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Quality Assurance Program Plan
for the
Lawrence Berkeley National Laboratory
Environmental Restoration Program
March 2017 Revision 6

Review and Approval

Prepared By:  David Baskin
               Environmental Restoration Program
               Environmental Services Group

Date: 17 March 2017

Reviewed By:  Jennifer Larson
               Assurance Manager
               Environment, Waste and Radiation Protection Department

Date: 3-17-2017

Approved By:  David Diamond
               Environmental Restoration Program
               Environmental Services Group

Date: 3/17/17

Approved By:  Ron Pauer
               Environmental Services Group Leader

Date: 3/20/17

Approved By:  David Kestell
               Environment, Waste and Radiation Protection Department
               Department Head

Date: 3/22/17
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1 Introduction

This Quality Assurance Program Plan (QAPrP) establishes the requirements for collecting environmental data at Lawrence Berkeley National Laboratory (“LBNL” or “Berkeley Lab”) involving the investigation and cleanup if required of soil, soil vapor, groundwater, and surface water contamination that resulted from historical releases of chemicals or radionuclides at the facility.

1.1 Purpose and Required Elements

The purpose of the QAPrP is to provide the requirements for applying quality assurance (QA) and quality control (QC) procedures in order to collect and analyze data that are scientifically valid, legally defensible, and of documented quality.

This QAPrP is formatted and organized in accordance with *EPA Region 9 Guidance for Quality Assurance Program Plans* (USEPA, 2012) and is designed to meet the requirements of U.S. Department of Energy (DOE) Order 414.1D *Quality Assurance* (DOE, 2011a)

A QAPrP has four main elements, as follows:
- Program management
- Data generation and acquisition
- Assessment and oversight
- Data review and usability

These elements are discussed in Sections 2 through 5. References are provided in Section 6.

1.2 Implementation

This QAPrP supersedes the current LBNL Environmental Restoration Program (ERP) Quality Assurance Program Plan (LBNL, 2009b) and becomes effective upon the final approval signature date. At that time, all requirements of this QAPrP will be implemented except possibly the requirement to enter collected data into the California State Water Resources Control Board (SWRCB) Geotracker online database. The ERP is currently establishing the process for complying with Geotracker requirements and anticipates complying with those requirements on or about March 1, 2017 (see Sections 2.8.2 and 2.8.3).
This section presents the set of elements that comprise the program management requirements for a QAPrP. The QAPrP must have defined goals; it must ensure that program personnel, along with subcontractors and analytical laboratories, understand and support these goals and their purpose; and it must document the approach to be used.

### 2.1 Distribution List

This QAPrP is an internal LBNL document and will be made available to regulatory agencies upon request as either an electronic (PDF) copy or a paper copy. It is available to LBNL staff, including data generators and data users, at [https://www2.lbl.gov/ehs/esg/Internal%20Documents/index.shtml](https://www2.lbl.gov/ehs/esg/Internal%20Documents/index.shtml).

### 2.2 Program/Task Organization and Planning Documentation

Berkeley Lab is a multipurpose research facility operated by the University of California (UC) as part of the DOE national laboratory system. The ERP, a section of the Environmental Services Group (ESG) under LBNL’s Environment, Health, and Safety Division (EH&S), conducts environmental work involving the investigation and cleanup of soil, soil vapor, groundwater, and surface water contamination that resulted from historical releases of chemicals or radionuclides at the facility.

#### 2.2.1 Program/Task Organization

This QAPrP provides the QA/QC requirements for the investigation, evaluation, and cleanup of historical releases of contaminants to the environment at Berkeley Lab. The primary regulatory agencies with jurisdiction over such releases are DTSC, USEPA, and DOE. DTSC has jurisdiction over the evaluation, and if necessary, remediation, of releases to the environment of all chemical contamination under Resource Conservation and Recovery Act (RCRA) regulations. The USEPA has primary jurisdiction over releases of polychlorinated biphenyls (PCBs), which are regulated under the Toxic Substances Control Act (TSCA). Releases of radionuclides fall under the jurisdiction of DOE.

In addition to these agencies, the East Bay Municipal Utilities District (EBMUD) regulates groundwater treatment system discharges to the sanitary sewer system. The Bay Area Air Quality Management District (BAAQMD) regulates air emissions associated with a soil vapor extraction system that is used for remediation. An organizational chart for the program is presented on Figure 2.1.

The ESG Leader has overall responsibility for ensuring that activities are conducted in compliance with environmental laws, regulations, permits, and agreements. This responsibility also includes the implementation of appropriate QA measures for site surveillance and monitoring activities, site characterization, and corrective actions associated with federal, state, and local environmental regulations pertinent to Berkeley Lab. Further, the ESG Leader is responsible for ensuring that sufficient resources (personnel, supplies, and equipment) are available for compliance with the requirements of this QAPrP and the associated ESG Procedures.
The LBNL Hazardous Waste Handling Facility (HWHF) operates under a RCRA Part B Hazardous Waste Facility Permit (Permit No. CA4890008986) issued by DTSC. The permit requires Berkeley Lab to notify DTSC when an immediate or potential threat to human health and/or the environment is identified and when new releases of hazardous waste and/or hazardous constituents or new Solid Waste Management Units are discovered. In accordance with the permit, DTSC may require Berkeley Lab to investigate, mitigate, and/or take other applicable action to address immediate or potential threats to human health and/or the environment and newly identified releases of hazardous waste and/or hazardous constituents. The permit stipulates that any required corrective action will be carried out under a Corrective Action Consent Agreement or Unilateral Corrective Action Order. Berkeley Lab has been negotiating a Corrective Action Consent Agreement with DTSC. This QAPrP has been written to comply with anticipated requirements of that agreement, regardless of whether the agreement is finalized.

The ERP, ESG contractors conducting environmental work, and the laboratories that analyze the samples collected under this QAPrP are the data generators. The users of the data are the ESG technical personnel responsible for performing the environmental work, the regulatory agencies overseeing the facility, and other interested stakeholders (e.g., the general public).
2.2.2 Data Generators

Data generators include the ERP Leader, the QA Manager, ESG technicians, ESG subcontractors conducting environmental work, and analytical laboratories, as described below.

*Environmental Restoration Program Leader.* The ERP Leader (or a representative) is responsible for ensuring that ERP site personnel and ESG subcontractors conducting ERP activities have access to both the current QAPrP and the ESG Procedures that are relevant to their required activities, and that they perform fieldwork in accordance with QAPrP and Procedure requirements. The ERP Leader (or a representative) is also responsible for ensuring that laboratory reporting meets the requirements of this QAPrP, and that corrective actions are initiated when conditions adverse to data quality are identified.

*Quality Assurance Manager.* The QA Manager (or representative) is responsible for reviewing the requirements of the QAPrP and for conducting technical systems audits. The QA Manager documents any corrective action requirements that ensue from the audit findings, and conducts and documents follow-up of such corrective action requirements.

*Environmental Services Group Technicians.* ESG technicians are responsible for collecting environmental samples and taking field measurements in accordance with ESG Procedures relevant to their required activities, QAPrP requirements, and any workplans prepared for specific activities. ERP technicians perform fieldwork in accordance with QAPrP and Procedure requirements and are responsible for recording deviations from requirements in field logbooks and reporting the deviations to the ERP Leader. If a problem is discovered that materially affects quality, the ERP Leader can invalidate the results and/or initiate the Nonconformance and Corrective Action Report (NCAR) process in accordance with EH&S Procedure 208, *Nonconformance and Corrective Action Reporting.*

*ESG Subcontractors.* ESG subcontractors conducting environmental work are responsible for collecting environmental samples and measurements according to ESG Procedures relevant to their required activities, this QAPrP, their firm’s standard operating procedures, and any workplans prepared for their specific activities. They are responsible for recording deviations from requirements in field logbooks and reporting the deviations to the ERP Leader. If a problem is discovered that materially affects quality, the ERP Leader can invalidate the results and/or initiate the NCAR process in accordance with EH&S Procedure 208.

*Analytical Laboratories.* Environmental samples are analyzed by contract analytical laboratories. All laboratories conducting environmental sample analysis for ESG must be certified by the SWRCB under the California Environmental Laboratory Accreditation Program (ELAP) for all requested analytical methods. All samples submitted for chemical or physical analysis with potential radionuclide contamination must be analyzed by a laboratory with a current radioactive materials license.

The following primary contract laboratories are currently used by ERP:

- For chemical and physical analyses: BC Laboratories, Inc. (Bakersfield, California) and Curtis & Tompkins Laboratories (Berkeley, California)
- For radionuclide analyses: GEL Laboratories (Charleston, South Carolina) and ALS Environmental (Fort Collins, Colorado)
The specific contract laboratories used may change over time due to contractual changes. In addition, laboratories not currently under contract may be used occasionally for specialty services. For example, TEG-Northern California (Rancho Cordova, California), an ELAP certified mobile laboratory, has been used on occasion for the real-time analysis of soil vapor samples.

2.2.3 Data Users

Data users include ERP personnel, the ESG Leader, the LBNL Waste Services Team, the LBNL Radiation Protection Group (RPG), ESG subcontractors conducting environmental work, and regulatory agencies, as described below.

The ESG leader and ERP personnel use the data generated under this QAPrP for the following purposes:

- Monitoring the effectiveness of the DTSC-approved groundwater remedial systems and other corrective measures that have been implemented for groundwater remediation.
- Collecting data at LBNL construction/demolition sites to assess the potential risk to site workers, future building occupants, and other potential receptors from subsurface contamination, and to determine whether regulatory notification is required.
- Providing data to support the selection, design, and operation of interim or final corrective measures, should corrective action be required by regulatory agencies.
- Ensuring compliance with LBNL's Wastewater Discharge Permit for groundwater treatment discharges.
- Ensuring compliance with LBNL’s BAAQMD Permit to Operate Plant #723 for Soil Vapor Extraction System near Buildings 53 and 58 for air emissions.
- Determining soil management and disposal requirements for waste soils generated during ERP and other LBNL activities.

The Waste Services Team use the data generated under this QAPrP for waste profiling purposes for offsite disposal of waste soil generated during ERP and other LBNL activities.

The RPG uses the data under this QAPrP to support Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) release surveys.

ESG subcontractors use the data generated under this QAPrP for activities such as completing workplans for additional investigation, performing risk assessments, and preparing designs and providing costs to modify or upgrade existing remedial systems or construct new systems.

DTSC uses the data generated under this QAPrP for the following purposes:

- Determining whether new corrective measures are required and, if so, how they should be implemented.
- Assessing overall compliance and progress of all approved corrective measures.
- Determining when corrective measures are complete.
- Approving determinations of technical impracticability, should achieving the required cleanup levels be deemed technically impracticable.
The DTSC supervisor is Karen Toth, who has the following contact information:

karen.toth@dtsc.ca.gov
Department of Toxic Substances Control
700 Heinz Ave., Suite 200
Berkeley, CA 94710-2737

DOE is the regulatory agency with oversight responsibility for radionuclides at Berkeley Lab. DOE uses the data generated under this QAPrP to assess compliance with DOE Orders and other requirements related to radionuclides.

Data generated under this QAPrP may also be used to assess TSCA investigation and cleanup requirements. The USEPA Region 9 PCB Coordinator is Carmen Santos, who has the following contact information:

santos.carmen@epa.gov
USEPA Region 9
75 Hawthorne Street
Mail Code: WST-5
San Francisco, CA 94105

The San Francisco Bay Regional Water Quality Control Board (RWQCB) uses the data generated under this QAPrP to assess compliance with the California Water Code (Porter-Cologne). The RWQCB site representative is Tina Low, who has the following contact information:

tlow@waterboards.ca.gov
Regional Water Quality Control Board – San Francisco Bay Region
1515 Clay Street, Suite 1400
Oakland, CA 94612

EBMUD uses data generated under this QAPrP to monitor compliance with requirements of LBNL’s Wastewater Discharge Permit for groundwater treatment system discharges (No. 50347891). The EBMUD contact is Marie Kulka, who has the following contact information:

marie.kulka@ebmud.com
East Bay Municipal Utility District, Source Control Division
P.O. Box 24055
Oakland, CA 94623-1055

The BAAQMD uses data generated under this QAPrP to monitor compliance with requirements of LBNL’s BAAQMD Permit to Operate Plant #723 for Soil Vapor Extraction System near Buildings 53 and 58 (No. A07223). The BAAQMD contact is Alfonso Borja, who has the following contact information:

aborja@baaqmd.gov
Bay Area Air Quality Management District
939 Ellis Street
San Francisco, CA 94109
2.3 Planning Documentation

2.3.1 Introduction

Collecting environmental data is required for the following routine activities:

- Operation, monitoring, and maintenance of the existing DTSC-approved corrective measures for remediation of volatile organic compound (VOC) contaminated groundwater, including monitoring changes in VOC concentrations in groundwater, complying with LBNL’s Wastewater Discharge Permit requirements for groundwater treatment discharges, and complying with LBNL’s Soil Vapor Extraction System Permit requirements for air emissions.
- Monitoring groundwater and/or surface water for tritium that was released as a result of operations associated with the former National Tritium Labeling Facility in Building 75 and the former Bevatron.
- Monitoring surface water for VOCs and metals to monitor the potential offsite migration of contaminants.
- Monitoring groundwater for metals in areas where they were previously detected at concentrations exceeding Berkeley Lab background levels and Maximum Contaminant Levels (MCLs) for drinking water.

