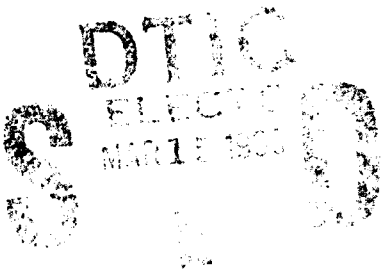
# HANDBOOK TO SUPPORT THE INSTALLATION RESTORATION PROGRAM (IRP) STATEMENTS OF WORK

## VOLUME I - REMEDIAL INVESTIGATION/FEASIBILITY STUDIES (RI/FS)

ENVIRONMENTAL RESTORATION DIV STAFF

MAY 1991 (REPRINT)





ENVIRONMENTAL RESTORATION DIVISION (ESR)
ENVIRONMENTAL SERVICES OFFICE
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)
BROOKS AIR FORCE BASE, TEXAS

**SPECIAL NOTICE**

This is a reprint of the *Handbook to Support the Installation Restoration Program (IRP) Statements of Work, Volume I-Remedial Investigation/Feasibility Studies (RI/FS)*, originally published in May 1991.

On 1 July 1991, the Air Force Installation Restoration Program (IRP) mission, formerly accomplished by the Human Systems Division's Human Systems Program Office, IRP Division (HSD/YAQ) was transferred to the newly formed Air Force Center for Environmental Excellence (AFCEE), Environmental Services Office (ES), Environmental Restoration Division (AFCEE/ESR), Brooks AFB, Texas.

All references to the *IRP Division, HSD/YAQ* or *Human Systems Division (AFSC)* which appear throughout the text of this handbook now refer to the **Environmental Restoration Division, AFCEE/ESR** and **AFCEE**, respectively.

Because *Volume I (May 1991)* of the *Handbook* has already been made part of contractual agreements between the IRP Division (now AFCEE/ESR) and its customers, the contents of this handbook, with the exception of the few changes noted below, have been left intact.

The cover of *Volume I (Reprint)* has been changed to reflect the new organizational changes. Also, the new organizational nomenclature has been incorporated into technical report cover and title page formats found in this reprint at pages 1-13, 1-14, 1-34, 1-35, 4-23, 4-24, A-1 and A-2.

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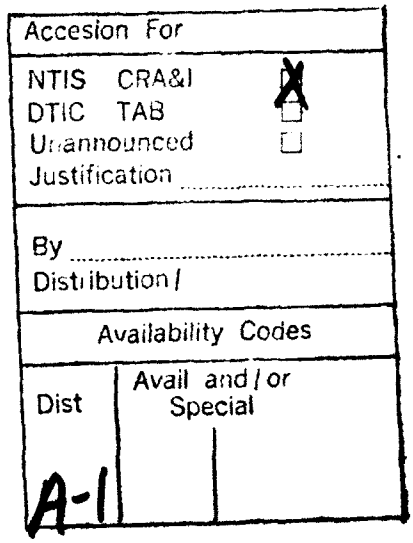
This document has been reviewed by the Air Force and is approved for publication.



# PREFACE

This Handbook was prepared by the Installation Restoration Program Division, Human Systems Program Office, Brooks Air Force Base, Texas, The MITRE Corporation, and Modern Technologies Corporation. The Handbook has evolved in response to revised Department of Defense, Air Force, and regulatory agency requirements and technical advances in the field of hazardous waste site investigations. It also reflects the experience and "lessons learned" from dealing with hazardous waste investigation projects. Many individuals contributed to this version of this Handbook and their efforts are greatly appreciated.

The Handbook provides document formats and requirements to contractors for the execution of Air Force Installation Restoration Program (IRP) Statements of Work (SOW) issued by HSD/YAQ. While we have attempted to be as comprehensive as possible, we understand the site and project variability that exists in the Air Force IRP. The requirements in this Handbook are, of necessity, somewhat general and must be expanded based on site-specific conditions. The contractor shall consider if the requirements in this Handbook are appropriate for the particular sites under investigation. All proposed deviations from the requirements in this Handbook shall be submitted in writing to the HSD/YAQ Technical Project Manager (TPM) for approval prior to proceeding with the affected work.

The requirements in this Handbook have been integrated with the SOW and the requirements in each subsection of the SOW are addressed in the Handbook.

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# 1.0 SCOPING DOCUMENT FORMATS

This section presents outlines for Installation Restoration Program (IRP) scoping documents. IRP Program Division (HSD/YAQ) contractors are required to use these outlines to prepare the scoping documents required by the Statement of Work (SOW). Failure to use these formats for a project deliverable will require revision of the document.

## 1.1 WORK PLAN OUTLINE

All Work Plans prepared by contractors for IRP projects shall appear in the following format, and all applicable components of the outline shall be addressed. The purpose of the Work Plan is to describe the work to be performed, explain project objectives, and present the rationale for conducting specific project activities. The technical requirements and guidance presented in this Handbook shall be incorporated as appropriate in the Work Plan.

**WORK PLAN OUTLINE**

| | |
|---|---|
| REPORT COVER | Use the Report Cover format provided at the end of this outline. |
| TITLE PAGE | Use the Title Page format provided at the end of this outline. |
| DISCLAIMER | Use the format in the Disclaimer provided at the end of this outline. |
| REPORT DOCUMENTATION PAGE, SF FORM 298 | Follow the example provided at the end of this outline. |
| PREFACE | Use the format in the Preface provided at the end of this outline. |

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1.3.2 Scoping Documents

1.3.3 Identity of Subcontractors and Their Roles

2.0 SUMMARY OF EXISTING INFORMATION

Summarize existing information from previous IRP reports and other available references.

2.1 Installation Environmental Setting--Summarize available information on the environmental setting of the entire installation and the demographics of the surrounding area.

2.2 Site-Specific Environmental Setting (approximately three pages of text for each site)--Briefly summarize available information on a site or zone basis. Repeat sections 2.2.1 through 2.2.6 for each site or zone.

2.2.1 Contaminant Sources and Contamination--Briefly describe past waste disposal practices and operations. Summarize existing information concerning the nature and extent of site contamination.

2.2.2 Geology--Briefly discuss and provide maps of geologic features related to project activities:

- Geomorphology.
- Stratigraphy, lithology, structure, tectonic history, and historic seismic events.
- Soil properties--texture, organic matter content, water content, pH, cation exchange capacity, etc.
- Soil geochemistry--background or naturally occurring concentrations of analytes.

2.2.3 Groundwater--Briefly discuss and provide maps of the following features of groundwater related to project activities. Emphasis should be placed on the aquifers or water bearing zones where potential exists for contamination.

- Identification, delineation, and classification of hydrogeologic units.
- Depth to water and its variability over time (seasonal and long-term variations).
- Aquifer characteristics such as storativity, transmissivity, and boundary conditions.
- Flow characteristics such as hydraulic gradients, velocities, and their variability over time.
- Location and discharge of springs.
- Water quality--background or naturally occurring concentrations of analytes, temporal and spatial variability of concentrations, including seasonal and pumping effects.
- Water use and well inventory.

2.2.4 Surface Water--Discuss and provide maps of the following characteristics of surface water related to project activities.

- Identification of streams, divides, wetlands, ponds, etc.
- Flow characteristics--velocity, discharge, seasonal variability, flood frequencies and zones, classification as gaining (effluent) or losing (influent) stream.
- Water quality--background or naturally occurring concentrations of analytes and their temporal and spatial variability.
- Water use.

2.2.5 Air--Discuss the following characteristics of the ambient air related to project activities:

- Climate.

- Meteorological conditions--temperature and precipitation; evapotranspiration (actual and potential); seasonal variability of wind velocity (average and maximum) and predominant direction.

- Air quality--background or naturally occurring concentrations of analytes upgradient of site; temporal and spatial variability.

2.2.6 Biology--Discuss the following characteristics of the ecological environment near the site or project activities:

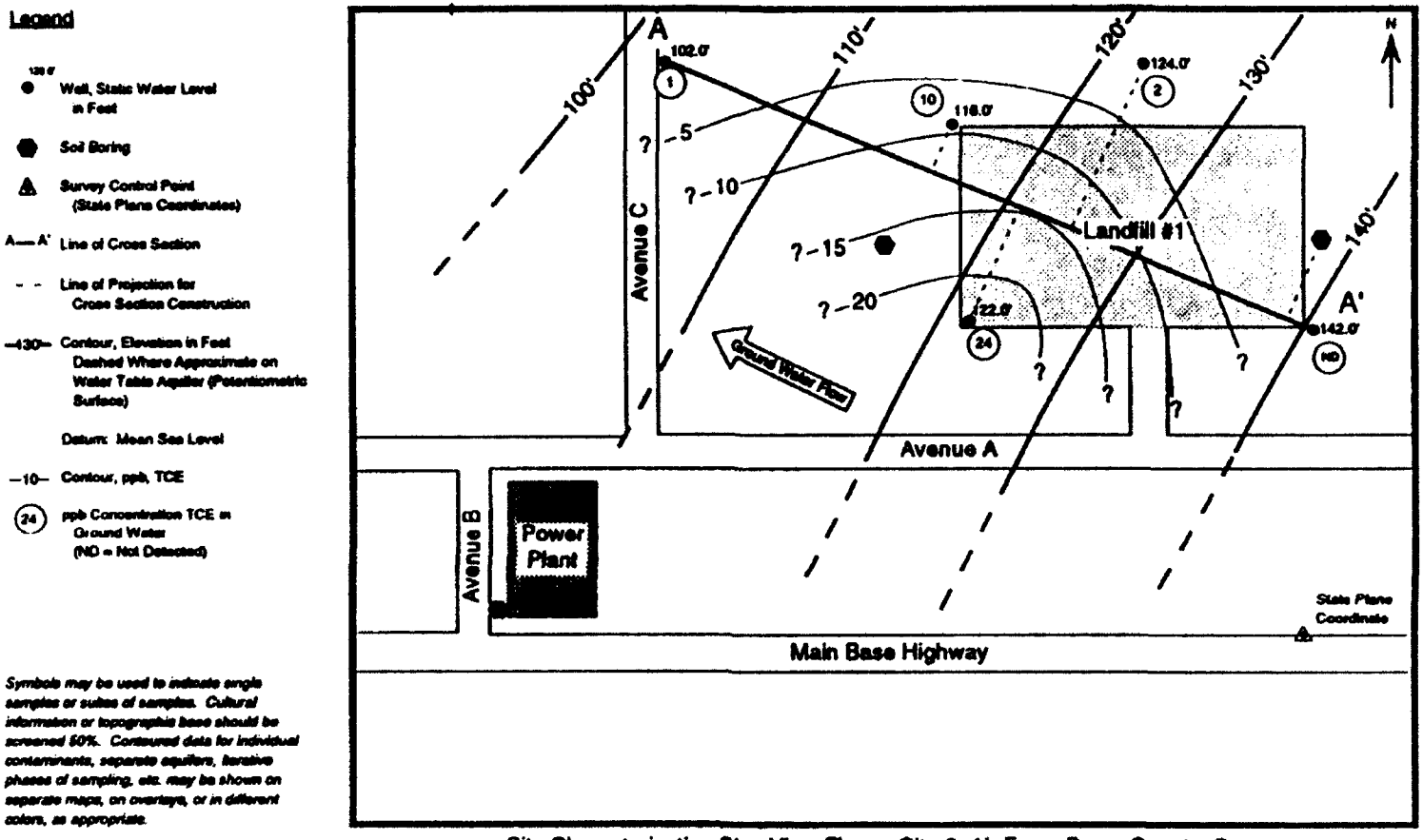
- Common biotic communities.

- Identification and location of threatened, endangered, or rare species.

- Sensitive environments or critical habitats.

2.3 Conceptual Site Model--Summarize, in a single table, existing information about the natural conditions and contamination at each site. The column headings and information content of the table are listed below. Any lack of information shall be clearly identified. In addition to the table, provide drawings of the conceptual site model similar to figures 1-1 and 1-2.

| Column Heading | Content |
|---|---|
| Site Identification | Identification used to uniquely identify each site in the past and for the current project. |
| Site Description | Brief description of site, e.g., fire training area, landfill, petroleum storage tank, spill area. Identify contaminant sources and amounts, and geologic and hydrologic conditions. |
| Background Concentrations | List background concentrations of chemicals in each medium investigated. These concentrations shall be derived from background samples associated with each site. The use of non-site specific literature values is unacceptable. Background is defined as the concentration of a chemical that would be found in a medium if the medium had not been affected by activities at the site. Background samples may have been contaminated by off-site sources. |
| Contaminants and Contaminated Media | List of analytes previously detected in environmental samples with concentrations greater than background levels that are supported by accurate and validated data and can be attributed to site activities. Identify media in which contaminants were detected (e.g., groundwater, soil, sediment), and maximum concentrations found in each medium. |
| Migration Pathway | Indication of whether each contaminant is expected to migrate through groundwater, surface water, or air. |
| Exposed Population | Estimate of the exposed human population for each exposure pathway: dermal, oral, inhalation. |
| Risk Estimate | Numerical estimate of the risk posed by carcinogens and non-carcinogens to the exposed population through each exposure pathway. |

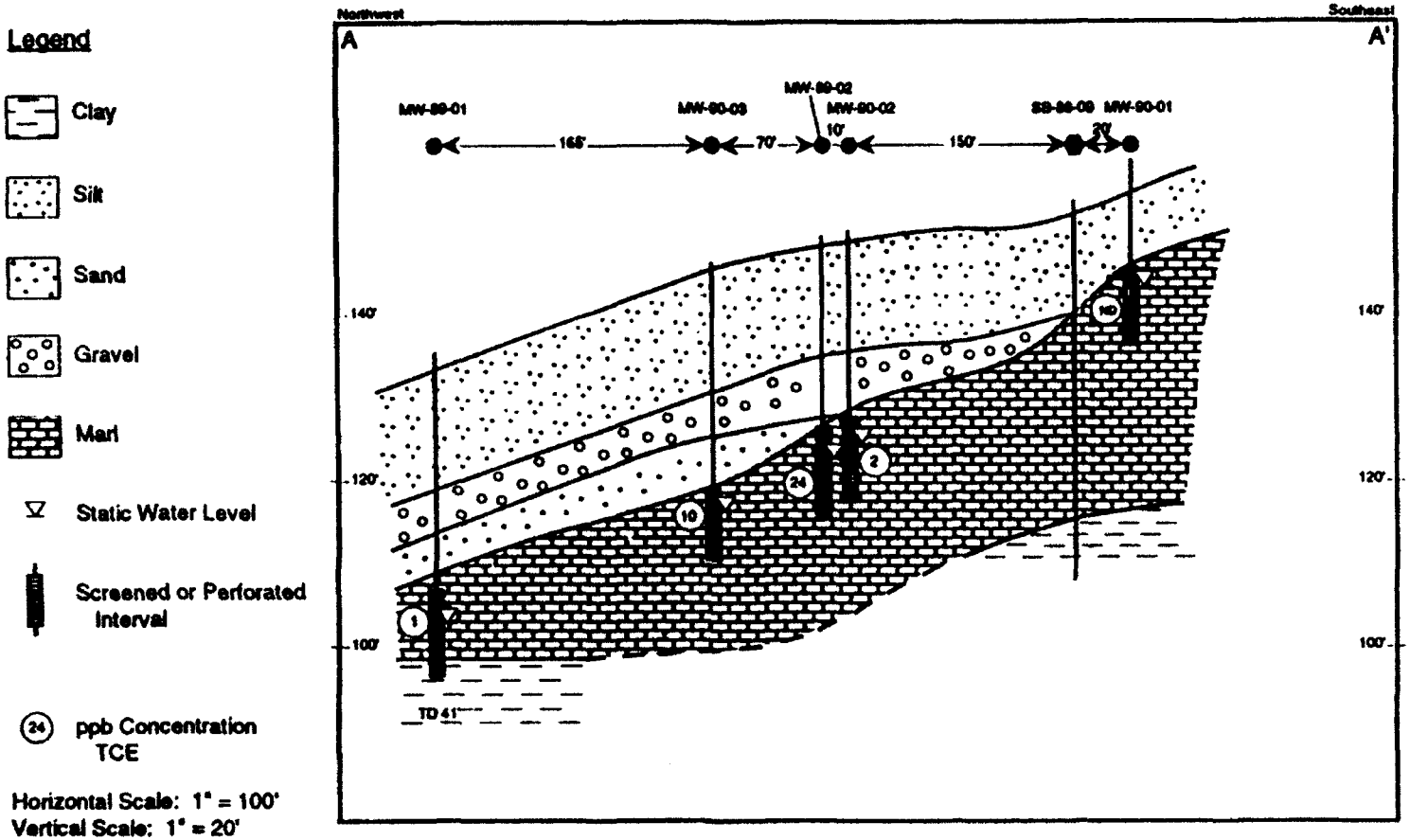



Site Characterization Plan View Figure, Site 2, Air Force Base, County, State
TCE Concentrations and Groundwater Contours

Data Compiled From Stage 1 PA Report Prepared by Consulting Firm, Inc.

*(In this example, additional investigation is necessary to characterize extent of TCE contamination.)*

Figure 1-1 Conceptual Site Model, Plan View




Cross Section A-A', Site 2, Air Force Base
County, State

Data Compiled From Stage 1 PA Report Prepared by Consulting Firm, Inc.

Figure 1-2 Conceptual Site Model, Cross Section

2.4 Remedial Action--Identify recommended remedial actions and interim remedial actions implemented at the installation. Identify potential remedial action objectives for each site and each medium based on the conceptual site model. The level of detail shall be consistent with the available data.

2.5 Applicable or Relevant and Appropriate Requirements (ARARS)--Identify potential contaminant-specific, location-specific, and action-specific ARARs based on the conceptual site model and preliminary alternatives. Consider all federal, state, and local laws, regulations, criteria, advisories, and guidance.

2.6 Data Needs--Summarize the data needs identified in the conceptual site model for each site and medium. Identify the data needed to characterize the site, complete the conceptual site model, better define ARARs, and perform an analysis of alternatives. The data needs shall be consistent with project objectives listed in section 1.3.1 and 3.1 of the Work Plan.

## 3.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY TASKS

This section shall describe, in general terms, what will be done and why at each site. How these activities will be accomplished and the details of each field task shall be described in the Sampling and Analysis Plan (SAP).

3.1 Site Objectives--Describe how task activities will complete or improve site characterization, the quantitative risk assessment, and analysis of no further action or remedial alternatives. Show how identified data needs will be addressed by the proposed field activities.

3.2 Field Investigation

3.2.1 Field Tasks--For the field activities required by the SOW or any others that will be conducted, identify the purpose of the activity, the location, and the rationale for selection of that activity and location. Provide a summary table listing all field tasks to be performed at each site. Specifics of the field tasks will be presented in the SAP. Examples of field activities and required explanations are:

- Aquifer testing--To derive hydraulic properties, such as transmissivity and storativity, the contractor shall propose test

designs and analytical methods. Possible tests include: slug tests, pumping tests, and laboratory falling-head or constant-head permeability tests. The design shall include locations of pumping and observation wells; the pumping discharge point; well completion diagrams; descriptions of pumps, slugs, water level and discharge measuring devices; and proposed analytical methods. Tests shall be designed to account for changes in water levels not caused by the testing.

The contractor shall demonstrate that the assumptions of the analytical method used matches the hydrogeological conceptual site model.

The contractor shall propose to the Air Force the intended analytical methods for deriving hydraulic properties, e.g., Theis method, Jacob straight line method, Hantush-Jacob method. The assumptions of the proposed analytical methods shall meet the hydrogeologic conceptual model.

When effective porosity or dispersivity are to be determined in the field the contractor shall propose tracer test designs and methods of analyzing test data. The design shall describe the tracers (e.g., dyes, salts), and the instruments for measuring tracer concentrations.

- Geophysical surveys--For each geophysical method used at each site, the following shall be summarized in the work plan:

  - Statement of the problem to be solved and how the chosen geophysical method addresses that problem.

  - Depth of investigation provided by chosen method, specific instrumentation, and survey spacing.

  - Lateral resolution capabilities of the chosen method, specific instrumentation, and survey spacing.

3.2.2 Sampling and Analysis Activities--Provide a summary table of samples and analyses to be performed for each site. Include number of samples for each matrix, type and number of analyses by analytical method for each sample, and field quality assurance/quality control (QA/QC) samples.

3.3 Literature Search--Identify the information sources and the objectives of the literature search.

3.4 Record Keeping--Identify the records of field and laboratory activities that will be maintained to document the project.

3.5 Data Assessment--Describe how project data will be assessed and analyzed to identify accurate and valid data, and to refine site models in accordance with the requirements in section 2 of this Handbook.

3.6 Risk Assessment--Describe how the project data will be used to determine contaminant fate and transport, and develop a risk estimate for each contaminant at each site, or to improve the existing estimates of risk in conformance with the requirements in section 2 of this Handbook.

3.7 Bench Scale/Treatability Studies--Describe any studies that will be conducted. See Volume II of the Handbook for further requirements.

3.8 Detailed Analysis of Alternatives (include this section only if a feasibility study is required)--Describe the process that will be used to conduct a detailed analysis of alternative remedial actions and to identify a recommended alternative.

## 4.0 REPORTING REQUIREMENTS

Describe the content and preparation of each of the documents required by the SOW. Requirements for the preparation of the following documents are provided in section 4.0 of this Handbook:

- Research and Development (R&D) Status Report.
- Informal Technical Information Reports (ITIRs).

- Technical Report.
- Decision Documents.

In addition, the creation of computerized data files in conformance with the latest version of the Installation Restoration Program Information Management System (IRPIMS) Data Loading Handbook shall be described.

## 5.0 PROJECT SCHEDULE

Provide a project schedule showing milestones and deliverables.

## REFERENCES

**Work Plan Report Cover**

*(Contractor's Report Number)*

INSTALLATION RESTORATION PROGRAM (IRP)

STAGE___ [1,2, etc]

WORK PLAN

*(Base and Address)*

*(Contractor's Name and Address)*
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**Work Plan Title Page**

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## WORK PLAN DISCLAIMER

NOTICE

This report has been prepared for the United States Air Force by _____ _____ for the purpose of aiding in the implementation of a final remedial action plan under the Air Force Installation Restoration Program (IRP). As the report relates to actual or possible releases of potentially hazardous substances, its release prior to an Air Force final decision on remedial action may be in the public's interest. The limited objectives of this report and the ongoing nature of the IRP, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this report, since subsequent facts may become known which may make this report premature or inaccurate. Acceptance of this report in performance of the contract under which it is prepared does not mean that the Air Force adopts the conclusions, recommendations or other views expressed herein, which are those of the contractor only and do not necessarily reflect the official position of the United States Air Force.

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|---|---|---|---|
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| G | - Grant | TA | - Task |
| PE | - Program Element | WU | - Work Unit Accession No. |

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•U.S.GPO:1990-0-273-271

## WORK PLAN PREFACE

## PREFACE

This section should briefly describe the nature of the work covered in the work plan and the time period for the work to be accomplished.

a. Purpose of the work/investigation

b. Professional responsibilities and roles (contractor personnel)

c. Acknowledgements

d. Period of work and TPM (e.g., "This work will be performed between February 1990 and September 1992. Captain Joseph W. Finagle, IRP Installation Restoration Program Division [HSD/YAQ] was the Technical Project Manager.")

Approved:

Name, Title and Signature
Contract Program Manager (or higher)

## 1.2 SAMPLING AND ANALYSIS PLAN (SAP) OUTLINE

All SAPs shall include both a Quality Assurance Project Plan (QAPP) and a Field Sampling Plan (FSP) describing how project activities will be accomplished. The SAPs shall be prepared in the following format and all applicable components of the outline shall be addressed. The requirements of this Handbook shall be incorporated in the SAP.

SAP OUTLINE

REPORT COVER — Use the Report Cover format provided at the end of this outline.

TITLE PAGE — Use the Title Page format provided at the end of this outline. The Title Page shall contain the following signatures: Contractors' Project Manager, Contractors' QA Officer, Contractors' Laboratory QA Officer, and TPM.

DISCLAIMER

REPORT DOCUMENTATION PAGE, SF Form 298

PREFACE (Contractor's Option)

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1.0 QUALITY ASSURANCE PROJECT PLAN (QAPP)

(Reference: "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," Quality Assurance Management Staff [QAMS]-005/80, U.S. Environmental Protection Agency [EPA] [1980]).

1.1 Introduction

1.1.1 The U.S. Air Force Installation Restoration Program--Provide a discussion on the background and objectives of the Air Force IRP, showing how the Air Force IRP complies with the legislative mandates. The discussion in the Work Plan may be referenced.

1.1.2 Purpose and scope--Briefly describe the purpose, scope, content, and use of this SAP.

1.2.1 Project background--Identify the Air Force base or facility and provide a figure showing the locations of all IRP sites. Summarize the contamination history at each site and the findings from previous IRP investigations in tabular format.

1.2.2 Project scope and objectives--Summarize the objectives and the work proposed for each site (in tabular form). Indicate the intended use of the data that will be acquired during this project.

1.2.3 Subcontractors--Identify all subcontractors and the service they will perform.

1.3 Project Organization and Responsibility--Provide a project organization chart identifying task managers and individuals responsible for QA/QC, including project, field, and laboratory QA officers. Describe the authority given to each responsible individual to effect change and approve corrective actions. If a subcontract laboratory is being used, the laboratory organization chart shall be integrated with the prime contractor's organization chart, clearly showing the coordination of QA/QC functions and the assignment of responsibilities in each organization.

1.4 Objectives for Measurement Data

1.4.1 Definition of Criteria--Clearly define how QA objectives will be assessed on a project-wide basis. At a minimum, criteria shall be established for accuracy, precision, completeness, comparability, and representativeness. Define terminology associated with the criteria and provide equations for computation where applicable. These assessment criteria shall measure the quality of field and laboratory performance for the entire project; they are not the same as control limits that are used to evaluate individual analytical results.

1.4.2 Goals--Provide numerical goals for each of the assessment criteria identified in the previous section. Identify the consequences of failing to meet the goals.

**Sampling and Analysis Plan Outline**

1.5 Sampling Procedures

1.5.1 Sampling protocols--List all applicable guidelines and reference documents for sample collection, transport, and storage. Provide detailed sampling protocols in the FSP.

1.5.2 Sample handling--The sample containers, sample volume, method of preservation, and holding times for each sample matrix and analytical method shall be presented in tabular format (see table 2-1 as an example).

1.6 Sample Custody

1.6.1 Field operations--Reference section 2.2 of the FSP.

1.6.2 Laboratory operations--Provide the following information for each laboratory involved in the project.

1.6.2.1 Sample handling--Describe sample receipt, storage, and tracking procedures.

1.6.2.2 Sample identification--Describe procedures for sample identification and the relation to field identification (i.e., how sample numbers are assigned). Also describe how analytical batches or lots are assembled and identified.

1.6.2.3 Sample custody records--Identify procedures and forms for establishing sample custody and control in the laboratory.

1.7 Calibration Procedures and Frequency for Field Test Equipment (reference section 2.3 of the FSP)

1.8 Analytical Procedures

1.8.1 Identification of methods--List all analytical methods to be used for this project and reference the source for each method. Provide a copy of all nonstandard methods (i.e., methods other than those published by EPA, American Society for Testing Materials [ASTM], American Public Health Association [APHA], and National Institute for Occupational Safety and Health [NIOSH]) in

an appendix to the SAP. In addition, all modifications to standard methods must be identified. A discussion of the effects of modifications on the comparability of the data shall be included.

1.8.2 Detection and Quantitation Limits.

1.8.2.1 Terminology--Define terms used for this project (i.e., detection limit, completeness, limit of quantitation, etc.).

1.8.2.2 Procedures--Describe procedures used in the laboratory to establish limits of detection and quantitation. Specify when the procedures will be performed and the frequency of verification. In no case shall the laboratory establish quantitation limits by multiplying the detection limits by an arbitrary factor.

1.8.2.3 Values--List laboratory-established detection and quantitation limits for each analyte and matrix required by the SOW. Discuss and make use of the information in section 2.2.3 of this Handbook.

1.8.3 Method calibration--Describe calibration procedures including preparation of calibration standards for each analytical method. Specify the frequency of initial calibration and continuing calibration checks, and provide the acceptance criteria for the calibration checks and the standards curve.

