | 125 | 55 | 135 |
| Methylene chloride | 96 | 14 | 55 | 140 | 40 | 155 |
| Naphthalene | 96 | 14 | 55 | 140 | 40 | 150 |
| n-Butylbenzene | 103 | 11 | 70 | 135 | 55 | 150 |
| n-Propylbenzene | 101 | 9 | 70 | 130 | 65 | 140 |
| o-Xylene | 100 | 7 | 80 | 120 | 75 | 130 |
| p-Isopropyltoluene | 102 | 10 | 75 | 130 | 65 | 140 |
| sec-Butylbenzene | 100 | 9 | 70 | 125 | 65 | 135 |
| Styrene | 100 | 11 | 65 | 135 | 55 | 145 |
| tert-Butylbenzene | 99 | 10 | 70 | 130 | 60 | 140 |
| Tetrachloroethene | 96 | 18 | 45 | 150 | 25 | 165 |
| Toluene | 100 | 7 | 75 | 120 | 70 | 130 |
| trans-1,2-Dichloroethene | 99 | 13 | 60 | 140 | 45 | 150 |
| trans-1,3-Dichloropropene | 98 | 15 | 55 | 140 | 40 | 155 |
| Trichloroethene | 99 | 9 | 70 | 125 | 60 | 135 |
| Trichlorofluoromethane | 103 | 15 | 60 | 145 | 45 | 160 |
| Vinyl chloride | 99 | 16 | 50 | 145 | 35 | 165 |

**Table G-5. LCS Control Limits for Volatile Organic Compounds SW-846 Method 8260 Solid Matrix[3]**

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| 1,1,1,2-Tetrachloroethane | 100 | 9 | 75 | 125 | 65 | 135 |
| 1,1,1-Trichloroethane | 101 | 11 | 70 | 135 | 55 | 145 |
| 1,1,2,2-Tetrachloroethane | 93 | 13 | 55 | 130 | 40 | 145 |
| 1,1,2-Trichloroethane | 95 | 11 | 60 | 125 | 50 | 140 |
| 1,1-Dichloroethane | 99 | 9 | 75 | 125 | 65 | 135 |
| 1,1-Dichloroethene | 100 | 12 | 65 | 135 | 55 | 150 |
| 1,1-Dichloropropene | 102 | 11 | 70 | 135 | 60 | 145 |
| 1,2,3-Trichlorobenzene | 97 | 12 | 60 | 135 | 50 | 145 |
| 1,2,3-Trichloropropane | 97 | 11 | 65 | 130 | 50 | 140 |
| 1,2,4-Trichlorobenzene | 98 | 11 | 65 | 130 | 55 | 140 |
| 1,2,4-Trimethylbenzene | 100 | 12 | 65 | 135 | 55 | 145 |
| 1,2-Dibromo-3-chloropropane | 87 | 16 | 40 | 135 | 25 | 150 |
| 1,2-Dibromoethane | 97 | 9 | 70 | 125 | 60 | 135 |
| 1,2-Dichlorobenzene | 97 | 7 | 75 | 120 | 65 | 125 |
| 1,2-Dichloroethane | 104 | 11 | 70 | 135 | 60 | 145 |
| 1,2-Dichloropropane | 95 | 8 | 70 | 120 | 65 | 125 |
| 1,3,5-Trimethylbenzene | 99 | 11 | 65 | 135 | 55 | 145 |
| 1,3-Dichlorobenzene | 98 | 9 | 70 | 125 | 65 | 135 |
| 1,3-Dichloropropane | 100 | 8 | 75 | 125 | 70 | 130 |
| 1,4-Dichlorobenzene | 98 | 9 | 70 | 125 | 65 | 135 |
| 2,2-Dichloropropane | 101 | 11 | 65 | 135 | 55 | 145 |
| 2-Butanone | 94 | 22 | 30 | 160 | 10 | 180 |
| 2-Chlorotoluene | 98 | 10 | 70 | 130 | 60 | 140 |
| 2-Hexanone | 97 | 16 | 45 | 145 | 30 | 160 |
| 4-Chlorotoluene | 100 | 9 | 75 | 125 | 65 | 135 |
| 4-Methyl-2-pentanone | 97 | 17 | 45 | 145 | 30 | 165 |
| Acetone | 88 | 23 | 20 | 160 | 10 | 180 |
| Benzene | 99 | 9 | 75 | 125 | 65 | 135 |
| Bromobenzene[4] | 93 | 9 | 65 | 120 | 55 | 130 |
| Bromochloromethane | 99 | 9 | 70 | 125 | 60 | 135 |
| Bromodichloromethane | 100 | 9 | 70 | 130 | 60 | 135 |
| Bromoform | 96 | 13 | 55 | 135 | 45 | 150 |
| Bromomethane | 95 | 21 | 30 | 160 | 10 | 180 |
| Carbon disulfide | 103 | 19 | 45 | 160 | 30 | 180 |
| Carbon tetrachloride | 100 | 11 | 65 | 135 | 55 | 145 |
| Chlorobenzene | 99 | 8 | 75 | 125 | 65 | 130 |
| Chlorodibromomethane | 98 | 11 | 65 | 130 | 55 | 140 |
| Chloroethane | 98 | 20 | 40 | 155 | 20 | 175 |

[3] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. LCS control limits are not available for Methyl tert-butyl ether and Total Xylene. Sufficient data to perform statistically significant analyses were not received for MTBE during the LCS study. Xylene may be reported on a project-specific basis as a total number; however, for the purposes of the DoD QSM, it will be analyzed and reported as m,p-Xylene and o-Xylene. Additional limits for poor performing compounds can be found in section G.5 and for surrogate compounds in section G.6.