Collecting environmental data is also required for the following non-routine activities:

- Determining soil management and disposal requirements for waste soils generated during ERP and other LBNL activities such as demolition or construction projects or other activities that require the disposal or onsite reuse of excavated soil.
- Assessing potential risks to construction workers and environmental liabilities at LBNL demolition/construction sites.
- Assessing the effectiveness of corrective measures using such methods as confirmation sampling of remedial excavations.
- Engineering evaluations for recommending corrective measures.
- Assessing releases of contaminants to the environment.
- Providing data for soil profiling purposes for offsite disposal.

QA planning documentation for the non-routine activities generally takes the form of a workplan, sampling and analysis plan, soil management plan, engineering evaluation, risk assessment, and/or other overall planning document that references this QAPrP and any ESG Procedures relevant to the activity. These documents are discussed further below.

2.3.2 Workplans, Sampling and Analysis Plans, and Other Overall Planning Documents

Each workplan, sampling and analysis plan, soil management plan, engineering evaluation, risk assessment, or other overall planning document is prepared under the direction of the ERP Leader. Before being implemented, the revised document is reviewed by a subject matter expert appropriate to the activity who is selected by the ERP Leader and ESG Leader, and by a representative of the Waste Services Team if waste management requirements are included in the activity. The final document is
approved by the ESG Leader. With the exception of engineering evaluations and risk assessments, these documents contain the following required elements, at a minimum:

- Overall purpose and scope for the work
- Sampling or testing locations and frequencies, and rationale for their selection
- Sampling or evaluation methodology
- Analytical or test method requirements
- Project-specific QA/QC requirements including the following elements:
  - Data quality objectives (DQOs)
  - Listing of analysis or testing requirements (e.g., VOCs)
  - Listing of matrices/media to be sampled/tested
  - Reporting Limits (RLs)
  - QC sample frequency
  - Data validation requirements
  - Field quality control samples (duplicates and blanks) and limits

Note that in some cases, relevant and appropriate elements present in the QAPrP may be incorporated by reference into the document. However, for some activities regulatory agencies may require that a stand-alone project-specific Quality Assurance Project Plan (QAPjP) be produced, which may duplicate some or all of the elements in the QAPrP.

In addition, it is important to note that each regulatory agency may have one or more guidance documents with different or overlapping requirements for workplans, sampling and analysis plans, or QAPjPs. Current pertinent guidance from the agencies with jurisdiction over the work being conducted should be consulted before preparing planning documentation.

2.3.2.1 Routine Operation, Monitoring, and Maintenance

Berkeley Lab is collecting data to document the progress of the implemented corrective measures toward achieving the required groundwater Media Cleanup Standards (MCSs). Data are being collected also to document whether site groundwater plumes are stable or attenuating and whether contamination is migrating off site in groundwater or surface water. The requirements for monitoring compliance with MCSs are specified in the LBNL Groundwater Monitoring and Management Plan (GMMP; LBNL, 2006), which is considered to be the overall planning document for this activity. The GMMP specifies that all groundwater and surface water monitoring will be performed in accordance with the ERP Quality Assurance Program Plan (QAPP) and the ERP standard operating procedures (G:\Environment, Waste and Radiation Protection\ESG\Procedures). This current QAPrP is Revision 6 to the ERP QAPP. Because all QA requirements for this activity are incorporated into the QAPrP and ESG Procedures, no additional QA planning documentation is required.

Berkeley Lab also collects groundwater and surface water samples to monitor tritium concentrations near the former National Tritium Labeling Facility, and metals concentrations in groundwater in several areas
where they were previously detected at concentrations exceeding Berkeley Lab background levels and MCLs. Monitoring methods and schedules for this sampling are specified in the GMMP.

2.3.2.2 Investigations

Workplans or sampling and analysis plans are prepared before implementing all voluntary investigations and investigations required by RCRA, TSCA, or DOE. A conceptual site model may be required that should describe physical characteristics of the investigation area, contaminant release and migration pathways, and risk pathways.

2.3.2.3 Soil Management and Disposal Requirements

Soil management plans or sampling and analysis plans are the overall planning documents prepared before implementing reuse or disposal of waste soil generated during demolition and/or construction activities. In most cases, relevant and appropriate elements present in the QAPrP may be incorporated by reference into a QAPjP.

Disposal facilities may have different acceptance criteria for waste soil. The Waste Services Team and current pertinent guidance or acceptance criteria from the disposal facilities should be consulted before preparing soil management plans or sampling and analysis plans for waste soil disposal or reuse.

2.3.2.4 Assessment of Corrective Measure Effectiveness

Workplans or sampling and analysis plans are the planning documents prepared to specify the requirements for assessing the effectiveness of corrective measures including any sampling requirements.

2.3.2.5 Engineering Evaluations for Corrective Measures and Risk Assessments

Engineering evaluations or risk assessments may be conducted to aid selection of corrective measures. These documents include the following required elements at a minimum:

- Overall purpose and scope for the work
- Testing locations, and the rationale for their selection
- Evaluation methodology
- Analytical or test method requirements
- Project-specific QA/QC requirements and, at a minimum, including the following elements:
  - Project-specific DQOs derived using the process described in Section 2.6.1
  - Listing of analysis, testing, or modeling requirements
  - Listing of matrices/media to be sampled/tested
  - Reporting limits
  - QC sample frequency
  - Data or model validation and calibration requirements
  - Field QC samples (duplicates and blanks) and limits
2.3.2.6 Activities That Overlap with Other Programs

Some of the activities described above may overlap with those of other LBNL programs or projects. For example, an investigation conducted as part of a RCRA investigation of non-radionuclides may be expanded to include analysis of collected samples for radionuclides to support a Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) release survey. Therefore, the need to incorporate QA requirements from other programs and projects should be considered before preparing planning documentation.

2.3.3 Quality Assurance Program Plan

Revisions to the QAPrP are conducted periodically when the ERP Leader, ERP QA Manager, or the ESG Leader determines that the program has changed sufficiently that the current QAPrP no longer covers all program QA requirements. The ERP Leader will also review the QAPrP at least once every five years to ascertain whether revision is needed. Revisions are prepared under the direction of the ERP Leader. Before implementation, the revised document must be reviewed by the ERP QA Manager and then approved by the ESG Leader.

2.3.4 ESG Procedures

ESG Procedures are controlled documents that describe standard operating procedures for both ERP activities and other unrelated ESG activities. ESG Procedures that apply to ERP activities are listed below.

- No. 200: Environmental Document Preparation
- No. 208: Nonconformance & Corrective Action Reporting
- No. 230: Groundwater and Soil Vapor Treatment System Inspection and Maintenance
- No. 231: Drilling, Logging, Sampling, and Destroying Borings
- No. 232: Installing, Developing, and Destroying Groundwater Wells
- No. 233: Groundwater Sampling
- No. 238: Soil Vapor Sampling and Sample Probe Installation
- No. 254: Sample Processing, Packaging, and Transport
- No. 263: Surface Water Sampling
- No. 266: Soil, Sediment, and Vegetation Sampling
- No. 268: Environmental Sample Tracking & Data Management

Revisions to these procedures are prepared under the direction of the ERP Leader. Before a procedure can be implemented, it must first be reviewed by the ERP Leader and ERP personnel who may implement the procedure, and then it must be approved by the ESG Leader and the Environment, Waste & Radiation Protection Department Head.
2.4 Problem Definition/Background

Berkeley Lab is located in the Berkeley/Oakland Hills in Alameda County, California, and occupies approximately 200 acres on the northeast side of the UC Berkeley campus (Figures 2.2 and 2.3). The western three-quarters of the LBNL site are in the City of Berkeley, and the eastern quarter is in the City of Oakland.

![Figure 2.2 Regional Setting of the Lawrence Berkeley National Laboratory](image)

Because Berkeley Lab is a research facility, hazardous chemicals and radionuclides have been used or produced as wastes at the site during its operation. Some of these constituents (primarily VOCs, PCBs, petroleum hydrocarbons, metals, and radionuclides) were released to the environment as a result of historical facility operations. The ERP conducts investigation and cleanup of potentially contaminated groundwater, soil, and soil vapor at Berkeley Lab in accordance with RCRA Corrective Action Program (CAP) requirements, with the following exceptions:

- PCB releases requiring cleanup are conducted in compliance with the TSCA under the oversight of the USEPA.
- Investigation and cleanup of radionuclide releases are conducted in compliance with DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE, 2011b) under the oversight of the DOE.
RCRA CAP requirements were previously specified in detail in Berkeley Lab’s 1993 RCRA HWHF Permit issued by DTSC. The current permit, issued in 2006, includes DTSC notification requirements for newly identified releases, but not detailed RCRA CAP requirements. The objectives of the CAP are to evaluate the nature and extent of releases of hazardous waste or hazardous waste constituents; to evaluate facility characteristics; and to identify, develop, and implement appropriate corrective measures to protect human health and the environment. The CAP has four primary components, which are described briefly below:

- **A RCRA Facility Investigation (RFI)** is intended to evaluate the nature and extent of the releases of hazardous waste and hazardous constituents, and to gather other data to support the Corrective Measures Study and/or the need to implement Interim Corrective Measures.
- **Interim Corrective Measures (ICMs)** are intended to control or abate imminent threats to human health and/or the environment from releases, or to prevent or control the further spread of contamination while long-term remedies are pursued.
- **A Corrective Measures Study (CMS)** is intended to develop and evaluate corrective measure alternative(s) and recommend the final corrective measures.
- **A Corrective Measures Implementation (CMI)** is intended to design, construct, operate, and maintain the corrective measures selected to address the contamination and to monitor their performance.

Berkeley Lab has completed a site-wide RFI, CMS, and CMI and has implemented ICMs where necessary to protect human health and the environment. The corrective measures required for soil
contamination were completed in 2006, whereas the corrective measures required for groundwater contamination are currently in the operation, maintenance, and monitoring stage (LBNL, 2007).

Berkeley Lab is collecting data to document the progress of the implemented corrective measures toward achieving the required groundwater MCSs, and to document that site groundwater plumes are stable or attenuating and that contamination is not migrating off site in groundwater or surface water. Berkeley Lab will use the data to determine when the required groundwater cleanup levels have been achieved – or to complete a technical impracticability evaluation if achieving the required cleanup levels is determined to be technically impracticable. A determination of technical impracticability requires DTSC approval.

In accordance with the HWHF Permit, if an immediate or potential threat to human health and/or the environment is identified, or if new releases of hazardous waste and/or hazardous constituents or a new solid waste management unit is identified, DTSC may require Berkeley Lab to investigate, mitigate, and/or take other applicable action to address any immediate or potential threat to human health or the environment. For newly identified solid waste management units, any DTSC-required corrective action would be conducted under either a Corrective Action Consent Agreement or a Corrective Action Order.

2.5 Program/Task Description

ERP activities, which include environmental measurements and sample collection and analysis, are discussed in the following subsections, as summarized briefly below:

- Routine operation, monitoring, and maintenance of the existing DTSC-approved RCRA corrective measures for remediation of VOC-contaminated groundwater, including complying with LBNL’s Wastewater Discharge Permit requirements for groundwater treatment discharges, and complying with LBNL’s Soil Vapor Extraction System Permit requirements for air emissions.

- Routine monitoring of groundwater and surface water for tritium that was released as a result of operations associated with the former National Tritium Labeling Facility in Building 75, and for metals in areas where they were previously detected in groundwater at concentrations exceeding Berkeley Lab background levels and MCLs.

- Non-routine characterization of soil, soil vapor, groundwater, and/or surface water contamination for the following purposes:
  - Determining the magnitude and extent of newly discovered environmental releases and providing data to support a determination as to whether further action is warranted.
  - Assessing potential risks to construction workers and environmental liabilities at LBNL demolition/construction sites.
  - Determining soil management and disposal requirements for waste soils generated during ERP and other LBNL activities.
  - Assessing the effectiveness of corrective measures using such methods as confirmation sampling of remedial excavations.

- Conducting engineering evaluations and risk assessments for the purpose of selecting corrective measures, either voluntarily (i.e., conducted outside of requirements for regulatory agency...
approval, primarily at LBNL sites slated for redevelopment) or as required by one or more of the following regulatory agencies:

- DTSC under RCRA (i.e., non-radionuclide releases)
- USEPA under TSCA (i.e., PCB releases)
- DOE (i.e., radionuclide releases)

2.5.1 Routine Operation, Monitoring, and Maintenance of Corrective Measures

The corrective measures approved by DTSC for remediating contaminated groundwater include in situ soil flushing and groundwater capture, enhanced bioremediation through subsurface injection of Hydrogen Release Compound® (HRC), and monitored natural attenuation (MNA). These measures have been implemented and are operational. Completion of corrective measures will be documented by comparing residual concentrations of chemicals of concern in groundwater to the required cleanup levels (MCSs), as described in the *RCRA Corrective Measure Study Report for the Lawrence Berkeley National Laboratory* (LBNL, 2005a). In addition, continued assessment of the effectiveness of MNA and enhanced bioremediation using HRC injection is documented by comparing concentrations of key hydrochemical parameters (e.g., nitrates, sulfates, and dissolved oxygen) to guideline parameter values listed in *Monitoring Protocols for Monitored Natural Attenuation and Enhanced Bioremediation* (LBNL, 2005b).

Details of the activities that are covered under provisions of the operation, monitoring, and maintenance of the existing CMI are provided in the *RCRA Corrective Measures Implementation (CMI) Workplan* (LBNL, 2005c), the *Groundwater Monitoring and Management Plan* (LBNL, 2006), and the *RCRA Corrective Measures Implementation (CMI) Report* (LBNL, 2007). Project tasks are summarized below.

