Environment, Health, and Safety
BERKELEY LAB

ENVIRONMENTAL SERVICES

Environmental Services Group (ESG)

Radiological Soil Management Plan

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Review and Approval

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Record of Revisions

Revision	Date	Description
0	2/01/2017	New document
1	11/02/2017	Updated Table 3 with correct gross alpha & beta analytical code, updated uranium isotopes alpha spectroscopy reporting limits, added DCGL sum-of-fractions language.
2	1/06/2022	Major revision of entire document, with most notable changes to the IFB background threshold values and the methodology for determining whether something is IFB.
3	05/31/2024	Entire document revised to streamline the radiological aspect of soil management on-site by reducing unnecessary details and redundant content with the Lab's *Soil Management Plan*. Implemented "risk zones" for soil management, whereby radiological sampling requirements are commensurate with the risk potential.
4	04/07/2025	Minor updates to Roles and Responsibilities for clarity on records retention. Added Section 6.1 to cover the *de minimis* soil volume special case. Added Section 5.3 to cover In Situ sampling with more clarity. Updated Figure A-1. Added Figures A-3 and A-4 and associated language in Sections 4.1 and 5.1. Changed wording of "Risk" to "Probability" relative to the management zones to not equate residual contamination with potential health and safety risk terminology. Updated references. Updated Table 5-1 sampling requirements to mirror the sitewide SMP. Updated Table 5-2 to be consistent with current ESG analytical suites.
5	07/18/2025	Improved clarity in Section 4.1 regarding occupational exposure concerns. Improved clarity in Section 5.6 for analytical laboratory accreditation requirements. Updated Figure A-4 to add Legend and remove the project area for Building 14, which determined the soil to be IFB in the FSSR.
6	05/19/2026	Minor narrative updates. Updated references. Updated Section 5.3, In Situ Sampling, to provide more instruction. Updated Table 5-1 to provide more clarity on the sampling requirements. Updated Table 5-2 to reflect current analytical requirements. Corrected typo in Figure A-2. Updated symbology in Figure A-3 for clarity. Updated Figures A-1 and A-4 to reflect current soil management control zones for radiological constituents.

Abbreviations

Berkeley Lab	Lawrence Berkeley National Laboratory
BTV	background threshold value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DCGL	derived concentration guideline level
DOE	U.S. Department of Energy
DTSC	Department of Toxic Substances Control
ESG	Environmental Services Group
EWRP	Environment, Waste & Radiation Protection
ft bg	feet below ground
IFB	indistinguishable from background
LBNL	Lawrence Berkeley National Laboratory
LLW	low-level waste
mrem/yr	millirem per year
NESHAP	National Emission Standards for Hazardous Air Pollutants
NNSS	Nevada Nuclear Security Site
pCi/g	picocuries per gram
PCO	Projects and Construction Office
PIMD	Projects & Infrastructure Modernization Division
RCRA	Resource Conservation and Recovery Act
ROC	radionuclide of concern
RPG	Radiation Protection Group
SMP	Soil Management Plan
TENORM	technologically enhanced naturally occurring radioactive material
WAC	waste acceptance criteria
WMG	Waste Management Group

1 Introduction

Development projects at the main site of Lawrence Berkeley National Laboratory (LBNL, Berkeley Lab) can disturb or excavate soil that has the potential to contain residual radioactivity in excess of background concentrations. Disturbed soil may be reused within the area of excavation, relocated to another on-site location, or transported off-site for disposal, depending on radionuclide concentrations. Management and disposition of soil that has the potential to contain residual radioactivity must comply with site procedures and several regulatory frameworks. This Radiological Soil Management Plan (hereafter referred to as the radiological SMP) supplements the *Soil Management Plan for Lawrence Berkeley National Laboratory* (LBNL, 2024; hereafter referred to as the sitewide SMP), which has been approved by the California Department of Toxic Substances Control (DTSC, 2018). The sitewide SMP addresses only nonradiological contaminants (metals, volatile organic chemicals, etc.), as DTSC does not regulate radiological constituents, thus driving the development of this radiological SMP as a supplement to the sitewide SMP. All soil disturbances or excavations at Berkeley Lab must first meet the requirements of the sitewide SMP, then meet the additional requirements of this radiological SMP.

1.1 Purpose

This radiological SMP has been developed to provide additional requirements to the sitewide SMP and clear and concise criteria for the management, assessment, sampling, and disposition for soil that is potentially or confirmed to be radiologically impacted and has been disturbed or excavated within the developed areas of LBNL.