[4] Provisional limits – outlier analyses during the LCS study resulted in LCS-CLs generated with data from fewer than four laboratories. Limits may be adjusted in the future as additional data become available.

**Table G-5. LCS Control Limits for Volatile Organic Compounds SW-846 Method 8260 Solid Matrix[3]** (continued)

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| Chloroform | 98 | 9 | 70 | 125 | 65 | 135 |
| Chloromethane | 90 | 13 | 50 | 130 | 40 | 140 |
| cis-1,2-Dichloroethene | 96 | 10 | 65 | 125 | 55 | 135 |
| cis-1,3-Dichloropropene | 99 | 9 | 70 | 125 | 65 | 135 |
| Dibromomethane | 100 | 9 | 75 | 130 | 65 | 135 |
| Dichlorodifluoromethane[4] | 85 | 17 | 35 | 135 | 15 | 155 |
| Ethylbenzene | 101 | 9 | 75 | 125 | 65 | 135 |
| Hexachlorobutadiene | 98 | 15 | 55 | 140 | 40 | 155 |
| Isopropylbenzene | 103 | 9 | 75 | 130 | 70 | 140 |
| m,p-Xylene | 102 | 8 | 80 | 125 | 70 | 135 |
| Methylene chloride | 97 | 14 | 55 | 140 | 40 | 155 |
| Naphthalene | 84 | 14 | 40 | 125 | 25 | 140 |
| n-Butylbenzene | 101 | 12 | 65 | 140 | 50 | 150 |
| n-Propylbenzene | 99 | 12 | 65 | 135 | 50 | 145 |
| o-Xylene | 101 | 8 | 75 | 125 | 70 | 135 |
| p-Isopropyltoluene | 104 | 10 | 75 | 135 | 65 | 140 |
| sec-Butylbenzene | 97 | 11 | 65 | 130 | 50 | 145 |
| Styrene | 101 | 9 | 75 | 125 | 65 | 135 |
| tert-Butylbenzene | 99 | 11 | 65 | 130 | 55 | 145 |
| Tetrachloroethene | 103 | 12 | 65 | 140 | 55 | 150 |
| Toluene | 99 | 9 | 70 | 125 | 60 | 135 |
| trans-1,2-Dichloroethene | 100 | 11 | 65 | 135 | 55 | 145 |
| trans-1,3-Dichloropropene | 96 | 10 | 65 | 125 | 55 | 140 |
| Trichloroethene | 101 | 8 | 75 | 125 | 70 | 130 |
| Trichlorofluoromethane | 106 | 27 | 25 | 185 | 10 | 215 |
| Vinyl chloride | 92 | 11 | 60 | 125 | 45 | 140 |

**Table G-6. LCS Control Limits for Semivolatile Organic Compounds SW-846 Method 8270 Water Matrix[5]**

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| Polynuclear Aromatics | | | | | | |
| 2-Methylnaphthalene | 75.0 | 9.5 | 45 | 105 | 35 | 115 |
| Acenaphthene | 77.6 | 10.1 | 45 | 110 | 35 | 120 |
| Acenaphthylene | 78.5 | 9.4 | 50 | 105 | 40 | 115 |
| Anthracene | 83.0 | 9.7 | 55 | 110 | 45 | 120 |
| Benz[a]anthracene | 82.7 | 8.9 | 55 | 110 | 45 | 120 |
| Benzo[a]pyrene | 81.3 | 9.5 | 55 | 110 | 45 | 120 |

[5] A number of sporadic marginal exceedances of the control limits are allowed depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. LCS control limits are not available for Benzidine, 2,6-Dichlorophenol, and N-nitrosopyrrolidine. Sufficient data to perform statistically significant analyses were not received for those analytes during the LCS study. Additional limits for poor performing compounds can be found in section G.5.