2.5.1.1 Groundwater Monitoring

Monitoring consists of collecting periodic groundwater samples for VOC analysis and hydrochemical indicator parameters, measuring groundwater elevations to estimate groundwater flow directions, and measuring flow rates and volumes of extracted and injected groundwater to monitor system performance. Compliance wells are located within and downgradient from the groundwater contamination plumes, as specified in the RCRA CMI Report (LBNL, 2007). The purpose of the wells is to assess progress toward achieving the required MCSs and to monitor for downgradient plume migration. In addition, key wells within the plumes are used to monitor geochemical parameters as part of the MNA and enhanced bioremediation remedies.

2.5.1.2 Surface Water Sampling

Surface water samples are collected to document that chemicals of concern are not migrating off site in surface water.

2.5.1.3 Treatment System Sampling

Water discharge samples are collected from groundwater treatment systems to document that the treatment systems comply with EBMUD wastewater discharge requirements, to determine when the
granular activated carbon (GAC) used for treatment needs to be changed out, and to document that treated water injected into the subsurface for in situ soil flushing purposes contains no detectable VOCs. Vapor measurements are collected from the soil vapor treatment system located on the Building 53/58 slope, to comply with the BAAQMD Permit to Operate requirement for determining treatment system effectiveness and to indicate when the GAC used for air treatment needs to be changed out.

2.5.1.4 Technical Report Preparation

The ERP submits semiannual progress reports to DTSC for review and approval. The first semiannual report covers activities completed from October 1 to March 31 (first and second quarters of fiscal year) and is due by the end of August; the second semiannual report covers activities completed from April 1 to September 30 (third and fourth quarters of fiscal year) and is due by the end of February of the following year. The semiannual progress reports include the following information related to RCRA CAP activities conducted at Berkeley Lab:

- A description of work completed
- Summaries of findings, including summaries of laboratory data
- Summaries of problems encountered or potential problems identified during the reporting period, and actions taken to rectify the problems
- Projected work for the next reporting period

In order to provide a comprehensive evaluation of the status of site contaminants, the reports also include descriptions and results of other assessments and investigations conducted by the ERP.

In addition to the semiannual ERP progress reports submitted to DTSC, other technical documents are produced as needed, including documents such as workplans and reports on rebound testing and well decommissioning, and requests for modifying and relocating treatment systems.

2.5.1.5 Site Closeout

After the required MCSs have been achieved at a specific groundwater unit, Berkeley Lab submits documentation requesting that DTSC certify that the corrective measure is completed. If a remedy is determined by Berkeley Lab not to be effective, an alternative remedy may be proposed and implemented upon approval by DTSC. If no alternative remedies are feasible, Berkeley Lab may request a determination of technical impracticability. If DTSC approves technical impracticability, the corrective measure will be terminated; continued long-term groundwater monitoring, however, would still be required.

2.5.2 Routine Monitoring for Tritium and Metals

2.5.2.1 Groundwater Monitoring

Monitoring consists of collecting periodic groundwater samples for tritium or metals analysis, and measuring groundwater elevations to estimate groundwater flow directions. Wells used for monitoring tritium are within and downgradient from the tritium plume that extends southward from the Building 75
area. Three wells in the former Bevatron area are also monitored for tritium. Wells used for monitoring metals are in various Berkeley Lab locations where metals concentrations have historically been elevated.

2.5.2.2 Surface Water Sampling

Surface water samples are collected to document that metals contamination is not migrating off site in surface water and to monitor tritium concentrations.

2.5.3 Non-Routine Characterization of Groundwater, Soil, Soil Vapor, and/or Surface Water Contamination

Characterization activities are conducted in order to assess potential risks to construction workers and environmental liabilities at LBNL demolition/construction sites, to determine soil management and disposal requirements for waste soils, and to assess the effectiveness of corrective measures using such methods as confirmation sampling of remedial excavations. These kinds of activities may be conducted based on Berkeley Lab policies or based on requests by regulatory agencies such as DTSC, DOE, or USEPA. Such activities may include the following sampling and assessment tasks.

2.5.3.1 Groundwater Sampling

Groundwater samples may be collected for site assessment, for human health or ecological risk assessment, or for documentation of groundwater conditions in light of potential site redevelopment.

2.5.3.2 Soil Sampling

Soil samples may be collected for site assessment, human health or ecological risk assessment, documentation of soil conditions in light of potential site redevelopment, and disposal profiling. Soil samples may also be collected and analyzed for radiological constituents as part of MARSSIM release surveys.

2.5.3.3 Soil Vapor Sampling

Soil vapor samples may be collected for site assessment in areas with potential VOC contamination, for assessment of human health risks associated with vapor intrusion to indoor air, or for screening of sites for potential site redevelopment.

2.5.3.4 Surface Water Sampling

Surface water samples may be collected for site assessment and for human health or ecological risk assessment.

2.5.3.5 Air Sampling

Indoor air samples may be collected to assess human health risks resulting from subsurface vapor intrusion to indoor air in cases where sampling of subsurface media indicates the potential for completed migration pathways to indoor air.
2.5.3.6 Membrane Interface Probe Logging

Membrane Interface Probe (MIP) logging is generally conducted in areas where soil or soil vapor sampling has indicated the presence of VOC contamination. MIP surveys provide qualitative information regarding the depth distribution of VOCs, and so are useful for targeting future corrective measures. MIP instrument packages generally include additional sensors that measure the electrical resistivity and relative hydraulic conductivity of subsurface soil, and thereby provide information about contaminant migration pathways.

2.5.4 Engineering Evaluations and Risk Assessments

Engineering evaluations may be conducted to evaluate possible corrective measures. Risk assessments may be conducted to evaluate the need for corrective measures or other mitigations for contamination that poses potential risks to human health or the environment. These tasks may include sampling of the various media described in the preceding subsections, in situ or ex situ testing of subsurface media, computer modeling, or engineering calculations.

2.5.5 Laboratory Analyses

Analytical data that are generated under provisions of this QAPrP for the tasks described in the preceding subsections consist primarily of concentrations of VOCs, metals, radionuclides, PCBs, and petroleum hydrocarbons in groundwater, surface water, and soil, as well as VOCs in soil vapor. Analyses for non-contaminant hydrochemical indicator parameters (e.g., nitrates, sulfates, total organic carbon, and dissolved oxygen) are required to support the continued evaluation of the potential effectiveness of MNA and enhanced bioremediation. Analyses of soil physical characteristics (e.g., permeability, grain size) are conducted to provide input to risk assessment models and engineering evaluations of remedial methods.

2.6 Quality Objectives and Criteria for Measurement Data

Data quality objectives (DQOs) are the qualitative and quantitative statements that clarify a study’s technical and quality objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used to establish the quality and quantity of data needed to support decisions.

2.6.1 The DQO Process

The DQO process consists of seven steps (USEPA, 2006):

- Step 1 – State the problem.
- Step 2 – Identify the goals.
- Step 3 – Identify the information inputs.
- Step 4 – Define the boundaries of the site.
- Step 5 – Develop the analytic approach.
- Step 6 – Specify performance or acceptance criteria.
• Step 7 – Develop the plan for obtaining data.

DQOs are required for the tasks described in Section 2.5. DQOs are included in this QAPrP for routine activities including operation, monitoring, and maintenance of the existing corrective measures (see Section 2.6.2).

For any additional work proposed by Berkeley Lab or requested by DTSC or USEPA, DQOs will be developed as needed and included in the investigation workplan for a given project. The analytical approach to a project may involve collecting various data types, including field measurements that may be qualitative to quantitative; use of real-time field instruments, such as membrane interface probe borings that are semi-quantitative; and certified laboratory analyses that are quantitative. The analytical approach will be developed in the DQO sections of each project-specific investigation workplan.

Depending on a project’s DQOs, any additional QA requirements not included in this QAPrP will be identified during workplan preparation and will be included in the workplan.

2.6.2 DQOs for the Operation, Monitoring, and Maintenance of CMI

2.6.2.1 Step 1: State the Problem

Contaminated groundwater at Berkeley Lab poses a potential threat to human health and the environment. To mitigate this potential threat, corrective measures have been implemented in accordance with the requirements specified in the RCRA CMI Report (LBNL, 2007). These measures have been designed to reduce residual concentrations of chemicals of concern to levels at or below the DTSC-required MCSs.

To address both risk-based and regulatory-based requirements, two sets of MCSs were developed. Cleanup to risk-based MCSs is the short-term goal for areas of Berkeley Lab where groundwater is not considered a potential drinking water source (i.e., the groundwater does not meet SWRCB well yield criteria for potential drinking water sources of at least 200 gallons per day). Cleanup to more stringent regulatory-based MCSs is the short-term goal for all areas where groundwater does meet the SWRCB well yield criteria, and is therefore considered a potential drinking water source. The regulatory-based MCSs for groundwater were set at California maximum contaminant levels [MCLs] for drinking water, as specified in Title 22, California Code of Regulations, Environmental Health.

In addition to the short-term goals described above, the overall long-term goal for all groundwater at Berkeley Lab, irrespective of well yield, is the reduction of contaminant concentrations to MCLs, if practicable.

2.6.2.2 Step 2: Identify the Goals

Data are collected for implementing corrective measures consistent with the provisions of this QAPrP, and are used to assess the technical success and ongoing practicability of the implemented corrective measures for attaining the required MCSs. The following principal questions are considered in the assessment:

• Has the implementation of the corrective measure attained the MCSs?
• Is the implementation of the corrective measure making progress toward attaining the MCSs?
• Is attaining the MCSs technically practicable?
• Should alternative corrective measures be considered?

The required decisions for this process and the sequence with which the decisions need to be resolved are outlined on Figure 2.4.

2.6.2.3 Step 3: Identify the Information Inputs

The primary decision input is the contaminant concentration data obtained from samples of soil and groundwater. These data are used to assess the magnitude and extent of groundwater contamination, with an emphasis on changes that may be occurring over time due to remedial activities. Supplemental input to support the decision consists of surface water sampling results that are used to document whether chemicals of concern are migrating off site in surface water.

Secondary decision input may include other sampling and monitoring information, as follows:

• The results of post-treatment water sampling to document compliance with the EBMUD wastewater discharge permit or to document the reinjection of clean water into the subsurface.
• The results of soil sampling to characterize waste soil for proper disposal.
• The results of inflow and post-treatment vapor monitoring to document compliance with the BAAQMD Permit to Operate.

2.6.2.4 Step 4: Define the Boundaries of the Site

Groundwater samples are collected at locations within the current boundaries of Berkeley Lab (with one exception), primarily from existing groundwater monitoring wells and temporary groundwater sampling points. Soil samples are collected from within the site boundaries. Surface water samples are collected from site creeks either within the site boundaries or downstream from the site boundaries.

2.6.2.5 Step 5: Develop the Analytic Approach

Continued progress toward MCSs in areas where in situ soil flushing is being conducted is assessed by reviewing concentration trends in wells not affected by treated water injection and also by reviewing mass removal trends. Mass removal is calculated using groundwater concentration and extraction/injection rate monitoring data.
Figure 2.4 Flowchart of RCRA Decision Process
The continued effectiveness of MNA and enhanced bioremediation using HRC injection is assessed by reviewing the results of monitoring VOC concentrations and hydrochemical parameters in the groundwater. These data are used to assess whether conditions indicative of natural attenuation or bioremediation are present, and whether these remedies are likely to result in reductions in VOC concentrations to MCSs.

Attainment of cleanup is evaluated by comparing sample concentrations to the DTSC-required MCSs. When the concentrations of chemicals of concern in all wells at a groundwater unit are less than MCSs for four consecutive quarters of monitoring in the absence of continued remediation, Berkeley Lab may request DTSC approval of completion of corrective measures. Approval of the request will signify that operation of the corrective measure can be terminated.

Compliance with permit requirements for wastewater treatment system operation is addressed by conducting sampling and reporting as specified in the associated permit. Compliance with permit requirements for vapor treatment system operation is addressed by monitoring as specified in the associated permit. Compliance with soil disposal requirements is addressed by conducting sampling and reporting as specified by the facility where disposal of waste soil is planned and complying with requirements specified the Soil Management Plan prepared by Berkeley Lab for the soil to be disposed of.

2.6.2.6 Step 6: Specify Performance or Acceptance Criteria

When evaluating attainment of MCS, two types of decision errors are possible:

- A Type I error would occur if it were decided that remediation is complete, but contaminant concentrations still exceed the MCSs.
- A Type II error would occur if it were decided that further remediation is necessary, but contaminant concentrations do not exceed the MCSs.

Generally, decisions based on sampling are made by comparing the MCSs to exposure point concentrations (EPCs) that are either maximum concentration values or 95% upper confidence limits (UCLs) on the mean of site sampling data. Since the 95% UCL is the least conservative of these two measures of site concentrations, there is up to a 5% chance of making a Type I error, which is considered a tolerable limit on decision errors. The potential consequences (threat to human health or the environment) of making a Type I error have been minimized by setting MCSs at levels where the theoretical Incremental Lifetime Cancer Risks (ILCRs) are less than or at the lowest level within the USEPA target range for risk managers, and hazard indices are less than 1.0. Although an ILCR anywhere within the target range for risk managers (between $10^{-4}$ and $10^{-6}$) is considered by the USEPA to be safe and protective of public health, the lowest reasonably achievable level within the target range has been selected as the risk-based MCS.