1.9 Data Reduction, Validation, and Reporting

1.9.1 Data management--Provide a data management flow chart identifying laboratory data review and contractor data validation including reporting functions (refer to section 1.13 of this outline for the requirements of the field and laboratory programs).

1.9.2 Data reduction--Describe data reduction process. Provide formulas used for calculations involving field measurements if they are not specified in field methods.

1.9.3 Data quality assessment--Describe data quality assessment procedures, including the review of field and laboratory data records, any statistical analyses (e.g., trend analysis, measures of variability, significance tests) used to evaluate data quality, and comparison of environmental data with quality control criteria to identify accurate, precise, and usable data. Identify procedures for handling out-of-control data, for using and preparing control charts, and assessing data associated with contaminated blanks.

1.9.4 Data validation and reporting--Describe the QA function that will occur during data validation and technical report preparation. Include, in outline form, the review steps undertaken to assure reporting of valid data and a table of all data qualifiers used and their specific meaning. (Refer to sections 2.3.1, 2.3.2, and 2.3.3.)

1.10 Internal Quality Control Checks for Field and Laboratory Operations

1.10.1 Field quality control--Reference section 2.4 of the FSP.

1.10.2 Laboratory quality control--Describe quality control for laboratory analyses, identifying the types of laboratory QC samples, the methods for establishment of control limits, and the use of historical data, at a minimum. Identify sources of control materials. Describe how analytical batches are established and how quality control samples are included in the batch.

1.10.3 Control limits--For each analytical method, summarize in tabular format the quality control checks, their frequency, acceptance criteria, and the corrective action if out-of-limits. Use the format in table 1-1.

1.11 Performance and System Audits--Describe participation in external and internal systems and performance audits for laboratory work. Specify audit frequencies and participating personnel. Identify officials who receive and act upon the results of audit reports. List laboratory certifications.

1.12 Preventive Maintenance

1.12.1 Procedures--Describe preventive maintenance procedures for laboratory equipment.

1.12.2 Schedule

1.13 Field and Laboratory Procedures used to Assess Data Precision, Accuracy, and Completeness

1.13.1 Formulas--Provide formulas used to calculate precision, accuracy, and completeness.

1.13.2 Control limits--Using the format in table 1-2 for each analytical method, identify the spiking compounds, their concentrations, and the laboratory established control limits for precision and accuracy.

1.13.3 Documentation--Describe documentation and review of QA/QC activities (refer to section 1.15 of this outline).

1.14 Corrective Action

1.14.1 Response--Describe responses to out-of-control events including: responsibilities of personnel for ensuring that such events are declared, notification procedures, and procedures for repeating or stopping work.

1.14.2 Reestablishment of control--Describe procedures for reevaluation of control limits and the reestablishment of control after the occurrence of an out-of-control event.

1.14.3 Documentation--Describe reporting of out-of-control events, corrective actions, and the establishment of control. Provide a corrective action documentation form.

1.15 Quality Assurance Reports

1.15.1 Reporting procedure--Identify periodic reports prepared for internal management and identify persons responsible for report preparation and review.

1.15.2 Report content--Identify report content including assessment of data accuracy, precision, and completeness, results of audits, and methods of identifying and correcting QA problems.

## Table 1-1. Summary of Internal Quality Control Procedures

| Analytical Method | Parameter | Quality Control Check | Frequency | Acceptance Criteria | Corrective Action |
|---|---|---|---|---|---|
| | | | — EXAMPLE DATA — | | |
| SW8020 | Purgeable Aromatics | Field Quality Control: | | | |
| | | Trip Blank | 1 for each cooler of water samples shipped to laboratory | No more than 4 target compounds, each with a concentration exceeding 3 times the method detection limit can be present. | Review lab QC data to determine if there is a laboratory problem. If not, and same compounds are found in field samples at similar concentrations, resample entire batch. |
| | | Duplicate | 1 for every 10 field samples | Water Samples - RPD < 30%<br>Soil Samples - RPD < 40% | Review lab QC data to determine if they are in control. If in control, flag data. Use data to evaluate whether proper collection procedures were followed. |
| | | *Laboratory Quality Control:* | | | |
| | | Reagent Blank | 1 per 12 hour day | Compounds must be below respective detection limits. | Step 1: Reanalyze<br>Step 2: If second reagent blank exceeds criteria, clean and recalibrate the analytical system to reestablish control.<br>Step 3: Document the corrective action taken. |
| | | *Surrogate Spike* | All blanks, standards, QC samples, field samples | (See Table __ for surrogate spiking compounds, spike concentrations, and laboratory control limits) | Step 1: Reanalyze<br>Step 2: If recovery still outside control limits, qualify the data. |
| | | Matrix Spike Duplicate (MSD) | 1 per every 20 project samples | (See Table __ for control limits for RPD) | Step 1: Analyze a new MSD.<br>Step 2: If still outside control limits, determine and correct problem, recalibrate, reanalyze all samples run since last satisfactory MSD analyses.<br>Step 3: Document corrective action taken. |

## Table 1-2. Laboratory Control Limits for Matrix Spikes, Matrix Spike Duplicates, and Surrogate Spikes

| Analytical Method | Spiking Compounds | Spike Concentration: Water (ug/L) | Spike Concentration: Soil/Sediments (mg/kg) | Laboratory-Established Control Limits: Percent Recovery (%): Water | Laboratory-Established Control Limits: Percent Recovery (%): Soil/Sediments | Laboratory-Established Control Limits: Relative Percent Difference (%): Water | Laboratory-Established Control Limits: Relative Percent Difference (%): Soil/Sediments |
|---|---|---|---|---|---|---|---|
| | | | — EXAMPLE DATA — | | | | |
| SW8020 | Matrix: | | | | | | |
| | Benzene | 10 | 0.01 | 75-125 | 75-125 | <20 | <30 |
| | Chlorobenzene | 10 | 0.01 | 75-125 | 75-125 | <20 | <30 |
| | 1,2-dichlorobenzene | 10 | 0.01 | 75-125 | 75-125 | <20 | <30 |
| | 1,3-dichlorobenzene | 10 | 0.01 | 75-125 | 75-125 | <20 | <30 |
| | 1,4-dichlorobenzene | 10 | 0.01 | 75-125 | 75-125 | <20 | <30 |
| | Ethylbenzene | 10 | 0.01 | 75-125 | 75-125 | <20 | <30 |
| | Toluene | 10 | 0.01 | 75-125 | 75-125 | <20 | <30 |
| | Surrogate: α,α,α-trifluoro toluene | 20 | 0.02 | 75-125 | 75-125 | --- | --- |

Numerical values are provided for illustration purposes ONLY. Laboratory must provide values based upon historical laboratory information. Use of EPA Contract Laboratory Program limits is an unacceptable substitute for laboratory-established control limits.

## 2.0 FIELD SAMPLING PLAN (FSP)

The FSP provides requirements and procedures for all field work to be conducted. The objective and purpose shall be stated for the overall plan and each operational segment. It shall be written with a level of detail so that a sampling team unfamiliar with the project would be able to collect required samples and associated information.

The FSP is considered part of the SAP although it may be bound separately to facilitate use by field personnel.

2.1 Field Operations--Provide detailed descriptions of the methods for conducting the field operations for this project. Provide the specifications applicable to the field activities described. Show the locations of all proposed field operations and sampling locations on site maps.

2.1.1 Site reconnaissance, preparation, and restoration procedures--Describe any special site preparation requirements (e.g., fencing off the site to prevent access by unauthorized personnel, heavy equipment to clear trees). Describe how and where decontamination of equipment and personnel will be performed. Provide information on the field office/laboratory locations and the location of emergency equipment (e.g., fire extinguishers, personnel safety equipment). Describe how the site will be restored after field activities have been completed.

2.1.2 Surface geophysical surveys--Describe the specific equipment to be used and how the survey will be conducted. Include information on equipment calibration, establishment of grid patterns, and quality control procedures.

2.1.3 Soil gas surveys--Describe the equipment to be used and how the survey will be conducted. Include information on equipment calibration, grid pattern, and quality control procedures. Refer to the information in paragraph 2.1.3.5 of section 2.0 of the Handbook prior to writing this description.

2.1.4 Borehole construction, lithologic sampling, and logging--Describe the drilling method and equipment to be used for lithologic

sampling and logging. If drilling fluid is to be used, provide information on its composition.

2.1.5 Monitor well construction and development--Identify methods and materials of construction, schedule, diameter, screen slot size, etc. Describe criteria to be used to determine placement of the well screen, and methods and duration of well development.

2.1.6 Aquifer tests--Describe the equipment to be used, including its calibration. Include methods for calculating aquifer characteristics.

2.1.7 Test pit excavation--Describe dimensions of test pits, method of excavation (e.g., shovel, backhoe), and method of shoring (if applicable).

2.1.8 Surveying--Specify the survey method and bench mark to be used.

2.1.9 Equipment decontamination--Describe the decontamination of drilling equipment, well construction materials, etc. Refer to the information in paragraph 2.1.1.3 of section 2.0 of the Handbook prior to writing this description.

2.1.10 Waste handling--Describe procedures for handling and disposing of waste generated on-site (e.g., well development fluids, equipment decontamination fluids, disposable protective clothing).

2.1.11 Summarize in tabular form the type and number of field activities to be conducted at each site. Identify the number of monitor wells to be constructed, the type and number of aquifer tests, frequency of sampling, etc.

2.2 Environmental Sampling

2.2.1 Procedures--Provide detailed descriptions of the methods and procedures to be used for collecting environmental samples from groundwater, surface water, soil, sediment, air, and biological materials. Provide enough detail so a field team not familiar with the project could properly collect all samples.

2.2.2 Sample handling--Identify types of sample containers, sample volumes, methods of preservation, sample identification, sample

holding times, and sample packaging and shipping method. Refer to table 2-1 for the requirements.

2.2.3 Sample custody--Identify procedures and forms for establishing sample custody in the field and during shipment to the laboratory.

2.2.4 QC samples--Describe the preparation, collection, frequency of use, and identification of field QC samples.

2.2.5 Sample analysis summary--For each analytical method, identify the reporting units, the total number of environmental samples for all media, the number of trip blanks, the number of ambient conditions blanks, the number of equipment blanks, the number of field duplicate samples, and the estimated number of second-column confirmations on a site-by-site and project total basis. Total the number of analyses for the entire project by each analytical method.

2.3 Field Measurements--The following information may be presented in tabular format:

2.3.1 Parameters--Identify parameters to be measured in the field and the equipment that will be used for the measurements.

2.3.2 Equipment calibration--Describe how and when the equipment used to measure each field parameter will be calibrated. Include sources of calibration materials and provide acceptance criteria for the calibration data.

2.3.3 Equipment maintenance--Describe equipment maintenance procedures and schedules.

2.3.4 Decontamination--Describe equipment decontamination procedures.

2.4 Field QA/QC Program

2.4.1 Control parameters--Identify and describe parameters that will be controlled during field operations, sampling, and measurement. Identify the frequency of control checks and sources of any control materials.

2.4.2 Control limits--Provide the acceptance criteria for each parameter that is controlled (use the format in table 1-1).

2.4.3 Corrective actions--Describe the actions required from field personnel in the event that controlled parameters exceed the acceptance criteria. Provide a copy of the form used to document exceedance of criteria and subsequent corrective actions.

2.5 Record Keeping--Identify the records of field operations, sampling, and measurement that will be maintained by field personnel. Include any forms that will be used.

2.6 Site Management--Identify the HSD/YAQ TPM and base point of contact (include phone numbers). Describe the support to be provided by the base during field activities. Discuss contingency plans to be initiated if problems are encountered during the field program (e.g., special notifications, backup equipment/personnel). Do not include contingency plans related to personnel safety. These are to be covered in the project Health and Safety Plan.

**Sampling and Analysis Plan Report Cover**

*(Contractor's Report Number)*

INSTALLATION RESTORATION PROGRAM (IRP)

STAGE___ [1,2, etc]

SAMPLING AND ANALYSIS PLAN

*(Base and Address)*

*(Contractor's Name and Address)*
*(Address)*

*(Date)*

*(Type of Report) [Final, Draft, etc.]*

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AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
ENVIRONMENTAL SERVICES OFFICE
ENVIRONMENTAL RESTORATION DIVISION (AFCEE/ESR)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

**Sampling and Analysis Plan Title Page**

INSTALLATION RESTORATION PROGRAM (IRP)

STAGE___ [1,2, etc]

SAMPLING AND ANALYSIS PLAN

FOR

*(Base & Address)*

*(Major Command Civil Engineer and Address)*

*(Date)*

PREPARED BY

*(Contractor's Name and Address)*

USAF CONTRACT NUMBER. _____, DELIVERY ORDER NO._____

CONTRACTOR CONTRACT NO._____, DELIVERY ORDER NO._____

| | |
|---|---|
| Contractor's Project Manager | Laboratory QA Officer |
| Contractor's QA Officer | USAF Technical Program Manager |

ENVIRONMENTAL RESTORATION DIVISION
*(Name, Grade, Title)*
TECHNICAL PROJECT MANAGER

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
ENVIRONMENTAL SERVICES OFFICE
ENVIRONMENTAL RESTORATION DIVISION (AFCEE/ESR)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

## 1.3 HEALTH AND SAFETY PLAN OUTLINE

Each site Health and Safety Plan (HSP) shall include, at a minimum, the elements listed below. The *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities* (NIOSH/Occupational Safety & Health Administration [OSHA]/U.S. Geological Survey [USGS]/EPA, 1985) provides additional general guidance, while 29 CFR 1910.120 contains specific requirements.

- Introduction
  - Background--Identify site location, and provide summaries of site history, conceptual site model, and planned activities.
  - Organization--Describe the safety organization structure, identify safety program members and describe their responsibilities, and provide an emergency telephone number for each safety program member.
  - Site map--Identify zones of exclusion, work staging areas, decontamination areas, alarms, emergency response equipment locations, site entrances and exits; evacuation routes, telephones, etc.
- Hazard Analysis--Identify potential health and safety risks for each task and operation. Identify site contaminants and hazardous materials that are planned for on-site use. Append material safety data sheets for each chemical hazard to the HSP.
- Site Worker Training--State each worker's OSHA training status under 29 CFR 1910.120. Identify the time, location, and subject matter of site worker training sessions. Include a schedule for the pre-entry briefings held prior to initiating on-site activities.
- Personnel Protection--Identify the personal protective equipment to be used by on-site employees for each protection level that may be required. Include equipment testing, decontamination procedures, and frequencies.
- Medical Surveillance--Describe medical surveillance program to be implemented to screen and monitor site personnel.

**Health and Safety Plan Outline**

- Monitoring--Identify the frequency of, and methods to be used to monitor ambient air, site personnel, and environmental media to ensure the safety of site personnel and the public. Include descriptions of instrumentation, calibration, and quality control practices. Identify action levels associated with each monitored parameter, and provide information to support the action level selected.

- Site Control--Identify procedures for controlling access to restricted areas and preventing contamination of clean areas and site personnel. Identify areas that require the use of personal protective equipment on a site map. Describe the steps to be taken to ensure safe working conditions and communication among site personnel.

- Decontamination Procedures

- Confined Space Entry Procedures

- Emergency Response Plan--Identify the safety practices, prepared procedures, emergency telephone numbers, and emergency response and follow-up for each site hazard identified in the HSP. Responses appropriate to all potential emergencies, spills, or contaminant releases should be described. The location and use of emergency response equipment, personnel, and services shall be described. Also identify all regulatory agencies requiring notification of an emergency response. Describe the system for contacting response personnel and regulatory authorities in the event of an emergency. Outline the emergency response documentation requirements.

## 1.4 COMMUNITY RELATIONS PLAN OUTLINE

A community relations plan (CRP) that documents the community relations history and the issues of community concern shall be prepared using appropriate portions of the CRP outlined below. Further guidance may be found in *Community Relations in Superfund: A Handbook*, Office of Solid Waste and Emergency Response (OSWER) Directive 9230.0-3B, (EPA, Interim, June 1988).

| SUGGESTED OUTLINE | SUGGESTED LENGTH |
|---|---|
| • Overview of CRP | |
| Purpose of CRP<br>Distinctive feature(s) of CRP for the site<br>Special circumstances | 1 paragraph-several pages |
| • Capsule Site Description | |
| Site history<br>Dates and types of releases<br>Nature and types of threats to public health and the environment | 1 page |
| • Community Background | |
| Community profile; economic and political structure<br>Chronology of involvement; past reactions of community towards site, citizen actions and attitudes towards the Air Force<br>Key community concerns; how each segment of the community perceives the risks posed by the site or its remediation | 3-7 pages |

**Community Relations Plan Outline**

| SUGGESTED OUTLINE | SUGGESTED LENGTH |
|---|---|
| • Highlights of Program | |
| Concrete details on approaches to be taken based on community background<br>Resources and meeting places to be used<br>Key individuals and organizations to involve<br>Areas of sensitivity to consider | 2-3 pages |
| • Techniques and Times | |
| Planned activities and when they will be conducted | 2-3 pages<br>matrix suitable |
| • Appendixes | |
| Mailing list of interested parties and key contacts*<br>Locations of meetings<br>Locations of information repositories | |

* Names and addresses of individuals should not be included in the plan presented to the information repository because release authorization has not normally been requested of these individuals. The names and addresses should be placed in the Public Affairs Office files.

## 2.0 PROJECT IMPLEMENTATION REQUIREMENTS

This section contains requirements for conducting IRP projects. This material is incorporated into the SOW by reference. The requirements shall be followed by IRP Program Division (HSD/YAQ) contractors in the preparation of work plans, sampling and analysis plans, in implementing field activities and laboratory analyses, and in documenting project activities in technical reports. The contractor shall ensure all of its subcontractors also follow these requirements.

## 2.1 HYDROLOGIC INVESTIGATIONS

### 2.1.1 General Requirements

The contractor shall comply with the requirements and guidelines given in the applicable documents listed in section 4 of this Handbook. Where conflicting guidance exists, follow the requirements of this Handbook. The following requirements apply to all hydrologic activities.

#### 2.1.1.1 Record Keeping

a. The contractor shall maintain field records sufficient to recreate all sampling and measurement activities and to meet all IRPIMS data loading requirements. The requirements listed in this section apply to all measuring and sampling activities. Requirements specific to individual activities are listed in the section that addresses each activity. The information shall be recorded with indelible ink in a permanently bound notebook with sequentially numbered pages. These records shall be archived in an easily accessible form and made available to the Air Force upon request.

b. The following information shall be recorded for all activities:

(1) Location.

(2) Date and time.

(3) Identity of people performing activity.

(4) Weather conditions.

c. The following additional information shall be recorded for all field measurements:

(1) The numerical value and units of each measurement.

(2) The identity of and calibration results for each field instrument.

d. The following additional information shall be recorded for all sampling activities:

(1) Sample type and sampling method.

(2) The identity of each sample and depth(s) from which it was collected.

(3) The amount of each sample.

(4) Sample description (e.g., color, odor, clarity).

(5) Identification of sampling devices.

(6) Identification of conditions that might affect the representativeness of a sample (e.g., refueling operations, damaged casing).

2.1.1.2 Containerization

a. All materials excavated from boreholes and test pits shall be examined to identify potential hazards.

b. Materials that are suspected to be hazardous because of abnormal color, odor, or organic vapor monitor readings, shall be containerized in conformance with the Resource Conservation and Recovery Act (RCRA), and state and local requirements.

c. The contractor shall provide the containers and transport them to a location designated by the Air Force.

d. The contents of the containers shall be analyzed as specified in annex A of the SOW.

e. Water discharges associated with well development, purging, and aquifer testing shall not be containerized unless called for in the SOW.

2.1.1.3 Decontamination

a. All equipment that may directly or indirectly contact samples shall be decontaminated at a designated decontamination area. This includes casing, drill bits, auger flights, the portions of drill rigs that stand above boreholes, sampling devices, and instruments such as slugs and sounders. In addition, the contractor shall take care to prevent the sample from coming into contact with potentially contaminating substances such as tape, oil, engine exhaust, corroded surfaces, and dirt.

b. The following procedure shall be used to decontaminate large pieces of equipment such as drill rigs, auger flights, and casing:

   (1) Wash the external surfaces of equipment high-pressure hot water and Alconox or equivalent. If necessary, scrub until all visible dirt, grime, grease, oil, loose paint, rust flakes, etc., have been removed. The inside surfaces of casing, drill rod, and auger flights shall also be washed as described above. Specific decontamination instructions shall be included in the SAP.

   (2) Rinse with potable water.

   (3) This decontamination procedure shall be performed before equipment is used and between each well or other sampling location.

c. The following procedure shall be used to decontaminate sampling devices such as split spoons, bailers, and hand augers:

   (1) Scrub the equipment with a solution of potable water and Alconox, or equivalent laboratory-grade detergent. Rinse equipment with copious quantities of potable water followed by a Reagent Grade II Water rinse. High pressure liquid chromatograph (HPLC) Grade Water or distilled water purchased in stores is not an acceptable substitute for Reagent Grade II Water (see section 2.1.3 for Type II Reagent Grade Water requirements).

   (2) Rinse equipment with pesticide-grade methanol.

   (3) Rinse equipment with pesticide-grade hexane. Certain states may prohibit the use of hexanes. In these cases a substitute solvent should be presented for approval by the TPM and discussed in terms of comparability and compatibility.

(4) Air dry equipment on a clean surface such as teflon, stainless steel, or oil-free aluminum. If the sampling device will not be used immediately after being decontaminated wrap it in oil-free aluminum foil. Note: The aluminum foil sold in stores is usually coated with a film of vegetable oil. Oil-free foil can be obtained from scientific supply houses.

d. Reagent grade water, methanol, and hexane shall be purchased, stored, and dispensed only in glass, stainless steel, or Teflon containers. These containers shall have Teflon caps or cap liners. It is the contractor's responsibility to assure these materials remain free of contaminants. Additional testing at no cost to the government may be necessary to verify the purity of materials (i.e., material blanks, etc.).

2.1.1.4 Geologic Standards

a. Lithologic descriptions

Consolidated materials:

(1) Descriptions of igneous, metamorphic, and sedimentary rocks shall follow standard professional nomenclature (cf. Tennissen, A.C., 1983, Nature of Earth Materials, 2nd Edition, p. 204-348). Special attention shall be given to describing fractures, vugs, solution cavities and their fillings or coatings, and any other characteristics affecting permeability.

(2) Colors shall be designated by the Munsell Color System.

Unconsolidated materials:

(3) Deposit names shall follow the name of the predominant particle size.

(4) Dimensions of the predominant and secondary sizes shall be recorded using the metric system.

(5) Descriptions of clastic deposits shall include symbols of the Unified Soil Classification System.

(6) The grain size and name of the deposit shall be accompanied by the predominant mineral content, accessory minerals, color, particle angularity, and other characteristics.

b. Illustrations--Sedimentary, igneous, and metamorphic rocks should be identified graphically by the symbols from Ridgeway, J. L., 1920, Preparation of Illustrations for Reports of the U.S. Geological Survey, Plate III. Columnar sections, well logs, well construction diagrams, cross-sections, three-dimensional (3-D) diagrams, and maps should use such standard patterns.

c. Scales--Scales for maps, cross-sections, or 3-D diagrams should be selected in accordance with the geologic and hydrologic complexity of the area and the purposes of the illustrations. Geophysical logs shall be run at a constant vertical scale of 1 inch equals 20 feet. When geophysical logs are superimposed on geologic logs for cross-sections or 3-D diagrams, the scales shall be the same. If defining geological conditions requires other scales, additional logs at those scales shall be provided.

d. Orientation--Cross-sections shall show the northern end on the viewer's right. If the line of cross-section is predominantly east-west, the eastern end is on the right. Maps shall be oriented with north toward the top, unless shape of the area dictates otherwise. Indicate orientation with a north arrow.

2.1.1.5 Surveying

All surveyed locations of field activities shall be measured by a certified land surveyor as the distance in feet from a reference location that is tied to the state plane system. The surveys shall be third order (cf. Urquhart, L.C., 1962 Civil Engineering Handbook, 4th edition, p. 96 and 97). An xy-coordinate system shall be used to identify locations. The x-coordinate shall be the east-west axis, the y-coordinate shall be the north-south axis. The reference location is the origin. The elevation of all newly installed wells and piezometers shall be surveyed at the water level measuring point (notch) on the riser pipe. Include the elevation of the ground surface in the survey.

2.1.2 Construction and Testing

2.1.2.1 Monitor Well Construction and Design

a. Drilling, lithologic sampling, and monitor well construction shall be supervised by a state licensed geologist, hydrogeologist, or geotechnical engineer. Decisions on well locations, depths, screened intervals, and other construction details shall be made collectively by the HSD/YAQ TPM and the contractor's project manager. When there is a possibility that floating petroleum products will be encountered, shallow monitor

wells shall be screened across the water table. The length of the screen shall be such that tidal and seasonal water table fluctuations shall not cause water levels to rise above or fall below the screened interval.

b. Drilling

(1) All drilling and well installations shall conform to state and local regulations. The contractor shall obtain and pay for all permits, applications, and other documents required by state and local authorities.

(2) The location of all borings shall be approved in writing by the base civil engineer before drilling commences.

(3) The rig shall be cleaned and decontaminated according to the specifications of section 2.1.1.3.

(4) The rig shall not leak any fluids that may enter the borehole or contaminate equipment that is placed in the hole. The use of rags or diapers to absorb leaking fluids is unacceptable.

(5) The only acceptable drilling fluids are air, water, and mud. The air shall be filtered to remove organic vapors, the water shall be from a source approved by the TPM, and the mud shall be 100 percent sodium bentonite approved by the TPM.

(6) When air is used, the effectiveness of the filter shall be checked at least every four hours. Air passing through the downstream end of the air line shall be monitored with an organic vapor monitor (e.g., photoionization detector [HNu], organic vapor analyzer [OVA]). If organic vapors are detected, their source (filter, contaminated line, etc.) shall be decontaminated or replaced.

(7) Lubricants shall not introduce contaminants. Unless Teflon tape is the only lubricant used, the contractor shall obtain written authorization from the TPM for any lubricant used on equipment that enters the hole.

(8) The contractor shall dispose of all trash, waste grout, cuttings, and drilling fluids as directed by the base civil engineer.

(9) When installing wells through more than one water bearing zone or aquifer, the contractor shall take measures to prevent cross-connection or cross-contamination of the zones or aquifers.

c. The borehole

(1) The borehole diameter shall be at least four inches larger than the outside diameter of the casing and well screen. In the case of a hollow stem auger, the inside diameter of the auger shall be at least four inches larger than the outside diameter of the casing and well screen.

(2) The borehole shall be straight and plumb within three degrees of vertical.

(3) Formation samples for lithologic description shall be obtained at each change in lithology or at five-foot intervals, whichever is less, or as specified in the SOW. All samples shall be monitored with an organic vapor monitor (e.g., HNu, OVA). Cuttings shall be screened for their hazardous characteristics as specified in section 2.1.1.2. Rock cores shall be stored in standard core boxes and missing sections of core shall be replaced with spacers.

(4) In addition to the information listed in section 2.1.1.1 record the following for each boring:

- Boring or well identification. (This identification shall be unique. The contractor is responsible for ensuring that it has not previously been used at the installation.)
- Purpose of boring (e.g., soil sampling, monitor well).
- Location in relation to an easily identifiable landmark.
- Name of drilling contractor.
- Drilling method.
- Types of drilling fluids and depths at which they were used.
- Diameter of surface casing, casing type, and methods of installation.

- Depth at which saturated conditions were first encountered.
- Lithologic descriptions and depths of lithologic boundaries.
- Sample depths.
- Zones of caving or heaving.
- Depths at which drilling fluid was lost and amount lost.
- Changes in drilling fluid properties.
- Drilling rate.
- Drilling rig reactions such as chatter, rod drops, and bouncing.

In addition to the above, the following information shall be recorded when rock core samples are collected:

- The depth interval, and top and bottom of each core shall be marked on the core box.
- Percentage of core recovered.
- Number of fractures per foot.
- Angle of fractures relative to the core axis.
- Breaks due to coring and core handling shall be distinguished from naturally occurring fractures.

(5) A standard penetration test shall be performed each time a split spoon sample is taken. The test shall be performed in accordance with ASTM method D-1586.

d. Casing

(1) All casing shall be new and unused, and decontaminated according to the specifications of section 2.1.1.3.

(2) Glue shall not be used to join casing. Casing shall be joined only with compatible welds or couplings that will not interfere with the planned use of the well.