1.2 Scope

This document pertains to soil and/or sediment (generically termed “soil” in this plan) disturbed (e.g., spoils from a borehole) or excavated from locations with potential or confirmed *radiological* impact. The following topics are covered:

- unrestricted reuse, which allows for the soils to be reused anywhere at Berkeley Lab
- restricted reuse by returning the soil back to the location from which it was removed
- relocation by moving soil to a different location at Berkeley Lab with ESG approval
- disposal at an off-site location within or outside the state of California
- sampling and analysis requirements and criteria to support disposition decisions

The radiological SMP *does not address nonradiological constituents* (e.g., metals, volatile organic compounds), nor does it address off-site LBNL locations, such as Donner Lab. For soil management of nonradiological constituents, refer to the sitewide SMP. Furthermore, the management of soil excavated in an area undergoing a regulatory agency–enforced cleanup action may be subject to

additional regulatory oversight and requirements. Lastly, large infrastructure projects are not addressed, as the demolition of a building with subsequent removal of the foundation that disturbs the underlying soil, for example, would have additional requirements. Such requirements could include a project-specific radiological/nonradiological SMP and/or other governing documents that must be approved by DOE. The requirements of such project-specific SMPs or other documents would supersede those described in this document.

1.3 Regulatory Basis

As a DOE-operated facility, Berkeley Lab is subject to DOE's authority and must comply with the environmental radiation protection and waste disposal requirements of the following standards and regulations:

- In accordance with DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE, 2025), the contractor must establish and implement procedures and practices to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE pursuant to the Atomic Energy Act of 1954 (as amended).

  The objectives of DOE O 458.1 are as follows:

  - To conduct DOE radiological activities so that exposure to members of the public is maintained within the established dose limits of DOE O 458.1.
  - To control the radiological clearance of DOE real and personal property.
  - To ensure that potential radiation exposures to members of the public are as low as reasonably achievable.
  - To ensure that DOE sites have the capabilities, consistent with the types of radiological activities conducted, to monitor routine and nonroutine radiological releases, and to assess the radiation dose to members of the public.
  - To provide protection of the environment from the effects of radiation and radioactive material.

- Code of Federal Regulations (CFR), Title 10, Part 835, Occupational Radiation Protection (10 CFR Part 835), which establishes radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from DOE activities. The dose limit to members of the public is 100 millirem per year (mrem/yr) above background from all sources, and the dose limit to radiation workers is 5,000 mrem/yr above background.

- California Executive Order No. D-62-02, which directed the State Water Resources Control Board and the Regional Water Quality Control Boards to impose a moratorium on the disposal of decommissioned materials into Class III and unclassified waste management units. Decommissioned materials, as defined in the Executive Order, are materials containing low

levels of radioactivity, arising from the decommissioning of a licensed site. Therefore, radioactivity in any material released for disposal in a California landfill must be indistinguishable from background (IFB).

- Code of California Regulations, Title 27, Environmental Protection – Division 2, Solid Waste, which defines landfill siting and classification requirements, as well as waste classification and management requirements. All wastes shall be properly characterized, classified, and demonstrated to meet the specific waste acceptance criteria (WAC) for the disposal facility. In general, radioactivity in any material released for disposal in a California landfill must be IFB.
- Radionuclides are defined as hazardous substances according to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), and in some cases, DOE facilities and sites are decommissioned under CERCLA. If a facility is being decommissioned under a Resource Conservation and Recovery Act (RCRA) permit or order, the U.S. Environmental Protection Agency or the state may have RCRA corrective action authority over decommissioning actions.
- Berkeley Lab's comprehensive radiological background study that derived specific background threshold values (BTVs) for radionuclides of concern (ROCs) that are used for IFB determinations.
- Individual landfill-specific WAC.

1.4 Project Approval

Small institutional projects are supported by the LBNL Environment, Waste & Radiation Protection (EWRP) Department, in coordination with the Facilities Division. However, large-scale capital projects may require environmental subcontractors managed by the Projects & Infrastructure Modernization Division to handle aspects of the project, such as preparing SMPs and Sampling and Analysis Plans, performing sampling, and conducting construction/demolition activities. In these cases, EWRP personnel are responsible for reviewing and approving project-specific plans related to soil sampling and analysis, release and clearance, and disposal.