Given the conservative nature of the EPCs used to compare site sampling data to MCSs, the probability of making a Type II error is relatively high, especially when maximum values are used to identify areas requiring remediation. The probability of making such errors varies significantly and is generally not
documented, since regulatory requirements include use of maximum values and UCLs rather than use of lower confidence limits, which are therefore not calculated. For soil remediation, the cost of remediating larger soil areas than needed to meet MCSs is generally weighed against the cost of additional sampling and assessment to better define appropriate EPCs and delineate areas exceeding MCSs. For groundwater samples, the possibility of making such errors is minimized by using long-term monitoring records to make site decisions, so that anomalous data points can be identified and mitigated (e.g., through resampling if decisions may be based on the anomalous data). Given the level of public and regulatory scrutiny, the higher probability of making a Type II error rather than a Type I error is considered tolerable.

2.6.2.7 Step 7: Develop the Plan for Obtaining Data

Groundwater and surface water samples are collected to evaluate the effectiveness of the DTSC-approved corrective measures in accordance with requirements specified in the *Groundwater Monitoring and Management Plan* (LBNL, 2006), which was approved by DTSC.

Wastewater samples are collected to determine compliance with the wastewater discharge permit. Exceedance of the permit requirements is a possible Type I decision error. The tolerance for making a Type I decision error is based on permit requirements for sampling, so it is not controlled by Berkeley Lab. This error will be minimized by regular monitoring and maintenance of the remedial systems and by following the analytical requirements set forth by the regulatory agency that issues the permit. Type II decision errors are not relevant to such compliance sampling.

Characterization samples for soil disposal are collected to determine compliance with landfill acceptance criteria. Exceedance of the requirements is a possible Type I decision error. The tolerance for making a Type I decision error is based on landfill requirements for sampling, so it is not controlled by Berkeley Lab. This error will be minimized by following ESG Procedures for soil sampling, processing, and handling and shipping. Type II decision errors are not relevant to such compliance sampling.

2.6.3 DQOs for Field Measurements

Field measurements will be reported as follows:

- pH to 0.1 pH units
- Conductivity to two significant figures for values below 100 micromhos per centimeter (μmhos/cm), and to three significant figures for values above 100 μmhos/cm
- Temperature to 1 degree Fahrenheit (°F)
- Survey locations to 0.01 foot horizontal and vertical
- Ionizable vapor concentrations to 1 part per million (ppm)
- Water levels to the nearest 0.01 foot
- Flow volume for extraction and injection wells to the nearest 1 gallon
- Flow rate to the nearest 0.1 gallon per minute (gpm)
- Soil sample depths to the nearest 0.1 foot
• Turbidity to 0.1 nephelometric turbidity units (NTUs)

2.7 Special Training/Certification

All subsurface environmental data collection must be conducted under the direct supervision of a California-licensed professional in good standing: either a Professional Geologist (PG), or a Professional Engineer – Civil (PE-Civil) with relevant experience and training. All reports presenting or interpreting such data and submitted to regulatory agencies require the signature and stamp of a PG or qualified PE-Civil.

All well locations must be surveyed by a California-licensed Land Surveyor in good standing. Other sampling locations must be either surveyed by a California-licensed Land Surveyor or located relative to previously surveyed locations using tape-and-compass methods under the direction of a PG or PE-Civil. The ERP Leader will determine for each case whether tape-and-compass methods may be used in lieu of a land survey.

Project field personnel are required to provide written acknowledgement that they have read and will implement requirements of this QAPrP. They must also read pertinent workplans and review and sign ESG Procedures before engaging in activities governed by those workplans or procedures. Equipment manuals are maintained in files available to all field personnel. In addition, the ERP Leader is responsible for ensuring that each staff member has the education, training, technical knowledge, and experience to perform assigned functions associated with the collection of field samples and data.

Project field personnel must have completed 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training in compliance with federal regulations (i.e., 29 CFR 1910.120). In addition, field personnel must have completed an 8-hour refresher course within the previous 12 months if the 40-hour training course was completed more than one year before. All personnel must receive three days of field training by a trained supervisor before conducting fieldwork without direct supervision. Supervisory personnel must have completed an 8-hour HAZWOPER supervisor training course. Additional task-specific training requirements are specified in the ESG Procedure applicable to the work activity being performed. Records of HAZWOPER training for ERP personnel are maintained in the LBNL training database (http://training.lbl.gov/).

2.8 Documents and Records

The most current versions of the QAPrP and ERP Procedures are available to ERP personnel on the ESG website: http://www2.lbl.gov/ehs/esg/.

Records generated by ERP activities are managed in accordance with the requirements of the Records Management Plan for the Environmental Services Group Environmental Radiological Protection and Environmental Restoration Program (“ERP Records Management Plan”; LBNL, 2015). The plan sets forth the procedures and requirements for the following general elements of records management:

• Types of records subject to the plan requirements
• Responsibilities
• Record indexing, managing electronic documents, using and returning records, and records inventory and annual review
• Records storage
• Archiving and retention of records

Most ERP records are generated electronically and reside on the ESG shared drive (G:\Environment, Waste and Radiation Protection\ESG\ERP). Certain reports, including the ERP semiannual progress reports, are available to the public on the ERP website (http://www2.lbl.gov/ehs/erp/index.shtml).

A printed version of all records is also produced. All active ERP printed records are maintained in the ESG Library in locking cabinets in Building 75B, Room 112. ESG Procedures are controlled documents that are maintained on the ESG website and as printed copies in a file cabinet in Building 75B, Room 114.

2.8.1 Field Operations Records

Documentation requirements for field activities are specified in ESG Procedures, which describe the information required and the protocol for completing such documentation and records as field logbooks, sample labels, and chain of custody.

2.8.2 Laboratory Records

The analytical laboratories are responsible for preparing data packages that include reports summarizing the results of analysis, as well as information necessary to perform data validation. The data packages include the following information:

• Chain-of-custody record
• Analyte list for each sample
• Reporting limits for each analyte
• Holding time chronology
• Quality control summary
• Analytical results
• Identification of analytical methods used
• Laboratory blank results
• Laboratory control sample results with percent recoveries and control limits
• Surrogate recoveries and control limits
• Matrix spike / matrix spike duplicate results with calculation of percent recoveries and relative percent difference and control limits
• A case narrative summarizing any analysis issues such as poor detection limits, missing data, results outside control limits, and exceedance of holding times

For soil and water data, each data package is provided as both an Adobe Acrobat portable document format (PDF) file and an electronic data deliverable (EDD) file compatible with the LBNL
Environmental Sampling Monitoring (ESM) database (LBNL, 2012a). Most data obtained by the EDDs only contain information sufficient for Level II data validation, which is the default validation level used for most ERP activities. For data packages with Level III or IV data validation requirements, additional information necessary for data validation is provided only in the PDF files. The PDF files are maintained electronically and in paper copy in the files of the ERP Data Manager). After three years, the paper copies can be sent to archive. The EDDs are uploaded from the analytical laboratories to the ESG website and then transferred into the ESM database, which is an Oracle database with a Microsoft Access user interface.

When all issues related to inputting data into the SWRCB’s Geotracker database have been solved (e.g. converting UC grid coordinates to State Plane coordinates) all soil, groundwater, surface water, and soil vapor laboratory data collected as part of ERP activities will also be submitted to the SWRCB’s Geotracker database in Geotracker EDD data format. Geotracker-compliant EDDs will generally be provided by the analytical laboratory. The ERP Leader will be responsible for ensuring that these EDDs are representative of the validated analytical data, and that they are archived electronically and uploaded to Geotracker.

2.8.3 Geotracker Non-Analytical Records

Non-analytical Geotracker records will also be uploaded to Geotracker upon completion. These records include electronic files representing the site map (i.e., Geotracker GEO_MAP file); boring/well survey information; depth to groundwater; boring logs and well screen intervals; location data (i.e., Geotracker GEO_XY file); elevation data (i.e., Geotracker GEO_Z file); and technical reports (e.g., workplans, assessments, and monitoring reports) in PDF format.

2.8.4 Land Survey, Well Log, and Water Level Records

Land survey records are provided to Berkeley Lab by a California-licensed Land Surveyor in spreadsheet format and are then entered into the ERP GISkey database, where they are registered to the LBNL AutoCAD site base map. The GISkey database is electronically archived on the ESG shared drive: \[G:\Databases\GIS Public].

2.8.5 Treatment System Records

Groundwater treatment systems are inspected on a regular basis, generally three times a week. During the inspection, the technician observes and evaluates the condition of the systems and associated components, including valves, pressure gauges, and totalizers. Observations of water leaks from pipes or overflows from holding tanks, for example, are also noted. Any components that are not operating properly are repaired. If necessary, flow volumes are adjusted to prevent overflows. All pressure gauges are read and filters replaced as necessary (e.g., there is a pressure drop greater than 2 pounds per square inch for a two-filter system and/or at the judgment of the technician). The inspection details are entered into an Excel spreadsheet.

The soil vapor extraction treatment system is inspected at least monthly, while effluent vapor concentrations are measured with a photoionization detector, and system airflow rates are measured with
a pitot tube and pressure gauge. These parameters are monitored monthly in accordance with requirements of LBNL’s BAAQMD Permit to Operate A0723. Data and observations are recorded either in the field logbook or in an Excel spreadsheet form. Information recorded includes system influent and effluent concentrations, flow rate, and date and time of system operation. The condition of the systems and associated components, including valves, pressure gauges, and fittings, are observed and evaluated during the monitoring. Air leaks from pipes or fittings are noted. Any component that is not operating properly is repaired and documented on the field log sheet.

2.8.6 Technical Reports

Semiannual progress reports are submitted to DTSC. Additional technical reports are produced as needed. The monitoring results for LBNL’s groundwater treatment system discharges are included in the semiannual self-monitoring reports that are submitted to EBMUD for all LBNL-permitted wastewater discharges.

2.8.7 Technical Systems Audit

Technical systems audits are performed under the direction of the QA Manager to evaluate overall compliance with this QAPrP, as described in Section 4.1.2.2. The results of the audit, including summaries of problems and corrective action requests and closeouts, are documented in a report that is submitted to the ERP Leader and ESG Leader. It is the responsibility of the ERP Leader to determine whether the deviations will result in any adverse effect on the data quality. If it is determined that corrective action is necessary, the ERP Leader initiates the Nonconformance and Corrective Action Report (NCAR) process in accordance with EH&S Procedure 208, Nonconformance and Corrective Action Reporting. Corrective action may include laboratory auditing and/or surveillance.
The purpose of this section is to ensure that appropriate methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are used and documented.

The analytical data that are generated under the provisions of this QAPrP consist primarily of concentrations of VOCs, metals, radionuclides, PCBs, and petroleum hydrocarbons in groundwater, surface water, and soil; and VOCs in soil vapor. Analyses for non-contaminant hydrochemical indicator parameters (including nitrates, sulfates, and dissolved oxygen) are also required to support the continued evaluation of the effectiveness of MNA and enhanced bioremediation using HRC, which are DTSC-approved corrective measures for groundwater in some areas of Berkeley Lab.

As described in Section 2.5, environmental activities that are carried out under the ERP can be divided into four categories:

- Routine operation, monitoring, and maintenance of the existing DTSC-approved corrective measures.
- Routine monitoring of groundwater and surface water for tritium that was released as a result of operations associated with the former National Tritium Labeling Facility in Building 75, and for metals in areas where they were previously detected at concentrations exceeding Berkeley Lab background levels.
- Non-routine characterization of soil, soil vapor, groundwater, and/or surface water contamination for the following purposes:
  - Assessing environmental liabilities and potential risks to construction workers at LBNL demolition/construction sites.
  - In conjunction with the Waste Services Group, determining soil management and disposal requirements for waste soils generated during ERP and other LBNL activities.
  - Assessing the effectiveness of corrective measures using such methods as confirmation sampling of remedial excavations.
- Non-routine engineering evaluations, risk assessments, or procedure/methodology modifications that are required by DTSC under RCRA, by USEPA under TSCA or by DOE (for radionuclides).

Sampling designs for the non-routine activities will be specified in project-specific investigation workplans that will be prepared by Berkeley Lab as described in Section 2.3.2. Those workplans will provide the DQOs and any data generation and acquisition requirements that differ from those specified in this section.

The following subsections describe the requirements for sampling design, sampling methods, sample handling and custody, analytical requirements, QC, instrument/equipment requirements, and data management. The sampling design requirements discussed are specific to routine ongoing operation, monitoring, and maintenance activities.
3.1 Sampling Design for Routine Operation, Monitoring, and Maintenance

3.1.1 Program Policy for Sampling Design

As discussed above, the sampling design for non-routine activities will be provided in the project-specific investigation workplans that will be prepared by Berkeley Lab. Sampling requirements for those activities will be derived through the DQO process.

For routine operation, maintenance, and monitoring of corrective measures, groundwater samples are collected from groundwater monitoring wells and analyzed for VOCs and metals in accordance with a schedule approved by both the RWQCB and DTSC (LBNL, 2006). Groundwater samples are also collected from temporary groundwater sampling points, groundwater extraction wells, slope stability wells, and hydraugers (subhorizontal hillside drains installed to increase slope stability) and analyzed for VOCs to help assess plume geometry and the effectiveness of the implemented corrective measures.

Tritium samples are collected in accordance with a DOE-approved schedule (LBNL, 2012c). Groundwater samples are collected for hydrochemical parameters indicative of the potential for biodegradation in accordance with a DTSC-approved schedule (LBNL, 2006). Any change in the monitoring schedule must be approved by DTSC (for VOCs and metals) or DOE (for tritium). The sampling design for these routine activities is described in the following subsections.