(3) All PVC shall conform to the ASTM standard F-480-88A or the National Sanitation Foundation Standard 14 (Plastic Pipe System).

(4) All metal casing shall be seamless stainless steel casing, unless prior authorization is obtained from the TPM. The casing "mill" papers shall be included in the appendix of the technical report.

(5) The casing shall be straight, and plumb within three degrees of vertical.

(6) A notch shall be cut in the top of the casing to be used as a measuring point for water levels.

e. Well screen

(1) All the requirements that apply to casing shall also apply to well screen, except for strength requirements.

(2) Monitor wells shall not be screened across more than one water-bearing unit.

(3) Screens shall be factory slotted or wrapped.

(4) Screen slots shall be sized to prevent 90 percent of the filter pack from entering the well. For wells where no filter pack is used, the screen slot size shall be selected to retain 60 percent to 70 percent of the formation materials opposite the screen.

(5) The bottom of the screen is to be capped. The cap shall be joined to the screen by threads.

(6) The contractor may propose open-hole wells in bedrock where cave-in is unlikely. Prior approval for such wells must be obtained in writing from the TPM.

f. The annular space

(1) The annular space between the well string and the borehole wall shall be filled with a filter pack, a bentonite seal, and casing grout.

(2) Any drilling fluids shall be thinned with potable water to a density less than 1.2 $g/cm^3$ (10 lb/gal) before the annular space is filled.

(3) As the annular space is being filled, the well string shall be centered and suspended such that it does not rest on the bottom of the hole. For wells greater than 50 feet deep, at least two centralizers shall be used, one at the bottom and one at the top of the screen. Additional centralizers shall be used as needed to keep the well string centered.

g. The filter pack

(1) The filter pack shall consist of silica sand or gravel and shall extend from the bottom of the hole to at least two feet above the top of the well screen. After the filter pack is emplaced the well shall be surged with a surge block for ten minutes. Place additional filter pack as required to return the level of the pack to two feet above the screen. Surge the well for five minutes. Place additional filter pack as required to bring its level to two feet above the screen. If gravel is used, six inches of course sand shall be placed on top of the gravel.

(2) The filter pack material shall be clean, inert, well-rounded and contain less than 2 percent flat particles.

(3) The sand or gravel shall be certified free of contaminants by the vendor or contractor. If decontamination is necessary the methods shall be approved in writing by the TPM.

(4) The filter pack shall have a grain size distribution compatible with the formation materials and the screen, as described in Chapter 12, *Groundwater and Wells*, 2nd ed.

(5) The filter pack shall not extend across more than one water-bearing unit.

(6) The filter pack shall be emplaced with a tremie pipe. The tremie shall be lifted from the bottom of the hole at the same rate the filter pack is set.

(7) The contractor may use formation materials as a filter pack when they are compatible with the slot size of the screen. Approval of the TPM is required before completion.

h. The bentonite seal

(1) The bentonite seal shall consist of at least two feet of bentonite between the filter pack and the casing grout.

(2) Only 100 percent sodium bentonite shall be used.

i. Casing grout

(1) The casing grout shall extend from the top of the bentonite seal to ground surface.

(2) The grout shall be mixed in the following proportions: 94 pounds of neat Type 1 Portland or American Petroleum Institute (API) Class A cement, not more than four pounds of 100 percent sodium bentonite powder, and not more than 8 gallons of potable water.

(3) The grout shall be pump tremied. Pumping shall continue until 20 percent of the grout has been returned to the surface.

j. Surface completion

(1) The base civil engineer shall determine surface completion (flush or projected above ground surface) requirements.

(a) If well stick-up is not acceptable, surface completions shall be flush with the land surface. Cut the casing about three inches below land surface and provide a water tight casing cap to prevent surface water from entering the well. A freely draining valve box with a locking cover shall be placed over the casing. The top of the casing shall be at least one foot above the bottom of the box. The valve box lid shall be centered in a three foot diameter, four inch thick concrete pad that slopes away from the box. The identity of the well shall be permanently marked on the valve box lid and the casing cap.

(b) If an above-ground-surface completion is used, extend the well casing two or three feet above land surface. Provide a casing cap for each well. Shield the extended casing with a steel sleeve that is placed over the casing and cap, and seated in a two-foot by two-foot by four-inch (2' x 2' x 4") concrete surface pad. The diameter of the sleeve shall be at least six inches greater than the diameter of the casing. Slope the pad away from the well sleeve. Install a lockable cap or lid. The

identity of the well shall be permanently marked on the casing cap and the protective sleeve.

Install three, 3-inch diameter concrete-filled steel guard posts if the base civil engineer determines the well is in an area where it needs such protection. The guard posts shall be five feet in total length and installed radially from the well head. Recess the guard posts approximately two feet into the ground and set in concrete. Do not install the guard posts in the concrete pad placed at the well base. The protective sleeve and guard posts shall be painted with a color specified by the base civil engineer.

(2) All wells shall be secured as soon as possible after drilling. Provide corrosion-resistant locks for both flush and above-ground-surface completions. The locks must either have identical keys or be keyed for opening with one master key. Deliver the lock keys to the base point of contact (POC) following completion of the field effort.

k. Piezometers

(1) Piezometers shall not be constructed using methods or materials that may contaminate groundwater.

(2) Piezometers that penetrate more than one water-bearing unit shall be constructed in a manner that allows fluid from only one unit to enter them.

(3) Piezometers shall be straight and plumb within three degrees of vertical.

l. Well/Piezometer Completion Diagrams

A completion diagram shall be submitted for each monitor well or piezometer installed. It shall include the following information:

- Well identification. (This shall be identical to the boring identification [section 2.1.2.1.c(4)].)
- Drilling method.
- Installation date(s).

- Elevations of ground surface and the measuring point notch.
- Total boring depth.
- Lengths and descriptions of the screen and casing.
- Lengths and descriptions of the filter pack, bentonite seal, casing grout, and any back-filled material.
- Elevation of water surface before and immediately after development.
- Summary of the material penetrated by the boring (see section 2.1.1.4).

2.1.2.2 Monitor Well Development

a. All newly installed monitor wells shall be developed. Development shall begin no sooner than 24 hours after installation to allow for grout curing.

b. All drilling fluids used during well construction shall be removed during development.

c. Wells shall be developed using surge blocks, and bailers or pumps. Any other techniques must be approved by the TPM. Wells shall be developed until (1) the suspended sediment content of the water is less than 0.75 ml/L as measured in an Imhoff cone according to method E160.5, (2) the turbidity remains within a ten nephelometric turbidity unit (NTU) range for at least 30 minutes, and (3) the purging criteria in section 2.1.3.2 are met.

d. No sediment shall remain in the bottom of the well.

e. No detergents, soaps, acids, bleaches, or other additives shall be used to develop a well.

f. All development equipment shall be decontaminated according to the specifications of section 2.1.1.3.

2.1.2.3 Groundwater Level Measurements

a. Water level measurements shall be taken in all wells and piezometers to determine the elevation of the water table or piezometric surface at least

once within a single 24-hour period. These measurements shall be taken after all wells and piezometers have been installed and developed and their water levels have recovered completely. Any conditions that may affect water levels shall be recorded in the field log.

b. Water level measurements shall be taken with electric sounders, air lines, pressure transducers, or water level recorders (e.g., Stevens recorder). Devices that may alter sample composition shall not be used.

c. For flowing wells, pressure gauges, manometers, or equivalent devices shall be used to measure the elevation of the piezometric surface.

d. All measuring equipment shall be decontaminated according to the specifications of section 2.1.1.3.

e. Groundwater levels shall be measured to the nearest 0.01 foot.

f. Static water levels shall be measured each time a well is sampled, before any fluids are withdrawn, and before any equipment enters the well. If the casing cap is air-tight, allow time prior to measurement for equilibration of pressures after the cap is removed.

2.1.2.4 Floating Hydrocarbon Measurements

The thickness of hydrocarbons floating in monitor wells shall be measured with an electronic interface probe. Hydrocarbon detection paste, or any other method that may affect water chemistry, shall not be used without the approval of the TPM. When detected, the presence of floating hydrocarbons shall be confirmed by withdrawing a sample with a clear Teflon bailer.

2.1.2.5 Groundwater Discharge Measurements

a. Groundwater discharge measurements shall be obtained during monitor well purging and aquifer testing. Groundwater discharges may be measured with orifice meters, containers of known volume, in-line meters, flumes, or wiers. Follow the guidelines given in the *Water Measurement Manual*, Bureau of Reclamation, 1967.

b. If discharge measuring devices are upstream of sample collection points, the devices shall be decontaminated according to the specifications in section 2.1.1.3.

c. Measurement devices shall be calibrated using containers of known volume.

2.1.2.6 Geophysics

a. General requirements for all geophysical surveys:

(1) The locations of boreholes logged with geophysical instruments shall be shown on a site map.

(2) Final results shall be presented in plan views and cross sections. Contours shall be used where appropriate.

(3) The interpretation of results shall discuss positive and negative results, and limitations of the method and data.

(4) The interpretation of the data shall be incorporated into the conceptual site model.

b Borehole Geophysical Survey Requirements

(1) All downhole equipment shall be decontaminated according to the specification of section 2.1.1.3.

(2) Borehole measurements shall be recorded both going into the hole and coming out of the hole.

(3) Paper copies of curves generated from each logging run shall show all the curves at the scale of 1 inch equals 20 feet. Each paper log shall indicate the location of the well, date of log acquisition, type of survey instrument, and a list of other instruments used in that borehole. Interpretations shall be annotated on the margins of paper log records.

(4) All logs shall be referenced to a measuring point notched in the surface casing or to ground level if the well is not cased.

(5) Radioactive sources or devices shall not be used unless they are explicitly called for in the SOW.

(6) Adverse borehole conditions shall be reported in the field log.

c. Surface Geophysical Survey Requirements

(1) The contractor shall correlate surface survey data (profiles and soundings) with at least one soil boring, wellbore or outcrop at the same site as the survey.

(2) The location and elevation of at least two points of the geophysical survey grid shall be surveyed according to the specifications of section 2.1.1.5.

2.1.2.7 Aquifer Testing for Hydraulic Properties

a. General

(1) Equipment shall be decontaminated and water levels measured according to the specifications of sections 2.1.1.3 and 2.1.2.3, respectively.

b. Slug Tests

(1) Slug tests are applicable to rocks of low hydraulic conductivity. Several tests are necessary to characterize an aquifer because slug tests only measure aquifer properties immediately adjacent to the borehole.

(2) The water level shall be static before the test begins. That is, it must not be recovering or receding as a result of sampling, development, pumpage of nearby wells, or related activities.

(3) The test shall be performed using a slug or by withdrawing water from the well. No fluid shall be put in the well.

c. Pumping tests

(1) The contractor shall use monitor wells as observation wells as much as possible.

(2) The pumping rate shall be determined by conducting step tests prior to the pumping test. The well shall be pumped at predetermined steps in order to determine the greatest rate that can be sustained without drawing the water level below the top of the screen. If a lower pumping rate is preferable because of factors such as nearby supply wells, disposal costs, or limited storage facilities, the lower

rate shall be approved by the TPM. The test shall not begin until water levels in all wells have completely recovered.

(3) The contractor shall monitor and regulate the discharge valve for either a constant-discharge or constant-head test.

(4) The discharge rate shall be measured at least ten times during the first 100 minutes of the test and at least every time water levels are measured thereafter. Discharge rates shall be measured in accordance with section 2.1.2.5.

(5) Water levels shall be measured at least ten times per log cycle for the first 100 minutes of the test and at least once every two hours thereafter.

(6) The pumped water shall be disposed so as not to recharge the portion of the aquifer being tested or otherwise affect the validity of the test.

(7) Time-drawdown or distance-drawdown data shall be analyzed during the test. The test shall be terminated when collection of additional data will not affect results, e.g., when water levels are essentially at equilibrium, when a well in low hydraulic conductivity rocks does not yield sufficient water to continue. Test durations may range from two hours to a week or more. A common test period is 24 hours.

(8) The drawdown or recovery data shall be adjusted for systematic influences such as diurnal fluctuations for unconfined aquifers, barometric/tidal effects for confined aquifers, interference of water supply wells, recharge during the pumping test, irrigation, partial penetration of the pumping well, dewatering, delayed yield, etc.

d. Other Test Methods

(1) The aquifer hydraulic parameters can be estimated from well specific capacity and from step-drawdown test. For low hydraulic conductivity rocks, ASTM D-4630 or D-4631 are applicable. For clay, ASTM D-1587 and D-2434 are applicable.

2.1.2.8 Hydrogeological Conceptual Model

The principal project hydrogeologist shall develop a conceptual model of base and site geological and hydrological conditions form pre-existing regional and local studies and information developed during the project. Maps and cross sections shall be used to depict the conceptual model (see section 2.3 of the work plan outline). The model will be the basis for evaluating monitor well and piezometer locations, contaminant distributions (plume delineation), and the closeness of fit to natural conditions of analytical or computer-based numerical models.

2.1.2.9 Analytical or Numerical Model Representations of the Hydrogeological Conceptual Model

a. Model Selection

(1) The principal project hydrogeologist shall be responsible for evaluating the fit of analytical or numerical groundwater flow and contaminant transport models to natural site conditions, and the model's ability to predict the spatial and temporal distribution of contaminants. Stratigraphy, geological structure, aquifer homogeneity or heterogeneity, hydraulic isotropy or anisotropy, tranmissivity, storativity, and effective porosity shall be considered. Leakance, dispersivity, and attenuation shall be considered as applicable.

b. Model Application

(1) The principal project hydrogeologist shall evaluate the reliability of predictions resulting from use of the model. Reliability will be based on sufficiency and representativeness of field data, model calibration, degree of change of field data during calibration, and model sensitivity to changes in selected variables. The values assigned to nodes of numerical models and the amount of change of field values shall be displayed on maps or cross sections.

2.1.2.10 Abandoning Borings and Monitor Wells

a. The contractor shall abandon borings and monitor wells when directed to do so by the SOW.

b. All abandonment shall be performed in accordance with state and local laws and regulations.

2.1.2.11 Test Pits

a. The location of each test pit shall be approved in writing by the base civil engineer before digging commences.

b. The contractor shall follow OSHA rules for excavation. The excavated material shall be screened for hazardous properties as specified in section 2.1.1.2 or as specified in the SOW.

c. Nonhazardous excavated material shall be backfilled immediately after the required information has been recorded. No test pit shall be left open overnight unless adequate safety precautions are employed and approved in writing by the TPM.

d. In vegetated areas, backfilled test pits shall be reseeded with native grasses.

e. In addition to the information listed in section 2.1.1.1, the following information shall be recorded for each test pit.

(1) The total depth, length, and width.

(2) The depth and thickness of distinct soil or lithologic units.

(3) A lithologic description of each unit.

(4) A description of any manmade materials encountered.

2.1.3 Sampling

2.1.3.1 General

The following requirements apply to all sampling activities:

a. In addition to the requirements of this Handbook, the contractor shall collect samples in accordance with the applicable documents listed in section 4. In cases where the documents disagree with this Handbook, the contractor shall comply with the Handbook. Unless a written exception is obtained from the TPM, any samples not collected as required by this Handbook shall be resampled and reanalyzed at no expense to the government.

b. Holding times--The contractor shall comply with the requirements in section 2.2.1 and table 2-1.

c. Chain-of-custody

(1) The contractor shall maintain chain-of-custody records for all field and field QC samples.

(2) A sample is defined as being under a person's custody if any of the following conditions exist:

- It is in their possession.
- It is in their view, after being in their possession.
- It was in their possession, and they locked it up.
- It is in a designated secure area.

(3) All sample containers shall be sealed in a manner that will prevent or detect tampering if it occurs. In no case shall tape be used to seal sample containers. Samples shall not be packaged with activated carbon unless prior approval is obtained from the TPM.

d. Field quality control samples--Five types of field QC samples shall be collected during the entire investigative effort. The number, type, and composition of these samples shall comply with the following requirements. The distribution of field QC samples by site, sampling round, etc., shall be specified in the contractor's Work Plan.

(1) One trip blank shall accompany every shipment or cooler, whichever is more frequent, of soil and water samples sent to the laboratory for the analysis of Volatile Organic Compounds (VOCs). This blank shall be analyzed for VOCs only.

Definition: A trip blank is a VOC sample bottle filled in the laboratory with Type II Reagent Grade Water, transported to the site, handled like a sample, and returned to the laboratory for analysis. Trip blanks shall not be opened in the field. The trip blank for soils is the same as for water samples.

## Table 2-1. Requirements for Containers, Preservation Techniques, Sample Volumes, and Holding Times

| Name | Method of Analysis | Container[1] | Preservation | Minimum Sample Volume or Weight | Maximum Holding Time |
|---|---|---|---|---|---|
| **Inorganic Tests** | | | | | |
| Alkalinity | A403 | P, G | Cool, 4°C | N/A | Analyze Immediately |
| Common Anions | E300 | P, G | None Required | 50 ml | 28 Days for Br, F, Cl, $SO_4$<br>48 hrs for $NO_3$, $NO_2$, $OPO_3$ |
| Cyanide, Total, and Amenable to Chlorination | SW9010 | P, G, T | Cool, 4°C, NaOH to pH>12[2]<br>0.6 g ascorbic acid | 500 ml or 4 ounces | 14 Days (water and soil) |
| Filterable Residue | E160.1 | P, G | Cool, 4°C | 100 ml | 7 Days |
| Non-Filterable Residue | E160.2 | P,G | Cool, 4°C | 100 ml | 7 Days |
| Hydrogen Ion (pH) | SW9040 | P, G | None Required | N/A | Analyze Immediately |
| Nitrogen, Nitrate+Nitrite | E353.2 | P, G | Cool, 4°C, $H_2SO_4$ to pH<2 | 500 ml | 28 Days |
| Specific Conductance | SW9050 | P, G | Cool, 4°C | N/A | Analyze Immediately |
| Temperature | E170.1 | P, G | None Required | N/A | Analyze Immediately |
| Total Organic Carbon | SW9060 | P, G, T | Cool, 4°C, HCl or $H_2SO_4$ to pH<2[2] | 500 ml or 4 ounces | 28 Days (water and soil) |
| **Metals** | | | | | |
| Chromium VI | SW7196 | P, G, T | Cool, 4°C | 500 ml or 8 ounces | 24 Hours (water and soil) |
| Mercury | SW7470, SW7471 | P, G, T | $HNO_3$ to pH<2,[2] Cool, 4°C | 500 ml or 8 ounces | 28 Days (water and soil) |

## Table 2-1. Requirements for Containers, Preservation Techniques, Sample Volumes, and Holding Times (Continued)

| Name | Method of Analysis | Container[1] | Preservation | Minimum Sample Volume or Weight | Maximum Holding Time |
|---|---|---|---|---|---|
| **Metals (Concluded)** | | | | | |
| Metals, except Chromium VI and Mercury | SW6010 and SW846 atomic absorption methods | P, G, T | $HNO_3$ to pH<2,[2] Cool, 4°C | 500 ml or 8 ounces | 180 Days (water and soil) |
| **Organic Tests** | | | | | |
| Petroleum Hydrocarbons | E418.1 | G, T | Cool 4°C, $H_2SO_4$ to pH<2[2] | 1 liter or 8 ounces | Water--28 Days<br>Soil--14 Days until Extraction<br>40 Days after Extraction |
| Fuel Hydrocarbons | SW8015 (modified), GC-FID[3] | G, teflon-lined Septum, T | Cool 4°C, $H_2SO_4$ to pH<2[2] | | Volatiles--14 days<br>Semivolatiles--14 Days until Extraction<br>40 Days after Extraction |
| Aromatic Volatile Organics | SW8020 | G, teflon-lined Septum, T | Cool, 4°C, HCl to pH <2,[2] 0.008% $Na_2S_2O_3$ | 2x40 ml or 4 ounces | 14 Days (water and soil)<br>7 Days unpreserved by acid |
| Chlorinated Herbicides | SW8150 | G, teflon-lined Cap, T | Cool, 4°C, pH 5-9 | 1 liter or 8 ounces | Water--7 Days until Extraction<br>40 Days after Extraction<br>Soil--14 Days until Extraction<br>40 Days after Extraction |
| Pesticides and PCB | SW8080, SW8140 | G, teflon-lined Cap, T | Cool, 4°C, pH 5-9 | 1 liter or 8 ounces | Water--7 Days until Extraction<br>40 Days after Extraction<br>Soil--14 Days until Extraction<br>40 Days after Extraction |

## Table 2-1. Requirements for Containers, Preservation Techniques, Sample Volumes, and Holding Times (Continued)

| Name | Method of Analysis | Container[1] | Preservation | Minimum Sample Volume or Weight | Maximum Holding Time |
|---|---|---|---|---|---|
| **Organic Tests (Continued)** | | | | | |
| Semivolatile Organics | SW8270 | G, teflon-lined Cap, T | Cool, 4°C, 0.008% $Na_2S_2O_3$ | 1 liter or 8 ounces | Water--7 Days until Extraction<br>40 Days after Extraction<br>Soil--14 Days until Extraction<br>40 Days after Extraction |
| Volatile Organics | SW8240, SW8015, SW8010 | G, teflon-lined Septum, T | Cool, 4°C, 0.008% $Na_2S_2O_3$ (HCL to pH<2 for volatile aromatics by SW8240)[2] | 2x40 ml or 4 ounces | 14 Days (water and soil)<br>7 Days unpreserved by acid |
| Polycyclic Aromatic Hydrocarbons (PAHs) | SW8310 | G, teflon-lined Cap, T | Cool, 4°C, Store In Dark, 0.008% $Na_2S_2O_3$ | 1 liter or 8 ounces | Water--7 Days until Extraction<br>40 Days after Extraction<br>Soil--14 Days until Extraction<br>40 Days after Extraction |
| Carbamate Pesticides | SW8318 | G, teflon-lined Cap, T | Cool, 4°C, 0.008% $Na_2S_2O_3$ | 1 liter or 8 ounces | Water--7 Days until Extraction<br>40 Days after Extraction<br>Soil--14 Days until Extraction<br>40 Days after Extraction |
| Dioxins | SW8280 | G, teflon-lined Cap, T | Cool, 4°C, 0.008% $Na_2S_2O_3$ | 1 liter or 8 ounces | Water--7 Days until Extraction<br>40 Days after Extraction<br>Soil--14 Days until Extraction<br>40 Days after Extraction |
| **Radiological Tests** | | | | | |
| Alpha, Beta, and Radium | SW9310, SW9315 | P, G, T | $HNO_3$ to pH<2[2] | 2 liters or 16 ounces | 180 Days |

## Table 2-1. Requirements for Containers, Preservation Techniques, Sample Volumes, and Holding Times (Concluded)

| Name | Method of Analysis | Container[1] | Preservation | Minimum Sample Volume or Weight | Maximum Holding Time |
|---|---|---|---|---|---|
| Toxicity Characteristic Leaching Procedure (TCLP) | SW1311 | G, teflon-lined Cap, T | Cool, 4°C | 1 Liter or 8 Ounces | Volatiles--14 Days to TCLP Extraction<br>14 Days after Extraction<br>Semivolatiles--14 Days to TCLP Extraction<br>7 Days to Prep. Extraction<br>40 Days after Prep. Extraction<br>Mercury--28 Days to TCLP Extraction<br>28 Days after Extraction<br>Metals--180 Days to TCLP Extraction<br>180 Days after Extraction |
| Explosive Residues | SMO2 | P, G, T | Cool, 4°C | 1 Liter or 8 Ounces | Water and Soils--56 Days to Extraction<br>40 Days after Extraction |

[1]Polyethylene (P), Glass (G), California brass (T)

[2]No pH adjustment for soil

[3]Gas Chromatography-Flame Ionization Detection (GC-FID)

(2) Ambient conditions blanks shall be taken during each VOC sampling round. An ambient conditions blank need not be taken at every site. Ambient conditions blanks shall be collected when samples are collected downwind of possible VOC sources such as active runways or engine test cells. This blank shall be analyzed for VOCs only.

Definition: An ambient conditions blank is Type II Reagent Grade Water that is poured into a sample container at a sampling site. It shall be handled like a sample and transported to a laboratory for analysis.

(3) One equipment blank shall be taken by each sampling team on each day of sampling. This blank shall be analyzed for all laboratory analyses requested for environmental samples collected at the site.

Definition: An equipment blank is Type II Reagent Grade Water that is poured into or pumped through the sampling device, transferred to a sample bottle, and transported to a laboratory for analysis.

(4) Ten percent of all water samples shall be field duplicates. Both duplicates shall be analyzed for the same parameters in the laboratory.

Definition: Field duplicates are two samples collected independently at a sampling location during a single act of sampling. Field duplicates shall be identified so that laboratory personnel are unable to distinguish them from normal field samples.

(5) Ten percent of all soil and sediment samples shall be field replicates. Both replicates shall be analyzed for the same parameters in the laboratory.

Definition: A field replicate is a single sample divided into two equal parts for analysis. Replicates are often called "splits." Field replicates shall be identified so that laboratory personnel are unable to distinguish them from normal field samples.

(6) Type II Reagent Grade Water--The contractor shall furnish analytical data or a manufacturer's certification that verifies the quality of the Type II Reagent Grade Water and shows it to be free

of analytes and contaminants that may interfere with the required laboratory analyses. The water's electrical conductivity shall be less than 1.0 micromho/cm (25 deg C). HPLC water or distilled water from sources such as supermarkets or gas stations shall not be used in place of Type II Reagent Grade Water.

Type II Reagent Grade Water shall be purchased and stored only in glass, stainless steel, or Teflon containers. These containers shall have Teflon caps or cap liners.

2.1.3.2 Monitor Well Purging and Sampling

a. Every time a casing cap is removed to measure a water level or collect a sample, the air in the breathing zone shall be checked with an organic vapor meter and the air in the well bore shall be checked with an explosimeter. Procedures in the contractor's HSP shall be followed when high concentrations of organic vapors or explosive gases are detected.

b. Purging to remove the water standing in a monitor well shall be conducted prior to sampling.

c. All purging and sampling equipment shall be decontaminated according to the specifications of section 2.1.1.3 and protected from contamination until ready for use.

d. Purge pump intakes shall be equipped with a check valve to prevent purged water from flowing back into the well.

e. Purging and sampling shall be performed in a manner that minimizes the agitation of sediments in the well and formation. Equipment shall not be allowed to free-fall into a well.

f. Except as noted below, at least three well bore volumes shall be removed from the well before it is sampled. The well bore volume is defined as the volume of submerged casing, screen and filter pack (or submerged casing and open hole, if a screen is not used).

g. The temperature, pH, electrical conductivity (EC), and turbidity shall be measured and recorded after removing each borehole volume during purging. The sample may be collected after three bore volumes have been removed and the temperature, pH, and EC have stabilized. Stabilization is defined as follows: temperature $\pm 1$ deg C, pH $\pm 0.1$ units, EC $\pm 5$ percent. If these parameters do not stabilize, the sample shall be taken after six

bore volumes have been removed. Record the total number of well bore volumes removed.

h. Samples shall be collected after the water level has recovered to 80 percent of its static level, or 16 hours after completion of purging, whichever occurs first.

i. When a monitor well is pumped dry before three well bore volumes have been removed, the sample shall be collected as soon as a sufficient amount of fluid has reentered the well.

j. Samples shall be collected in order of increasing contamination. Samples that are expected to be least contaminated shall be collected before samples that are expected to be more contaminated.

k. Samples shall not be collected within 24 hours of monitor well development.

l. Samples to be analyzed for volatile or gaseous constituents shall not be withdrawn with pumps that exert a vacuum on the sample (e.g., centrifugal, peristaltic)

m. The portions of bailer lines that enter the water shall be stainless steel or Teflon coated.

n. The pH meters shall be calibrated immediately before a well is purged and immediately before the final value is measured. At least two buffer solutions that bracket the expected sample pH shall be used (e.g., 4.0 and 7.0).

o. EC meters shall be calibrated daily. At least two solutions that bracket the expected range of sample ECs shall be used.

p. Thermometers shall be calibrated monthly. The expected range of sample temperatures shall be bracketed.

q. Turbidity meters shall be calibrated at least daily using a standard within the expected range of sample turbidities.

r. Duplicate measurements of pH, EC, temperature, and turbidity shall be taken at a frequency of one in ten samples and used to estimate the precision of the field analytical measurements.

s. Required sample containers, preservation methods, and holding times are given in section 2.2.1. Also see table 2-1.

t. The pH of preserved samples shall be checked in the field by pouring a small amount of sample onto pH paper. The paper shall not touch the sample inside the container. Do not check the pH of acidified VOC samples.

u. Water samples requiring filtering in the SOW shall be filtered through a 0.45 μm membrane filter immediately (within five minutes) after sampling and prior to preservation. Do not use vacuum filtration or any method that may aerate the samples. Exposure of samples to atmospheric oxygen shall be kept to a minimum. In-line filtration and use of disposable filter assemblies are preferred. Filters with larger pores may be used as pre-filters. If samples are filtered, the contractor shall filter Type II Reagent Grade Water and analyze the filtered water for metals. This shall be done once per sampling round to assure that filtration does not bias sample results.

v. Samples to be analyzed for volatile constituents shall be taken first and immediately sealed in a container so that no head-space exists. These samples shall not be composited, homogenized, or filtered.

w. In addition to the information required in section 2.1.1.1, the following information shall be recorded each time a well is purged and sampled. This information shall be presented in the ITIR and encoded in IRPIMS files when required.