2 Roles and Responsibilities

Environmental Services Group (ESG): ESG oversees both radiological and nonradiological impacts on Real Property, air, water, soil, and any other environmental media to ensure compliance with various regulatory frameworks. ESG personnel facilitate cross-functional management of environmental assessment activities, determine ROCs for projects, oversee or delegate historical site assessments, and design and implement program plans for sampling and analysis, stormwater protection, and soil management associated with construction and demolition activities performed at Berkeley Lab. Additional responsibilities also include sampling environmental media, comparing analytical results with assessment criteria, delegating sampling or analysis tasks to a responsible subcontractor, and reviewing subcontractor work plans for environmental compliance, among other like tasks. For both large- and small-scale projects, ESG retains records relating to the management, release and clearance, sampling decisions, and disposal requirements for environmental media and Real Property.

Facilities: Berkeley Lab's Facilities Division is responsible for performing soil excavation activities, providing estimates for soil volumes, identifying the location of the soil, summarizing the characteristics and known history of the soil, planning the project schedule and budget, and providing the preferred alternative for management of the soil (e.g., off-site disposal or return to excavation site). Other responsibilities include managing soil stockpiles in accordance with the applicable SMPs.

Projects & Infrastructure Modernization Division (PIMD): PIMD is responsible for promoting and facilitating a disciplined approach to managing LBNL projects with a focus on ensuring the quality of project deliverables and the overall performance of project management at Berkeley Lab. PIMD oversees all projects at Berkeley Lab, by providing efficient and effective professional and technical expertise, follow-on services, and an integrated management approach to Berkeley Lab's research and support programs. The Projects and Construction Office (PCO) within PIMD carries out design and construction of new facilities and renovations and modifications, alterations and improvements, remediation, and reconstruction activities in existing facilities, in conformance with all applicable building and life safety codes. The PCO's mission is to provide quality turnkey construction project services to enable world-class science programs at Berkeley Lab. PIMD personnel ensure that projects in any phase comply with the requirements contained in this radiological SMP.

Radiation Protection Group (RPG): RPG holds programmatic responsibility for Berkeley Lab's radiological release of materials, equipment, and areas; occupational radiation protection in accordance with 10 CFR Part 835; preparation of release and clearance survey plans; and oversight of all radiological work conducted on site. RPG is responsible for retaining records related to 10 CFR 835.

Subcontractor: An environmental company or individual contracted by Berkeley Lab to fulfill responsibilities of other responsible groups. Delegated responsibilities may include designing and implementing Sampling and Analysis Plans, collecting and transporting samples, comparing analytical

results with assessment criteria, generating waste profiles, shipping waste, and preparing project reports. When a subcontractor fulfills the responsibility of a Berkeley Lab group for an element of a project, the original responsible group provides oversight and approval of the subcontractor's work. The subcontractor retains project-related documents and provides them to EWRP to support the project and upon request.

Waste Management Group (WMG): Berkeley Lab's waste management programs establish requirements for the management of generated wastes, including identification, characterization, and accumulation functions of waste management in work areas. Additional responsibilities include ensuring WAC compliance, creating waste profiles, and properly manifesting and coordinating the packaging and transport of regulated wastes (including all radioactive and/or hazardous wastes) to off-site treatment, storage, and disposal facilities selected and/or approved by WMG. WMG is responsible for retaining all waste-related records, which includes any required shipping documents (e.g., waste manifests, waste acceptance criteria).

3 Key Terms and Definitions

Background Radiation: Radiation from any of the following:

- naturally occurring radioactive materials but excluding technologically enhanced naturally occurring radioactive material (TENORM)
- cosmic sources
- global fallout as it exists in the environment (e.g., from the testing of nuclear explosive devices and nuclear reactor accidents)
- radon and its decay products in concentrations or levels existing in buildings or the environment that have not been elevated as a result of current or prior activities

Background Threshold Value (BTV): The concentration at which a radionuclide can be statistically distinguished from the background population.

Contaminated Soil: Soil that exceeds IFB concentrations (i.e., BTVs).

Derived Concentration Guideline Level (DCGL): A derived radionuclide-specific activity concentration that if exceeded requires the soil to be disposed of off-site at a landfill located outside the state of California.

Developed Areas: Areas on the LBNL main site that have been developed or had been historically developed, and thus have the potential for impact due to Berkeley Lab operations. These areas are classified as low probability, moderate probability, and high probability for residual radioactivity to be present above background based on current knowledge and data or historical operations.