3.1.2 Groundwater Sampling

Groundwater samples are collected for analysis for VOCs, metals, hydrochemical parameters, and radionuclides, as well as for other analytes (e.g., PCBs and petroleum hydrocarbons) that have been detected in the groundwater or are considered a potential concern.

3.1.2.1 VOCs

The groundwater monitoring program at Berkeley Lab has three primary objectives related to VOCs:

- Evaluate the effectiveness of the corrective measures that have been implemented to achieve the required MCSs.
- Ensure that the plumes of VOC-contaminated groundwater are not migrating either on or off site.
- Monitor the progress toward the long-term goal of cleanup of VOC-contaminated groundwater to MCLs in those areas where risk-based concentrations are the required MCSs but concentrations still exceed MCLs.

To accomplish these objectives, groundwater is monitored for VOCs in the following areas:

- Where MCSs for groundwater are exceeded.
- Downgradient from areas where MCLs are exceeded, to monitor for potential contaminant migration into areas of clean groundwater.
- Downgradient from areas of VOC-contaminated groundwater, to monitor for potential off-site migration.
- Where the required risk-based groundwater MCSs have been achieved but VOC concentrations still exceed MCLs.
3.1.2.2 Inorganic Elements (Metals and Geochemical)

Groundwater samples are collected for analysis for selected metals from wells where concentrations exceeded MCLs and LBNL background levels (LBNL, 2009a) in 2005 to assess long-term trends. Groundwater samples from selected locations are also analyzed annually for hydrochemical parameters (e.g., dissolved oxygen and nitrate) indicative of the potential for biodegradation. The purpose of this sampling is to provide the data necessary to assess the potential effectiveness of MNA and/or enhanced bioremediation for achieving the required MCSs.

3.1.2.3 Radionuclides

Radionuclides, including tritium, are not regulated under RCRA, but are addressed under the oversight of DOE. Concentrations of tritium detected in the groundwater have continued to decline since closure of the National Tritium Labeling Facility in 2001, with all concentrations below the MCL since 2005. Radionuclide data are included in the semiannual progress reports submitted to DTSC to provide comprehensive documentation of the status of site contaminants.

3.1.2.4 Other Analytes and Parameters

In addition to the regulatory requirements for groundwater sampling noted above, selected groundwater samples may be analyzed for other site-related contaminants, such as PCBs and petroleum hydrocarbons, to observe long-term trends.

3.1.3 Surface Water Sampling

Surface water samples are collected to monitor the potential migration of groundwater contaminants to surface water in accordance with requirements specified in the *Groundwater Monitoring and Management Plan* (LBNL, 2006). Samples are collected from all flowing site creeks twice a year (rainy season and dry season) and analyzed for VOCs and metals. Surface water samples are also collected for tritium analysis from two of the creeks (Chicken Creek and North Fork Strawberry Creek) where tritium has been historically detected.

3.1.4 Soil Vapor Sampling

Soil vapor samples are occasionally collected from the Building 53/58 soil vapor extraction wells to quantify VOC concentrations below the sensitivity of the photoionization detector used for the monthly system monitoring required by the BAAQMD permit. The frequency of soil vapor sampling is determined by the ERP Leader.

3.2 Sampling Methods

The sampling methods for ERP activities are presented in the subsections below.

3.2.1 Program Policy for Sampling Methods

ERP sampling is conducted in accordance with methods specified in ESG Procedures, posted on the ESG website at https://www2.lbl.gov/ehs/esg/Internal%20Documents/index.shtml. The ESG Procedures are
based largely on regulatory agency guidance documents (e.g., *Advisory Active Soil Gas Investigations* [Cal/EPA et al., 2015]). The ERP Leader is responsible for revising procedures whenever major changes are warranted (e.g. because of significant revisions of the guidance documents). Changes to procedures can also be made when warranted by completing an “On the Spot” Revision form that is attached as a supplement to the specific procedure. The “On the Spot” Revision form must be reviewed and signed by the affected program leaders, the ESG Leader, and the field technicians who carry out the work. The signed “On the Spot” Revision form is included as a supplement to the procedure until the procedure is formally revised to reflect the new protocol.

### 3.2.2 QA Program-Defined Requirements

ERP sampling activities are conducted in accordance with the following ESG Procedures:

- No. 230: Groundwater and Soil Vapor Treatment System Inspection and Maintenance
- No. 231: Drilling, Logging, Sampling, and Destroying Borings
- No. 232: Installing, Developing, and Destroying Groundwater Wells
- No. 233: Groundwater Sampling
- No. 238: Soil Vapor Sampling and Sample Probe Installation
- No. 263: Surface Water Sampling
- No. 266: Soil, Sediment, and Vegetation Sampling

Field personnel are responsible for documenting deviations from procedure requirements in field logbooks, and for reporting the deviations to the ERP Leader. LBNL subcontractors may follow their own procedures for specific field activities but they must be consistent with LBNL Procedure requirements.

Table 3.1 summarizes the requirements for sample containers, sample volumes, preservation methods, and maximum holding times for the most common soil analytical methods requested by Berkeley Lab.

Table 3.2 summarizes the program requirements for sample containers, sample volumes, preservation methods, and maximum holding times for the most common groundwater analytical methods requested by Berkeley Lab.

### 3.2.2.1 Sample Location Surveying

The elevation and \( x, y \) coordinates of sampling locations will be surveyed by a California-licensed land surveyor. The locations will be surveyed using the UC grid datum. In some cases, it may not be necessary to survey the sampling location. In such cases, the location should be measured (using tape and compass) to positions whose coordinates are known or can be determined, so that the sampling location can be documented (to within approximately 1 to 2 feet) in the ERP geographic information system (GIS) database. The ERP Leader is responsible for determining what accuracy is required and when surveying of sampling locations may not be required.
Table 3.1 Soil Sampling Container, Preservation Method, and Holding Time Summary

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Container</th>
<th>Preservation</th>
<th>Holding Time</th>
</tr>
</thead>
</table>
| VOCs<sup>a</sup> (b optional)                    | 3 × 40 mL Terra Core or equivalent | • methanol  
  • sodium bisulfate  
  • cold to 4°C | 14 days |
| VOCs<sup>b</sup>                                  | 4 oz. Gi, or sleeve                  | Cold to <6°C | 14 days |
| Metals – total                                   | 16 oz. Gi or stainless steel sleeve | Cold to <6°C | 6 months, 28 days for Hg |
| Metals – Waste extraction test (WET) or soluble threshold limit concentration (STLC) | 16 oz. Gi or stainless steel sleeve | Cold to <6°C | 6 months, 28 days for Hg |
| Total petroleum hydrocarbons (TPH): oil/diesel/kerosene/gasoline | 16 oz. Gi or sleeve | Cold to <6°C | 14/40<sup>d</sup> days |
| PCBs                                             | 16 oz. Gi or sleeve                  | Cold to <6°C | 14/40<sup>d</sup> days |
| Tritium (H<sup>3</sup>)                           | 20 grams Pl or Gi                    | None         | 6 months |
| Gamma Spectroscopy                               | 200 grams Pl or Gi                   | None         | 6 months |
| Gross Alpha and Beta                             | 20 grams Pl or Gi                    | None         | 6 months |

<sup>a</sup> Samples collected for contaminant characterization.  
<sup>b</sup> Samples collected for soil disposal purposes.  
<sup>c</sup> Alternative containers may be acceptable – check with analytical laboratory. Non-glass containers are preferable because of the potential for glass to break.  
<sup>d</sup> Days to extraction/days to analysis.  
Hg = mercury; Gi = glass jar; mL = milliliter; Pl = plastic bottle

Table 3.2 Groundwater Sampling Container, Preservation Method, and Holding Time Summary

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Container</th>
<th>Preservation</th>
<th>Holding Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOCs</td>
<td>3 × 40 mL VOA</td>
<td>HCl, Cold to &lt;6°C</td>
<td>14 days</td>
</tr>
<tr>
<td>Metals</td>
<td>500 mL Pl</td>
<td>45 μm filtered (for dissolved), HNO&lt;sub&gt;3&lt;/sub&gt;</td>
<td>6 months, 28 days for Hg</td>
</tr>
<tr>
<td>Tritium (H&lt;sup&gt;3&lt;/sup&gt;)</td>
<td>250 mL AG</td>
<td>None</td>
<td>6 months</td>
</tr>
<tr>
<td>TPH: Gasoline</td>
<td>2 × 40 mL VOA</td>
<td>Cold to &lt;6°C, HCl</td>
<td>28 days</td>
</tr>
<tr>
<td>TPH: Oil/Diesel/Kerosene</td>
<td>1 L AG</td>
<td>Cold to &lt;6°C</td>
<td>14/40&lt;sup&gt;b&lt;/sup&gt; days</td>
</tr>
<tr>
<td>PCBs</td>
<td>1 L AG</td>
<td>Cold to &lt;6°C</td>
<td>7/40&lt;sup&gt;b&lt;/sup&gt; days</td>
</tr>
</tbody>
</table>

<sup>a</sup> Alternative containers may be acceptable – check with analytical laboratory. Non-glass containers are preferable because of the potential for glass to break.  
<sup>b</sup> Days to extraction/days to analysis.  
AG = amber glass bottle; HCl = hydrochloric acid; Hg = mercury; HNO<sub>3</sub> = nitric acid; Pl = plastic bottle; VOA = volatile organic analysis vial; μm = micrometer

3.3 Sampling Handling and Custody

ERP sample handling and custody requirements are discussed briefly in the subsections below.
3.3.1 Program Policy for Sample Handling and Custody

ERP sample handling and custody are conducted in accordance with the following ESG Procedures:

- No. 254: Sample Processing, Packaging, and Transport
- No. 268: Environmental Sample Tracking & Data Management

Custody of samples must be traceable at all times to legally responsible parties through the chain-of-custody (COC) process. The COC form documents possession of the samples from the time of collection until disposal of the sample.

3.3.2 QA Program-Defined Requirements

Tracking of each sample is initiated during collection, by entering information in the field logbook, sample collection form, COC record, and sample label. The sample collection forms, COC records, and sample labels are generated from the ESM Microsoft Access database, as described in ESG Procedure 268 Environmental Sample Tracking & Data Management. Occasionally, COC forms and sample labels will be generated outside the data management system process, particularly when time constraints on sample collection preclude the required data entry process. The sample information will then be entered into the database as soon as practicable.

3.4 Analytical Methods

3.4.1 Program Policy for Analytical Methods

Berkeley Lab has established reporting limits (RLs) that its contract laboratories are required to meet. The RLs are based on implementation of the DQO process for routine sampling activities. RLs generally correspond with practical quantitation limits (PQLs), the lowest analyte concentrations that can be quantitatively determined with suitable precision and accuracy. In some cases, however, PQLs may be lower than RLs because of factors unrelated to analytical performance (e.g., comparison of detected concentrations to LBNL background levels, MCLs, or published regulatory agency screening criteria). The contract-required laboratory RLs, which generally correspond to PQLs, are specified in LBNL internal documents available at the ESG website (https://www2.lbl.gov/ehs/esg/Internal%20Documents/index.shtml).

Maximum allowable RLs are generally derived from published regulatory screening levels or other criteria based on risk to human health or the environment. RWQCB environmental screening levels (ESLs) are the applicable criteria for soil for the leaching to groundwater pathway and are based on MCLs for drinking water sources (RWQCB, 2016). The applicable screening criteria for soil and soil vapor are DTSC regional screening levels (RSLs) (DTSC, 2016) and LBNL background levels (LBNL, 2009a). When concentrations of analytes are high enough to require sample dilution, the PQLs (and possibly RLs) are modified according to the required dilution factor.

Although the required cleanup level at Berkeley Lab is to industrial land use criteria, maximum allowable RLs for soil are set at residential land use levels because DTSC can impose land use restrictions on areas of Berkeley Lab that present a potential risk to hypothetical future residents. The specific values of ESLs
and RSLs are not provided in this QAPrP because they change over time. Current ESLs are available online at http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/esl.shtml. DTSC-recommended RSLs are available online at https://www.dtsc.ca.gov/assessingrisk/humanrisk2.cfm (DTSC, 2016). The applicable soil vapor screening criteria are calculated by dividing the industrial indoor air RSL by the soil vapor intrusion attenuation factor ($\alpha$) of 0.0005 for future commercial structures (DTSC, 2011). As noted above, groundwater RLs are based on MCLs.

Required analytical methods for ERP activities are described in Section 3.4.2. Alternative USEPA-approved analytical methods may be substituted as long as they conform to the requirements specified in this QAPrP (i.e., as long as the method can be used to obtain the required PQL, RL, etc.). Should alternative analytical methods or RLs become necessary for routine activities, the modification and the rationale for making the modification will be documented in the semiannual progress report for the period in which the modification was made. Should alternative analytical methods or RLs become necessary for non-routine activities, the modification and the rationale for making the modification will be documented in the investigation workplan, or in the investigation report should the modification become necessary after the investigation begins.

3.4.2 Program-Defined Analytical Methods Requirements

3.4.2.1 VOCs, SVOCs, PCBs, and Metals

The analytical methods and processes for determining maximum allowable RLs for VOCs, semivolatile organic compounds (SVOCs), PCBs, and metals in soil, groundwater, and surface water, as well as for VOCs in soil vapor, are listed in Table 3-3. If samples are collected for other analytes, a similar process will be followed for determining the required RL. When it is not possible to achieve the required RLs, the maximum allowable RL is adopted from USEPA Test Method SW-846 (USEPA, 2016).