**Table G-6. LCS Control Limits for Semivolatile Organic Compounds SW-846 Method 8270 Water Matrix[5]** (continued)

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| Benzo[b]fluoranthene | 81.8 | 12.1 | 45 | 120 | 35 | 130 |
| Benzo[k]fluoranthene | 84.6 | 13.2 | 45 | 125 | 30 | 135 |
| Benzo[g,h,i]perylene | 80.5 | 14.1 | 40 | 125 | 25 | 135 |
| Chrysene | 82.1 | 8.9 | 55 | 110 | 45 | 120 |
| Dibenz[a,h]anthracene | 84.7 | 14.1 | 40 | 125 | 30 | 140 |
| Fluoranthene | 85.2 | 10.4 | 55 | 115 | 45 | 125 |
| Fluorene | 80.6 | 10.3 | 50 | 110 | 40 | 120 |
| Indeno[1,2,3-cd]pyrene | 84.3 | 13.6 | 45 | 125 | 30 | 140 |
| Naphthalene | 70.8 | 10.5 | 40 | 100 | 30 | 115 |
| Phenanthrene | 84.0 | 11.0 | 50 | 115 | 40 | 130 |
| Pyrene | 88.6 | 13.2 | 50 | 130 | 35 | 140 |
| Phenolic/Acidic | | | | | | |
| 2,4,5-Trichlorophenol | 79.7 | 10.3 | 50 | 110 | 40 | 120 |
| 2,4,6-Trichlorophenol | 80.7 | 10.7 | 50 | 115 | 40 | 125 |
| 2,4-Dichlorophenol | 76.3 | 9.6 | 50 | 105 | 40 | 115 |
| 2,4-Dimethylphenol | 68.8 | 13.5 | 30 | 110 | 15 | 125 |
| 2,4-Dinitrophenol | 75.8 | 20.6 | 15 | 140 | 10 | 160 |
| 2-Chlorophenol | 71.3 | 11.4 | 35 | 105 | 25 | 115 |
| 2-Methylphenol | 73.3 | 11.7 | 40 | 110 | 25 | 120 |
| 2-Nitrophenol | 75.8 | 12.4 | 40 | 115 | 25 | 125 |
| 3-Methylphenol/4-Methylphenol | 71.3 | 13.0 | 30 | 110 | 20 | 125 |
| 4,6-Dinitro-2-methylphenol | 84.9 | 15.0 | 40 | 130 | 25 | 145 |
| 4-Chloro-3-methylphenol | 78.6 | 10.7 | 45 | 110 | 35 | 120 |
| Pentachlorophenol | 77.6 | 13.3 | 40 | 115 | 25 | 130 |
| Basic | | | | | | |
| 3,3'-Dichlorobenzidine | 65.2 | 15.3 | 20 | 110 | 10 | 125 |
| 4-Chloroaniline | 62.2 | 15.6 | 15 | 110 | 10 | 125 |
| Phthalate Esters | | | | | | |
| Bis(2-ethylhexyl) phthalate | 84.2 | 14.0 | 40 | 125 | 30 | 140 |
| Butyl benzyl phthalate | 81.1 | 11.7 | 45 | 115 | 35 | 130 |
| Di-n-butyl phthalate | 84.8 | 10.3 | 55 | 115 | 45 | 125 |
| Di-n-octyl phthalate | 87.4 | 16.6 | 35 | 135 | 20 | 155 |
| Diethyl phthalate | 79.2 | 12.9 | 40 | 120 | 30 | 130 |
| Dimethyl phthalate | 75.9 | 16.9 | 25 | 125 | 10 | 145 |
| Nitrosoamines | | | | | | |
| N-Nitrosodi-n-propylamine | 80.9 | 15.7 | 35 | 130 | 20 | 145 |
| N-Nitrosodimethylamine | 67.9 | 14.1 | 25 | 110 | 10 | 125 |
| N-Nitrosodiphenylamine | 79.6 | 10.6 | 50 | 110 | 35 | 120 |
| Chlorinated Aliphatics | | | | | | |
| Bis(2-chlorethoxy)methane | 76.2 | 10.2 | 45 | 105 | 35 | 115 |
| Bis(2-chloroethyl) ether | 73.3 | 12.3 | 35 | 110 | 25 | 120 |
| Bis(2-chloroisopropyl) ether | 78.2 | 17.5 | 25 | 130 | 10 | 150 |
| Hexachlorobutadiene | 65.2 | 12.6 | 25 | 105 | 15 | 115 |
| Hexachloroethane | 60.9 | 11.1 | 30 | 100 | 15 | 105 |

**Table G-6. LCS Control Limits for Semivolatile Organic Compounds SW-846 Method 8270 Water Matrix[5]** (continued)

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| Halogenated Aromatics | | | | | | |
| 1,2,4-Trichlorobenzene | 71.7 | 11.6 | 35 | 105 | 25 | 120 |
| 1,2-Dichlorobenzene | 67.3 | 11.4 | 35 | 100 | 20 | 115 |
| 1,3-Dichlorobenzene | 64.8 | 10.9 | 30 | 100 | 20 | 110 |
| 1,4-Dichlorobenzene | 64.8 | 10.9 | 30 | 100 | 20 | 110 |
| 2-Chloronaphthalene | 76.5 | 9.3 | 50 | 105 | 40 | 115 |
| 4-Bromophenyl phenyl ether | 82.9 | 10.2 | 50 | 115 | 40 | 125 |
| 4-Chlorophenyl phenyl ether | 80.6 | 10.3 | 50 | 110 | 40 | 120 |
| Hexachlorobenzene | 82.3 | 10.0 | 50 | 110 | 40 | 120 |
| Nitroaromatics | | | | | | |
| 2,4-Dinitrotoluene | 84.3 | 11.2 | 50 | 120 | 40 | 130 |
| 2,6-Dinitrotoluene | 82.7 | 11.3 | 50 | 115 | 35 | 130 |
| 2-Nitroaniline | 81.8 | 11.2 | 50 | 115 | 35 | 125 |
| 3-Nitroaniline | 72.6 | 17.7 | 20 | 125 | 10 | 145 |
| 4-Nitroaniline | 77.2 | 13.7 | 35 | 120 | 20 | 130 |
| Nitrobenzene | 76.8 | 10.8 | 45 | 110 | 35 | 120 |
| Neutral Aromatics | | | | | | |
| Carbazole | 82.5 | 11.4 | 50 | 115 | 35 | 130 |
| Dibenzofuran | 80.3 | 8.8 | 55 | 105 | 45 | 115 |
| Others | | | | | | |
| 1,2-Diphenylhydrazine | 84.8 | 9.4 | 55 | 115 | 45 | 120 |
| Benzyl alcohol | 71.0 | 13.8 | 30 | 110 | 15 | 125 |
| Isophorone | 81.0 | 10.5 | 50 | 110 | 40 | 125 |