(1) Depth to water before and after purging.

(2) Well bore volume calculation.

(3) Sounded total depth of the monitor well.

(4) The condition of each well, including visual (mirror) survey.

(5) The thickness of any floating hydrocarbon layer.

(6) Field parameters such as pH, temperature, and specific conductance.

2.1.3.3 Soil Borings and Soil Sampling

a. Soil boring and sampling shall be supervised by a geologist, hydrogeologist, or geotechnical engineer. Decisions regarding boring locations and depths shall be made collectively by the boring supervisor and the HSD/YAQ TPM.

b. All drilling shall conform to state and local regulations. The contractor shall obtain all permits, applications, and other documents required by state and local authorities.

c. The location of all borings shall be approved in writing by the base civil engineer before drilling commences.

d. The drill rig and all equipment that enters the hole shall be decontaminated according to the specifications of section 2.1.1.3.

e. The drill rig shall not leak any fluids that may enter the hole or contaminate equipment that is placed in the hole. The use of rags or diapers to absorb leaking fluids is unacceptable. All leaking fluids shall be caught in a proper container until the leak is repaired.

f. No fluids shall be used to advance soil borings.

g. Lithologic samples shall be collected every five feet or at each change in lithology, whichever is less, or as specified in the SOW. Collect soil samples for laboratory analysis based on odors, discoloration, and organic vapor meter readings. The maximum number of soil samples for laboratory analysis, and required analyses, are specified in the SOW.

h. A standard penetration test shall be performed each time a split spoon sample is taken. The test shall be performed in accordance with ASTM D-1586.

i. Soils to be analyzed for volatile constituents shall be taken with a California (brass) ring or equivalent sampler. These samples shall not be composite or homogenized. The ends of the rings shall be covered with Teflon or oil-free metal foil. The rings shall then be sealed with end caps. In no case shall the end caps or foil be secured with tape.

j. Excavated soil shall be screened for hazardous properties as specified in section 2.1.1.2.

k. Boreholes shall be abandoned as specified in section 2.1.2.7.

l. The contractor shall dispose of all trash as directed by the base civil engineer.

m. All boreholes shall be surveyed according to the specifications of section 2.1.1.4.

n. The information specified in section 2.1.2.1.c(4) shall be recorded for each soil boring.

2.1.3.4 Surface Water and Sediment Sampling

a. Sampling equipment shall be decontaminated as specified in section 2.1.1.3.

b. Collect samples so as not to cause cross-contamination; obtain any background samples first, then the furthest downstream sample, and then move upstream toward the source or discharge point. Obtain the water sample at each location before the sediment sample. Measure and record pH, temperature, and specific conductance at each surface water sampling point. Permanently mark the location where surface water or sediment samples are collected (e.g., flagged stake in stream bank). Record the location on a project map for each site or zone, whichever applies.

c. Samples shall be taken from the active stream bed on the stream side nearest the source of contamination or suspected plume.

d. Thermometers, pH meters, and electrical conductivity meters shall be calibrated as specified in section 2.1.3.2.

e. The following records shall be maintained in addition to those specified in section 2.1.1.1:

(1) The width, depth, and flow rate of streams.

(2) Surface water conditions, e.g., floating oil or debris, gassing.

(3) The location of any discharge pipes, sewers, or tributaries.

(4) If sediment cores are taken, the percent recovery shall be recorded.

2.1.3.5 Soil Gas Sampling and Analysis

a. The analysis of soil gas samples shall conform to the requirements of sections 2.2.2, 2.2.3, 2.2.5, 2.2.6, and 2.2.8. The soil gas analytical equipment shall be calibrated initially by using certified gas standards at selected concentrations to form multipoint calibration curves for all analytes. At a minimum, continuing daily calibration shall be done using a single point gas standard to verify the initial calibration curve. In addition, periodic system blank analyses shall be performed to assure a contaminant free sampling system.

b. In addition to the information listed in section 2.1.1.1, the following information shall be recorded. If only qualitative data are required, only items 1 and 6 are needed.

(1) Soil gas sample or probe depth.

(2) Apparent moisture content (dry, moist, saturated) of the sampled zone.

(3) Soil gas purge rate, sampling system leak rate, and pump vacuum.

(4) Description of sample containers (if any).

(5) Location of sample analysis.

(6) Location and grid layout of sampling stations.

2.1.3.6 Suction Lysimeters

a. Lysimeters shall be installed in four-inch (nominal) diameter borings. No fluids (including air) shall be used to advance the borings.

b. The excavated soil shall be saved for backfilling and not allowed to dry.

c. Soil excavated from the bottom six-inches of the boring shall be loosened and pebbles greater than 1/4-inch in diameter removed. The soil shall be placed around the porous cup and tamped to ensure intimate contact between the cup and soil.

d. Unless prior authorization is given by the HSD/YAQ TPM, soil slurries shall not be placed around the porous cup. If a slurry is necessary, Reagent Grade II Water shall be used. The volume of water added shall

be recorded. At a minimum, the volume of slurry shall be drawn and discarded before samples are taken for analysis. In all cases where a slurry is used, the first volume of sample that enters the lysimeter shall be discarded.

e. Excavated soil shall be backfilled in the horizon from which it came and tamped to a density approximating its undisturbed condition. The soil shall be backfilled in lifts not greater than one foot.

f. A three-inch thick bentonite plug shall be placed six inches below land surface to prevent fluids from running down the boring.

g. The porous cups shall be saturated with Reagent Grade II Water at the time of installation so that gas will not enter the sampler. The cup may be saturated by placing an evacuated lysimeter in a container of water. The saturated cups may be stored for several hours in a sealed plastic bag containing a saturated towel or sponge.

h. All lysimeters and associated equipment (e.g., pump used to expel sample) shall be decontaminated according to the specifications in section 2.1.1.3.

i. Samples collected from suction lysimeters shall be preserved and handled the same as groundwater samples.

j. In addition to the information required in section 2.1.1.1, the following information shall be recorded:

   (1) The depth at which the porous cup is installed.

   (2) The final pressure at the time the lysimeter is evacuated and the pressure at the time the lysimeter is sampled.

   (3) The time between lysimeter evacuation and sampling.

## 2.2 LABORATORY ANALYSIS

This section presents requirements that shall be followed during all IRP activities for fixed base, mobile and field laboratories, and analysis of all environmental media. Reported analytical results that do not meet the criteria in this section and those specified in the SAP for analyte lists; method calibrations; detection and quantitation limits; control limits for surrogates or spikes; and duplicates shall be resampled and/or reanalyzed at no cost to the Government.

2.2.1 Sample Preservation and Holding Times

a. Project samples shall be preserved and analyzed within the time intervals specified in table 2-1. Samples not preserved and analyzed in accordance with these requirements shall be resampled and analyzed within the specified holding times at no cost to the Government.

b. Sample preservation and temperature shall be checked immediately upon receipt of samples at the laboratory. The results of these checks shall be recorded on the chain-of-custody form submitted with the sample.

c. For samples analyzed by gas chromatography, first-column analysis and second column confirmations shall be completed within the holding times specified above. If the holding time is exceeded on a second-column confirmation, the contractor shall resample and reanalyze the sample at no cost to the Government, even if the first-column analysis was conducted within the holding time.

d. Extraction is defined as completion of the sample preparation process as described in the applicable method, including any necessary extract cleanup prior to volume reduction procedures.

e. Analysis completion is defined as completion of all analytical runs, including dilutions, second-column confirmations, and any required re-analyses.

2.2.2 Instrument Calibration

a. Analytical instruments shall be periodically calibrated in accordance with the methods of analysis specified in the SOW. Records of standard preparation and instrument calibration shall be maintained.

b. Instrument calibration shall be checked using material prepared independently of the calibration standards at the frequency specified in the method, or daily, whichever is more frequent. Control limits shall be established and recorded for evaluating the instrument response to the calibration check.

c. Both of the calibration requirements specified in subsections "a" and "b" shall meet the method specified or SAP approved criteria prior to analysis of project samples.

2.2.3 Detection and Quantitation Limits

a. The laboratory shall establish detection limits for each analyte listed in the SOW using procedures outlined in one of the following references:

- The applicable EPA SW-846 publication protocol or standard method.
- 40 Code of Federal Regulations (CFR) 136, Appendix B.
- "Principles of Environmental Analysis" (*Analytical Chemistry*, Vol 55, paper 2210-2218, Dec 1983).
- The most recent EPA Contract Laboratory Program (EPA-CLP) SOW.

b. The detection limits established by the laboratory shall not exceed those in table 2-2. The laboratory shall maintain records of the determinations, and of the comparison with the limits in the table.

c. A practical quantitation limit shall be experimentally established or derived and verified for each analyte to be analyzed as part of the SOW. These limits shall be based upon the results of spiking at the estimated quantitation limit in accordance with SW-846 protocols, or the results of matrix spiking of past HSD/YAQ samples or samples of similar matrix. these limits shall not exceed those in table 2-2. The procedure used to determine quantitation limits shall be fully explained in section 1.8.2 of the SAP.

d. All analytes detected above the quantitation limit shall be reported as quantitative with a known accuracy and precision. All analytes detected at a concentration less than the quantitation limit shall be reported and qualified as estimated.

e. The analyte lists, detection, and quantitation limits established by the laboratory shall be submitted to HSD/YAQ in the SAP for approval prior to the analysis of any project samples. Documentation supporting the establishment of detection and quantitation limits, such as chromatograms, calculations, etc., shall be made available to the TPM upon request.

f. All requests for variations from the requirements of this section (2.2) shall be submitted in writing to HSD/YAQ prior to analysis of any project samples.

**Table 2-2. Maximum Allowable Quantitation Limits**

| Parameter | Method W-Water S-Soil | Analyte | | Maximum Quantitation Limits Water | | Soil/Sediment (mg/kg) (f) |
|---|---|---|---|---|---|---|
| Alkalinity | A403(W) | Carbonate | | 10 | mg/L | - |
| | | Bicarbonate | | 10 | mg/L | - |
| | | Hydroxide | | 10 | mg/L | - |
| Gross Alpha & Gross Beta Radioactivity (Total Suspended and Dissolved) | SW9310 | | | 4 | pCi/L(a) | (b) |
| Radium | SW9315 | | | 1 | pCi/L(a) | (b) |
| Residue, Filterable | E160.1(W) | Total Dissolved Solids | | 10 | mg/L | - |
| Residue, Nonfilterable | E160.2(W) | Total Suspended Solids | | 5 | mg/L | - |
| Common Anions | E300(W) | Chloride | | 0.2 | mg/L | - |
| | | Fluoride | | 0.2 | mg/L | - |
| | | Sulfate | | 0.2 | mg/L | - |
| | | Nitrate | | 0.1 | mg/L | - |
| | | Ortho-Phosphate | | 0.1 | mg/L | - |
| Nitrogen, Nitrate+nitrite | E353.2(W) | Nitrate+nitrite | | 0.05 | mg/L | - |
| Petroleum Hydrocarbons | E418.1(W) SW3550/E418.1(S) | | | 1 | mg/L | 30 |
| | SW8015 (Modified) | Gasoline | | 1.0 | mg/L | 10 |
| | | Diesel, jet fuel | | 1.0 | mg/L | 10 |
| 1,2-Dibromoethane (EDB) | SW8011 | | | 0.05 | µg/L | (b) |
| Arsenic (d) | SW7060(W & S) | | | 0.005 | mg/L | 0.5 |
| Lead (d) | SW3005/SW7421(W & S) | | | 0.005 | mg/L | 0.5 |
| Mercury | SW7470(W) SW7471(S) | | | 0.001 | mg/L | 0.1 |
| Selenium (d) | SW7740(W & S) | | | 0.005 | mg/L | 0.5 |
| ICP Screen for Metals | SW3005/SW6010(W) SW3050/SW6010(S) | Aluminum | Al | 0.5 | mg/L | 50 |
| | | Antimony | Sb | 0.5 | mg/L | 15 |
| | | Arsenic | As | 0.3 | mg/L | 30 |
| | | Barium | Ba | 0.1 | mg/L | 10 |
| | | Beryllium | Be | 0.01 | mg/L | 1 |
| | | Cadmium | Cd | 0.005 | mg/L | 0.5 |
| | | Calcium | Ca | 1 | mg/L | 100 |
| | | Chromium | Cr | 0.05 | mg/L | 5 |
| | | Cobalt | Co | 0.05 | mg/L | 5 |
| | | Copper | Cu | 0.05 | mg/L | 5 |
| | | Iron | Fe | 0.05 | mg/L | 5 |
| | | Lead | Pb | 0.2 | mg/L | 5 |

**Table 2-2. Maximum Allowable Quantitation Limits (Continued)**

| Parameter | Method W-Water S-Soil | Analyte | | Maximum Quantitation Limits Water | | Soil/Sediment (mg/kg) (f) |
|---|---|---|---|---|---|---|
| | | Magnesium | Mg | 1 | mg/L | 100 |
| | | Manganese | Mn | 0.02 | mg/L | 2 |
| | | Molybdenum | Mo | 0.10 | mg/L | 10 |
| | | Nickel | Ni | 0.15 | mg/L | 15 |
| | | Potassium | K | 5 | mg/L | 100 |
| | | Selenium | Se | 1 | mg/L | 50 |
| | | Silver | Ag | 0.05 | mg/L | 5 |
| | | Sodium | Na | 1 | mg/L | 100 |
| | | Thallium | Tl | 0.4 | mg/L | 7 |
| | | Vanadium | V | 0.10 | mg/L | 10 |
| | | Zinc | Zn | 0.02 | mg/L | 2 |
| Purgeable Halocarbons | SW5030/SW8010 (W & S) | Bromobenzene | | 5 | µg/L | 0.05 |
| | | Bromodichloromethane | | 1.0 | µg/L | 0.05 |
| | | Bromoform | | 2.0 | µg/L | 0.05 |
| | | Bromomethane | | 10 | µg/L | 0.010 |
| | | Carbon tetrachloride | | 1.0 | µg/L | 0.005 |
| | | Chlorobenzene | | 2.5 | µg/L | 0.005 |
| | | Chloroethane | | 5 | µg/L | 0.005 |
| | | Chloroform | | 0.5 | µg/L | 0.005 |
| | | 1-Chlorohexane | | 5 | µg/L | 0.005 |
| | | 2-Chloroethyl vinyl ether | | 10 | µg/L | 0.010 |
| | | Chloromethane | | 1.0 | µg/L | 0.005 |
| | | Dibromochloromethane | | 1.0 | µg/L | 0.005 |
| | | Dibromoethane | | 5 | µg/L | 0.005 |
| | | 1,2-Dichlorobenzene | | 2.0 | µg/L | 0.005 |
| | | 1,3-Dichlorobenzene | | 3.0 | µg/L | 0.005 |
| | | 1,4-Dichlorobenzene | | 2.0 | µg/L | 0.005 |
| | | 1,1-Dichloroethane | | 1.0 | µg/L | 0.005 |
| | | 1,2-Dichloroethane | | 1.0 | µg/L | 0.005 |
| | | 1,1-Dichloroethene | | 1.0 | µg/L | 0.005 |
| | | trans-1,2-Dichloroethene | | 1.0 | µg/L | 0.005 |
| | | Cis-1,3-Dichloropropene | | 5 | µg/L | 0.005 |
| | | 1,2-Dichloropropane | | 1.0 | µg/L | 0.005 |
| | | trans-1,3-Dichloropropene | | 3 | µg/L | 0.005 |
| | | Methylene chloride | | 2 | µg/L | 0.005 |
| | | 1,1,1,2-Tetrachloroethane | | 5 | µg/L | 0.005 |
| | | 1,1,2,2-Tetrachloroethane | | 1.0 | µg/L | 0.005 |
| | | Tetrachloroethene | | 1.0 | µg/L | 0.005 |
| | | 1,1,1-Trichloroethane | | 1.0 | µg/L | 0.005 |
| | | 1,1,2-Trichloroethane | | 1.0 | µg/L | 0.005 |
| | | Trichloroethene | | 1.0 | µg/L | 0.005 |
| | | Trichlorofluoromethane | | 1.0 | µg/L | 0.005 |
| | | Trichloropropene | | 10 | µg/L | 0.010 |
| | | Vinyl Chloride | | 2.0 | µg/L | 0.005 |
| Nonhalogenated Volatile Organics | SW5030/SW8015 (W) | Diethyl ether | | 50 | µg/L | (b) |
| | | Ethanol | | 50 | µg/L | |
| | | Methyl ethyl ketone (MEK) | | 50 | µg/L | |
| | | Methyl isobutyl ketone (MIBK) | | 50 | µg/L | |

**Table 2-2. Maximum Allowable Quantitation Limits (Continued)**

| Parameter | Method W-Water S-Soil | Analyte | Maximum Quantitation Limits Water | | Soil/Sediment (mg/kg) (f) |
|---|---|---|---|---|---|
| Purgeable Aromatic Volatiles | SW5030/SW8020 (W & S) | Benzene | 1.0 | µg/L | 0.01 |
| | | Chlorobenzene | 2 | µg/L | 0.02 |
| | | 1,2-Dichlorobenzene | 4 | µg/L | 0.04 |
| | | 1,3-Dichlorobenzene | 4 | µg/L | 0.04 |
| | | 1,4-Dichlorobenzene | 0.5 | µg/L | 0.01 |
| | | Ethylbenzene | 4 | µg/L | 0.04 |
| | | Toluene | 2 | µg/L | 0.02 |
| | | Xylenes | 2 | µg/L | 0.02 |
| Phenols | SW8040 | 4-Chloro-3-methylphenol | 4 | µg/L | 0.3 |
| | | 2-Chlorophenol | 3 | µg/L | 0.2 |
| | | 2,4-Dichlorophenol | 4 | µg/L | 0.3 |
| | | 2,4-Dimethylphenol | 3 | µg/L | 0.2 |
| | | 2,4-Dinitrophenol | 130 | µg/L | 10 |
| | | 2-Methyl-4,6-dinitrophenol | 160 | µg/L | 10 |
| | | 2-Nitrophenol | 5 | µg/L | 0.4 |
| | | 4-Nitrophenol | 30 | µg/L | 2 |
| | | Pentachlorophenol | 30 | µg/L | 2 |
| | | Phenol | 2 | µg/L | 0.2 |
| | | 2,4,6-Trichlorophenol | 7 | µg/L | 5 |
| Organochlorine Pesticides & PCBs | SW3510/SW8080(W) SW3550/SW8080(S) | Aldrin | 0.04 | µg/L | 0.0015 |
| | | alpha-BHC | 0.03 | µg/L | 0.0015 |
| | | beta-BHC | 0.05 | µg/L | 0.0015 |
| | | delta-BHC | 0.05 | µg/L | 0.0015 |
| | | gamma-GHC (Lindane) | 0.04 | µg/L | 0.0015 |
| | | Chlordane | 0.05 | µg/L | 0.0015 |
| | | 4,4'-DDD | 0.1 | µg/L | 0.003 |
| | | 4,4'-DDE | 0.04 | µg/L | 0.003 |
| | | 4,4'-DDT | 0.10 | µg/L | 0.003 |
| | | Dieldrin | 0.05 | µg/L | 0.003 |
| | | Endosulfan I | 0.05 | µg/L | 0.0015 |
| | | Endosulfan II | 0.1 | µg/L | 0.003 |
| | | Endosulfan sulfate | 0.1 | µg/L | 0.003 |
| | | Endrin | 0.06 | µg/L | 0.003 |
| | | Endrin aldehyde | 0.1 | µg/L | 0.003 |
| | | Heptachlor | 0.03 | µg/L | 0.002 |
| | | Heptachlor epoxide | 0.05 | µg/L | 0.002 |
| | | Methoxychlor | 0.5 | µg/L | 0.015 |
| | | Toxaphene | 2.5 | µg/L | 0.16 |
| | | PCB-1016 | 1.0 | µg/L | 0.03 |
| | | PCB-1221 | 1.0 | µg/L | 0.03 |
| | | PCB-1232 | 1.0 | µg/L | 0.03 |
| | | PCB-1242 | 1.0 | µg/L | 0.03 |
| | | PCB-1248 | 1.0 | µg/L | 0.03 |
| | | PCB-1254 | 1 | µg/L | 0.03 |
| | | PCB-1260 | 1 | µg/L | 0.03 |

**Table 2-2. Maximum Allowable Quantitation Limits (Continued)**

| Parameter | Method W-Water S-Soil | Analyte | Maximum Quantitation Limits Water | | Soil/Sediment (mg/kg) (f) |
|---|---|---|---|---|---|
| Organophosphorus Pesticides | SW3510/SW8140(W) SW3550/SW8140(S) | Azinphos methyl | 15 | µg/L | 1.0 |
| | | Bolstar | 1.5 | µg/L | 0.1 |
| | | Chorpyrifos | 3.0 | µg/L | 0.2 |
| | | Coumaphos | 15 | µg/L | 1.0 |
| | | Demeton-O | 2.5 | µg/L | 0.2 |
| | | Demeton-S | 2.5 | µg/L | 0.2 |
| | | Diazinon | 6.0 | µg/L | 0.4 |
| | | Dichlorvos | 10.0 | µg/L | 0.7 |
| | | Disulfoton | 2.0 | µg/L | 0.1 |
| | | Ethoprop | 2.5 | µg/L | 0.2 |
| | | Fensulfothion | 15 | µg/L | 1.0 |
| | | Fenthion | 1.0 | µg/L | 0.1 |
| | | Merphos | 2.5 | µg/L | 0.2 |
| | | Mevinphos | 3.0 | µg/L | 0.2 |
| | | Naled | 1.0 | µg/L | 0.1 |
| | | Parathion methyl | 0.3 | µg/L | 0.02 |
| | | Phorate | 1.5 | µg/L | 0.10 |
| | | Ronnel | 3.0 | µg/L | 0.2 |
| | | Stirophos | 50 | µg/L | 3.4 |
| | | Tokuthion | 5.0 | µg/L | 0.4 |
| | | Trichloronate | 1.5 | µg/L | 0.1 |
| Chlorinated Phenoxy Acid Herbicides | SW8150(W & S) | 2,4-D | 12 | µg/L | 0.8 |
| | | 2,4-DB | 9 | µg/L | 0.6 |
| | | 2,4,5-T | 2 | µg/L | 0.1 |
| | | 2,4,5-TP | 1.7 | µg/L | 0.1 |
| | | Dalapon | 60 | µg/L | 4.0 |
| | | Dicamba | 2.7 | µg/L | 0.2 |
| | | Dichloroprop | 6.5 | µg/L | 0.5 |
| | | Dinoseb | 0.7 | µg/L | 0.05 |
| | | MCPA | 2500 | µg/L | 170 |
| | | MCPP | 1900 | µg/L | 130 |
| Semivolatile Organic Compounds | SW3510/SW8270(W) SW3550/SW8270(S) | **Base/Neutral Extractables** | | | |
| | | Acenapthene | 10 | µg/L | 0.3 |
| | | Acenaphthylene | 10 | µg/L | 0.3 |
| | | Anthracene | 10 | µg/L | 0.3 |
| | | Benzo (a) anthracene | 10 | µg/L | 0.3 |
| | | Benzo (b) fluoranthene | 10 | µg/L | 0.3 |
| | | Benzo (k) fluoranthene | 10 | µg/L | 0.3 |
| | | Benzo (g,h,i) perylene | 10 | µg/L | 0.3 |
| | | Benzo (a) pyrene | 10 | µg/L | 0.3 |
| | | Benzyl alcohol | 10 | µg/L | 0.3 |
| | | bis (2-Chloroethoxy) methane | 10 | µg/L | 0.3 |
| | | bis (2-Chloroethyl) ether | 10 | µg/L | 0.3 |
| | | bis (2-Chloroisopropyl) ether | 10 | µg/L | 0.3 |
| | | bis (2-ethylhexyl) phthalate | 10 | µg/L | 0.3 |
| | | 4-Bromophenyl phenyl ether | 10 | µg/L | 0.3 |
| | | Butyl benzyl phthalate | 10 | µg/L | 0.3 |
| | | 4-Chloroaniline | 10 | µg/L | 0.3 |
| | | 2-Chloronaphthalene | 10 | µg/L | 0.3 |

**Table 2-2. Maximum Allowable Quantitation Limits (Continued)**

| Parameter | Method W-Water S-Soil | Analyte | Maximum Quantitation Limits Water | | Soil/Sediment (mg/kg) (f) |
|---|---|---|---|---|---|
| | | 4-Chlorophenyl phenyl ether | 10 | µg/L | 0.3 |
| | | Chrysene | 10 | µg/L | 0.3 |
| | | Dibenz (a,h) anthracene | 10 | µg/L | 0.3 |
| | | Dibenzofuran | 10 | µg/L | 0.3 |
| | | Di-n-Butylphthalate | 10 | µg/L | 0.3 |
| | | 1,2-Dichlorobenzene | 10 | µg/L | 0.3 |
| | | 1,3-Dichlorobenzene | 10 | µg/L | 0.3 |
| | | 1,4-Dichlorobenzene | 10 | µg/L | 0.3 |
| | | 3,3'-Dichlorobenzidine | 20 | µg/L | 0.6 |
| | | Diethyl phthalate | 10 | µg/L | 0.3 |
| | | Dimethly phthalate | 10 | µg/L | 0.3 |
| | | 2,4-Dinitrotoluene | 10 | µg/L | 0.3 |
| | | 2,6-Dinitrotoluene | 10 | µg/L | 0.3 |
| | | Di-n-octyl phthalate | 10 | µg/L | 0.3 |
| | | Fluoranthene | 10 | µg/L | 0.3 |
| | | Fluorene | 10 | µg/L | 0.3 |
| | | Hexachlorobenzene | 10 | µg/L | 0.3 |
| | | Hexachlorobutadiene | 10 | µg/L | 0.3 |
| | | Hexachlorocyclopentadiene | 10 | µg/L | 0.3 |
| | | Hexachloroethane | 10 | µg/L | 0.3 |
| | | Indeno (1,2,3,-cd) pyrene | 10 | µg/L | 0.3 |
| | | Isophorone | 10 | µg/L | 0.3 |
| | | 2-Methylnaphthalene | 10 | µg/L | 0.3 |
| | | Naphthalene | 10 | µg/L | 0.3 |
| | | 2-Nitroaniline | 50 | µg/L | 1.6 |
| | | 3-Nitroaniline | 50 | µg/L | 1.6 |
| | | 4-Nitroaniline | 50 | µg/L | 1.6 |
| | | Nitrobenzene | 10 | µg/L | 0.3 |
| | | n-Nitrosodiphenylamine | 10 | µg/L | 0.3 |
| | | n-Nitrosodipropylamine | 10 | µg/L | 0.3 |
| | | Phenanthrene | 10 | µg/L | 0.3 |
| | | Pyrene | 10 | µg/L | 0.3 |
| | | 1,2,4-Trichlorobenzene | 10 | µg/L | 0.3 |
| | | **Acid Extractables** | | | |
| | | Benzoic acid | 50 | µg/L | 1.6 |
| | | 4-Chloro-3-methylphenol | 10 | µg/L | 0.3 |
| | | 2-Chlorophenol | 10 | µg/L | 0.3 |
| | | 2,4-Dichlorophenol | 10 | µg/L | 0.3 |
| | | 2,4-Dimethylphenol | 10 | µg/L | 0.3 |
| | | 4,6-Dinitro-2-methylphenol | 50 | µg/L | 1.6 |
| | | 2,4-Dinitrophenol | 50 | µg/L | 1.6 |
| | | 2-Methylphenol | 10 | µg/L | 0.3 |
| | | 4-Methylphenol | 10 | µg/L | 0.5 |
| | | 2-Nitrophenol | 10 | µg/L | 0.3 |
| | | 4-Nitrophenol | 50 | µg/L | 1.6 |
| | | Pentachlorophenol | 30 | µg/L | 1.0 |
| | | Phenol | 10 | µg/L | 0.3 |
| | | 2,4,5-Trichlorophenol | 50 | µg/L | 1.6 |
| | | 2,4,6-Trichlorophenol | 10 | µg/L | 0.3 |