VOCs in soil vapor may be sampled and analyzed using alternative methods as noted below:

- Mobile laboratories, such as TEG, may be used for the real-time analysis of soil vapor samples for VOCs. The mobile laboratory will use USEPA Methods 8260, 8021, or TO-15, as required by the workplan governing the soil vapor work, and will be required to achieve the same RLs as a fixed laboratory.
- Passive samplers, such as the Waterloo Membrane Sampler™, may be used to collect a time-weighted average sample.

3.4.2.2 Petroleum Hydrocarbons

Target analytes and laboratory RLs for sample analyses performed on soil samples for which petroleum hydrocarbons may be a potential concern are summarized in Table 3-4a. RLs for petroleum hydrocarbons were based on laboratory quantitation limits and set well below the lowest RWQCB ESLs. The lowest current ESLs for each petroleum hydrocarbon target analyte for each medium (soil, groundwater, and surface water) are summarized in Table 3-4b.
### Table 3-3 Target Analytes and Process for Determining Maximum Allowable Reporting Limits for VOCs, SVOCs, PCBs, and Metals

<table>
<thead>
<tr>
<th>Analyte Group</th>
<th>Analytical Method</th>
<th>Maximum Allowable RL</th>
<th>Soil</th>
<th>Groundwater</th>
<th>Surface Water</th>
<th>Soil Vapor</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOCs</td>
<td>8260 or TO-15 (soil vapor)</td>
<td>Laboratory quantitation limits</td>
<td></td>
<td></td>
<td></td>
<td>Calculated from Indoor Air industrial RSL and attenuation factor of 0.0005 for future commercial structures</td>
</tr>
<tr>
<td>SVOCs</td>
<td>8270</td>
<td>The more conservative of the ESL for groundwater protection or construction worker safety or RSL for residential land use</td>
<td></td>
<td></td>
<td></td>
<td>WQC</td>
</tr>
<tr>
<td>PCBs(a)</td>
<td>8082</td>
<td>The more conservative of the ESL for groundwater protection or construction worker safety or RSL for residential land use, or LBNL background level</td>
<td></td>
<td></td>
<td></td>
<td>MCLs</td>
</tr>
<tr>
<td>Metals</td>
<td>6000/7000 series</td>
<td>The more conservative of the ESL for groundwater protection or construction worker safety, RSL for residential land use, or LBNL background level</td>
<td></td>
<td></td>
<td>WQC hardness = 250 mg/L</td>
<td></td>
</tr>
</tbody>
</table>

*a* Soil samples collected for TSCA compliance will be analyzed using EPA Method 8082A (gas chromatography with electron capture or electrolytic conductivity detection), with manual Soxhlet extraction per EPA Method 3540C, with PCB concentrations reported for individual Aroclors on a dry weight basis.


MCL: maximum contaminant levels (drinking water standards in Title 22, California Code of Regulations).


WQC: USEPA National Ambient Water Quality Criteria for freshwater aquatic life lowest observed effect level (chronic).

mg/L = milligrams per liter

### Table 3.4a Target Analytes and Reporting Limits for Petroleum Hydrocarbons

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Analytical Method</th>
<th>RL</th>
<th>Soil</th>
<th>Groundwater</th>
<th>Surface Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel Range Organics</td>
<td>8015M</td>
<td></td>
<td>10 mg/kg</td>
<td>50 µg/L</td>
<td>50 µg/L</td>
</tr>
<tr>
<td>Gasoline Range Organics</td>
<td>8015M</td>
<td></td>
<td>1 mg/kg</td>
<td>50 µg/L</td>
<td>50 µg/L</td>
</tr>
<tr>
<td>Oil Range Organics</td>
<td>8015M</td>
<td></td>
<td>50 mg/kg</td>
<td>300 µg/L</td>
<td>300 µg/L</td>
</tr>
</tbody>
</table>

µg/L = micrograms per liter; mg/kg = milligrams per kilogram
Table 3.4b Target Analytes and Environmental Screening Levels for Petroleum Hydrocarbons

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Soil</th>
<th>Groundwater</th>
<th>Surface Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel Range Organics</td>
<td>230 mg/kg</td>
<td>100 µg/L</td>
<td>440 µg/L (freshwater ecotoxicity)</td>
</tr>
<tr>
<td>Gasoline Range Organics</td>
<td>100 mg/kg</td>
<td>100 µg/L</td>
<td>640 µg/L (freshwater ecotoxicity)</td>
</tr>
<tr>
<td>Oil Range Organics</td>
<td>5,100 mg/kg</td>
<td>50,000 µg/L</td>
<td>not specified</td>
</tr>
</tbody>
</table>

3.4.2.3 Radionuclides

LBNL contract-required RLs for analysis for tritium in soil, groundwater, and surface water are listed in Table 3-5. The soil RL is slightly above the Preliminary Remediation Goal (PRG) for residential soil (https://epa-prgs.ornl.gov/radionuclides/). The RL for groundwater and surface water is two orders of magnitude less than the MCL. All three RLs are near the analytical sensitivity (Minimum Detectable Activity [MDA]) that can be obtained using conventional analytical laboratory methods. RLs required for other radionuclides in soil are provided in Table 3-5. RLs for radionuclides are near the analytical sensitivity (MDA) that can be obtained using conventional analytical laboratory methods.

Table 3-5 Reporting Limits for Principal Radionuclide Analyses

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Soil</th>
<th>Groundwater</th>
<th>Surface Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum Allowable Reporting Limit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tritium</td>
<td>0.2 pCi/g</td>
<td>200 pCi/L</td>
<td>200 pCi/L</td>
</tr>
<tr>
<td>Co-60</td>
<td>†</td>
<td>‡</td>
<td>‡</td>
</tr>
<tr>
<td>Cs-137</td>
<td>0.1 pCi/g</td>
<td>‡</td>
<td>‡</td>
</tr>
<tr>
<td>Eu-152, -154, or -155</td>
<td>†</td>
<td>‡</td>
<td>‡</td>
</tr>
<tr>
<td>Sr-90</td>
<td>0.3 pCi/g</td>
<td>‡</td>
<td>‡</td>
</tr>
<tr>
<td>Am-241</td>
<td>1</td>
<td>‡</td>
<td>‡</td>
</tr>
<tr>
<td>Cm-243/244</td>
<td>1 pCi/g</td>
<td>‡</td>
<td>‡</td>
</tr>
<tr>
<td>Pu-238</td>
<td>1 pCi/g</td>
<td>‡</td>
<td>‡</td>
</tr>
<tr>
<td>Pu-239/240</td>
<td>1 pCi/g</td>
<td>‡</td>
<td>‡</td>
</tr>
<tr>
<td>U-233/234, , or -236</td>
<td>2</td>
<td>‡</td>
<td>‡</td>
</tr>
<tr>
<td>U-235/236</td>
<td>1</td>
<td>‡</td>
<td>‡</td>
</tr>
<tr>
<td>U-238</td>
<td>0.035</td>
<td>‡</td>
<td>‡</td>
</tr>
<tr>
<td>Gross Alpha</td>
<td>2 pCi/g</td>
<td>2 pCi/L</td>
<td>3 pCi/L</td>
</tr>
<tr>
<td>Gross Beta</td>
<td>2 pCi/g</td>
<td>2 pCi/L</td>
<td>3 pCi/L</td>
</tr>
</tbody>
</table>

† = The reported concentrations for these and other gamma spectroscopy analytes will be the minimum detectable concentration derived by the analytical laboratory in the counting time required to achieve a reporting limit for cesium-137 of 0.1 picocuries per gram (pCi/g).

‡ = Maximum allowable reporting limit will be established based on purpose of sampling should determination of analyte activity in groundwater or surface water be required.
3.4.2.4 Field Measurements

Field measurement parameters include electrical conductivity, turbidity, pH, temperature, and ionizable vapor concentrations. These measurements are made using calibrated commercially manufactured instruments. Groundwater elevations are determined using an electric water level meter with an integrated measuring tape to measure from the surveyed top-of-casing elevation.

3.5 Quality Control

3.5.1 Program Policy for Quality Control

The QC policy has appropriate checks in place to identify and correct possible errors or bias in results and data of known quality produced. The appropriate checks are described below.

3.5.2 Program-Defined Quality Control Requirements

The following subsections describe general requirements for collecting and evaluating QC samples for most ERP sample types for routine activities. In general, these requirements will also be adopted for non-routine sampling. The rationale for any deviations from these requirements should be described in project-specific workplans or sampling and analysis plans, as described in Section 2.3.

3.5.2.1 Laboratory QC Samples

Laboratory QC samples consist primarily of method blanks, spiked samples (laboratory control samples [LCSs], matrix spike / matrix spike duplicate [MS/MSD], and surrogate spikes), duplicate samples, calibration checks, and interference checks. Method blanks, LCS and MS/MSD samples, and calibration checks are run for all chemical analyses, usually in batches of 20 samples or less. Surrogate spike samples are run for all organic analyses. Interference checks are run for all metals analyses. Method blanks, LCSs, and MS/MSD samples are run for all radionuclide analyses. The frequency of analysis, the representative acceptance criteria (control limits), and the corrective action for results outside control limits for the principal laboratory QC samples are shown in Table 3-6.

Method Blanks

A method blank is a clean sample or a sample of matrix prepared by the laboratory that is analyzed under conditions identical to those of field samples. Method blanks are used to detect cross-contamination during sample preparation and analysis and indicate bias introduced by the analytical procedure.

Spiked Samples

Laboratory control samples consist of an interference-free matrix that is spiked with known concentrations of target analytes. LBNL’s Statement of Work for Analytical Services (LBNL, 2012b) requires that LCSs be run for all batches of 20 samples or less. The LCSs are used to document laboratory performance by checking the bias, precision, and accuracy of the sample preparation and analytical procedures, free of any matrix effects. LCSs are prepared by the analytical laboratory before
samples are analyzed and consist of the same type of “clean” matrix as the batch samples. LCSs are run for radionuclides and organic analyses (according to specific USEPA SW-846 methods and when matrix spike recoveries are out of range).

**Table 3-6 Summary of Laboratory QC Samples**

<table>
<thead>
<tr>
<th>QC Check</th>
<th>Frequency*</th>
<th>Acceptance Criteria**</th>
<th>Corrective Action If out of Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method Blank</td>
<td>One for each sample batch of up to 20 samples</td>
<td>&lt;PQL or MDA</td>
<td>Laboratory to evaluate and correct source of contamination. Assess impact on sample results and request re-analysis of associated samples if necessary.</td>
</tr>
<tr>
<td>LCS</td>
<td>One for each sample batch of up to 20 samples</td>
<td>%R = analyte-specific laboratory control limits</td>
<td>Laboratory to evaluate and correct source of error. Assess impact on sample results and request re-analysis of associated samples.</td>
</tr>
<tr>
<td>MS/MSD</td>
<td>One matrix spike/matrix spike duplicate sample pair for every 20 samples</td>
<td>%R = analyte-specific laboratory control limits RPD &lt; 20% (water) RPD &lt; 30% (soil)</td>
<td>Laboratory to flag MS recoveries as attributable to matrix effects.</td>
</tr>
<tr>
<td>Surrogate Spike</td>
<td>One surrogate recovery analysis for each sample analyzed for applicable GC and GC/MS methods</td>
<td>%R = analyte-specific laboratory control limits</td>
<td>Assess impact on sample results and request re-analysis of associated samples if necessary.</td>
</tr>
</tbody>
</table>

* Frequency of analysis is method specific and may vary from those shown.
** Acceptance criteria are method dependent and analyte specific and may vary from those shown.

A **matrix spike / matrix spike duplicate (MS/MSD)** pair consists of two separate aliquots of a field sample submitted for organic analysis, both spiked with equal known concentrations of one or more contaminant analytes. The MS/MSD samples are then analyzed using the same protocols as those used for the unspiked sample aliquot. Matrix spiked samples are used to determine the effect of the matrix on a method’s recovery efficiency.

A **surrogate spike** is a known quantity of a non-contaminant organic compound added to samples for organic analysis. The percent recovery of the surrogate is used to assess the bias and accuracy of the method.

Laboratories must meet minimum acceptance criteria as found in the **Quality Systems Manual for Environmental Laboratories** (QSM; DOE/DoD, 2013).
The frequency of analysis, representative acceptance criteria (control limits), and corrective action for results outside control limits for the principal laboratory QC samples are shown in Table 3-6. Acceptance criteria are method dependent and analyte specific and may vary from those shown. For method blanks, any detection is outside control limits. For spiked samples, the percent recovery (%R) is calculated and compared to control limits.

For MS/MSD samples, the relative percent difference (RPD) between the concentration of the matrix spike and matrix spike duplicate is calculated and compared to the laboratory control limits.

RPD is calculated as follows:

\[
RPD = \left( \frac{|X_1 - X_2|}{0.5(X_1 + X_2)} \right) \times 100%
\]

where:

\( X_1 \) = MS result

\( X_2 \) = MSD result

Percent recovery (%R) is calculated as follows:

\[
\%R = \left( \frac{SSR - SR}{SA} \right) \times 100
\]

where:

\( SSR \) = analyte concentration of spiked sample

\( SR \) = analyte concentration of unspiked sample

\( SA \) = actual concentration of analyte added to the sample

\( R \) = concentration recovered

**Duplicate Samples**

A laboratory duplicate is created by the laboratory and consists of two separate aliquots of a field sample. The duplicate sample results are used to assess the precision of the sample preparation and analytical method. Acceptance criteria are the same as those listed for duplicate soil or split water field QC samples listed below.