**Table G-7. LCS Control Limits for Semivolatile Organic Compounds SW-846 Method 8270 Solid Matrix[6]**

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| Polynuclear Aromatics | | | | | | |
| 2-Methylnaphthalene | 77.3 | 10.0 | 45 | 105 | 35 | 115 |
| Acenaphthene | 77.3 | 10.3 | 45 | 110 | 35 | 120 |
| Acenaphthylene | 75.7 | 10.4 | 45 | 105 | 35 | 115 |
| Anthracene | 79.9 | 9.0 | 55 | 105 | 45 | 115 |
| Benz[a]anthracene | 81.6 | 9.8 | 50 | 110 | 40 | 120 |
| Benzo[a]pyrene | 80.7 | 10.3 | 50 | 110 | 40 | 120 |
| Benzo[b]fluoranthene | 79.7 | 11.4 | 45 | 115 | 35 | 125 |
| Benzo[k]fluoranthene | 83.8 | 12.9 | 45 | 125 | 30 | 135 |
| Benzo[g,h,i]perylene | 81.8 | 14.7 | 40 | 125 | 25 | 140 |
| Chrysene | 82.6 | 9.9 | 55 | 110 | 45 | 120 |

[6] A number of sporadic marginal exceedances (ME) of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. LCS control limits are not available for Benzidine, 2,6-Dichlorophenol, 1,2-Diphenylhydrazine, and N-nitrosopyrrolidine. Sufficient data to perform statistically significant analyses were not received for those analytes during the LCS study. Additional limits for poor performing compounds can be found in section G.5.

**Table G-7. LCS Control Limits for Semivolatile Organic Compounds**
**SW-846 Method 8270 Solid Matrix[6]** (continued)

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| Dibenz[a,h]anthracene | 82.9 | 13.9 | 40 | 125 | 25 | 140 |
| Fluoranthene | 83.9 | 10.1 | 55 | 115 | 45 | 125 |
| Fluorene | 78.3 | 9.8 | 50 | 110 | 40 | 115 |
| Indeno[1,2,3-cd]pyrene | 79.7 | 13.8 | 40 | 120 | 25 | 135 |
| Naphthalene | 73.4 | 11.1 | 40 | 105 | 30 | 120 |
| Phenanthrene | 80.1 | 10.0 | 50 | 110 | 40 | 120 |
| Pyrene | 84.4 | 12.8 | 45 | 125 | 35 | 135 |
| Phenolic/Acidic | | | | | | |
| 2,4,5-Trichlorophenol | 80.1 | 10.4 | 50 | 110 | 40 | 120 |
| 2,4,6-Trichlorophenol | 76.3 | 11.0 | 45 | 110 | 30 | 120 |
| 2,4-Dichlorophenol | 77.2 | 10.9 | 45 | 110 | 35 | 120 |
| 2,4-Dimethylphenol | 67.3 | 11.9 | 30 | 105 | 20 | 115 |
| 2,4-Dinitrophenol | 72.6 | 20.0 | 15 | 130 | 10 | 150 |
| 2-Chlorophenol | 74.7 | 10.3 | 45 | 105 | 35 | 115 |
| 2-Methylphenol | 71.7 | 10.6 | 40 | 105 | 30 | 115 |
| 2-Nitrophenol | 76.2 | 11.5 | 40 | 110 | 30 | 120 |
| 3-Methylphenol/4-Methylphenol | 73.9 | 10.9 | 40 | 105 | 30 | 120 |
| 4,6-Dinitro-2-methylphenol | 83.1 | 18.0 | 30 | 135 | 10 | 155 |
| 4-Chloro-3-methylphenol | 79.5 | 11.1 | 45 | 115 | 35 | 125 |
| 4-Nitrophenol | 77.0 | 20.2 | 15 | 140 | 10 | 160 |
| Pentachlorophenol | 71.9 | 15.6 | 25 | 120 | 10 | 135 |
| Phenol | 69.7 | 10.2 | 40 | 100 | 30 | 110 |
| Phthalate Esters | | | | | | |
| Bis(2-ethylhexyl) phthalate | 87.4 | 13.3 | 45 | 125 | 35 | 140 |
| Butyl benzyl phthalate | 86.4 | 12.3 | 50 | 125 | 35 | 135 |
| Di-n-butyl phthalate | 83.2 | 9.1 | 55 | 110 | 45 | 120 |
| Di-n-octyl phthalate | 86.4 | 15.2 | 40 | 130 | 25 | 145 |
| Diethyl phthalate | 82.2 | 10.6 | 50 | 115 | 40 | 125 |
| Dimethyl phthalate | 79.6 | 10.2 | 50 | 110 | 40 | 120 |
| Nitrosoamines | | | | | | |
| N-Nitrosodi-n-propylamine | 76.8 | 12.3 | 40 | 115 | 30 | 125 |
| N-Nitrosodimethylamine | 66.1 | 15.9 | 20 | 115 | 10 | 130 |
| N-Nitrosodiphenylamine | 82.4 | 11.1 | 50 | 115 | 40 | 125 |
| Chlorinated Aliphatics | | | | | | |
| Bis(2-chlorethoxy)methane | 75.5 | 10.9 | 45 | 110 | 30 | 120 |
| Bis(2-chloroethyl) ether | 71.1 | 11.2 | 40 | 105 | 25 | 115 |
| Bis(2-chloroisopropyl) ether | 68.4 | 15.7 | 20 | 115 | 10 | 130 |
| Hexachlorobutadiene | 78.2 | 12.9 | 40 | 115 | 25 | 130 |
| Hexachloroethane | 71.9 | 12.6 | 35 | 110 | 20 | 120 |
| Halogenated Aromatics | | | | | | |
| 1,2,4-Trichlorobenzene | 77.4 | 11.2 | 45 | 110 | 30 | 120 |
| 1,2-Dichlorobenzene | 70.9 | 8.7 | 45 | 100 | 35 | 105 |
| 1,3-Dichlorobenzene | 69.7 | 10.3 | 40 | 100 | 30 | 110 |
| 1,4-Dichlorobenzene | 69.0 | 11.4 | 35 | 105 | 25 | 115 |