**Table 2-2. Maximum Allowable Quantitation Limits (Continued)**

| Parameter | Method W-Water S-Soil | Analyte | Maximum Quantitation Limits Water | | Soil/Sediment (mg/kg) (f) |
|---|---|---|---|---|---|
| Volatile Organic Compounds (VOCs) | SW8240 (W & S) SW8260[h] | Acetone | 10 | µg/L | 0.010 |
| | | Benzene | 5 | µg/L | 0.005 |
| | | Bromodichloromethane | 5 | µg/L | 0.005 |
| | | Bromoform | 5 | µg/L | 0.005 |
| | | Bromomethane | 10 | µg/L | 0.010 |
| | | 2-Butanone (MEK) | 10 | µg/L | 0.010 |
| | | Carbon disulfide | 5 | µg/L | 0.005 |
| | | Carbon tetrachloride | 5 | µg/L | 0.005 |
| | | Chlorobenzene | 5 | µg/L | 0.005 |
| | | Dibromochloromethane | 5 | µg/L | 0.005 |
| | | Chloroethane | 10 | µg/L | 0.010 |
| | | 2-Chloroethyl vinyl ether | 10 | µg/L | 0.010 |
| | | Chloroform | 5 | µg/L | 0.005 |
| | | Chloromethane | 10 | µg/L | 0.010 |
| | | 1,1-Dichloroethane | 5 | µg/L | 0.005 |
| | | 1,2-Dichloroethane | 5 | µg/L | 0.005 |
| | | 1,1-Dichloroethene | 5 | µg/L | 0.005 |
| | | trans-1,2-Dichloroethene | 5 | µg/L | 0.005 |
| | | 1,2-Dichloropropane | 5 | µg/L | 0.005 |
| | | cis-1,3-Dichloropropene | 5 | µg/L | 0.005 |
| | | trans-1,3-Dichloropropene | 5 | µg/L | 0.005 |
| | | Ethylbenzene | 5 | µg/L | 0.005 |
| | | 2-Hexanone | 10 | µg/L | 0.010 |
| | | Methylene chloride | 5 | µg/L | 0.005 |
| | | 4-Methyl-2-pentanone (MIBK) | 10 | µg/L | 0.010 |
| | | Styrene | 5 | µg/L | 0.005 |
| | | 1,1,2,2-Tetrachloroethane | 5 | µg/L | 0.005 |
| | | Tetrachloroethene | 5 | µg/L | 0.005 |
| | | Toluene | 5 | µg/L | 0.005 |
| | | 1,1,1-Trichloroethane | 5 | µg/L | 0.005 |
| | | 1,1,2-Trichloroethane | 5 | µg/L | 0.005 |
| | | Trichloroethene | 5 | µg/L | 0.005 |
| | | Vinyl acetate | 10 | µg/L | 0.010 |
| | | Vinyl chloride | 10 | µg/L | 0.010 |
| | | Xylenes (total all isomers) | 5 | µg/L | 0.005 |
| Dioxins | SW8280 (W & S) | | 10 ng/L (e) | | 0.01 µg/kg (e) |
| Polynuclear Aromatic Hydrocarbons | SW8310 | Naphthalene | 18 | µg/L | 1.0 |
| | | Acenaphthylene | 23 | µg/L | 1.5 |
| | | Acenaphthene | 18 | µg/L | 1.0 |
| | | Fluorene | 2 | µg/L | 0.1 |
| | | Phenanthrene | 6 | µg/L | 0.4 |
| | | Anthracene | 7 | µg/L | 0.5 |
| | | Fluoranthrene | 2 | µg/L | 0.1 |
| | | Pyrene | 3 | µg/L | 0.2 |
| | | Benzo(a)anthracene | 1 | µg/L | 0.01 |
| | | Chrysene | 1.5 | µg/L | 0.10 |
| | | Benzo(b)fluoranthene | 1 | µg/L | 0.01 |
| | | Benzo(k)fluoranthene | 1 | µg/L | 0.01 |

**Table 2-2. Maximum Allowable Quantitation Limits (Continued)**

| Parameter | Method W-Water S-Soil | Analyte | Maximum Quantitation Limits Water | Soil/Sediment (mg/kg) (f) | |
|---|---|---|---|---|---|
| | | Benzo(a)pyrene | 1 | µg/L | 0.01 |
| | | Dibenzo(a,h)anthracene | 1 | µg/L | 0.01 |
| | | Benzo(g,h,i)perylene | 1 | µg/L | 0.01 |
| | | Indeno(1,2,3-cd)pyrene | 1 | µg/L | 0.01 |
| Phenols (total) | SW9065 (W) | | 0.02 | mg/L | - |
| Cyanide (total) | SW9010(c) | | 0.02 | mg/L | 1.0 |
| Toxicity Characteristic Leaching Procedure | SW1311 | Arsenic | 5.0 | mg/L | - |
| | | Barium | 100.0 | mg/L | - |
| | | Cadmium | 1.0 | mg/L | - |
| | | Chromium | 5.0 | mg/L | - |
| | | Lead | 5.0 | mg/L | - |
| | | Mercury | 0.2 | mg/L | - |
| | | Selenium | 1.0 | mg/L | - |
| | | Silver | 5.0 | mg/L | - |
| | | Endrin | 0.02 | mg/L | - |
| | | Lindane | 0.4 | mg/L | - |
| | | Methoxychlor | 10.0 | mg/L | - |
| | | Toxaphene | 0.5 | mg/L | - |
| | | 2,4-D | 10.0 | mg/L | - |
| | | 2,4,5-TP (Silvex) | 1.0 | mg/l | - |
| | | Benzene | 0.5 | mg/L | - |
| | | Carbon tetrachloride | 0.5 | mg/L | - |
| | | Chlordane | 0.03 | mg/L | - |
| | | Chlorobenzene | 100.0 | mg/L | - |
| | | Chloroform | 6.0 | mg/L | - |
| | | o-Cresol | 200.0 | mg/L | - |
| | | m-Cresol | 200.0 | mg/L | - |
| | | p-Cresol | 200.0 | mg/L | - |
| | | Cresol (total) | 200.0 | mg/L | - |
| | | 1,4-Dichlorobenzene | 7.5 | mg/L | - |
| | | 1,2-Dichlorethane | 0.5 | mg/L | - |
| | | 1,1-Dichloroethylene | 0.7 | mg/L | - |
| | | 2,4-Dinitrotoluene | 0.1 | mg/L | - |
| | | Heptachlor (and its epoxide) | 0.008 | mg/L | - |
| | | Hexachlorobenzene | 0.1 | mg/L | - |
| | | Hexachloro-1,3-butadiene | 0.5 | mg/L | - |
| | | Hexachloroethane | 3.0 | mg/L | - |
| | | Methyl ethyl ketone | 200.0 | mg/L | - |
| | | Nitrobenzene | 2.0 | mg/L | - |
| | | Pentachlorophenol | 100.0 | mg/L | - |
| | | Pyridine | 5.0 | mg/L | - |
| | | Tetrachloroethylene | 0.7 | mg/L | - |
| | | Trichloroethylene | 0.5 | mg/L | - |
| | | 2,3,5-Trichlorophenol | 400.0 | mg/L | - |
| | | 2,4,6-Trichlorophenol | 2.0 | mg/L | - |
| | | Vinyl Chloride | 0.2 | mg/L | - |

**Table 2-2. Maximum Allowable Quantitation Limits (Concluded)**

| Parameter | Method W-Water S-Soil | Analyte | Maximum Quantitation Limits Water | Soil/Sediment (mg/kg) (f) |
|---|---|---|---|---|
| Air Analyses | | | | |
| Volatile Organic Compounds, non-polar | TO-1, TO-2 | (g) | (b) | |
| Organochlorine Pesticides and PCBS | TO-4 | (g) | (b) | |
| Phenols | TO-9 | (g) | (b) | |
| Dioxins | TO-9 | (g) | (b) | |
| Polynuclear Aromatic Hydrocarbons | TO-13 | (g) | (b) | |
| Volatile Organics in connisters | TO-14 | (g) | (b) | |

a. Report must include calibration standards and precision data.
b. Establish limits of detection and quantitation at time of analysis or specify in the SAP.
c. Leach cyanides from soil samples using method SW9010(A).
d. For furnace analyses modify the SW3005 digestion procedure by substituting 4 milliliters concentrated nitric acid for the 5 milliliters concentrated hydrochloric acid specified by the method (a total of 7 milliliters nitric acid will be added).
e. Detection limit per congener as in method SW8280.
f. Detection limits given are for the low-level method. Mid and high-level methods would have a corresponding adjustment in limits that will be specified in the SAP. These specified levels shall be verified by matrix spiking per paragraph 2.2.5.
g. Listed in the "Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air," June 1988, EPA/600/4-89/017.
h. This method may be substituted for method SW8240 on a project-specific basis when lower reporting limits are required. This method should be specified in the SAP with detection and quantitation limits similar to those for methods SW8010/SW8020.

2.2.4 Analyte Identification

a. For gas chromatography methods, analyte retention times and retention time windows shall be established using the procedure in the appropriate method and used to ensure accurate identification of peaks.

b. For gas chromatography methods, confirmation of analytes present in concentrations greater than detection limits is required as specified in the SOW. Quantitative confirmation may be made by either second-column gas chromatography or by gas chromatography/mass spectroscopy (GC/MS), and the data from both the initial analysis and the confirmation shall be reported. The primary result is the more accurate concentration reported for the analyte after the first- and second-column results have been evaluated by the laboratory. It is normally selected by evaluating chromatographic peaks, calibration events, and quality control. The primary result shall not be obtained by averaging the first- and second-column results.

2.2.5 Quality Assurance and Quality Control

a. The laboratory shall identify control parameters for each analytical method, experimentally establish control limits and reevaluate them at regular intervals, and take scheduled control measurements to detect trends and out-of-limit values. Records of these activities shall be maintained by the laboratory. EPA-CLP or method-specified control limits are unacceptable substitutions for laboratory generated control limits except when the laboratory limits are outside the method-specified limits. The laboratory is allowed to default to method-specified limits as long as it is in the process of performing corrective actions to bring their limits to within those of the published method.

b. Laboratory QC samples (e.g., blanks, matrix spikes, matrix spike duplicates, external control materials), must be included with the analyses of all field samples, as detailed in the contractor's SAP. At a minimum, the laboratory must analyze the QC samples specified in the analytical method at the frequency indicated by the method. At least one matrix spike/matrix spike duplicate pair shall be analyzed for every 20 project samples. The spiking solutions shall include all analytes of interest as specified in the SW846 methods and approved in the SAP. The contractor may supplement the QC samples required by the method to ensure accurate and precise data; however, no increase in the contract analytical price will be permitted.

c. The exceedance of control limits or presence of analytes in laboratory blanks at concentrations greater than three times the detection limits as determined in the laboratory and approved in the SAP indicates a need for corrective action. Quanititation and detection limits shall not be raised because of blank contamination. Corrective actions shall be performed prior to proceeding with reanalysis. No analytical data shall be corrected for the presence of analytes in blanks.

d. Environmental samples shall be grouped in specific analytical batches. Each batch shall include enough calibration and QC events to allow it to stand as an autonomous data set. The identity of each batch shall be unambiguously reported with the analytical data (see the latest version of the IRPIMS Data Loading Handbook).

2.2.6 Corrective Action

a. Corrective actions shall be implemented whenever laboratory blank contamination is detected or QC sample results exceed control limits.

b. All corrective actions associated with the project defined in the SOW shall be documented and the records shall be submitted with analytical results in ITIRs and Technical Reports.

2.2.7 Completeness

The laboratory shall establish a measure of completeness objective for the analytical results of the environmental samples analyzed for this project. Completeness shall be specified in the SAP for any of several aggregations of analytical data including groups of samples, analytical batches, analytical methods, and analytes within a method. Failure to achieve the completeness criteria approved by HSD/YAQ in the SAP shall require resampling and reanalysis at no cost to the government.

2.2.8 Record Keeping

a. The laboratory shall maintain records sufficient to recreate each analytical event conducted pursuant to the SOW. At a minimum the records shall contain the following:

- Chain-of-custody forms.

- Initial and continuous calibration records including standards preparation traceable to the original material and lot number.

- Instrument tuning records, if applicable.
- Method blank analyses.
- Internal standard results, if applicable.
- Surrogate spiking and results (if required).
- Spike and spike duplicate records and results.
- Laboratory duplicate records and results (if done).
- Raw data including instrument printouts, bench work sheets, and/or chromatogram with compound identification, and quantitation reports.
- Other QC samples and results (e.g., inductively coupled plasma [ICP] interference check standards results, results of the matrix quantitation limit studies, and the results of blank spiking).

b. The laboratory shall maintain and use written procedures for each analytical method and QA/QC function.

c. Laboratory data shall be presented in hard copy and computerized formats consistent with the SOW, this Handbook, and the latest version of the IRPIMS Data Loading Handbook.

d. The following units of measure shall be used for reporting analytical results:

Water samples--Inorganics and metals: mg/L

Water samples--Organics: µg/L

Water samples--Radioactivity: pCi/L

Soil and sediment samples--Organics, inorganics, and metals: mg/kg, dry basis

Soil and sediment samples--Radioactivity: pCi/kg, dry basis

Water, soil, and sediment samples--Toxicity Characteristic Leaching Procedure (TCLP): mg/L for all analytes

Soil Gas--GC or GC/MS: parts per billion of analyte by volume

Soil Gas--OVA and HNu: parts per million of calibration gas by volume

e. Dry Basis--Report moisture content for each soil/sediment sample. The contractor shall modify the equation for moisture content given in ASTM D-2216 as follows:

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

where, w = moisture content, percent by weight

W1 = weight of container and sample as received

W2 = weight of container and ovendried sample

WC = weight of container

## 2.3 DATA QUALITY ASSESSMENT

Upon completion of all field and analytical work specified in the SOW, the contractor shall assess the quality of data generated as a result of these activities. This data quality assessment shall be presented in the Technical Report. The assessment of environmental data occurs in two phases. Field records and analytical data are reviewed during the first phase to identify valid data and are subsequently evaluated with respect to environmental conditions in the second phase. Requirements for these assessments are identified and discussed in the following text.

### 2.3.1 Review of Field Records

The contractor shall evaluate all field records for the following:

- Completeness of field records.
- Identification of valid samples.
- Correlation of field test data.
- Identification of anomalous field test data.
- The accuracy and precision of the field test data and measurements.

Each of these evaluations is discussed in the following text.

The check of field record completeness shall ensure that all requirements for field activities in the SOW have been fulfilled, complete records exist for each field activity, and that the procedures specified in program planning documents have been implemented. Field documentation shall ensure sample integrity and provide sufficient technical information to recreate each field event. The results of the completeness check should be documented and environmental data affected by incomplete records shall be identified in the technical report.

The identification of valid samples involves interpretation and evaluation of the field records to detect problems affecting the representativeness of environmental samples. For example, field records can indicate whether a well is properly constructed or if unanticipated environmental conditions were encountered during construction. The lithologic and geophysical logs may be consulted to determine if a well is screened only in the water-bearing zone of concern. Records should also note sample properties such as clarity, color, odor, etc. Photographs may show the presence or absence of obvious sources of potential contamination, such as operating combustion engines near a well during sampling. Field audit reports are another source of data for review. Those judgments of sample validity shall be documented in the technical report, and environmental data associated with poor or incorrect field work shall be identified.

The results of field tests obtained by more than one method shall be correlated. For example, geophysical surveys of subsurface geology can be conducted by using both ground penetrating radar and resistivity. The results of these two measurements should be compared. Similarly, the results of borehole geophysical surveys obtained by electrical resistivity, spontaneous potential, gamma ray, and caliper logging shall be correlated. The findings of these correlations shall be documented and the significance of anomalous data shall be discussed in the technical report.

Anomalous field data shall be identified and explained to the extent possible. For example, a water temperature for one well that is significantly higher than any other well temperature in the same aquifer shall be explained in the technical report. Widely differing calculations of aquifer characteristics from test data obtained at several wells shall be explained in the technical report. Also, differences in well depths from construction records compared to field measurements shall be evaluated and explained. The assessment of the quality of field measurements shall be based on instrument calibration records and a review of any corrective action reports. The accuracy and precision of field measurements shall be discussed.

### 2.3.2 Review of Laboratory Data

All laboratory data shall be reviewed by both the laboratory and contractor personnel At a minimum, the review of laboratory data shall focus on the following subjects:

- Chain-of-custody forms.
- Holding times.
- Method calibration limits.
- Method blanks.
- Laboratory established detection and quantitation limits.
- Analytical batch control records including spike recoveries and duplicate results.
- Corrective actions.
- Formulas used for analyte quantitation.
- Calculations supporting analyte quantitation.
- Completeness of data.

The establishment of detection, quantitation, and control limits shall be verified. Method validation is a continuous process and the reviewer shall ensure that control charts and statistical calculations have been updated to include recent data. Any control limits outside of the acceptable range specified in the analytical methods shall be identified. Any trends or problems with the data shall be noted and evaluated in the technical report. Any laboratory established detection and/or quantitation limits that exceed those in the SAP or this Handbook shall be identified. The absence of records supporting the establishment of control criteria and detection limits shall also be noted in the technical report.

The results of analytical batch quality control and calibration check samples shall be compared to SAP-specified acceptance criteria. Data not within control limits require corrective action and reviewers shall check that corrective action reports and the results of reanalysis are available. Similarly, sample holding times and preservations shall be compared to those required in section 2.2.1. If holding times were exceeded, evidence of resampling and analysis within the proper holding

time shall be noted. Samples associated with out-of-control QC data shall be identified in the technical report, and an assessment of the utility of such analytical results shall be recorded. Corrective action reports shall be referenced in this assessment.

Method calibrations and continuing calibration verifications shall be reviewed to assure conformance to acceptance criteria and completeness of records. The review shall also ascertain that the calibration events can be recreated and that no project samples were analyzed when the instrument was not in proper tune or calibration.

The check of laboratory data completeness shall ensure that all samples and analyses required by the SOW have been processed, complete records exist for each analysis and the associated QC samples, and that the procedures specified in the work plan, QAPP, and standard operating procedures (SOPs) have been implemented. The results of the completeness check shall be documented in the technical report in a tabular form identical to tables A-3, A-4, and A-5 of the SOW.

### 2.3.3 Evaluation of Environmental Data

Using the reviews of field records and laboratory data, environmental data that are not representative of environmental conditions because they were generated through poor field or laboratory practices, shall not be used in the evaluation process. This determination shall be made using the professional judgment of a multidisciplinary team (e.g., chemists, hydrologists, QA officers), and other personnel having direct experience with the data collection effort. This coordination is essential for the identification of valid data and the proper evaluation of that data. Historical data not supported by proper documentation and acceptable QC results shall not be used.

After valid data are identified in accordance with section 2.3.2 of this Handbook, the following steps shall be implemented to interpret the data, at a minimum:

- Evaluate field duplicate results.
- Evaluate field and laboratory blank results.
- Evaluate sample matrix effects on environmental data.
- Interpret and integrate environmental data to formulate conclusions and recommendations.

Precise field duplicate results indicate reproducible sampling technique and precise laboratory analysis. Field duplicate results not within control limits could indicate a heterogeneous sample medium, poor sampling technique, or a lack of analytical precision. If laboratory split samples or duplicates are precise, the problem may be associated with field activities. If homogenized samples show poor precision, the imprecision is probably in the laboratory analytical process.

Analyses of blanks shall be assessed to determine sources of contamination and the impact of any contamination on the analytical results for environmental samples. The use of several different types of blanks helps to identify contamination sources. Examples of sources capable of contaminating field and trip blanks include combustion engine exhaust, container cleaning solvents, or pollution from off-site sources, particularly if the seal on the blank container is not airtight. The water or the container used to prepare field and trip blanks may also be sources of contamination. Method blank results are useful to detect laboratory contamination from reagents, equipment, ambient sources, sample handling, or instrument carry-over. The presence of a contaminant in a blank requires corrective action to eliminate the source of contamination and reestablish analytical control. Contamination proven to be a constant, low-level systematic error that cannot be eliminated shall be noted in the technical report, and its impact on the analytical results for environmental samples shall be evaluated. Under no circumstances shall the results for environmental samples be "corrected" for blank contamination.

Assessment of the sample matrix can help to define the sources of anomalous data. The matrix can cause either a high or low bias to the results of normal environmental samples. High analytical results occur when analytes are inadvertently added to samples by dropping contaminated materials in wells, allowing contact with a contaminated environment, or similar problems. High results may also be caused by native material in the sample. For example, thallium appearing in the ICP analysis of saline waters maybe a spectral interference caused by other substances in the sample. Also, high calcium concentrations in water analyzed by ICP may generate spectral interferences for other metals. Contamination may also cause low results through adsorption or dilution. For example, improper development may leave drilling muds in a well that will adsorb metals from water, and water added to a well during development could reduce the concentrations of analytes in a contaminated aquifer. Potential matrix effects identified through laboratory tests or field records shall be identified and their impact on results for environmental samples shall be described in the technical report.

## 2.4 CONCEPTUAL SITE MODEL

Conceptual site models shall be developed for each site at the earliest stage in the IRP process to facilitate integration and analysis of validated laboratory data and field records. Conceptual site models shall be developed after a review of all available site information at the stage of preliminary assessment (PA). It shall then be further refined or revised with the inclusion of additional site data whenever appropriate throughout the IRP process. Conceptual site models are to be used to: (1) integrate information form various disciplines, (2) identify additional data needs, (3) facilitate the selection of remedial designs, and (4) guide risk assessment.

Conceptual site models shall identify migration routes and potential receptors, integrate geologic and hydrologic information, and provide the basis for human health and ecological risk assessment and evaluation of alternative remedial actions. The five elements of a conceptual site model are: (1) identification of contaminants, (2) characterization of the source of contamination, (3) delineation of potential migration pathways considering geologic and hydrologic conditions, (4) identification of both human and ecological receptors, and (5) determination of the concentrations of contaminants in environmental media at the point of exposure to receptors. The complexity and sophistication of the site model shall be consistent with the complexity of the site and the amount of data available. All assumptions and limitations shall be clearly identified. Identify the sources of any equations and justify their use.

### 2.4.1 Contaminant Identification and Establishment of Background Concentrations

Site contaminants are those hazardous substances detected in environmental samples at concentrations greater than background levels. This definition requires that the quantification of analytes shall be accurate; background concentrations shall be established; and the difference between the analyte concentration and background levels shall be established.

Background concentrations shall be established through the collection of background samples for each medium (e.g., groundwater, soil, air) investigated at each site. For groundwater, background is defined as follows: "The quality of groundwater that would exist at a site if the site had not affected groundwater quality." Similar definitions apply to the other media. Background samples may be contaminated, but not by the site in question. Thus, a groundwater sample collected between two sites may represent the contaminant plume emanating from one site and background water quality with respect to the other site. Literature values shall not be used in place of site-specific background concentrations.

Once the background concentrations are established, contaminant concentrations shall be shown to be higher than background levels. The methods used to differentiate contaminants from background levels shall be described in the technical report.

### 2.4.2 Source Characterization

At a minimum, the following four source characteristics shall be measured or estimated for each site:

- Source location and boundaries (area and depth).
- Source volume or amount.
- Hazardous constituents present in source and their concentrations.
- Time, duration, and rate of hazardous constituent release from source.

If no evidence of a source exists, field records and laboratory data shall be reviewed to ascertain that contamination exists at a site. If the contamination is confirmed, the area of contamination shall be considered to be a source and migration pathways and receptors shall be determined.

If there are multiple sites in proximity to one another such that it is not possible to determine the individual source or sources, the affected sites shall be aggregated into a zone. Migration pathways and receptors shall be determined for the zone, rather than for individual sites.

### 2.4.3 Potential Migration Pathways Identification

Potential migration pathways through groundwater, surface water, direct contact, and air routes shall be identified for each source. If a source of contamination cannot be identified, migration pathways from the zone of contamination shall be identified.

Contaminant transport shall be estimated for all applicable pathways. When contamination is detected at a receptor contact point and the exposure pathway is complete, the existing risk shall be estimated directly using the methodology in section 2.5. For example, if contamination is detected in a well used as a source of drinking water, the risk associated with exposure to the contaminants shall be estimated on the basis of the concentrations of the contaminants present in the well. In addition, the impact of potential future migration of the contaminants to the receptor contact point shall be evaluated. Incomplete exposure pathways shall be

clearly identified. An exposure pathway is incomplete if any of the following elements is missing: (1) a mechanism of contaminant release, (2) a transport medium, (3) a point of potential human contact with the contaminated medium, and (4) an exposure route at the contact point.

2.4.3.1 Groundwater Pathway

Identify and justify the equations or models used to estimate groundwater transport. Selection of appropriate equations or models requires knowledge of the location of the source or contaminant, the density and water solubility of the contaminant, and other site and contaminant-specific information. For those contaminants that are slightly soluble in water, concentrations below the limit of solubility shall be evaluated as soluble contaminants. At concentrations greater than the limit of solubility, the contaminants shall be evaluated both as soluble and insoluble phases. Transport shall be estimated for each contaminant present at a site.

2.4.3.2 Surface Water Pathway

Surface water transport shall be evaluated only if any of the following conditions are met: (1) a perennial body of water (river, lake, continuous stream, drainage ditch, etc.) is located within two miles of the source or area of contamination; (2) an uninterrupted pathway exists from the source or area of contamination to the surface water; (3) sampling and analysis results from the surface water body or sediments indicate contaminant levels above background; and (4) contaminated groundwater is known or suspected to discharge to a surface water body. Identify and justify equations used and assumptions made.

2.4.3.3 Air Pathway

Contaminant transport through air shall be determined for contaminants in the surface soil capable of migrating as gasses or as suspended particulate matter.

2.4.4 Receptor Identification

The populations of humans or other species at risk due to their existence in contaminant migration pathways are designated receptors and shall be identified according to the following guidance.

2.4.4.1 Human Receptors

For each site contaminant, determine areas within which receptors may be affected using the results of transport models developed for each pathway. These areas shall be determined on the basis of the principal downgradient or downwind

(based on wind rose data) directions. Identify potential human receptors, both permanent and transient, within the affected areas. Populations served by drinking water sources within areas that may be affected by contaminated groundwater or surface water shall be identified as potential receptors even if they reside outside the area. If no permanent or transient receptors exist for a site or its affected area, no further action is appropriate. When determining receptors, consider actual or potential commercial and recreational uses of surface water within the affected area. Identify receptors that fall within the affected area for more than one site or affected area. Consider receptors that may come into direct contact with site contaminants. Justify all assumptions and identify all sources of information.

2.4.4.2 Ecological Receptors

Locate and identify terrestrial and aquatic habitats for plants and animal within and around the study area. Consult with local and state officials, and Federal Natural Resource Trustees to determine whether any of the areas identified qualify as critical habitats or sensitive environments. Identify all important, declining, endangered, or rare species that either inhabit (whether permanently or transiently) or migrate through the study area. Important species are those with commercial or recreational value, as well as those whose abundance or other characteristics contribute to either the well-being or the perceived value of a given region.

2.4.5 Contaminant Concentration at Receptors

Contaminant concentrations at the receptor nearest to each source or zone of contamination shall be estimated for each complete migration pathway. The maximum plausible (highest concentration) exposure to any receptor (all potential pathways considered) shall also be determined and used in the risk assessment. If contaminant concentrations at a receptor are known from field or laboratory analysis of samples, use these concentrations in the risk assessment. Predictive modeling shall be used to estimate future contaminant concentrations at potential receptor contact points where contaminant concentrations are expected to change, provided that models exist that are based on assumptions that match natural conditions. Either analytical or numerical models may be used. The EPA *Superfund Exposure Assessment Manual* (SEAM), EPA/540/1-88/001, OSWER Directive 9285.5-1, April 1988, contains information on a variety of models that are a available for predicting the transport of contaminants through each of the three migration pathways. Whenever predictive modeling is performed, a model should be chosen on the basis of its compatibility with site conditions. Justification of all assumptions, and example model "runs" shall be provided. The requirements of section 2.1.2.9, Analytical or Numerical Model Representations of the Hydrogeological Conceptual Model, also apply here.