**Calibration Checks and Interference Checks**

The laboratory runs initial and continuing calibration blanks, initial and continuing calibration verifications, and interference check samples, as required for equipment calibration.

**3.5.2.2 Field QC Samples**

Field QC samples include trip blanks, equipment/field blanks, duplicates, and splits. The required frequency, acceptance criteria, and corrective action for field QC samples are summarized in Tables 3-7 and 3-8.

- **Trip Blank.** A trip blank is a clean sample of matrix that is maintained with the collected samples while in transit to the laboratory, where it is stored, prepared, and analyzed along with the sample batch. Trip blanks provide a measure of the positive interferences that may be introduced by the sample preservation, transportation, storage, and analysis; they are used to identify contamination derived from sample transport containers (e.g., field storage, ice chest).
• **Equipment/Field Blank.** An equipment/field blank is collected by pouring organic-free water (i.e. treated groundwater or deionized or distilled water) into the sample collection equipment and from there into a sample bottle. The equipment blank should be collected immediately after decontaminating the equipment. Equipment/field blanks are used to verify the effectiveness of cleaning procedures and determine the type of contaminants introduced through contact with sampling equipment.

• **Field Duplicate.** Field duplicate samples consist of two samples collected independently at a sampling location during a single sampling event. Field duplicates are collected to evaluate the precision of the sample collection method; however, variability in duplicate sample results can be an indicator of matrix variability and heterogeneity.

• **Field Split.** A field split sample is two or more representative portions taken from one sample or subsample and analyzed by different laboratories. The results are compared to check interlaboratory variability of results.

### Table 3-7 Frequency of Field QC Samples

<table>
<thead>
<tr>
<th>QC Check</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip Blank (water)</td>
<td>One for every VOC shipment unless the shipment has an equipment blank included.</td>
</tr>
<tr>
<td>Equipment Blank (water)</td>
<td>One per each analytical method. Approximately one for every 20 samples.</td>
</tr>
<tr>
<td>Field Duplicate or Split (water and soil)</td>
<td>One per each analytical method. A minimum of one out of every 20 samples.</td>
</tr>
</tbody>
</table>

### Table 3-8 Summary of Corrective Actions for Field QC Samples

<table>
<thead>
<tr>
<th>QC Check</th>
<th>QC Result</th>
<th>Sample Result</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank Samples (Equipment or Trip)</td>
<td>Detect</td>
<td>Non-detect</td>
<td>No action.</td>
</tr>
<tr>
<td></td>
<td>&lt;RL</td>
<td>&lt;RL</td>
<td>Report as &lt;RL (not detected).</td>
</tr>
<tr>
<td></td>
<td>≥RL</td>
<td>≥RL</td>
<td>Use professional judgment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥RL but &lt;blank result</td>
<td>Report at sample result and qualify as non-detect or invalid based on professional judgment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥RL and ≥blank result</td>
<td>Use professional judgment.</td>
</tr>
<tr>
<td>Field Duplicate or Split</td>
<td>RPD &gt; 35% at concentrations greater than 5 times the QL or MDA</td>
<td>Investigate differences in results.</td>
<td></td>
</tr>
</tbody>
</table>

### 3.6 Instrument/Equipment Testing, Inspection, and Maintenance

#### 3.6.1 Program Policy for Instrument/Equipment Testing, Inspection, and Maintenance

Because of the numerous instruments and equipment used for sampling and monitoring, specific procedures for testing, inspection, and maintenance are not provided in this QAPrP. Instead, for routine maintenance, ERP field personnel should refer to the manufacturer manuals that are provided with the
equipment or that are available online. ERP field personnel are responsible for arranging for instrument/equipment replacement or factory repair when required.

### 3.7 Instrument/Equipment Calibration and Frequency

#### 3.7.1 Program Policy for Instrument/Equipment Calibration and Frequency

All laboratory analytical instruments are calibrated according to laboratory-specific QA criteria and the requirements of the QSM (DoD/DOE, 2013). Field equipment and instruments are maintained and calibrated to operate according to the manufacturer's specifications.

#### 3.7.2 Program-Defined Instrument/Equipment Calibration and Frequency

The following subsections describe requirements for calibration of instruments for both contracted laboratories and ERP field instruments.

##### 3.7.2.1 Laboratory

The laboratory’s calibration program verifies that equipment is of the proper type, range, accuracy, and precision. Frequency of calibration is based on the type of equipment, inherent stability, manufacturer's recommendations, values provided in recognized standards, intended data use, specified analytical methods, effect of error on the measurement process, and prior experience.

Records are prepared and maintained for each piece of equipment subject to calibration. Records demonstrating accuracy of preparation, stability, and proof of continuity of reference standards are also maintained.

For radionuclide analysis, recognized procedures are adopted, such as American National Standards Institute (ANSI) N42.15-1990, *Performance Verification of Liquid Scintillation Counting Systems*, and Draft ANSI Standard N13.30, *Performance Criteria for Radio Bioassay*. Instrument performance of the liquid scintillation counter is assessed by the internal software of the manufacturer using National Institute of Standards and Technology (NIST) standards. All requirements found in *Quality Systems for Radiochemical Testing*, which is Volume 1, Module 6 of the QSM (DOE/DoD, 2013), are followed by the environmental laboratories for radiochemical analyses.

The laboratory runs and documents calibration standards as specified by USEPA protocol SW-846, including performance evaluation samples. The accuracy of calibration standards is determined from QC check samples available from USEPA or NIST traceable vendors.

##### 3.7.2.2 Field

ERP equipment operations manuals and calibration/maintenance logbooks are maintained in files in the ERP field office. The manuals include operating, maintenance, and calibration instructions. Calibrations are recorded in the instrument logbooks or field sampling data sheets.

Field personnel verify that equipment/instruments are properly calibrated before use, either by checking the instrument label and prior calibration data or by performing calibration checks. The principal field
instruments that may be used by the ERP are listed in Table 3-9, along with a summary of calibration requirements.

**Table 3-9 Calibration Criteria for Field Instruments**

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Measurement</th>
<th>QC Check</th>
<th>Minimum Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>YSI 3000</td>
<td>temperature, water level, and conductivity</td>
<td>check against factory-supplied potassium chloride standard</td>
<td>daily, before use</td>
</tr>
<tr>
<td>YSI 33</td>
<td>salinity, conductivity, and temperature</td>
<td>check against factory-supplied standard</td>
<td>daily, before use</td>
</tr>
<tr>
<td>Hach HQ40D</td>
<td>pH, temperature, conductivity, dissolved oxygen</td>
<td>check against factory-supplied standard</td>
<td>daily, before use</td>
</tr>
<tr>
<td>Oakton</td>
<td>pH, conductivity, temperature, total dissolved solids</td>
<td>check against factory-supplied standard</td>
<td>daily, before use</td>
</tr>
<tr>
<td>LaMotte 2008</td>
<td>turbidity</td>
<td>check against factory-supplied standard</td>
<td>daily, before use</td>
</tr>
<tr>
<td>Orion 130</td>
<td>conductivity, temperature, and salinity</td>
<td>check against factory-supplied standard</td>
<td>daily, before use</td>
</tr>
<tr>
<td>Orion 260</td>
<td>pH</td>
<td>check against factory-supplied standard buffers</td>
<td>daily, before use</td>
</tr>
<tr>
<td>Sensidyne (FID)</td>
<td>organic vapor</td>
<td>check against 200 ppmv methane or 100 ppmv isobutylene</td>
<td>every 3 months</td>
</tr>
<tr>
<td>Thermo Environmental Instruments PID</td>
<td>organic vapor</td>
<td>check against ambient air and isobutylene span gas</td>
<td>daily, before use</td>
</tr>
<tr>
<td>Solinst 101</td>
<td>water level</td>
<td>reference to steel tape</td>
<td>not required</td>
</tr>
<tr>
<td>Keck Kir-89</td>
<td>oil-water interface</td>
<td>reference to steel tape</td>
<td>not required</td>
</tr>
</tbody>
</table>

FID = flame ionization detector  ppmv = parts per million by volume  PID = photoionization detector

### 3.8 Inspection/Acceptance of Supplies and Consumables

**3.8.1 Program Policy for Inspection/Acceptance of Supplies and Consumables**

Purchase orders for supplies and consumables are placed through the LBNL procurement system. All materials are visually inspected by users upon receipt to ensure that they are undamaged and in clean condition, and that they conform to what is listed on the packing invoice. The material/equipment is also compared to the type/model listed on the purchase order. If possible, equipment is tested before installation to ensure that it runs properly. Any deviations must be reported to the ERP Leader.
3.9 Non-Direct Measurements

Non-direct measurements consist of data obtained from outside sources or from computer models that are used to make program decisions. Data and computer models are generally obtained from regulatory agency publications and websites. Before the release of deliverables incorporating decisions based on such data and/or models, the ERP Leader must verify that they are valid for the proposed uses, that they use appropriate model parameters, that they are current, and that they include all appropriate revisions. The ERP Leader will also arrange for an independent review of the model by a qualified reviewer. When a numerical model is required, the code is first verified against available analytical solutions to check the accuracy of the mathematical calculation. The selected model is also calibrated against site data. Sensitivity analyses are then conducted to obtain information about how these model parameters will affect the results.

In addition to data and computer models obtained from regulatory agencies, ERP may use data obtained from the LBNL Radiation Protection Group (RPG). Those data and model results are generally published as controlled documents that have been reviewed and approved by DOE.

3.10 Data Management

The data management requirements are presented in the subsections below.

3.10.1 Program Data Management Policies

All ERP data and other records generated by the ERP are managed in accordance with requirements of the ERP Records Management Plan (LBNL, 2015).

3.10.2 Program-Defined Data Management Requirements

All field data must be recorded in permanent ink, with mistakes crossed out with a single line, initialed, and dated rather than erased. The single line through the error will allow the original error to still be readable, as will the corrected entry, date, and initials of the person making the change. Alternatively, field data can be recorded on a laptop computer, generally into a Microsoft Excel spreadsheet. The data will include the date, initials (or name) of the sampler/analyst, method used, item, system, sample and/or location description, and any other relevant information.

To avoid errors in comparing data, data will be recorded and reported in the following standard units:

- Water chemistry analytical results for organics in µg/L (ppb)
- Soil chemistry analytical results in mg/kg (ppm)
- Soil gas chemistry results in µg/m³
- Field vapor screening results in ppmv
- Flow rates in gallons per minute (gpm)
- Groundwater elevations in feet above mean sea level
- Dimensions, distances in feet
- Time in hours, minutes, seconds on 24-hour clock
- Temperature in degrees Fahrenheit
- Conductivity in µmhos/cm
- Water radiological analysis results in picocuries per liter (pCi/L)
- Soil radiological analysis results in picocuries per gram (pCi/g)
- Turbidity in NTUs
- pH in pH units

Historically, the analytical data generated by the ERP was entered into 4th Dimension, a relational database program. Since October 1, 2007, the analytical data have been entered into the ESM database (an Oracle database with Microsoft Access interface) directly from the analytical laboratory EDDs. The data in the Access database are managed in accordance with requirements of ESG Procedure 268, *Environmental Sample Tracking & Data Management*. Some groundwater data (i.e., laboratory hydrochemical parameter results) and soil vapor data that do not have ESM-compatible EDDs are still entered into the 4th Dimension database.
4 Assessment and Oversight

This section addresses the methods for assessing the effectiveness of ERP implementation and associated QA and QC activities. Assessment helps ensure that QAPrP requirements are implemented as described. The purpose of assessment and oversight is to confirm that measurement activities or the use of data by the ERP takes place according to this QAPrP.

4.1 Assessment Activities and Program Planning

4.1.1 Assessment of Subsidiary Organizations

Environmental subcontractors may perform tasks that fall under this QAPrP. Under the ERP Leader oversight and direction, subcontractors will be required to read the sections of this QAPrP relevant to the tasks they have been subcontracted to perform, and all conditions of this QAPrP will apply to any data collected by subcontractors. They will also be required to read any ESG Procedures and investigation workplans relevant to their activities. The ERP Leader (or a representative) will review the work of subcontractors when a task has been completed to confirm that QAPrP conditions have been met.

4.1.2 Assessment of Program Activities

4.1.2.1 Overall Program Assessment

The ERP Leader monitors the status of ERP projects and reviews records to ensure that project tasks are being conducted in accordance with requirements of this QAPrP and applicable ESG Procedures. This QAPrP will be reviewed at least every five years by the ESG Leader and revised as necessary.

4.1.2.2 Technical Systems Audit

The QA Manager (or representative) conducts a periodic technical systems audit (TSA) of ERP field activities. TSAs are conducted to assess compliance with requirements of this QAPrP, associated Procedures, and any investigation workplan in effect at the time the TSA is being conducted. The TSAs include an assessment of equipment, personnel, training, procedures, and recordkeeping for all ERP field activities. The QA Manager will provide a written assessment of the TSA results to the ERP Leader. If a problem is discovered that materially affects quality, the ERP Leader initiates the Nonconformance and Corrective Action Report (NCAR) process in accordance with EH&S Procedure 208, Nonconformance and Corrective Action Reporting. The TSA may also result in a recommendation by the QA Manager or ERP Leader that the QAPrP be revised sooner than the five-year review or that an analytical laboratory audit is required.