**Table G-7. LCS Control Limits for Semivolatile Organic Compounds SW-846 Method 8270 Solid Matrix** (continued)

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| 2-Chloronaphthalene | 75.2 | 9.9 | 45 | 105 | 35 | 115 |
| 4-Bromophenyl phenyl ether | 81.7 | 11.8 | 45 | 115 | 35 | 130 |
| 4-Chlorophenyl phenyl ether | 79.6 | 10.7 | 45 | 110 | 35 | 120 |
| Hexachlorobenzene | 82.5 | 11.7 | 45 | 120 | 35 | 130 |
| Nitroaromatics | | | | | | |
| 2,4-Dinitrotoluene | 82.0 | 11.4 | 50 | 115 | 35 | 130 |
| 2,6-Dinitrotoluene | 80.2 | 10.7 | 50 | 110 | 35 | 125 |
| 2-Nitroaniline | 81.0 | 12.2 | 45 | 120 | 30 | 130 |
| 3-Nitroaniline | 68.8 | 13.8 | 25 | 110 | 15 | 125 |
| 4-Nitroaniline | 73.6 | 13.1 | 35 | 115 | 20 | 125 |
| Nitrobenzene | 77.2 | 11.9 | 40 | 115 | 30 | 125 |
| Neutral Aromatics | | | | | | |
| Carbazole | 80.4 | 12.3 | 45 | 115 | 30 | 130 |
| Dibenzofuran | 77.1 | 8.8 | 50 | 105 | 40 | 110 |
| Others | | | | | | |
| Benzyl alcohol | 70.9 | 17.4 | 20 | 125 | 10 | 140 |
| Isophorone | 77.0 | 11.4 | 45 | 110 | 30 | 125 |

**Table G-8. LCS Control Limits for Chlorinated Herbicides SW-846 Method 8151 Water Matrix[7]**

| Analyte | Median | Lower Control Limit | Upper Control Limit |
|---|---|---|---|
| 2,4-D | 88 | 35 | 115 |
| 2,4-DB | 99 | 45 | 130 |
| 2,4,5-T | 83 | 35 | 110 |
| 2,4,5-TP (Silvex) | 87 | 50 | 115 |
| Dalapon | 62 | 40 | 110 |
| Dicamba | 86 | 60 | 110 |
| Dichloroprop | 91 | 70 | 120 |
| Dinoseb | 65 | 20 | 100 |
| MCPA | 93 | 60 | 145 |

[7] LCS control limits were generated using non-parametric statistics (see section G.1 for further explanation). LCS control limits are not available for MCPP. Sufficient data to perform statistically significant analyses were not received for the analyte during the LCS study.

**Table G-9. LCS Control Limits for Chlorinated Herbicides SW-846 Method 8151 Solid Matrix**[8]

| Analyte | Median | Lower Control Limit | Upper Control Limit |
|---|---|---|---|
| 2,4-D | 88 | 35 | 145 |
| 2,4-DB | 108 | 50 | 155 |
| 2,4,5-T | 86 | 45 | 135 |
| 2,4,5-TP (Silvex) | 90 | 45 | 125 |
| Dicamba | 90 | 55 | 110 |
| Dichloroprop | 99 | 75 | 140 |

**Table G-10. LCS Control Limits for Polynuclear Aromatic Hydrocarbons SW-846 Method 8310 Water Matrix**[9]

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| Acenaphthene | 70 | 11 | 35 | 105 | 25 | 115 |
| Acenaphthylene | 74 | 13 | 35 | 115 | 20 | 125 |
| Anthracene | 77 | 12 | 40 | 110 | 30 | 125 |
| Benz[a]anthracene | 81 | 11 | 50 | 110 | 40 | 125 |
| Benzo[a]pyrene | 79 | 11 | 45 | 115 | 35 | 125 |
| Benzo[b]fluoranthene | 82 | 10 | 50 | 110 | 40 | 125 |
| Benzo[k]fluoranthene | 79 | 10 | 50 | 110 | 40 | 120 |
| Benzo[g,h,i]perylene | 77 | 14 | 35 | 120 | 20 | 135 |
| Chrysene | 83 | 11 | 50 | 115 | 40 | 125 |
| Dibenz[a,h]anthracene | 64 | 15 | 20 | 110 | 10 | 125 |
| Fluoranthene | 82 | 11 | 50 | 115 | 35 | 125 |
| Fluorene | 69 | 11 | 35 | 105 | 25 | 115 |
| Indeno[1,2,3-cd]pyrene | 80 | 11 | 45 | 110 | 35 | 125 |
| Naphthalene | 68 | 12 | 35 | 105 | 20 | 115 |
| Phenanthrene | 80 | 13 | 40 | 120 | 25 | 135 |
| Pyrene | 80 | 9 | 50 | 110 | 45 | 115 |