## 2.5 BASELINE RISK ASSESSMENT

The baseline risk assessment is an estimate of the potential risk to human health and the environment associated with exposure to site contaminants in the absence of remediation. The results of the baseline risk assessment may be used to: (1) support a "No Further Action" decision, (2) prioritize the need for remediation, or (3) provide the basis for quantification of remedial objectives. The following guidance for conducting a baseline human health risk assessment is consistent with the guidance provided in EPA *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual* (HHEM), Part A, EPA/540/1-89/002, OSWER Directive 9285.7-01a, December 1989. The most recent EPA guidance available should be used in conducting risk assessment for the IRP.

An ecological assessment shall be a part of the baseline risk assessment to evaluate the potential environmental effects of contaminants at the study area or the probable impact of project activities on the environment. The nature, extent, and detail of the ecological assessment shall be determined in consultation with the TPM based on the characteristics of the study area and the site contaminants. General guidance for conducting the ecological assessment is contained in EPA *Risk Assessment Guidance for Superfund, Volume 2: Environmental Evaluation Manual*, EPA/540/1-89/001, March 1989. More detailed information, that is consistent with the EPA guidance, can be found in the MITRE Technical Report *General Guidance for Ecological Risk Assessment at Air Force Bases*. This report is appended to this Handbook.

Independent risk assessments shall be developed for each site or zone. When performing the baseline risk assessment, consider both current and future use. A risk assessment shall be developed for each human receptor population identified and shall include consideration of every contaminant to which that receptor population is exposed and every pathway of exposure. The following methodology shall be used for baseline risk assessments.

### 2.5.1 Selection of Site Contaminants

Unless otherwise approved by the TPM, all site contaminants identified by the procedure in section 2.4.1 shall be subjected to a baseline risk assessment. See EPA *Guidance for Data Useability in Risk Assessment*, EPA/540/G-90/008, OSWER Directive 9285.7-05, October 1990, or the most recent guidance for information on minimum data quality requirements for environmental analytical data to support baseline risk assessment. Site contaminants and their averaged concentrations (geometric means) shall be summarized in the technical report for each site or zone, using the format presented in table 2-3. Additional analytical data, including range

of detected concentrations, detection frequency, 95 percent confidence limits, and background analyte concentrations shall also be provided in the technical report.

### 2.5.2 Exposure Assessment

The objectives of an exposure assessment are to identify actual and potential exposure pathways, to characterize receptor populations, and to estimate the magnitude and rate of exposure at contact points. Contaminant concentrations at a receptor contact point shall be estimated for complete exposure pathways, using the procedure outlined in the conceptual site model section of this Handbook. Additional information can be found in the applicable portions of the SEAM or the most recent guidance.

#### 2.5.2.1 Pathway Analysis

Identify incomplete exposure pathways as determined in the conceptual site model. Incomplete pathways require no further analysis. For complete pathways, exposure point estimates shall be based on the conceptual site model. After the actual and potential exposure points have been identified, the locations where human contact is likely to occur shall be analyzed for current and future use scenarios. Human contact mechanisms include ingestion, dermal absorption, and inhalation. The possibility of human contact is determined by analyzing the activities (social and work) of potential receptors. The pattern of social and work related activities will indicate if water is used for domestic consumption, recreational activities (e.g., swimming, fishing), irrigation, or other types of commercial uses.

The results of the pathway analysis shall be presented in technical reports using the tabular format illustrated in table 2-4. Conservative, yet realistic assumptions should be made. Clearly identify all assumptions in table 2-3.

#### 2.5.2.2 Estimation of Chemical Intake

The estimation of chemical intake shall be conducted for each completed pathway. The parameters that define chemical intake are: contaminant concentration, frequency of contact, and duration of exposure.

Determine intakes for receptors closest to the source and maximum plausible exposure as identified in the conceptual site model.

Standard values for the parameters used in these calculations (body weight, breathing rates, water consumption, etc.) shall be those found in the HHEM (exhibits 6-11 through 6-19), *Exposure Factor Handbook*, EPA/600/8-99/043, July 1989, or the most recent guidance. These same sources also contain algorithms that shall be used

to calculate chemical intake for the most common exposure scenarios: inhalation from showering with contaminated water; ingestion from water and food consumption and contaminated soil ingestion by young children; and dermal contact with contaminated soil and water. The intakes shall be expressed as mass of contaminant per day per kilogram of body weight (mg/kg day). Daily intakes from intermittent exposures shall be estimated by multiplying the intake per event by the number of exposure events over the exposure period and dividing this projection by the total number of days in the exposure period.

### 2.5.3 Toxicity Assessment

Toxicity assessment is the evaluation of the toxicity information available on chemicals to determine their potential to cause adverse health effects in receptors, either human or ecological. In all cases, adverse health effects are proportional to dose. However, the approach used to develop useful parameters for applicability to risk assessment is different for human health consideration and for ecological risk assessment.

#### 2.5.3.1 Human Toxicity Assessment

The potential health effects of non-carcinogens in humans shall be estimated using the EPA reference doses (RfDs). An RfD is an estimate of the upper limit of a daily exposure dose for the human population, including sensitive subpopulations, that is likely to cause no deleterious effects during a lifetime of exposure. RfDs are expressed in units of mg/kg-day. The EPA estimates of RfDs, which can be obtained on-line through the Integrated Risk Information System (IRIS) database, shall be used to assess toxicity. Only if information is not available in IRIS, should other information sources be used. Such sources include: EPA Health Effects Assessment Summary Tables, other EPA criteria documents (including drinking water criteria documents, drinking water health advisory summaries, and air quality criteria document), and toxicological profiles from the Agency for Toxic Substances and Disease Registry (ATSDR).

The health risks associated with exposure to potential carcinogens are evaluated using the slope factors (SFs) developed by the EPA. The SF is an upper-bound estimate of a carcinogenic response per unit intake of a chemical over a lifetime. The EPA weight of evidence classification should always be provided to indicate the strength of the evidence that the chemical is a human carcinogen. The SF values contained in the EPA IRIS electronic data base, which are expressed in units of mg/kg-day, shall be used to estimate the excess lifetime cancer risk associated with exposure to low concentrations of potential carcinogens.

**Table 2-3. Summary of Chemicals of Potential Concern at Site _____**

| Chemical | Soil | | Groundwater | | Surface Water | Sediment | Air |
|---|---|---|---|---|---|---|---|
| | Surface Soil (mg/kg) | Subsurface Soil (mg/kg) | Monitor Well (µg/L) | Residential Wells (µg/L) | (µg/L) | (mg/kg) | (µg/m$^3$) |
| | | | --EXAMPLE DATA-- | | | | |
| Benzene | 0.01 | 1.2 | 21.2 | 0.17 | ND | N/A | N/A |
| 1,1-Dichloro-ethylene | ND | 1.7 | 9.8 | 0.09 | ND | N/A | N/A |
| Lead | 72.4 | 14.2 | 3.7 | ND | 1.3 | 5.1 | N/A |
| Trichloro-ethylene | 0.03 | 6.1 | 60.0 | 12.1 | ND | N/A | N/A |

N/A = Not available

ND = Not detected

**Table 2-4. Potential Pathways of Exposure to Contaminants Originating at Site ____ under Current-Use Conditions**

| Potentially Contaminated Medium | Potential Routes of Exposure | Potential Receptors | Pathway Complete? | Exposed Population Estimate |
|---|---|---|---|---|
| | | | -- EXAMPLE DATA -- | |
| Soil (on-site) | Dermal absorption incidental ingestion | Recreational users | Yes. Site is waterfowl habitat that is leased for hunting purposes. | 30 |
| Soil (off-site) | Dermal absorption incidental ingestion | Gardeners and farmers | Yes. Area is used for agricultural purposes. | 60 |
| Air (on-site) | Inhalation of volatile contaminants from soil or surface water and/or fugitive dust. | Recreational users | No. Volatilization from soil and surface water is unlikely. On-site area is marshy and covered with sparse vegetation, so that no dust is expected. | 0 |
| Groundwater (on-site) | Dermal absorption, inhalation, ingestion | Recreational users | No. Groundwater on-site is not currently used for any purpose. | 0 |
| Groundwater (off-site) | Inhalation ingestions | Residential users | Yes. Residential wells show that there are measurable levels of contaminants. | 90 |
| Surface water | Dermal absorption, incidental ingestions | Recreational users | Yes. While persons are hunting, contact with surface water is likely. | 30 |
| (fishing) | Ingestion | Recreational users | No. There are not fishing activities reported on site. | 0 |
| (swimming) | Dermal absorption incidental ingestion | Recreational users | No. There are no swimming activities reported on site. | 0 |

2.5.3.2 Ecological Toxicity Assessment

Establish appropriate assessment endpoints (i.e., toxic effects in target species) for each ecological contaminant of concern. Target species are species inhabiting (permanently or transiently) or migrating through the study area that are deemed important by virtue of being rare, endangered, declining, possessing commercial/ recreational value, or otherwise contributing to the perceived value of the region. Selection of target species should be made in consultation with the TPM after conferring with local and state officials, and Federal Natural Resource Trustees. Determine the environmental concentration of the contaminant that is likely to elicit changes in an assessment endpoint in the target species. Such information may be obtained through a search of the scientific literature. Where data for eliciting the endpoint of concern in a specific target species are not available, other toxicity data (e.g., lethal concentration, 50 percent [$LC_{50}$]; or lowest observed effect level [LOEL]) may be used to derive a surrogate for effective concentration. If toxicity data are unavailable, EPA ambient water criteria or other no observed effect level (NOEL)-type data may be used. The distinction between the effective concentration of the contaminant (one that causes an effect, e.g., $LC_{50}$) and a "safe concentration (one that will probably not elicit an effect, e.g., NOEL) should be considered in the interpretation of the risk assessment.

2.5.4 Risk Characterization

This section describes how the data assembled in the previous sections shall be used to quantitatively estimate risk and interpret the significance of the estimated risk. The numerical estimates of risk shall be accompanied by explanatory text interpreting and qualifying the results.

2.5.4.1 Human Health Risk

2.5.4.1.1 Non-Carcinogenic Risk

The tabular format summarizing the estimated risk calculation for non-carcinogens presented in table 2-5 shall be used in technical reports for each complete exposure pathway at each site. Non-carcinogenic effects are presumed to be threshold events. The risk estimate shall be based on the numerical ratio of the estimated chemical intake to the RfD. This ratio is called the hazard quotient. In the absence of data sufficient to estimate the risk of mixtures of contaminants, risk shall be assumed to be additive for each contaminant. The hazard index is equal to the sum of the hazard quotients. If the hazard index is greater than unity as a result of summing several hazard quotients, it is advisable to segregate the compounds by effect and by mechanism of action and to calculate separate hazard indexes for each group. The hazard indexes of contaminants present for each exposure pathway at

**Table 2-5. Exposures and Non-Carcinogenic Risks Associated with Ingestion of Groundwater at Site _____**

| Chemical | Concentration (mg/L) Average | Concentration (mg/L) Maximum | Chronic Daily Intake (mg/kg-day) Average | Chronic Daily Intake (mg/kg-day) Maximum | Reference Dose (mg/kg-day) | Hazard Quotient* Average | Hazard Quotient* Maximum | Hazard Index* Average | Hazard Index* Maximum |
|---|---|---|---|---|---|---|---|---|---|
| **--EXAMPLE DATA--** | | | | | | | | | |
| 1,1-Dichloro-ethylene | 4.8-02 | 1.7E-01 | 1.4E-03 | 4.9E-03 | 9.0E-03 | 0.2 | 0.5 | | |
| Tetrachloro-ethylene | 1.8E-01 | 7.0E-01 | 5.1E-03 | 2.0E-02 | 1.0E-02 | 0.5 | 2 | | |
| 1,1,1-Trichloro-ethane | 2.8E-01 | 1.1E+00 | 8.0E-03 | 3.1E-02 | 9.0E-02 | 0.09 | 0.3 | | |
| | | | | | | | | 0.8 | 3 |

*Hazard quotients and hazard indexes shall be expressed as one significant figure only.

each site shall be added to estimate both average and maximum plausible exposure scenarios. The hazard indexes of carcinogens shall also be calculated if appropriate RfD values are available.

A hazard index lower than unity indicates that the contaminants at the site are not likely to present a health risk. A hazard index greater than unity indicates that the combined chemical intake exceeds the recommended safety threshold. In this situation, the chemical contaminants shall be evaluated individually to identify potential risk. The hazard index is not a mathematical prediction of incidence or severity of adverse health effects, rather it constitutes a numerical index to assist in the identification of a condition of imminent threat.

#### 2.5.4.1.2 Carcinogenic Risk

The tabular format summarizing the estimation of risk posed by carcinogens presented in table 2-6 shall be used in technical reports for each completed exposure pathway at each site. The excess lifetime risk associated with potential carcinogens shall be estimated by multiplying the chronic intake of each chemical by its slope factor. The chronic intake is the sum of the daily intakes from all completed exposure pathways. The carcinogenic effects of the contaminants shall be considered to be additive. Therefore, the risk estimates for the individual chemicals shall be added to obtain an estimate of the risk posed by one exposure pathway at a site.

### 2.5.4.2 Ecological Risk

Characterize the present and future potential exposure of target species to the ecological contaminants of concern based on environmental fate and transport as predicted by the conceptual site model, frequency and duration of contact (including influence by species mobility), bioaccumulation potential, and food chain considerations. Any seasonal variation that could influence the exposure scenario should be considered.

Develop an ecological risk characterization (ERC) for indicator species/habitats for each ecological contaminant of concern. Include a discussion of the assumptions and uncertainties for each ERC. Where critical/endangered habitats and sensitive environments are being characterized, the acceptable risk will be lower than for the general ecological community. The ERC should be quantified by using the ecological quotient method (see appendix C). The ecological quotient is defined as the ratio between the observed contaminant concentration and the endpoint concentration or beuch mark concentration for the indicator species/habitat. When peer reviewed dose-response data are available they should be included in the assessment. If NOEL-type values are used as surrogates for effective concentrations, the ecological quotient will be substantially more conservative as an indicator of risk.

**Table 2-6. Exposures and Carcinogenic Risks Associated with Ingestion of Groundwater at Site ____**

| Chemical | Concentration (mg/L) Average | Concentration (mg/L) Maximum | Chronic Daily Intake (mg/kg-day) Average | Chronic Daily Intake (mg/kg-day) Maximum | Slope Factor $(mg/kg\text{-}day)^{-1}$ | Weight of Evidence | Extra Lifetime Cancer Risk* Average | Extra Lifetime Cancer Risk* Maximum |
|---|---|---|---|---|---|---|---|---|
| **--EXAMPLE DATA--** | | | | | | | | |
| Arsenic | 1.9E-05 | 5.7E-05 | 5.4E-07 | 1.6E.06 | 2.0E+00 | A | 1E-06 | 3E-06 |
| Benzene | 9.7E-04 | 4.2E-03 | 2.8E-05 | 1.2E-04 | 2.9E-02 | A | 8E-07 | 4E-06 |
| Chloroform | 4.6E-03 | 7.2E-02 | 1.3E-04 | 2.1E-03 | 6.1E-03 | B2 | 8E-07 | 1E-05 |
| Dieldrin | 6.1E-06 | 8.8E-05 | 1.7E-07 | 2.5E-06 | 1.6E+01 | B2 | 3E-06 | 4E-05 |
| | | | | | | | 6E-06 | 6E-05 |

* All cancer risks shall be expressed as one significant figure only.

2.5.4.3 Evaluation of Risk

The risk estimates for carcinogens and non-carcinogens shall be evaluated to determine whether any population groups are in imminent danger and to identify contaminants posing the greatest risks so that remedial actions can be directed at those chemicals. Compliance with ARARs shall also be assessed.

Human exposure point concentration estimates shall be compared to ARARs as a way of assessing potential adverse effects associated with a site. ARARs consist of federal drinking water maximum contaminant levels (MCLs), proposed MCLs, federal ambient water quality criteria, national ambient air quality standards, and state environmental standards. ARARs may be chemical-specific, or based on location or action-specific requirements. If none of the exposure pathways for human contact are complete, no risk is posed by exceeding the ARAR. It is not necessary to calculate risk levels for ARARs except in unusual circumstances. Sources of ARARs can be found in EPA *Data Quantity Objections for Remedial Response Activities: Development Process*, EPA/540/G-87/003, OSWER Directive 9355.0-7B, March 1987, EPA Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, *Compliance with Other Laws Manual*, EPA/540/G-89/006, OSWER Directive 9234.1-01, August 1988, or more recent guidance.

The total risk to exposed populations posed by all sites on the entire installation shall also be evaluated. The first step is to identify exposed population groups common to more than one site. Then the site-specific risks posed by each contaminant to the common population groups shall be evaluated together (i.e., the hazard indexes shall be added, or daily intakes shall be summed to obtain the chronic dose). The significance of these aggregated risks shall be discussed in the technical report. In addition, contaminants capable of causing both carcinogenic and non-carcinogenic effects shall be identified.

All risk assessment findings shall be put in perspective by identifying and discussing the uncertainties inherent to the assessment. These uncertainties may be related to sampling and analysis, assumptions used for the development of exposure scenarios, selection of toxicity parameters, hydrogeological data, etc. The potential impact of each uncertainty factor on risk estimates with respect to both direction (i.e., over- or underestimate risk) and magnitude (e.g., order of magnitude) shall also be indicated. The technical report shall also identify areas where a moderate amount of additional data might substantially reduce the uncertainty in the baseline risk assessment.

## 2.6 FEASIBILITY STUDY

The purpose of the feasibility study is to examine site characteristics, cleanup goals, and the performance of alternative remedial technologies so that the most effective approach for the remediation of each site can be identified. The feasibility study shall address every migration pathway that poses, or could pose, an unacceptable risk to human health or the environment at each site. The feasibility study shall be conducted according to the requirements in the following subsections. These requirements are consistent with, but not identical to, the corresponding recommendations in *Guidance for Conducting Remedial Investigations and Feasibility Studies under Comprehensive Environmental Response*, CERCLA of 1980, EPA/540/G-89, OSWER directive 9355.3-01, October 1988.

### 2.6.1 Site Characterization for Remediation

A brief summary of site characterization data from the remedial investigation and quantitative risk estimates shall be presented for each site in the tabular format illustrated in table 2-7. The design parameters necessary to define the physical and chemical properties of each contaminated environmental medium shall be included in the table. The design parameters indicated in table 2-7 are provided for illustration and are not inclusive. This table shall summarize the site-specific information necessary to conduct the screening and detailed analysis of remedial alternatives.

The text supporting the table shall discuss the RCRA status of each site and the contaminated material within each site. In addition, any unusual conditions that may affect remediation shall be discussed. The site cleanup goals presented in the table may be derived either from ARAR requirements or from acceptable levels of risk. The basis for each cleanup goal shall be identified in the text.

### 2.6.2 Screening of Remedial Alternatives

The alternative approaches to remediation at each site that shall be screened include containment, treatment, and removal of contaminated materials. The site characterization data shall be used to identify which general approach, or combination of approaches, to remediation is likely be most effective for each migration pathway at each site. Factors favoring the selection of an approach include:

- Ease of implementation with respect to technical feasibility and regulatory compliance.
- Brevity of project duration.

**Table 2-7. Remedial Action Characterization for Site _____**

| Media | Contaminants | Volume of Contaminated Media | Range of Environmental Concentration | Pathway and Maximum Risk | Target Concentration for Remediation | Design Parameters |
|---|---|---|---|---|---|---|
| Groundwater | | | | | | Transmissivity<br>Porosity<br>Depth to Water, etc. |
| Soil | | | | | | Average Grade<br>Bulk Density Extent<br>Depth of Contamination, etc. |
| Surface Water | | | | | | Flow Rate<br>Velocity<br>Depth<br>Width, etc. |
| Sediment | | | | | | Depth Below Surface<br>Depth of Contamination, etc. |
| Air | | | | | | Wind Rose |

- Effectiveness of reducing contamination and risk to acceptable levels.

Because the screening process addresses approaches to remediation rather than specific remedial technologies, the evaluation is qualitative rather than quantitative. However, the screening analysis shall use the quantitative site characterization data to recommend an approach to remediation. The rationale for selecting an approach shall be documented in the technical report. The results of the screening study shall be summarized in the tabular format presented in table 2-8.

### 2.6.3 Detailed Evaluation of Remedial Alternatives

The detailed evaluation shall identify the remedial technology most likely to be successful for each recommended remedial approach identified by the screening study. Thus, several remedial technologies shall be evaluated for remediating each migration pathway at each site. The number of technologies selected for detailed evaluation shall be determined based on knowledge of alternatives that have proven to be successful under conditions similar to those at each site. Unproven technologies and those known to perform inadequately under site conditions shall not be evaluated.

The following criteria shall be used to evaluate alternative technologies and the associated supporting information shall be provided in the technical report:

- Successful application of the technology under site conditions supported by identification of project locations, dates, and managing entity.

- Total project cost supported by an estimate itemizing technology testing, capital equipment, operating and maintenance labor, equipment, environmental testing and monitoring, and closure costs.

- Risk reduction supported by numeral estimates of risk posed to site workers or other receptors during remediation and the risk posed by any contaminants remaining after remediation. Estimates of technology performance necessary to calculate risk reduction shall be supported by references to successful applications.

- Project duration supported by an estimated schedule showing major milestones, including any permitting activities that may be required.

- Data gaps supported by the identification of any environmental testing or treatability studies necessary to determine the effectiveness of a remedial technology under site conditions.

**Table 2-8. Remedial Action Screening for Site _____**

| Media | Remedial Action | Projected Treatment Efficiency | Retained or Rejected | Rationale |
|---|---|---|---|---|
| | | | | |

In addition to discussing the application of each of these criteria in the text of the technical report, the detailed evaluation shall be summarized in the tabular format presented in table 2-9.

The results of the detailed evaluation shall be a recommended technology, or combination of technologies, to remediate each migration pathway posing an unacceptable risk at each site. If such a determination cannot be made with available information, data gaps shall be identified and a testing program capable of providing the missing information shall be proposed. A tabular summary of the qualitative evaluation for the nine criteria specified in OSWER Directive 9355.3-01 shall also be presented in the technical report.

### 2.6.4 Siting Analysis

The siting analysis identifies potential locations for establishing remedial units, any required permitting activities, and the coordination required to remediate more than one site at an installation. The analysis shall include an installation map showing proposed locations for on-site remedial units and proposed transportation routes for any off-site remediation. The analysis shall also include estimates of the area (footprint) required for each remedial unit and of the flow rates for all influent and effluent streams. The regulatory status of each effluent shall be determined based on the previous estimates of technology efficiencies.

**Table 2-9. Summary of Remedial Action Evaluation at Site _____**

| Media | Contaminants | Remedial Action | Remedial Action Efficiency | Initial Risk | Reduced Risk Level | Bench or Treatability Study Required | Level of Worker Protection | Project Cost | Project Duration |
|---|---|---|---|---|---|---|---|---|---|

## 3.0 IRPIMS DATA MANAGEMENT

The contractor shall establish a data management plan to meet the data deliverable requirements of the Installation Restoration Program Information Management System (IRPIMS).

**3.1** The contractor shall be responsible for recording field and laboratory data into a computerized format as required by the SOW and the most current version of the IRPIMS Data Loading Handbook (mailed under separate cover).

**3.2** All IRP contractors that have been tasked and approved to load IRPIMS data shall be required to deliver individual IRPIMS data files (e.g., analytical results, groundwater level data) in sequence according to a controlled time schedule.

**3.3** IRPIMS training is available to the contractor upon written request.

**3.4** All IRPIMS data files prepared by contractors are required to be error-free before they are delivered to the Air Force. All data files delivered to the Air Force will be electronically evaluated for format compliance and data integrity. Any errors identified by the Air Force shall be corrected by the contractor.

## 4.0 PROJECT DELIVERABLES REQUIREMENTS

This section contains requirements for the preparation of project deliverables required by the SOW. Use of these formats is mandatory.

IRP contractors shall submit data in ten structured American Standard Code Information Interchange (ASCII) files for entry into IRPIMS. Instructions for preparing and submitting these files are contained in the most recent version of the IRPIMS Data Loading Handbook.

## 4.1 R&D STATUS REPORT

Monthly reports shall be prepared by the project leader or program manager to describe the technical status and progress of the project. The purpose of the R&D Status Report is to inform the TPM of the progress of the project and to justify the hours billed during the period. These reports shall discuss the following items:

a. Identification of installation and activity in progress.

b. Status of work at each site and progress to date.

c. Percentage completion of each task and sections of reports, and schedule status.

d. Difficulties encountered during the reporting period.

e. Actions being taken to rectify problems.

f. Activities planned for the next month.

g. Changes in personnel.

The monthly progress report shall list target and actual completion dates for each element of activity, including project completion, and shall provide an explanation of any deviation from the milestones in the Work Plan. Deviations in milestones or activities specified in the SOW and approved Work Plan that are reported in the R&D Status Report and accepted by the TPM do not constitute modifications in the SOW. Modifications shall be processed in writing to the TPM. The failure of the TPM to detect deviations from a SOW or approved Work Plan that are reported in the R&D Status Report does not grant the contractor permission to proceed in error.

The level of detail in the R&D Status Report shall support the hours claimed for the same time period. The report shall identify activities such as well installation and sampling, analysis of data, report writing, and other items requiring major manpower commitments. Analytical results generated during the reporting period shall be submitted with the next R&D Status Report. Chapters or sections of the technical report may be submitted with the R&D Status Report as they are drafted. Provide a detailed table of contents for required deliverables with the first R&D Status Report after development.

## 4.2 INFORMAL TECHNICAL INFORMATION REPORTS

Informal Technical Information Reports (ITIRs) shall be prepared if required in the SOW. The format of the ITIRs shall be proposed by the contractor to the TPM, except for the ITIRs described below.

### 4.2.1 Analytical Data ITIR

Analytical data ITIRs shall be submitted electronically or as hard copy, whichever is specified in the SOW. Electronic data shall conform with the requirements specified in the most recent IRPIMS Data Loading Handbook.

### 4.2.2 Hard Copy Analytical Data ITIR Outline

1.0 ANALYTICAL RESULTS

(Use format in table 4-1 at end of technical report outline)

2.0 CROSS-REFERENCE TABLE

(Use format in table 4-2 at end of technical report outline, showing the page numbers of the data in the ITIR.)

3.0 HOLDING TIMES

(Use format in table 4-3 at end of technical report outline)

4.0 QA/QC SUMMARY REPORT

(Use format in table 4-4 at end of technical report outline)

5.0 CHAIN-OF-CUSTODY FORMS

Show the following:

- Unique sample identification.
- Date and time of sample collection.
- Source of sample (including name, location, and sample type).
- Preservative used.
- Analyses required.
- Name of collector(s).
- Serial number of custody seals and transportation cases (if used).
- Custody transfer signatures and dates.

### 4.2.3 Site Characterization Summary ITIRs

The purpose of this ITIR is to provide a comprehensive description of the site-specific environmental characterization including the nature and extent of the contamination and the interpretation of the data associated with a particular site. This will serve as the core document from which the remedial investigation (RI) report will be developed. It should at a minimum contain the following sections: (1) introduction, (2) site investigations conducted, (3) conceptual site model (see section 2.4 of this Handbook), and (4) appendixes that include technical information such as field records, field measurement data, laboratory analytical data, QA/QC of all data, and chain-of-custody forms.