4.1.2.3 Laboratory Audits

Laboratories used during ERP activities are certified and/or audited by the appropriate accreditation body, as follows:

- DOE Consolidated Audit Program (DOECAP) – audit only
- U.S. Department of Defense (DoD) ELAP – accreditation
- SWRCB ELAP / National Environmental Laboratory Accreditation Program (NELAP) – accreditation for analysis of hazardous wastes, drinking water, and wastewater

The accreditation bodies are responsible for performing laboratory audits as required by their certification process. DOECAP audits analytical laboratories annually, with occasional exceptions.

The ERP Leader will assess the data verification (see Section 5.1) results to determine whether a laboratory has a problem that materially affects quality. If there is a problem, the ERP Leader initiates the NCAR process in accordance with EH&S Procedure 208. Corrective action may include laboratory auditing and/or surveillance.

4.1.2.4 Performance Evaluation

Analytical laboratories participate in the following performance evaluation (PE) programs: Water Supply, Water Pollution, and DOE MAPEP (Mixed Analyte Performance Evaluation Program), as applicable. The PE program consists of analysis of PE samples (samples with a known amount of an analyte in a convenient matrix prepared by an outside organization). These check samples provide information on the accuracy of the analytical method. The acceptance criteria are method dependent and analyte specific. The performance in these PE programs is evaluated by DOECAP and accreditation bodies during audits of the analytical laboratories.

The ERP Leader may evaluate a laboratory’s performance when the validity of laboratory results is questionable. If a problem is discovered that materially affects quality, the ERP Leader initiates the NCAR process in accordance with EH&S Procedure 208.

4.2 Documentation of Assessments

The results of TSA, NCAR, and PE assessments will be retained and used during five-year reviews of this QAPrP.

4.2.1 Number, Frequency, and Types of Assessments

Overall program assessment by the ERP Leader is ongoing. The ESG Leader will determine the need for a QAPrP revision at least every five years based on recommendations from the ERP Leader.

TSAs are performed periodically or as needed. Laboratory audits take place as required by the accreditation body or as deemed necessary by the QA Manager or ERP Leader. PE sample rounds take place as specified by the PE program (Water Supply, Water Pollution, or MAPEP).
This section addresses the QA activities that occur after the data collection process is complete. The ERP is required to verify and assess the field and laboratory data to ensure that they are usable. Data quality must meet the overall program objectives and be usable for decision making. Review of data entered into the ESM database is the shared responsibility of the submitting party, the ESG Leader, and ERP personnel.

5.1 Data Verification, Validation, and Assessment

5.1.1 Data Verification

Data verification is the process for evaluating the completeness, correctness, consistency, and compliance of a data set or QC data against methods, procedures, historical analytical results, or contractual requirements. Verification of field data is performed under the direction of the ERP Leader by checking field procedures and comparing data to previous measurements. Laboratory analytical data and reports are verified by the ERP Leader (or a representative). The ESM database verifies that all requested analyses for each sample have been completed by the laboratory. In addition, the ESM database verifies that all QC samples have been processed.

5.1.2 Data Validation

The second step in the data review process – data validation – focuses on the analytical data themselves. Data validation is the systematic, independent process put in place to determine the analytical limitations of a body of data based on specific QC criteria. Data validation is to be conducted by reviewing only original records of field data collection or original laboratory reports, including the EDDs. Field data recording requirements are included in ESG Procedures.

The ERP Leader (or a representative) reviews laboratory analytical data in accordance with the QA requirements of this QAPrP. Data validation procedures used to assess the validity of data follow USEPA and DOE guidance, as appropriate to the analytical methods used.

The ESM database assists with data validation by flagging the following conditions:

- Positive results in method blanks and field blanks
- Laboratory control samples outside the acceptance range
- Matrix spike duplicates outside the acceptance range
- Surrogate recovery outside the acceptance range
- Relative percent difference outside acceptance range
- Requested RLs not met
- Holding time exceeded
5.1.3 Data Assessment

Data assessment is the process of using the results of data verification and data validation together with any other information known about the data collection event to determine overall data usability. It is the last step before decisions that use the data are made.

5.2 Approaches to Verification, Validation, and Assessment

5.2.1 Approaches to Data Verification

Data review and verification procedures are discussed below. Approaches are consistent with USEPA Guidance on Environmental Data Verification and Data Validation (USEPA, 2002).

5.2.1.1 Field Data

Field measurements that depart from historical trends are rechecked at the time of measurement, when possible. After field sampling activities are completed, the ERP Leader (or a representative) reviews all field reports and COC records to assess compliance with the following requirements specified in this QAPrP:

- Required sampling procedures were followed.
- All specified samples were collected.
- Samples were collected at the appropriate locations and depths.
- The required number of QC samples was collected.

The ERP Leader (or a representative) reviews field documentation to verify that sample collection and handling procedures were conducted in accordance with requirements of this QAPrP and applicable ESG Procedures.

5.2.1.2 Laboratory Data

Analytical data that depart from historical trends are rechecked at the direction of the ERP Leader. The laboratory may be requested to re-analyze the sample if sufficient sample volume remains; if sample re-analysis is not feasible, then confirmation sampling may be conducted.

The analytical laboratories are responsible for preparing a report summarizing the results of analysis and for preparing an EDD. The report and EDD will include all information necessary to perform data review and verification. The EDD will follow the format required by the LBNL data management system (LBNL, 2015). Data reports from the laboratory will include the following elements:

- COC record
- Analyte list for each sample
- RLs for each analyte
- Holding time chronology
- QC summary
• Analytical results
• Identification of analytical methods used
• Laboratory blank results
• LCS results with percent recoveries and control limits
• Surrogate recoveries and control limits
• MS/MSD results with calculation of percent recoveries and relative percent difference and control limits

In addition, each report includes a case narrative that contains a statement from the responsible laboratory personnel that addresses whether the results meet quality acceptance criteria and discusses results outside control limits and holding times, corrective actions, and comments on variations such as poor detection limits and missing data, and on initial and continuing calibrations that were not met.

A full list of elements, with more detail, for the laboratory deliverables is found in section 5 (“Analytical Data Deliverables”) of the Statement of Work for Analytical Services (LBNL, 2012b).

Paper copies of the laboratory reports are maintained in the files of the ERP Data Manager. The EDDs are entered into the ESM database.

5.2.2 Approaches to Data Validation

The approach in this QAPrP to data validation is based on a graded scale; a full validation is not proposed for routine ERP data because of the volume of data generated and its repetitive nature (i.e., wells are sampled regularly). Project-specific investigation workplans may require a more detailed validation process depending on the end use of the data.

The ERP Leader (or a representative) reviews the records of field data collection and laboratory reports to determine whether the laboratory reporting is accurate and complete, and to assess compliance with DQO requirements specified in this QAPrP or in specific investigation workplans. The ERP Leader (or a representative) verifies that QC criteria were met by checking the following, as applicable:

• Samples were extracted and analyzed within required holding times.
• No analytes were detected in method blank.
• No analytes were detected in trip blank or equipment blank.
• LCSs were within control limits.
• Surrogate and MS/MSD recoveries were within control limits.
• Duplicate and split sample precision was within control limits.
• Preservation requirements were met.

QC requirements for field QC samples and the corrective action for when those QC criteria are not met are provided in Table 3-8. QC requirements for preservation and holding times and corrective action when those criteria are not met are outline in Table 5-1.
### Table 5-1 Preservation and Holding Time Actions

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Corrective Action</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample properly preserved and analyzed within holding time</td>
<td>Detect</td>
<td>Non-Detect</td>
<td></td>
</tr>
<tr>
<td>Sample not received at laboratory at required temperature</td>
<td>Qualify</td>
<td>Reject</td>
<td></td>
</tr>
<tr>
<td>Sample not preserved as required</td>
<td>Qualify</td>
<td>Reject</td>
<td></td>
</tr>
<tr>
<td>Sample properly preserved but analyzed outside required holding time</td>
<td>Qualify</td>
<td>Reject</td>
<td></td>
</tr>
</tbody>
</table>

If the laboratory reports are incomplete, in error, or inconsistent with the DQOs of this QAPrP, the ERP Leader (or a representative) requests that the laboratory review and/or re-evaluate results and/or reporting procedures, and submit revised reports. If possible, samples will be re-analyzed. When laboratory procedures are suspected to be the cause of anomalous results, the ERP Leader initiates the NCAR process, in accordance with EH&S Procedure 208, *Nonconformance and Corrective Action Reporting*, and sends the report to the laboratory for corrective action.

During data verification and validation, unacceptable or suspect data must be evaluated to determine the cause. If the evaluation indicates that the cause was noncompliance with an established procedure or requirement that materially affects data quality, the ERP Leader initiates the NCAR process, in accordance with EH&S Procedure 208. If the suspect data have been included in the ESM database, the data are identified by data qualifier “flags” in the database and in all applicable data tables.

#### 5.2.3 Approaches to Data Assessment

The data usability assessment will be performed by the ERP Leader (or a representative) by comparing field and laboratory data to DQOs specified in this QAPrP or to DQOs specified in project-specific investigation workplans. The DQO parameters are defined and discussed in Section 2 of this QAPrP. The ERP Leader (or a representative) will also review all data to compare them to previously obtained results if available or to identify anomalies within the data sets. Analytical results are deemed usable if sample integrity has not been compromised by missed holding times or inappropriate storage or handling.

Other factors that are evaluated to assess data usability include whether samples were collected and analyzed as planned, data were reduced and processed as required, laboratory calibration criteria were met, and laboratory and field QC samples (blanks and LCS) met the acceptance criteria listed in Section 3.5. The ERP Leader determines individually by case when such questionable data are usable for their intended purpose.

### 5.3 Reconciliation with Data Quality Objectives

Measurement data must be assessed in order to ensure that the DQOs for the ERP are met and that quantitative measures of data quality are provided. Precision, accuracy, completeness, and limitations are
determined from QC sample results and then applied to the results for environmental samples. Corrective actions will be initiated whenever data quality indicators suggest that DQOs have not been met.

Corrective actions will begin with identifying the source of the problem, which could be failure to adhere to method procedures, improper data reduction, equipment malfunctions, or systemic contamination. Corrective actions may include more intensive staff training, equipment repair followed by a more intensive preventive maintenance program, or removal of the source of systemic contamination. Once resolved, the corrective action procedure will be fully documented, and if DQOs are not met, the samples in question must be recollected and/or re-analyzed.

If the results of duplicate samples are above the acceptance criteria specified in this QAPrP, the results are reviewed and evaluated. Duplicate sample results above the acceptance criteria may not indicate invalid data, but may result from matrix variability and inhomogeneity. If the variability can be attributed to matrix variability or inhomogeneity, the results are considered valid, with a note that matrix interference may be present.
6 References


LBNL, 2009a. *Analysis of Background Distributions of Metals in Soil at Lawrence Berkeley National Laboratory*, Environmental Restoration Program, Lawrence Berkeley National Laboratory, Berkeley, California, April.


Appendix A Abbreviations and Acronyms

%R percent recovery
μg/L microgram per liter
μm micrometer(s)
μmhos/cm micromhos per centimeter
ANSI American National Standards Institute
BAAQMD Bay Area Air Quality Management District
Cal/EPA California Environmental Protection Agency
CAP Corrective Action Program (RCRA)
CFR Code of Federal Regulations
CMI Corrective Measures Implementation
CMS corrective measures study
COC chain of custody
DoD U.S. Department of Defense
DOE U.S. Department of Energy
DOECAP Department of Energy Consolidated Audit Program
DOE MAPEP Department of Energy Mixed Analyte Performance Evaluation Program
DQO data quality objective
DTSC Department of Toxic Substances Control
EBMUD East Bay Municipal Utility District
EDD electronic data deliverable
EH&S Environment, Health and Safety Division
ELAP Environmental Laboratory Accreditation Program
EPC exposure point concentration
ERP Environmental Restoration Program
ESG Environmental Services Group
ESL environmental screening level
ESM Environmental Sampling Monitoring (database)
GAC granular activated carbon
GC gas chromatograph
GIS geographical information system
GMMP Groundwater Monitoring and Management Plan
HAZWOPER Hazardous Waste Operations and Emergency Response
HRC Hydrogen Release Compound®
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPD</td>
<td>relative percent difference</td>
</tr>
<tr>
<td>RSL</td>
<td>regional screening level</td>
</tr>
<tr>
<td>RWQCB</td>
<td>San Francisco Bay Regional Water Quality Control Board</td>
</tr>
<tr>
<td>STLC</td>
<td>soluble threshold limit concentration</td>
</tr>
<tr>
<td>SVOC</td>
<td>semivolatile organic compound</td>
</tr>
<tr>
<td>SWRCB</td>
<td>State Water Resources Control Board</td>
</tr>
<tr>
<td>TPH</td>
<td>total petroleum hydrocarbons</td>
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<tr>
<td>TSA</td>
<td>technical systems audit</td>
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<tr>
<td>TSCA</td>
<td>Toxic Substances Control Act</td>
</tr>
<tr>
<td>UC</td>
<td>University of California</td>
</tr>
<tr>
<td>UCL</td>
<td>upper confidence limit</td>
</tr>
<tr>
<td>USEPA</td>
<td>U.S. Environmental Protection Agency</td>
</tr>
<tr>
<td>VOC</td>
<td>volatile organic compound</td>
</tr>
<tr>
<td>WET</td>
<td>waste extraction test</td>
</tr>
<tr>
<td>WQC</td>
<td>Water Quality Criteria</td>
</tr>
</tbody>
</table>