[8] LCS control limits were generated using non-parametric statistics (see section G.1 for further explanation). LCS control limits are not available for Dalapon, MCPA, and MCPP. Sufficient data to perform statistically significant analyses were not received for those analytes during the LCS study. Additional limits for poor performing compounds can be found in section G.5.

[9] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits.

**Table G-11. LCS Control Limits for Polynuclear Aromatic Hydrocarbons SW-846 Method 8310 Solid Matrix**[10]

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| Acenaphthene | 71 | 12 | 35 | 110 | 20 | 120 |
| Acenaphthylene | 73 | 13 | 35 | 115 | 20 | 125 |
| Anthracene | 86 | 13 | 45 | 125 | 35 | 140 |
| Benz[a]anthracene | 78 | 9 | 50 | 105 | 40 | 115 |
| Benzo[a]pyrene | 86 | 15 | 40 | 135 | 25 | 150 |
| Benzo[b]fluoranthene | 89 | 11 | 55 | 120 | 45 | 130 |
| Benzo[k]fluoranthene | 84 | 12 | 50 | 120 | 35 | 135 |
| Benzo[g,h,i]perylene[11] | 85 | 10 | 55 | 115 | 45 | 125 |
| Chrysene | 87 | 11 | 55 | 120 | 45 | 130 |
| Dibenz[a,h]anthracene | 81 | 11 | 45 | 115 | 35 | 125 |
| Fluoranthene | 88 | 16 | 40 | 135 | 25 | 150 |
| Fluorene | 76 | 10 | 45 | 105 | 35 | 115 |
| Indeno[1,2,3-cd]pyrene | 95 | 13 | 55 | 135 | 45 | 145 |
| Naphthalene | 80 | 11 | 50 | 110 | 40 | 120 |
| Phenanthrene | 91 | 12 | 55 | 125 | 45 | 135 |
| Pyrene | 82 | 11 | 50 | 115 | 40 | 125 |

**Table G-12. LCS Control Limits for Explosives SW-846 Methods 8330 and 8330A Water Matrix**[12]

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| 1,3,5-Trinitrobenzene | 102 | 13 | 65 | 140 | 50 | 150 |
| 1,3-Dinitrobenzene | 103 | 18 | 45 | 160 | 30 | 175 |
| 2,4-Dinitrotoluene | 98 | 12 | 60 | 135 | 50 | 145 |
| 2,6-Dinitrotoluene | 99 | 13 | 60 | 135 | 50 | 150 |
| 2,4,6-Trinitrotoluene (TNT) | 98 | 15 | 50 | 145 | 35 | 160 |
| 2-Amino-4,6-dinitrotoluene[13] | 101 | 17 | 50 | 155 | 35 | 170 |
| 2-Nitrotoluene | 88 | 15 | 45 | 135 | 30 | 150 |
| 3-Nitrotoluene | 90 | 14 | 50 | 130 | 35 | 145 |
| 4-Amino-2,6-dinitrotoluene[13] | 104 | 16 | 55 | 155 | 40 | 170 |
| 4-Nitrotoluene | 90 | 14 | 50 | 130 | 35 | 145 |
| Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) | 106 | 18 | 50 | 160 | 35 | 180 |
| Methyl-2,4,6-trinitrophenylnitramine (Tetryl)[13] | 98 | 25 | 20 | 175 | 10 | 200 |
| Nitrobenzene | 94 | 15 | 50 | 140 | 35 | 155 |
| Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) | 99 | 6 | 80 | 115 | 75 | 120 |

[10] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits.

[11] Provisional limits – outlier analyses during the LCS study resulted in LCS-CLs generated with data from fewer than four laboratories. Limits may be adjusted in the future as additional data become available.

[12] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. LCS control limits were generated using solid phase extraction with acetonitrile only, without removing outliers from the data set (see section G.1 for further explanation).

[13] Provisional limits – outlier analyses during the LCS study resulted in LCS-CLs generated with data from fewer than four laboratories. Limits may be adjusted in the future as additional data become available.