## 4.3 TECHNICAL REPORTS

In most cases, the technical report will include a discussion of both the RI and feasibility study (FS). However, if the SOW specifies a separate preliminary assessment (PA) report, RI report, or FS report, the following technical report sections shall be included:

| PA Report Format | RI Report Format | FS Report Format |
|---|---|---|
| Title Pages, Preface, etc. | Title Pages, Preface, etc. | Title Pages, Preface, etc. |
| Executive Summary | Executive Summary | Executive Summary |
| 1.0 | 1.0 | 1.0 |
| 3.1 | 2.0 | 3.1.4 |
| 3.2 | 3.0 | 3.2.3 |
| 3.3 | 5.0 | 3.3.2 |
| 5.0 | Appendixes | 3.3.3 |
| References | | 4.0 |
| | | 5.0 |
| | | Appendixes (as appropriate) |

Provide detailed tables of content to the TPM for approval as soon as they are developed for the corresponding report with the next R&D Status Report.

The following outline shall be used for preparing RI/FS technical reports. Subsections describing activities not required by the SOW may be deleted. Use of figures and tables is specifically required in the following outline paragraphs:

| Figures | Tables |
|---|---|
| Executive Summary | Executive Summary |
| 1.2 | 2.2.1 |
| 1.3 | 3.1.1 |
| 2.2.1 | 4.0 |
| 3.1.1 | Appendix G |
| 3.1.4 | |
| 3.2.1 | |
| 3.2.2 | |

Provide other figures and tables to the extent needed to make the report more readable, and to present data in a logical and understandable manner. The technical report outline follows:

## TECHNICAL REPORT OUTLINE

REPORT COVER PAGE (See attached format, page 4-23)

TITLE PAGE (See attached format, page 4-24)

DISCLAIMER

REPORT DOCUMENTATION PAGE, SF Form 298

PREFACE (Optional)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY--This section shall present a summation of the cumulative knowledge available to date from both current and previous IRP investigations, as well as from other studies identified in the course of the literature search. This section shall include text, summary tables, and figures that provide an overview of the investigative procedures and the major conclusions and findings of the investigation. After reviewing the summary, the reader should be familiar with the intent, objectives, and noteworthy results of the IRP investigation and what critical conclusions can be made regarding the control, management, and remediation of the hazardous waste sites on the Air Force installation. The need for any future IRP investigations beyond the scope of the current efforts should also be mentioned here. Other items to be included are:

- Location map (8 1/2" x 11") and brief descriptions of sites.
- Investigative procedures, scientific surveys conducted, and methodologies used for the current project.
- Time frame for various aspects of the current investigation.
- Summary of field program (e.g., number of wells drilled, type and number of samples taken) in tabular form.
- Significance of the findings of this investigation relative to applicable environmental standards.
- Recommendations identifying the site, recommended activities, and the rationale for selecting the activities, in tabular form.

1.0 INTRODUCTION

1.1 The Air Force IRP--Briefly describe the objectives and implementation of the IRP.

1.2 Installation Description--Briefly describe the physical geography, climate, geology, hydrology, industrial activities, etc., for the entire installation. Incorporate newly collected data from each site with existing information to present an installation-wide view of the environmental setting. Site-specific information should be provided in section 3 of this outline. Include the following 8 1/2" x 11" maps:

- Regional location map showing Air Force installation, major roads, streams, industries, towns, etc.
- Topography of installation.
- Surface water drainage.
- Regional geologic cross-section.
- Geology.
- Well location map in vicinity of installation.
- Groundwater flow directions.

1.3 Site Inventory--Identify sites and present a brief history of investigative activities and findings. Include an installation map showing site locations.

1.4 Remedial Actions--Describe any past or present remedial actions.

2.0 PROJECT ACTIVITIES

2.1 Project Objectives--Identify general and site-specific objectives for sampling and analysis.

2.2 Field Activities

2.2.1 Field Program--Provide a brief summary demonstrating compliance with HSD/YAQ requirements, including:

- Project summary similar to annex A of the SOW.

- Summary of well construction procedures, if applicable, with a well completion diagram. Include a table of well construction and development details for all wells.

- Table of survey data including coordinates and elevations for all sampling locations. This table shall be consistent with IRPIMS data loading guidance.

- Overview of sampling and measurement methods.

- Record keeping.

- Identity of field team members, subcontractors used and the tasks they performed.

2.2.2 Chronology of Field Work.

2.2.3 Field QA/QC--Provide a brief summary including:

- Description of the field QA/QC program.

- Problems detected and corrective actions taken during field program.

- QA activities, i.e., audits, record reviews, etc.

2.3 Laboratory Analyses

2.3.1 Analytical Program--Provide a brief summary, including:

- Identification of analytical laboratories performing work and the analyses conducted in a tabular format similar to tables A-3 and A-4 in the SOW.

- Identification of parameters for analysis, references to analytical methods, and specifications of the methods for establishing and calculating detection, quantitation, and control limits in each laboratory.

2.3.2 Chronology of Laboratory Analyses

2.3.3 QA/QC program--include:

- Types of laboratory QC samples and materials used to control project data (by method).
- Frequency of QC sample analysis.
- Reference appendix G for the specific acceptance criteria for QC sample results.
- Problems detected during laboratory analysis, especially out-of-control conditions.
- Corrective actions taken to correct QC problems.
- Calculations of completeness of analytical results.
- QA activities, i.e., audits, evaluation of performance sample results, etc.

## 2.4 Data Evaluation

### 2.4.1 Methodology for data quality assessment--Briefly describe the procedures used to identify valid data. Include a copy of the data validation summary.

### 2.4.2 Data Analysis and Interpretation

Describe the system used for:

- Selection of analytical methods for analyzing results of aquifer tests.
- Review of selected analytical methods.
- Review of calculations, including reduction of field data.
- Review of the conceptual site model, including the geologic and hydrologic environment that is envisioned as data are synthesized.
- Review of illustrations, map cross-sections, 3-D diagrams, etc., for accuracy of plotted data and the geologic and hydrologic interpretations presented on the illustrations.

2.4.3 Methodology for risk estimation--Briefly outline the procedures used to determine contaminant fate and transport, estimate risks to human health, evaluate compliance with ARARs, and assess environmental risk.

3.0 REMEDIAL INVESTIGATION--Information from project activities shall be used to interpret data and develop numerical estimates of risk posed by contaminants at each site. The format presented in this section shall be repeated to develop a conceptual site model for each site. The use of maps and tables in addition to those specified is encouraged. Repeat sections 3.1 through 3.3 for each site or zone.

3.1 Sampling and Analysis Results

3.1.1 Review of field and laboratory data--Summarize site data and identify invalid data as described in sections 2.3.1, 2.3.2, and 2.3.3 of this Handbook.

3.1.2 Data summary--Present analytical and geochemical data for all sampling locations in tabular format (a format is provided in table 3-1). Show all sampling locations on a site map. Include a separate site map showing soil gas survey results if such data are available.

3.1.3 Background levels--Identify background concentrations of analytes in the proximity of the site. See definition of background in section 2.4.1 of this Handbook.

3.1.4 Contaminants--Identify site contaminants from accurate and validated data and estimate the extent of contamination. Show contaminant plumes on site maps and show analyte concentrations adjacent to sampling locations.

3.1.5 Trend analysis--Compare project data with historical data and identify changes in concentration over time.

3.1.6 Source--Characterize contaminant sources with respect to location quantity, physical state, the process that generated wastes, and other relevant information. Show source locations on site maps.

3.2 Migration Pathways--The methodology presented in section 2.4 of this Handbook shall be used to identify potential migration pathways and

receptors. Clearly indicate all assumptions made and justify the selection of equations used.

3.2.1 Migration potential--Estimate the attenuation and rates of contaminant migration from the affected media for each potential migration pathway. At a minimum, evaluate the following environmental characteristics for each potential pathway:

- Subsurface migration--concisely discuss the following features that may affect contaminant fate and transport:
  - Topography.
  - Stratigraphy, lithology, structure. Include the following illustrations:
    -- Columnar sections.
    -- Site-specific geologic cross-sections developed from field activities.
  - Soil properties.
  - Identification and classification of hydrologic units. Include a 8 1/2" x 11" maps of water table elevations or the potentiometric surface showing flow directions for each site. Describe changes of water levels or potentiometric surface over time.
  - Aquifer characteristics such as storativity, transmissivity, effective porosity, and boundary conditions.
  - Groundwater flow characteristics such as velocity, hydraulic gradients, and variability over time.
- Surface migration--concisely discuss the following characteristics of surface water and soil that may affect contaminant fate and transport.
  - Identification of watershed and drainage courses for streams, wetlands, ponds, etc. Classification as gaining or losing.

- Location and discharge of springs.

- Flow characteristics--velocity, discharge, seasonal variation, and flood frequencies, as applicable.

- Soil characteristics--permeability, texture, etc.

• Air transport--concisely discuss the following characteristics that may affect contaminant fate and transport:

- Climatic

-- temperature

-- precipitation

-- evapotranspiration (actual and potential)

-- seasonal variability of wind velocity and predominant direction

3.2.2 Receptors--Identify areas of potential exposure to human and ecologic receptors from the sources of contamination. Identify populations potentially exposed to contaminants through groundwater, surface water, or air routes. Show the locations of potential receptors, including the results of any well inventory, on site or installation maps.

3.2.3 Contaminant concentrations at receptors--Summarize calculations used to estimate contaminant concentrations at receptors nearest to the source that maybe affected by groundwater, surface water, or air. Discuss the uncertainties inherent in these calculations and indicate a probable range of concentrations.

3.3 Risk Assessment--The methodology presented in section 2.5 of this Handbook shall be used to develop a numerical estimate of risk posed by site contaminants.

3.3.1 Exposure--Identify the mechanism of human exposure to site contaminants and estimate the dose received by the potentially exposed population for each exposure pathway, including:

- Ingestion
- Dermal contact
- Inhalation

Assess the environmental impact of contaminants and project activities on threatened, endangered or rare species, sensitive environments, and critical habitats on or near the site.

3.3.2 Risk estimate--Summarize calculations of risk posed by each site contaminant through each exposure pathway. Analyze the significance of each risk estimate.

3.3.3 Identification of ARARs--Compare contaminant concentrations found in the environment and estimated at receptors to ARARs.

4.0 FEASIBILITY STUDY - The methodology and formats in section 2.6 of this Handbook shall be used to develop and present the feasibility study.

4.1 Site Characterization--Summarize remedial investigation data necessary to characterize each site for evaluation of remedial alternatives. Identify the RCRA status of the site and site materials.

4.2 Screening Analysis of Remedial Alternatives--Determine whether containment, treatment, removal, or some combination, is the most effective approach to remediating each migration pathway posing a threat or potential threat to human health or the environment at each site. Provide the rationale for each determination.

4.3 Detailed Analysis of Remedial Alternatives--Identify alternative remedial technologies for each approach, evaluate the alternatives, and recommend a technology or combination of technologies to remediate each migration pathway posing a threat at each site.

4.4 Siting Analysis--Identify potential locations for remediation units at the installation, discuss the integration of concurrent remedial activities at

sites, identify major regulatory issues, and estimate remedial unit sizes and capacities.

## 5.0 CONCLUSIONS AND RECOMMENDATIONS

### 5.1 Categorization of Sites

#### 5.1.1 Category 1--No further action because no significant impact to human health or the environment exists.

#### 5.1.2 Category 2--Further study is required to categorize the site.

#### 5.1.3 Category 3--Remedial action is required.

5.2 Future Studies--Identify site-specific objectives for further work at category 2 sites. Clearly identify additional data needs and specific recommendations for obtaining the data. Identify any treatability studies or bench/pilot scale studies that may be needed to complete the detailed analysis of alternatives.

5.3 Remediation--Provide suggestions for implementation of preferred remedial actions at category 3 sites.

APPENDIXES

A. References and a glossary of Definitions, Nomenclature, and Units of Measurement

B. Copy of the Task Descriptions/SOW--Incorporate all schedules of change and variations into original SOW.

C. Well Data and Lithologic Logs, including:

   1. Well Design and Well Completion Information

   2. Drilling Logs

   3. Lithologic Description of Units Penetrated

D. Field Data

   1. Sampling Field Forms

   2. Aquifer Testing Data and Analyses

   3. Geophysical Data

   4. Geotechnical and Engineering Data

   5. Air Quality Data

   6. Biological Data

E. Surveying Data

F. Chain-of-Custody Forms

G. Analytical Data for water, soil, sediment, air, and biological sampling including results and control limits for QC samples such as blanks, spikes, and duplicates.

   Provide a summary table of analytical data including detection and quantitation limits (use format in table 4.1). Laboratory QC data must be traceable to the applicable analytical batch or sample set. Provide a cross-reference table for sample identification (use format in table 4-2); a table

## Table 4-1. Analytical Data Summary (1)

Base: _____

Site: _____
Method Extraction: _____
Method Analytical: _____

Matrix: _____
Units: _____

| Parameters (2) | Detection Limit (3) | Quantitation Limit (3) | Action Levels (4) | Environmental Sample | | | | Field Blank (6) | | | Lab Blank (7) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Field ID ____ Batch ID ____ (5) | Field ID ____ Batch ID ____ | _____ _____ | _____ _____ | Trip Field ID ____ Batch ID ____ | Equipment Field ID ____ Batch ID ____ | Ambient Field ID ____ Batch ID ____ | Field ID ____ Batch ID ____ |
| LIST ALL METHOD ANALYTES<br>Surrogates (8)<br>Analyte 1<br>2<br>3 | | | | | | | | | | | |
| | | | | | | | | | | | (9) |

## NOTES TO TABLE 4-1

1. Each Analytical Data Summary shall include results from one site, method, and matrix. Provide as many such tables as necessary.

2. List all analytes tested for using the identified method. The use of an option of listing only positively identified (confirmed data greater than the detection limit) analytes in this column is available at the direction of the TPM. When only the positively identified analytes are listed in this table, provide a separate list of all analytes tested in the method (implying a not detected value).

3. Detection and quantitation limits must be laboratory established and approved in the SAP.

4. List the most stringent applicable action levels in this column. Include the sources of these action levels in footnotes to table 4-1. If an action level does not exist, provide the background value or range.

5. List values for all method analytes (unless using the option for reporting only positive values from note 2 above).

   For gas chromatographic analyses, report three results:

   - First-column analysis.

   - Second-column analysis (if confirmation is required).

   - Primary result--The primary result is the concentration reported for the analyte after the first- and second-column results have been evaluated by the laboratory. For confirmed results, this number is usually (but not necessarily) the same as the first-column concentration. Where there are coeluting peaks on the first-column, the second-column analytical result should be reported as the primary result. Provide an appropriate footnote explaining the rationale behind this decision. Averaging first- and second-column results to obtain the primary result is not permitted.

The following flags may be used to further explain data:

- J=Estimated data (explain why estimation was necessary).
- B=Analyte was identified in the laboratory or field blank.
- R=Data are unusable (analyte may or may not be present).

6. Results of field QC samples that are common to more than one matrix or site are to be duplicated in appropriate table 4-1. When multiple field blanks are collected for environmental samples from the same site, identify which blanks are associated with which environmental samples.

7. Include results of the laboratory blank(s) relevant to the field samples presented.

8. Provide the laboratory-established control limits next to the name of the surrogate.

9. This portion of the table may be used to report field measurements (e.g., pH, temperature). Field measurements may also be submitted as a separate analytical summary table.

**Table 4-2. Sample Identification Cross-Reference**

| Site ID | Field ID | Field Batch ID | Laboratory ID | Lab Batch ID | Sample Description | Page |
|---|---|---|---|---|---|---|

NOTES:

(1) Consecutively number all pages in the Analytical Data Appendix. The numbers listed under "Page" in this table must reflect the location(s) of lab report(s) within the Analytical Data Appendix.

(2) The laboratory batch is used to correlate QC samples with specific environmental samples. Batch numbers may be indicated for each analytical method or by whatever system of nomenclature is used in the laboratory. This correlation of QC samples with environmental samples should be consistent with the analytical results presented in section 3.2.

(3) The field batch is used to correlate field QC samples (trip blanks, equipment blanks, ambient conditions blanks, etc.) with specific environmental samples. The batch ID should be a 2 digit number to be consistent with the IRPIMS database.

(4) Examples of sample description include groundwater sample, soil sample, field blank, matrix spike duplicate, etc.

(5) The field ID shall be identical to that used for the IRPIMS computerized data. Specifically, the field ID shall consist of the installation ID (AFIID), the location cross-reference (LOCXREF), and the sampling date (LOGDATE).

summarizing sample collection, extraction and analysis dates (use format in table 4-3); and a table listing control limits for laboratory QC samples (use format in table 4-4).

H. Any correspondence with federal, state, or local governmental agencies.

I. Data from Related or Previous IRP Investigations. This appendix shall include data or text from other investigations that are pertinent to this particular IRP effort.

J. Well Abandonment Records.

K. Biographies of Key Personnel.

L. Quality Assurance/Quality Control for Production of Documents.

The contractor shall explain the system by which the following are confirmed: (a) data in the narrative and in illustrations conform to tabulated data; (b) tabulated data conforms to data recorded on field forms; (c) typographical errors are eliminated; and (d) mechanical scrambling of segments of the printed narrative is eliminated.

M. Data Validation Summary

## Table 4-3. Summary of Extraction and Analysis Dates

| Sample Numbers | | Sampling | [Method 1] | | | | [Method 2] | | | | [Method 3] | | [Method 4] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Field | Lab | Date | Extraction Date | Elapsed Time | Analysis Date | Elapsed Time | Extraction Date | Elapsed Time | Analysis Date | Elapsed Time | Analysis Date | Elapsed Time | Analysis Date | Elapsed Time |

NOTES: (1) Identify holding times exceeding Air Force requirements with an asterisk (*).

Table 4-4. Quality Control Report

**Field Sample ID by Matrix** (1)

Solid ☐
Water ☐

**Analytical Method:** _____
**Analytical Batch ID:** _____
**Date of Analysis:** _____
**Instrument ID:** _____
**Calibration Reference #:** _____

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

**Laboratory Blank Contamination Summary**

| Analytes | Detection Limit | Quantitation Limit | Lab Blank Result | Acceptance Criteria | Corrective Action |
|---|---|---|---|---|---|
| _____ (2) | (3) | (3) | | (4) | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| Quality Control Samples | Target Concentrations (5) | Recovery (%) | | | RPD (%) | | Corrective Action (7) |
|---|---|---|---|---|---|---|---|
| | | Spike | Spike Duplicate | Control Limits (6) | Result | Control Limits (6) | |
| Laboratory Control Sample<br>List Spiked Analytes<br>Analyte 1<br>2<br>3<br>4<br>5<br>___<br>___<br>___<br>___<br>___ | | | | | | | |
| Matrix Spike (8)<br>List of Analytes<br>Analyte 1<br>2<br>3<br>4<br>5<br>___<br>___<br>___ | | | | | | | (9) |

## NOTES TO TABLE 4-4

1. Laboratory sample identification may be added to field sample identification as an option.

2. List only analytes found in the laboratory blank.

3. Detection and quantitation limits used in the analysis of Air Force samples must be established in the laboratory and approved in the SAP. Include units of measure as required in section 2.2.8 of this Handbook.

4. Refer to section 2.2.5.c of this Handbook.

5. Include units of measure (see section 2.2.8).

6. The control limits used for the analysis of Air Force samples must be established in the laboratory and approved in the SAP.

7. Provide a brief corrective action explanation. Include a detailed explanation of corrective actions in the text of the technical report (see section 2.3.3 of the technical report outline).

8. Matrix spike and matrix spike duplicates may be submitted on a separate sheet, arranged in the same format.

9. Describe the effects of matrix interference on field samples. State which analytes may be affected and how.

10. Attach a glossary of terms and symbols used in the table.

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## 4.4 DECISION DOCUMENTS

The purpose of a decision document is to summarize the Air Force rationale for selecting a particular remedial action. Remedial actions include the selection of a No Further Action alternative. The decision document is used to formally document that selection by ensuring appropriate Air Force, and state and federal agency coordination and concurrence.

Using the following format, the contractor shall prepare a decision document for the remedial action alternative selected at the following categories of non-National Priorities List (NPL) sites as specified in section 5.0 of the technical report.

- Category 1 Sites--Sites and/or zones where no further IRP action (including remedial action) is required.

- Category 3 Sites--Sites, zones and/or operable units where the feasibility study process has been completed and a remedial action alternative has been selected.

The format for documenting the selection of a remedial action alternative (including a No Further Action alternative) for an NPL site (i.e., the Record of Decision [ROD]) will be negotiated by the Air Force on a site-by-site basis with the appropriate regulatory agencies. However, for the purpose of costing the development of a ROD for an NPL site, HSD/YAQ anticipates that the format will be very similar to the Decision Document Outline.

### DECISION DOCUMENT OUTLINE

1.0 INTRODUCTION

1.1 Site Location and Description

1.1.1 Location, address (include maps, site plan as appropriate).

1.1.2 Area of site, topography, location with respect to floodplains.

1.1.3 Adjacent land uses

1.1.4 Location of and distance to nearby populations

1.1.5 General surface and groundwater resources

1.1.6 Surface and subsurface features (e.g., number and volume of tanks, lagoons, structures, drums).

## 2.0 SITE HISTORY

### 2.1 Describe Site History in Terms of:

2.1.1 How site was established

2.1.2 Period of operation

2.1.3 History of ownership

2.1.4 Site uses over period of operation (types of wastes received, treatment, storage, and disposal practices).

2.1.5 Type of permits applied for and/or approved, identities of permitting authorities.

2.1.6 History of releases

2.1.7 Waste characteristics

## 3.0 CURRENT SITE STATUS

### 3.1 Physiography and Climate

### 3.2 Soils

3.2.1 Soil description

3.2.2 Soil contamination

### 3.3 Groundwater

3.3.1 Hydrogeologic setting

3.3.2 Groundwater contamination

3.4 Surface Water

3.4.1 Flow rates

3.4.2 Contaminant loads

3.5 Receptors

3.5.1 Human

3.5.2 Ecological

4.0 DATA ANALYSIS/RISK ASSESSMENT

4.1 Soils

4.2 Groundwater

4.3 Surface Water

4.4 Air

4.5 Summary

5.0 SELECTED ACTION

5.1 Alternatives Evaluation

5.1.1 Discuss all alternatives considered and reasons for selecting or not selecting (include No Further Action alternatives).

5.2 Consistency with Environmental Laws

5.2.1 Discuss how a No Further Action alternative complies with ARARs.

6.0 REGULATORY AGENCY/PUBLIC INVOLVEMENT

6.1 Discuss coordination with regulatory agencies and how their concerns have been handled.

6.2 Briefly describe the level of community involvement and nature of support or concern, and how concerns have been addressed.

6.3 Responses to all public comments.

**DECISION DOCUMENT**
**(Signature Page)**

[FOR CATEGORY 1 SITES]

TECHNICAL DOCUMENT TO SUPPORT

NO FURTHER ACTION

[FOR CATEGORY 3 SITES]

TECHNICAL DOCUMENT TO SUPPORT

A REMEDIAL ACTION ALTERNATIVE

I. Base/Installation/Facility

II. Name and Location

III. Statement of Basis

IV. Description of the Selected Remedy

V. Declaration of Consistency with CERCLA as Amended by Superfund Amendments and Reauthorization Act (1986) (SARA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP)

Signatures

U.S. Air Force

State Regulatory Agency

U.S. EPA

## 4.5 IRPIMS DATA FILES

The contractor, when tasked by the SOW, shall prepare and deliver IRPIMS data files per the requirements set forth in the most current version of the IRPIMS Data Loading Handbook. The structured ASCII files that the contractor shall deliver include:

| | |
|---|---|
| BCHCON | Contract Information File |
| BCHLDI | Location Definition Information File |
| BCHSLI | Site and Location Information File |
| BCHWCI | Well Completion Information File |
| BCHGWD | Groundwater Level Data File |
| BCHSAMP | Environmental Sampling Information File |
| BCHCALC | Calculated Hydrologic Parameter File |
| BCHLTD | Lithologic Description File |
| BCHTEST | Sample Preparation Information File |
| BCHRES | Analytical Results File |

# APPENDIX A

# STANDARD FORMATS AND FORMS

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SAMPLE DISCLAIMER
FOR IRP REPORTS

NOTICE

This report has been prepared for the United States Air Force by _____ for the purpose of aiding in the implementation of a final remedial action plan under the Air Force Installation Restoration Program (IRP). As the report relates to actual or possible releases of potentially hazardous substances, its release prior to an Air Force final decision on remedial action may be in the public's interest. The limited objectives of this report and the ongoing nature of the IRP, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this report, since subsequent facts may become known which may make this report premature or inaccurate. Acceptance of this report in performance of the contract under which it is prepared does not mean that the Air Force adopts the conclusions, recommendations, or other view expressed herein, which are those of the contractor only and do not necessarily reflect the official position of the United States Air Force.

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# APPENDIX B

# REFERENCES

**Public Laws**

UNITED STATES CODE

| | |
|---|---|
| PL 96-510 | Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 |
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**Regulations**

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| | |
|---|---|
| 40 CFR 136.3e, Table II | Required Containers, Preservation Techniques, and Holding Times |
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| 40 CFR 136, Appendix B | Definition and Procedure for the Determination of the Method Detection Limit |
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| | |
|---|---|
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**Presidential Documents**

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| | |
|---|---|
| EO 12088 | Federal Compliance with Pollution Control Standards (13 Oct 1978) |
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ENVIRONMENTAL PROTECTION AGENCY

| | |
|---|---|
| EPA-330/9-S1-002 | National Enforcement Investigations Center (NEIC) Manual for Groundwater/Subsurface Investigations at Hazardous Waste Sites |
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| D-2487 | Unified Soil Classification System |
| D-2488 | Recommended Practices for Visual-Manual Description of Soils |
| Annual Book of ASTM Standards | Section 11, Water and Environmental Technology |

**Guidance Documents**

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| | |
|---|---|
| OSWER 9355.3-01 | Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, October 1988 |
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# APPENDIX C

# GENERAL GUIDANCE FOR ECOLOGICAL RISK ASSESSMENT AT AIR FORCE BASES

# General Guidance for Ecological Risk Assessment at Air Force Installations

John M. DeSesso, Ph.D.
Fred T. Price, Ph.D.

December 1990

CLIENT:
Human Systems Division IRP Program Office

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## SECTION 1

## INTRODUCTION

The Superfund Amendments and Reauthorization Act of 1986 makes repeated reference to protection of health and the environment. As a result, the Environmental Protection Agency (EPA) has written guidance for the protection of human health (*Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual*, 1989) and the environment (*Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual*, 1989). The amount of guidance available for ecological risk assessment is less than that for human health. This document provides an overview of the fundamentals of risk assessment and guidance for conducting an ecological risk assessment. Ecological risk assessment can be divided into two general types based on habitats (terrestrial [land] and aquatic [freshwater and marine]). Guidance is provided for conducting both types of risk assessment.

## SECTION 2

## FUNDAMENTALS OF RISK ASSESSMENT

Risk assessment characterizes the probability that exposure to hazardous substances in the environment will produce adverse effects. Most of the effort in the development of risk assessment methods has been directed at human health risk assessment; however, the component parts of the risk assessment process for other biological organisms parallel those of human health risk assessment and can be described in the same terms.

Risk assessment consists of four components. The first component, hazard assessment, involves identifying the presence of a contaminant that potentially causes an adverse effect. The second component, dose-response assessment, characterizes the relationship between the dose of the hazardous substance and the incidence of the adverse effect and defines the concentration of contaminant that will produce the adverse effect. Generally, information relevant to these first two components is available in the scientific literature. The third component, exposure assessment, measures or estimates the amount of the contaminant substance that comes into contact with receptors. This evaluation considers field measurements of the concentration of contaminant in various environmental media, the transport of contaminated media to receptors, and the duration, magnitude, and frequency of receptor contact. The final component of risk assessment, risk characterization, combines the information from the preceding three tasks to (1) estimate the likelihood that the measured concentrations of the hazardous substance will cause the adverse effect and (2) discuss the uncertainties associated with the risk estimates.

The quantitative assessment of risk is fraught with uncertainty due to the inability of the risk assessor to quantify all the information that must be used. While the concentration of each contaminant in sampled media can be measured with relative accuracy, the exposure concentration at the point of contact with a receptor is generally not measured and must be estimated by environmental transport modelling techniques. These models estimate exposure concentrations through the use of assumptions concerning physical characteristics of the media and the environmental behavior of the contaminants in the media. The unpredictable nature of receptor behavior that leads to (or avoids) exposure contributes to uncertainty in defining the magnitude, frequency, and duration of exposure. In addition, most toxicity data are gathered from experiments that were conducted in laboratory animals using doses that greatly exceed anticipated environmental exposures. Thus the expected incidence of a harmful effect at low doses must be based on observations at high doses. In addition, the expected harmful effects in one species (the receptor) often must be based on observations in another species (often a laboratory species). These extrapolations and assumptions are major sources of uncertainty in the risk assessment process.