**Table G-13. LCS Control Limits for Explosives SW-846 Methods 8330 and 8330A Solid Matrix**[14]

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| 1,3,5-Trinitrobenzene | 99 | 9 | 75 | 125 | 65 | 135 |
| 1,3-Dinitrobenzene | 102 | 8 | 80 | 125 | 70 | 135 |
| 2,4-Dinitrotoluene | 102 | 7 | 80 | 125 | 75 | 130 |
| 2,6-Dinitrotoluene | 100 | 7 | 80 | 120 | 70 | 130 |
| 2,4,6-Trinitrotoluene (TNT) | 99 | 14 | 55 | 140 | 45 | 155 |
| 2-Amino-4,6-dinitrotoluene | 102 | 7 | 80 | 125 | 75 | 130 |
| 2-Nitrotoluene | 101 | 7 | 80 | 125 | 70 | 130 |
| 3-Nitrotoluene | 100 | 7 | 75 | 120 | 70 | 130 |
| 4-Amino-2,6-dinitrotoluene | 101 | 7 | 80 | 125 | 75 | 130 |
| 4-Nitrotoluene | 101 | 8 | 75 | 125 | 70 | 135 |
| Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) | 103 | 10 | 70 | 135 | 65 | 145 |
| Nitrobenzene | 100 | 8 | 75 | 125 | 70 | 130 |
| Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) | 100 | 9 | 75 | 125 | 65 | 135 |

**Table G-14. LCS Control Limits for Organochlorine Pesticides SW-846 Method 8081 Water Matrix**[15]

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| 4,4'-DDD | 88 | 20 | 25 | 150 | 10 | 170 |
| 4,4'-DDE | 87 | 18 | 35 | 140 | 15 | 160 |
| 4,4'-DDT | 92 | 15 | 45 | 140 | 30 | 155 |
| Aldrin | 83 | 19 | 25 | 140 | 10 | 155 |
| alpha-BHC | 94 | 11 | 60 | 130 | 50 | 140 |
| alpha-Chlordane | 93 | 10 | 65 | 125 | 55 | 135 |
| beta-BHC | 96 | 10 | 65 | 125 | 55 | 135 |
| delta-BHC | 91 | 15 | 45 | 135 | 30 | 150 |
| Dieldrin | 95 | 11 | 60 | 130 | 50 | 140 |
| Endosulfan I[16] | 80 | 10 | 50 | 110 | 40 | 120 |
| Endosulfan II | 79 | 17 | 30 | 130 | 10 | 150 |
| Endosulfan sulfate | 96 | 14 | 55 | 135 | 40 | 150 |
| Endrin | 95 | 13 | 55 | 135 | 45 | 145 |
| Endrin aldehyde | 96 | 14 | 55 | 135 | 40 | 150 |
| Endrin ketone | 102 | 8 | 75 | 125 | 70 | 135 |
| gamma-BHC | 82 | 18 | 25 | 135 | 10 | 155 |
| gamma-Chlordane | 94 | 11 | 60 | 125 | 50 | 135 |
| Heptachlor | 87 | 15 | 40 | 130 | 30 | 145 |
| Heptachlor epoxide | 96 | 11 | 60 | 130 | 50 | 140 |
| Methoxychlor | 103 | 16 | 55 | 150 | 40 | 165 |

[14] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. Additional limits for poor performing compounds can be found in section G.5.

[15] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. LCS control limits are not available for Hexachlorobenzene and Toxaphane. Sufficient data to perform statistically significant analyses were not received for those analytes during the LCS study. Additional limits for surrogate compounds can be found in section G.6.

[16] Provisional limits – outlier analyses during the LCS study resulted in LCS-CLs generated with data from fewer than four laboratories. Limits may be adjusted in the future as additional data becomes available.

**Table G-15. LCS Control Limits for Organochlorine Pesticides SW-846 Method 8081 Solid Matrix** [17]

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| 4,4'-DDD | 81 | 18 | 30 | 135 | 10 | 155 |
| 4,4'-DDE | 97 | 10 | 70 | 125 | 60 | 135 |
| 4,4'-DDT | 92 | 16 | 45 | 140 | 30 | 155 |
| Aldrin | 93 | 16 | 45 | 140 | 30 | 155 |
| alpha-BHC | 93 | 10 | 60 | 125 | 50 | 135 |
| alpha-Chlordane | 92 | 10 | 65 | 120 | 55 | 130 |
| beta-BHC | 95 | 11 | 60 | 125 | 50 | 135 |
| delta-BHC | 94 | 12 | 55 | 130 | 45 | 145 |
| Dieldrin | 96 | 10 | 65 | 125 | 55 | 135 |
| Endosulfan I | 74 | 20 | 15 | 135 | 10 | 155 |
| Endosulfan II | 89 | 17 | 35 | 140 | 20 | 160 |
| Endosulfan sulfate | 99 | 12 | 60 | 135 | 50 | 145 |
| Endrin | 97 | 12 | 60 | 135 | 50 | 145 |
| Endrin aldehyde | 92 | 18 | 35 | 145 | 20 | 165 |
| Endrin ketone | 100 | 11 | 65 | 135 | 55 | 145 |
| gamma-BHC | 91 | 11 | 60 | 125 | 50 | 135 |
| gamma-Chlordane | 96 | 10 | 65 | 125 | 55 | 135 |
| Heptachlor | 96 | 15 | 50 | 140 | 35 | 155 |
| Heptachlor epoxide | 98 | 11 | 65 | 130 | 55 | 140 |
| Methoxychlor | 100 | 14 | 55 | 145 | 45 | 155 |

**Table G-16. LCS Control Limits for Polychlorinated Biphenyls SW-846 Method 8082 Water Matrix**[18]

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit |
|---|---|---|---|---|
| Aroclor 1016 | 85 | 20 | 25 | 145 |
| Aroclor 1260 | 87 | 19 | 30 | 145 |

**Table G-17. LCS Control Limits for Polychlorinated Biphenyls SW-846 Method 8082 Solid Matrix**[18]

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit |
|---|---|---|---|---|
| Aroclor 1016 | 90 | 16 | 40 | 140 |
| Aroclor 1260 | 96 | 12 | 60 | 130 |

[17] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. LCS control limits are not available for Hexachlorobenzene, Hexachlorocyclopentadiene, and Toxaphane. Sufficient data to perform statistically significant analyses were not received for those analytes during the LCS study. Additional limits for surrogate compounds can be found in section G.6.

[18] LCS control limits are not available for Aroclors 1221, 1232, 1242, 1248, 1262, and 1268. Sufficient data to perform statistically significant analyses were not received for those analytes during the LCS study. Additional limits for surrogate compounds can be found in section G.6.

**Table G-18. LCS Control Limits for Metals SW-846 Methods 6010 and 7470 Water Matrix**[19]

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| Aluminum | 97 | 5 | 80 | 120 | 80 | 120 |
| Antimony | 98 | 4 | 80 | 120 | 80 | 120 |
| Arsenic | 98 | 4 | 80 | 120 | 80 | 120 |
| Barium | 99 | 4 | 80 | 120 | 80 | 120 |
| Beryllium | 99 | 4 | 80 | 120 | 80 | 120 |
| Cadmium | 100 | 4 | 80 | 120 | 80 | 120 |
| Calcium | 98 | 4 | 80 | 120 | 80 | 120 |
| Chromium | 100 | 4 | 80 | 120 | 80 | 120 |
| Cobalt | 99 | 3 | 80 | 120 | 80 | 120 |
| Copper | 99 | 3 | 80 | 120 | 80 | 120 |
| Iron | 102 | 4 | 80 | 120 | 80 | 120 |
| Lead | 99 | 4 | 80 | 120 | 80 | 120 |
| Magnesium | 98 | 4 | 80 | 120 | 80 | 120 |
| Manganese | 100 | 4 | 80 | 120 | 80 | 120 |
| Mercury | 100 | 5 | 80 | 120 | No ME | No ME |
| Molybdenum | 95 | 5 | 80 | 120 | 75 | 120 |
| Nickel | 100 | 4 | 80 | 120 | 80 | 120 |
| Potassium | 98 | 4 | 80 | 120 | 80 | 120 |
| Selenium | 98 | 6 | 80 | 120 | 75 | 120 |
| Silver | 97 | 5 | 80 | 120 | 75 | 120 |
| Sodium | 99 | 4 | 80 | 120 | 80 | 120 |
| Thallium | 97 | 4 | 80 | 120 | 80 | 120 |
| Vanadium | 99 | 4 | 80 | 120 | 80 | 120 |
| Zinc | 100 | 4 | 80 | 120 | 80 | 120 |

[19] The as-generated limits have been adjusted to reflect Method requirements and acceptable calibration uncertainty. A number of sporadic marginal exceedances of the control limits are allowed for Method 6010, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits.

**Table G-19. LCS Control Limits for Metals SW-846 Methods 6010 and 7471 Solid Matrix** [20]

| Analyte | Mean | Standard Deviation | Lower Control Limit | Upper Control Limit | Lower ME Limit | Upper ME Limit |
|---|---|---|---|---|---|---|
| Aluminum | 95 | 5 | 80 | 120 | 75 | 120 |
| Antimony | 96 | 5 | 80 | 120 | 75 | 120 |
| Arsenic | 95 | 4 | 80 | 120 | 80 | 120 |
| Barium | 98 | 3 | 80 | 120 | 80 | 120 |
| Beryllium | 99 | 4 | 80 | 120 | 80 | 120 |
| Cadmium | 97 | 4 | 80 | 120 | 80 | 120 |
| Calcium | 97 | 4 | 80 | 120 | 80 | 120 |
| Chromium | 99 | 5 | 80 | 120 | 80 | 120 |
| Cobalt | 98 | 4 | 80 | 120 | 80 | 120 |
| Copper | 97 | 3 | 80 | 120 | 80 | 120 |
| Iron | 100 | 4 | 80 | 120 | 80 | 120 |
| Lead | 95 | 4 | 80 | 120 | 80 | 120 |
| Magnesium | 96 | 3 | 80 | 120 | 80 | 120 |
| Manganese | 97 | 4 | 80 | 120 | 80 | 120 |
| Mercury | 100 | 6 | 80 | 120 | No ME | No ME |
| Molybdenum | 96 | 5 | 80 | 120 | 75 | 120 |
| Nickel | 97 | 4 | 80 | 120 | 80 | 120 |
| Potassium | 96 | 4 | 80 | 120 | 80 | 120 |
| Selenium | 93 | 4 | 80 | 120 | 75 | 120 |
| Silver | 96 | 7 | 75 | 120 | 70 | 125 |
| Sodium | 96 | 4 | 80 | 120 | 80 | 120 |
| Thallium | 94 | 4 | 80 | 120 | 80 | 120 |
| Vanadium | 99 | 3 | 80 | 120 | 80 | 120 |
| Zinc | 95 | 5 | 80 | 120 | 75 | 120 |

[20] The as-generated limits have been adjusted to reflect Method requirements and acceptable calibration uncertainty. A number of sporadic marginal exceedances of the control limits are allowed for Method 6010, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits.

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