From this brief description it is clear that the goal of risk assessment is to determine whether a problem exists and, if so, the magnitude of the problem. Activities associated with deciding whether the mitigation of the problem through remedial actions is warranted or selecting the appropriate remedial alternative are considered to be risk management activities and are distinct from risk assessment.

## SECTION 3

## ECOLOGICAL RISK ASSESSMENT

### 3.1 INTRODUCTION

Ecology is the study of the interactions among populations of organisms occupying the same or adjacent habitats. Estimates of risk to organisms other than humans fall within the purview of ecological risk assessment. Ideally, ecological risk assessment would estimate the potential for occurrence of adverse effects that are manifested as changes in the diversity, health, and behavior of the constellation of organisms that share a given environment over time. MITRE suggests that this could be accomplished by (1) estimating the health risk to individual species, (2) evaluating the health of the community of exposed species (taking population dynamics into account), and (3) determining the potential adverse effects of contamination over several life cycles of the species under study. These three phases of ecological risk assessment are described in the following paragraphs.

### 3.2 PHASE I: ECOLOGICAL QUOTIENTS

An ecological risk assessment (ERA) should be performed on an ongoing basis starting in the earliest stages of the Installation Restoration Program. The individual steps performed during the ERA may be iterative. For example, risk characterization should be updated and refined throughout the ERA process as new information becomes available. Ecological areas included in the ERA should not be limited by the property boundaries of the study area if affected environments or habitats are located beyond the property boundaries. The following steps provide general guidance for the performance of an ERA. Although the steps are listed in sequential order, several steps may be performed simultaneously.

1. Assemble all data that may be relevant to the ERA of the study area, including historical information. Identify all ecological contaminants, locate all sources and contaminated media for each site (include maps), and estimate source size and volume. Quantify the contamination to the extent possible through concentration data for each relevant medium. Ensure that all analytical data are accurate and defensible.

2. Identify contaminants of concern by determining the ecological toxicity, environmental persistence, and bioaccumulation potential of all contaminants and, where appropriate, synergism between toxicants. Published research and ecological toxicity databases should be consulted first. Where published toxicity data are inadequate, bioassays of indicator species may be necessary. A qualified professional should be consulted before making the decision to conduct laboratory or field toxicity tests.

3. Establish background (ambient) concentrations of all ecological contaminants found at the study area. Background concentrations of contaminants should be determined from samples collected at the same time and from the same media as the contaminated samples, but from nearby locations with similar physiography.

4. Develop a conceptual model of the sites that identifies the source(s) of contamination, the likely migration pathways, and the extent of migration based on information such as topography, hydrology, geology, and geochemistry of the area and the physical properties of the contaminants (e.g., volatility, water solubility).

5. Identify and locate habitats and environments (both terrestrial and aquatic) on or surrounding the study area (include maps). Confer with local, state, and Federal Natural Resource Trustees to assist in establishing whether any of the areas identified above qualify as critical habitats or sensitive environments and to determine the identity of any important or endangered species that may inhabit or migrate through the study area. Identify the recreational and commercial uses of all ecological resources (e.g., surface water bodies) in or near the study area.

6. Conduct a field survey to check the validity of all ecological data, to select indicator species or habitats where applicable, and to verify the appropriateness of the conceptual site model. Locate all surface water bodies (including intermittent water bodies and drainage pathways).

7. Based on the results of the ERA to this point, identify any additional environmental data that will be needed to assess ecological risk to the study area. Plan and conduct sampling and analyses (including background samples), where appropriate, to provide missing information.

8. Establish appropriate assessment endpoints (e.g., toxic effects in target species) for all ecological contaminants of concern. Determine the effective dose of each contaminant of concern (i.e., the concentration that produces the assessment endpoint in the target species). Where data for a specific species or endpoint are unavailable, other toxicity data (e.g., $LC_{50}$ or LOEL)[1] may be used to derive a surrogate for effective concentration. For example, EPA ambient water quality criteria or other NOEL-type data may be used. However, the distinction between the concepts of effective concentration (one that produces an effect, $LC_{50}$) and a "safe" concentration (one that will not produce an effect, NOEL)[2] should be considered in the interpretation of the assessment results.

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[1] $LC_{50}$ is the concentration of contaminant which produces death to 50 percent of the test animals. LOEL is the "lowest observed effect level."

[2] NOEL is "no observed effect level."

9. Characterize exposure (present and future potential) based on environmental fate and transport of contaminants as predicted by the physical model developed above and ecological food chain considerations, including bioaccumulation potential. Determine the magnitude and frequency of exposure for each indicator species/habitat. Consider the effects of seasonal variations on the exposure scenario. Exposure characterization may require sampling and analysis of biota (tissue analysis) for contaminants. Computer models of fate and transport may be needed to predict future exposures.

10. Develop an ecological risk characterization (ERC) for indicator species/habitats for each ecological contaminant of concern. Include a discussion of the level of confidence, assumptions, and uncertainties for each ERC. Where critical/endangered habitats and sensitive environments are being characterized, the acceptable risk will be lower than for the general ecological community. The ERC should be quantitative, whenever possible. This can be most easily accomplished by using the ecological quotient method. The formula for the ecological quotient follows:

$$\text{Ecological Quotient} = \frac{\{\text{observed contaminant concentration}\}}{\{\text{effective concentration or surrogate}\}}$$

When appropriate dose-response data are available, they should be included in the assessment. When NOEL-type values are used as a surrogate for effective concentration, the quotient will have a significantly more conservative meaning as an indicator of risk. Both current and future risk (based on fate and transport modelling data or anticipated future activities) should be included.

11. Address the impacts of human activities on the environment at the study area. This should include any ongoing or proposed remediation (whether undertaken for human health, ecological, or aesthetic reasons) that may affect the ecological resources at or near the study area.

This approach quantitates the potential for risk to individual species independent of the interactions among species. It is limited by the number of species considered and the availability of information on the toxicity of the contaminants. The potential for adverse effects to the entire ecological community is inferred from information derived from a subset of the extant species in the community or from surrogate species.

### 3.3 PHASE II: BIOLOGICAL DIVERSITY

The health of the ecological community at a site can be measured by determining the biological diversity of the area affected by contamination compared to the biological diversity of a nearby similar but unaffected area. The results of a biological diversity analysis can be used to bolster the findings of the ecological quotient-based risk assessment. The biological diversity type of assessment

is similar in design and approach to human epidemiology studies. It is retrospective rather than predictive. When quantitative risk estimates are available, conclusions from a biological diversity analysis can be confirmatory and can be carried out as a second phase of the ecological risk assessment as discussed below.

Analysis of the biological diversity of a given region must be preceded by careful definition of (1) the boundaries of the territory to be studied and (2) the period of time during which the community will be measured. For the purpose of an ecological assessment, an equally important consideration is the identification of a nearby control area that is not contaminated but that exhibits nearly identical physiographic, topological, and climatic characteristics. The biological diversity analysis can take the form of a complete census in which all extant species are identified and the total numbers of individuals of each species are counted. The number of different species identified (species "richness") and the total number of individuals in each species (species "evenness") taken together provide an indication of biological diversity for the community in question. Comparison of the measurements made at the control and contaminated sites can provide a qualitative measure of the ecological similarity between the two sites. Interpretation of the significance of differences in measurements between the sites is not always straightforward. When a large number of species is present, the analysis becomes excessively complex. The populations within ecological communities are dynamic; under normal conditions, changes in their distribution are expected to occur from time to time. For this reason, the detection of change by itself does not necessarily mean that contaminants are exerting biological effects. If a difference from background is detected, and if the ecological quotient is equal to or greater than unity, a change in diversity strengthens the confidence that can be placed in the quantitative risk assessment. Similarly, no change in biological diversity coupled with an ecological quotient that is less than unity bolsters the conclusion that the contamination is not exerting an adverse effect.

The suggested, practical alternative to a complete census is to monitor the distribution of selected species. While this approach ignores some species within a territory, it is more incisive because (1) the resulting analysis will lead to a more clear-cut result due to the smaller number of species which one must track and the reduced possibility of confounding effects due to species interactions and (2) with careful selection of the species to be monitored, any changes from background should be relatively easy to interpret. Selected species should include any endangered or declining species, species whose abundance or other characteristics contribute to the perceived value of a region (e.g., sequoias in California redwood forests; species of commercial or recreational importance), and a suite of species whose status reflects the general health of the community. In general, the selected species will include those species for which ecological quotients were calculated in phase I. The predictions of the species-specific ecological quotients can be confirmed by direct observation of the number and health of that species. In addition, the health of selected species for which no ecological quotients are available will confirm or contradict the general potential for ecological damage indicated by the full range of calculated ecological quotients. Effects not anticipated in the ecological quotients calculated in phase I may become apparent in phase II. If the results of the two phases disagree, further investigation may be required as described in phase III.

## 3.4 PHASE III: POPULATION STUDIES

In the event that there is either an apparent decline in population size of a species that is deemed important in the presence of a low ecological quotient or no apparent effect on population size in the presence of a high ecological quotient (predicted effect), a more detailed study may be required. This may take the form of a population study (for organisms with a relatively short life span).

Population studies involve taking a census of the number of individuals in each life stage for selected species at several time points over the course of one to several life cycles or seasons. These studies can be expanded by including observations of the health or intoxication of individuals at different life stages for each time interval. The temporal aspect of the study design is likely to provide insight into any age-related or life-stage-specific sensitivities of the organism in question. This type of study is analogous to prospective epidemiology studies. Confounding factors that may affect the interpretation of the analysis include unusual extremes of climate such as drought, heat waves, excessive rain or flooding, or untimely frost, that could cause deviations from the expected numbers of individuals. The confounding factors can affect the species under study directly (e.g., temperature affecting hatching rate, floods that drown larvae) or indirectly (e.g., die-offs of prey, increased or decreased presence of predators).

## 3.5 UNCERTAINTIES

Assessment of ecological risks possesses other dimensions compared to human health risk assessment that add further uncertainty to the assessment. Not only are multiple species involved, each of which may be subject to overt, as well as insidious, toxicological effects caused by contaminants, but also interactions among the species at the assessment site could potentially be perturbed, thereby adversely affecting the health of the ecosystem as a whole. Among the subtle adverse effects that may not be discovered by traditional toxicity testing are seemingly minor physiological and/or behavioral changes that may result in reduced fecundity, altered rates of maturation of individuals leading to a decrease in the number of adults available for mating, any changes that may affect the ability of the species in question to compete for food or to avoid predation, or avoidance of certain contaminants resulting in emigration.

## SECTION 4

## SPECIAL CONSIDERATIONS IN TERRESTRIAL RISK ASSESSMENT

### 4.1 INTRODUCTION

When assessing the impacts of any agent on an ecosystem, the ecosystem itself can be described according to climatic, geological, and topographical characteristics. Among the most obvious divisions of ecosystems is the separation on the basis of terrestrial (land) versus aquatic (freshwater and marine) habitats. While both general types of ecosystem are important, considerably more ecotoxicological information exists for aquatic systems than for terrestrial ecosystems (Bordeau et al., 1990). The purpose of the remaining portion of the present document is to highlight and expand the consideration of those steps in an ecological risk assessment for terrestrial areas that require special emphasis and to explain the importance of key concepts in ecological risk assessment.

### 4.2 ENVIRONMENTAL TRANSPORT MEDIA OF INTEREST

For ecological risk assessments, the environmental transport media of greatest interest are surface water and soil because these are the media that are most frequently in contact with the organisms of concern. While surface water is of primary interest to aquatic ecosystems, terrestrial ecosystems involve both soil and surface water. The reason that both media are of concern in terrestrial assessment is because many terrestrial receptors contact surface water bodies for such reasons as drinking, development through some of the life stages (e.g., tadpole stage of frogs and toads, larval stage of dragonflies), and living in or near the water (e.g., beaver, muskrat, some snakes). Consequently, areas of contaminated soil and territories near contaminated surface water bodies as well as near contaminated soils are likely to require terrestrial risk assessment. In addition, certain types of terrestrial environments are likely to be affected by contaminated air. While, in general, the concentrations of contaminants found in the air pathway do not pose a great risk to animal species, forests and lichen can be exquisitely sensitive to airborne contamination (Grodzinski and Yorks, 1981; Bourdeau et al., 1990). Thus, when terrestrial ecological assessments are conducted at or near forested areas, the air may be an important environmental transport medium for certain classes of receptors.

### 4.3 ASSESSMENT ENDPOINTS

Depending upon the dose of a given substance, a spectrum of undesirable effects may be observed that ranges from relatively benign effects at lower doses (e.g., dryness of the mouth) to serious or life threatening effects at higher doses (e.g., cardiac arrhythmia). Consequently, the dose of a contaminant to a given receptor that causes a relatively minor, reversible toxic effect (e.g., shaking and listlessness) is likely to be much lower than the dose of the same substance that is lethal in the same species. Since effective concentrations may be reported and listed in databases for several adverse effects of a substance, care must be taken to ensure that the endpoint selected for use in

ecological risk assessment is one that is biologically relevant for potential ecological damage. Examples of biologically relevant endpoints include death, growth, fecundity, and overt signs of toxicity (Suter, 1990).

## 4.4 EFFECTIVE CONCENTRATIONS

Effective concentrations are determined under controlled conditions in laboratory toxicity tests that examine specific endpoints. Many of these are available in the scientific literature or in databases. Thus, there is a source of effective concentrations for many substances in a variety of species. However, the species of test organism in which the effective concentrations were measured must be noted. Differences in sensitivity to hazardous substances among species of organisms are well known as confounding factors in risk assessment. In addition to species differences, pronounced variation in response to hazardous substances has been reported for laboratory and feral test organisms of the same species and for laboratory organisms that are exposed in the field and feral organisms that are used in the laboratory (Schaeffer and Beasley, 1989). These facts must be considered as a possible explanation for cases when the ecological quotient predictions calculated in phase I do not agree with the field observations made in phases II or III.

## 4.5 RECEPTOR MOBILITY

An important characteristic of ecological receptors that should be considered in exposure assessment is their mobility relative to the area of contamination. The mobility of a receptor can be indexed to the average foraging range of a typical member of the species under consideration. Adult plants (by definition), soil organisms, and most flightless invertebrates can be considered to be stationary due to the small area within which they live their lives. Small vertebrates (including amphibians, reptiles, many terrestrial and some volant avian species, and small arboreal and burrowing mammals) constitute a category of mobile receptors whose foraging area is likely to be up to several acres. A final group of transient receptors is made up of larger vertebrates including grazing species (e.g., deer, moose, cattle), predators (e.g., coyote, wolf, fox, bear), most volant birds, and raptors (e.g., hawk, eagle, falcon). The foraging areas of transient species are likely to be several square miles.

## 4.6 EXPOSURE CONCENTRATION AT RECEPTORS

The exposure concentration of the site contaminants in environmental transport media should be measured at or near the presumed point of contact with receptors or estimated from modelling of contaminant migration. When there is insufficient information about contaminant uptake and absorption efficiencies of receptors, this measured value is used to estimate dose. Other factors that must be considered in the estimation of dose to receptors include the duration of the exposure and the frequency with which the receptor comes into contact with the contaminant. Duration of exposure can be affected by the environmental removal of contaminants (e.g., through decomposition by photo-oxidation or bacterial degradation, or through leaching and eventual transport to another location). In the event that the contaminant is stable in the environment, as is frequently the case, the dose estimate

will only be affected by the frequency of contact that the receptor has with the contaminated media. Frequency of contact can be related to receptor mobility because both direct contact with the contaminated media and ingestion thereof can be directly related to the amount of time the receptor remains in the contaminated area.

## 4.7 TERRESTRIAL ECOLOGICAL QUOTIENT

The sizes of the foraging ranges vary considerably among terrestrial receptors, as discussed above. The calculation of ecological quotients for terrestrial receptors should be modified to account for the effect of receptor mobility on the frequency and duration of contact with contaminated media. When the foraging area exceeds the area of contamination, a correction factor that accounts for less than full-time exposure is required. MITRE suggests that the fractional exposure be calculated as the ratio of the contaminated area to foraging area and be designated the mobility factor, $\Theta$. The value of $\Theta$ will range such that $1 \geq \Theta > 0$. When applicable, the mobility factor would appear in the formula for a terrestrial ecological quotient as follows:

$$EQ_{ter} = \frac{\Theta \text{ (exposure concentration)}}{\text{effective concentration or surrogate}}$$

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# APPENDIX

# TERRESTRIAL TOXICITY TEST METHODS

## A.1 INTRODUCTION

Terrestrial toxicity test methods for contaminants at hazardous waste sites are less developed than aquatic toxicity test methods. However, there are a group of terrestrial test methods that are off-the-shelf techniques and are widely used. The toxicity tests discussed below are from this group and fall into two broad categories. These categories are microbial toxicity tests and single species bioassays. Examples of each category are briefly described in the following paragraphs along with advantages and limitations. Additional information regarding ecological (aquatic and terrestrial) test methods can be found in Ecological Assessment of Hazardous Waste Sites, a Field and Laboratory Reference (1989) and Review of Ecological Risk Assessment Methods (1988).

## A.2 MICROBIAL TOXICITY TEST METHODS

The principle behind microbial toxicity testing is that stress to a microbial community caused by a contaminant can be measured indirectly by observing changes (i.e., adenosine triphosphate [ATP] content or the bioluminescence) in the characteristics of microbes.

ATP is found in all living cells. The fact that ATP is rapidly destroyed after cell death makes it ideal for distinguishing between living and dead cells. The basic assay of ATP consists of measuring the light emission following the reaction of firefly luciferin with ATP in the presence of luciferase and $Mg^{2+}$. An example of the ATP assay is the ATP-TOX system test. Growth inhibition usually occurs when rapidly growing bacterial cells are exposed to toxicants. After several life cycles, the toxic effects can be estimated by comparing sample cell growth to a control by measuring the ATP content.

Bioluminescence assays are based on the sensitivity (inhibition) of bioluminescent bacteria to toxicants. An example of bioluminescence assay is Microtox (marketed by Microbics Corporation). Pure Microtox reagent (living bacteria) emits light. When toxic material is added to the reagent, the light output drops. The higher the concentration of toxicant, the greater the light loss. The Microtox instrument measures the light level before and after a sample of unknown toxicity is added to the reagent. The amount of decrease in the light level determines the toxicity of the sample.

| Advantages | Limitations |
|---|---|
| Quick and inexpensive.[1] | Difficult to extrapolate results for bacteria to species of concern, communities, or populations. |
| Easy to use. | |
| Can be taken to the field--useful as a screening tool. | May not be sensitive to all waste site contaminants. |
| | NaCl may affect the toxicity of heavy metals. |

## A.3 SINGLE SPECIES BIOASSAYS

Single species bioassays are, for the most part, short-term tests that assess the acute toxicity of contaminated soils or sediments. These tests include earthworm tests, seed germination tests, root elongation tests, insect body burden tests, and avian toxicity tests. The first three single species bioassays will be discussed in the following paragraphs..

Earthworms improve soil aeration and drainage within terrestrial environments and are considered representative soil macroinvertebrates. An example of an earthworm test is the *Eisenia foetida* earthworm 14-day soil acute toxicity test. *Eisenia foetida* is used in these tests because it is easily cultured in the laboratory, reaches maturity in 7 to 8 weeks, and is responsive to a wide range of toxicants. Test soil concentrations include a range of site soil or sediment concentrations, such as 90 percent, 60 percent, 30 percent, 10 percent, 2 percent, and 0 percent (control sample). Once exposure systems are prepared and the sample has been screened through a 1/4-inch soil sieve, ten adult earthworms are added to three replicate chambers and incubated at 20 +/- 2°C for 14 days. Temperature and humidity are controlled. Mortality is noted, and appropriate statistical techniques are applied to derive the $LC_{50}$. The higher the number of earthworms tested, the greater the sensitivity of the test.

Seed germination tests measure the effects of hazardous wastes on a critical stage in the developmental biology of plants. A variety of test species have been used; an example, lettuce *Lactuca sativa*, will be further discussed. The test procedure involves grading the seeds and preparing exposure systems using petri dish bottoms and plastic bags. As in the example of earthworms, a range of test soil concentrations is tested. Test soils are placed in the petri dishes, and 40 seeds are planted per dish. After seeding, 16-mesh silica sand is layered over the seeds, and the petri dish is irrigated to 85 percent water holding capacity. The petri dish is then placed upright in a plastic bag and sealed, leaving as much air space as possible inside. The sealed bags are placed in a growth

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[1]Less than 1/2 hour and approximately $10 per sample.

chamber for 120 hours at 24 +/- 2°C. The first 48 hours are completed in total darkness and the balance 16:8 hours light-dark. After 120 hours, the number of seeds that have germinated in each dish is determined. The $LC_{50}$ is derived from statistical analysis on the count data.

Root elongation is an important early developmental event in the growth and survival of plants. Unlike seed germination tests, the root elongation test evaluates only the water soluble constituents of a sample. As a general rule, root elongation is more sensitive than seed germination. This test may be done with a number of economically important species that germinate and grow rapidly. The test is done with graded seeds, which are placed in petri dishes. A logarithmic series of test concentrations plus control samples is prepared and added to filter paper-lined petri dish bottoms. The test solutions are absorbed by the filter paper in each petri dish. The seeds are placed on the filter papers and incubated in the darkened, humid container at 24 +/- 2°C for 120 hours. At the end of the test, root length is measured, and an estimate of the $EC_{50}$ is calculated.

| Advantages | Limitations |
|---|---|
| Provides data on specific species and contaminants at the site. | Can not be used to evaluate toxicity on a community or population level. |
| Results are specific to the location of the sample hence they can be used to map extent and distribution of bioavailable contamination. | Exposure conditions are not directly comparable to field exposures. |
| Acute toxicity tests are quick, easy, and inexpensive to conduct when compared to chronic testing. | Acute tests are less sensitive measures of toxicity when compared to chronic tests. |

## LIST OF REFERENCES

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# APPENDIX D

# COST SUMMARY

## Table D-1. _____ Air Force Base Cost Breakdown Summary

| | | | Task 1 Proj/Subcont. Management | | Task 2 Meetings | | Task 3 Scoping | | Task 4 Field Investigations | | Task 5 Reports | | Task 6 Other Deliverables | | Total Hours/Costs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DIRECT LABOR** | | | | | | | | | | | | | | | | |
| Personnel Level | USAF Contract Year | Rate/ Hour | Hours | Dollars | Hours | Dollars | Hours | Dollars | Hours | Dollars | Hours | Dollars | Hours | Dollars | Total Hours | Total Dollars |
| Senior | 2 | | | | | | | | | | | | | | | |
| Senior | 3 | | | | | | | | | | | | | | | |
| Mid | 2 | | | | | | | | | | | | | | | |
| Mid | 3 | | | | | | | | | | | | | | | |
| Junior | 2 | | | | | | | | | | | | | | | |
| Junior | 3 | | | | | | | | | | | | | | | |
| Technician | 2 | | | | | | | | | | | | | | | |
| Technician | 3 | | | | | | | | | | | | | | | |
| Support | 2 | | | | | | | | | | | | | | | |
| Support | 3 | | | | | | | | | | | | | | | |
| TOTAL DIRECT LABOR | | | | | | | | | | | | | | | | |
| **DIRECT EXPENSES** | | | | | | | | | | | | | | | | |
| Travel | | | | | | | | | | | | | | | | |
| Travel | | | | | | | | | | | | | | | | |
| Travel | - Subsistence | | | | | | | | | | | | | | | |
| OTHER | - Equipment/Supplies | | | | | | | | | | | | | | | |
| | - Telephone | | | | | | | | | | | | | | | |
| | - Postage & Shipping | | | | | | | | | | | | | | | |
| | - Computer/Word Proc. | | | | | | | | | | | | | | | |
| | - Supplies & Disposab | | | | | | | | | | | | | | | |
| | - Reproduction | | | | | | | | | | | | | | | |
| | - Miscellaneous | | | | | | | | | | | | | | | |
| TOTAL DIRECT EXPENSES | | | | | | | | | | | | | | | | |
| **SUBCONTRACTS** | | | | | | | | | | | | | | | | |
| Drilling/MW Installation | | | | | | | | | | | | | | | | |
| Soil Gas Surveying | | | | | | | | | | | | | | | | |
| Treatability Studies | | | | | | | | | | | | | | | | |
| Analytical Laboratory | | | | | | | | | | | | | | | | |
| Other/Miscellaneous | | | | | | | | | | | | | | | | |
| TOTAL SUBCONTRACT COST | | | | | | | | | | | | | | | | |
| **FEE** | | | | | | | | | | | | | | | | |
| LABOR FEE: | | | | | | | | | | | | | | | | |
| EXPENSES FEE: | | | | | | | | | | | | | | | | |
| SUBCONTRACTS FEE: | | | | | | | | | | | | | | | | |
| TOTAL FEE | | | | | | | | | | | | | | | | |
| TASK BUDGET TOTALS | | | | | | | | | | | | | | | | |

---- EXAMPLE ----

NOTE: THE CONTRACTOR SHALL PROVIDE THE AIR FORCE A SUMMARY OF COSTS IN A FORMAT SIMILAR TO THIS TABLE.

# APPENDIX E

# LIST OF ACRONYMNS

## ACRONYMNS

| | |
|---|---|
| APHA | American Public Health Association |
| API | American Petroleum Institute |
| ARAR | Applicable or Relevant and Appropriate Requirements |
| ASTM | American Society for Testing and Materials |
| ASCII | American Standard Code Information Interchange |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| AWWA | American Water Works Association |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (PL-96-510) - SUPERFUND |
| CFR | Code of Federal Regulations |
| CLP | Contract Laboratory Program |
| CRP | Community Relations Plan (or Profile) |
| deg C | Degree Centigrade or Celsius |
| EC | Electrical Conductivity |
| EPA | Environmental Protection Agency |
| ERC | Ecological Risk Characterization |
| FS | Feasibility Study |
| FSP | Field Sampling Plan |
| GC/MS | Gas Chromatography/Mass Specroscopy |
| HHEM | Human Health Evaluation Manual |
| HNu | Photoionization Detector (trade name) |
| HPLC | High Pressure Liquid Chromatograph |
| HSD | Human Systems Division |
| HSD/YAQ | Installation Restoration Program Division |
| HSP | Health and Safety Plan |
| ICP | Inductively Coupled Plasma |
| IRIS | Integrated Risk Information System |
| IRP | Installation Restoration Program |
| IRPIMS | Installation Restoration Program Information Management System |
| ITIR | Informal Technical Information Report |
| LC50 | Lethal Concentration, 50 percent |
| LOEL | Lowest Observed Effect Level |
| MCL | Maximum Contaminant Level |
| NAAQS | National Ambient Air Quality Standards |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR 300) |
| NEIC | National Enforcement Investigations Center |
| NIOSH | National Institute for Occupational Safety and Health |
| NPL | National Priorities List |
| NOEL | No Observed Effect Level |
| NTU | Nephelometric Turbidity Unit |

## ACRONYMNS (Concluded)

| | |
|---|---|
| NWWA | National Water Well Association |
| OSHA | Occupational Safety and Health Administration |
| OSWER | Office of Solid Waste and Emergency Response |
| OVA | Organic Vapor Analyzer (meter) |
| PA | Preliminary Assessment |
| POC | Point of Contact |
| QAMS | Quality Assurance Management Staff |
| QAPP | Quality Assurance Project Plan |
| QA/QC | Quality Assurance/Quality Control |
| RCRA | Resource Conservation and Recovery Act |
| R&D | Research and Development |
| RfD | Reference Doses |
| RI | Remedial Investigation |
| ROD | Record of Decision |
| SAP | Sampling and Analysis Plan |
| SARA | Superfund Amendments and Reauthorization Act (1986) |
| SEAM | Superfund Exposure Assessment Manual |
| SF | Slope Factors |
| SF 298 | Standard Form 298, "Report Documentation Page" |
| SOP | Standard Operating Procedure |
| SOW | Statement of Work |
| TCLP | Toxic Characteristic Leaching Procedure |
| TPM | Technical Project Manager |
| USGS | United States Geological Survey |
| VOC | Volatile Organic Compound |
| WPCF | Water Pollution Control Federation |
| 3-D | Three-Dimensional |

# INDEX