Disposal: The disposal of disturbed or excavated waste soil at an off-site facility (typically a landfill) that possesses a current permit to accept the specific type of waste soil generated.

Hazardous Waste: Waste containing chemical contaminants that meet State of California ("California hazardous") or federal ("RCRA hazardous") waste regulations.

Historical Site Assessment: An in-depth review of historical information, process knowledge, and existing soil characterization data to evaluate environmental conditions, assess the potential for impacts, identify contaminants of concern, and determine whether the soil has been adequately characterized. For small, well-understood sites, this review is commonly conducted as part of Berkeley Lab's penetration permit process. For larger or more complex projects, a more comprehensive review is conducted, which may include extensive historical research, interviews, etc.

Indistinguishable from Background (IFB): The detectable concentration of a radionuclide that is not statistically different from the background concentration (i.e., BTV) of that radionuclide for a specific site.

Non-impacted Soil: Soils that are located in the undeveloped areas of LBNL and meet the nonradiological requirements of the sitewide SMP.

Radionuclide of Concern (ROC): A radionuclide that is known or suspected to be present in a specific area or media. While most ROCs at LBNL are anthropogenic and will not have a BTV, they can also be naturally occurring and thus will have an associated BTV.

Real Property: Land and anything permanently affixed to the land such as buildings, fences, and those things attached to the buildings, such as light fixtures, plumbing and heating fixtures, or other such items, that would be personal property if not attached. This also includes sanitary sewer lines.

Relocation: Soil disposition category in which unrestricted reuse soils, or in extraordinary cases, restricted reuse soils, may be moved to a different location in Berkeley Lab. This soil must also meet the requirements of the sitewide SMP for nonradiological constituents and may need to meet additional RPG requirements (e.g., DCGL sum of fractions must be less than or equal to one). Relocation from the project site to a different location requires approval and tracking by ESG.

Restricted Reuse: Soil disposition category under which disturbed or excavated soil with radionuclide concentrations above IFB concentrations (i.e., BTVs) but less than DCGLs may be reused within the boundaries of the same disturbance/excavation area from which it was removed. This disturbed/excavated soil must also meet the requirements of the sitewide SMP for nonradiological constituents and may need to meet additional RPG requirements (e.g., DCGL sum of fractions must be less than or equal to one).

Technologically Enhanced Naturally Occurring Radioactive Material (TENORM): Material found in nature that emits ionizing radiation and that has been concentrated or exposed to the accessible environment as a result of human activities such as disturbing soil, manufacturing, mineral extraction, or water processing.

Undeveloped Area: Areas on the main site of LBNL that have been determined to have had no current or historical development activities (i.e., no significant disturbance to the soil), have not become contaminated by Berkeley Lab operations, and are thus considered nonimpacted.

Unrestricted Reuse: Soil disposition category under which disturbed or excavated soil with radionuclide concentrations below IFB may be reused at any location in Berkeley Lab. This disturbed/excavated soil must also meet the requirements of the sitewide SMP for nonradiological constituents.

Waste Acceptance Criteria (WAC): Qualitative and quantitative criteria specified by the operator of a waste facility and used to determine acceptability of a waste for receipt into the facility for treatment, storage, or disposal.

4 Soil Assessment and Management Process

The disturbance or excavation of soil at Berkeley Lab is conducted over multiple phases in accordance with internal procedures, including the sitewide SMP. Prior to excavating or disturbing soil of any amount on site, a penetration permit through ESG is required, and for larger projects, additional requirements may include written procedures, work plans, survey plans, or project-specific Sampling and Analysis Plans, any of which, if applicable, must be approved by ESG. While the specific phases and scale of soil excavation are typically dependent on the size and scope of the project to be performed, the general sequence of steps is as follows:

- Scoping
- Initial assessment
- Site characterization
- Soil disturbance or excavation
- Soil disposition

Table 4-1 provides a general overview of the soil management process, including a brief description of each step, and further details are provided in Sections 4.1–4.4. Because Table 4-1 is a general summary, not all steps listed will be applicable to every project.

Table 4-1. Radiological Soil Assessment Steps

Sequence	Step	Radiological Soil Assessment Description
Scoping	1	The Project notifies EWRP personnel of upcoming work that involves soil disturbance (penetration, excavation, etc.) and provides a scope of the work (including applicable documentation) and a tentative schedule.
	2	EWRP reviews the preliminary scope of work and schedule for the planned soil disturbance or excavation and establishes radiological soil management zones (see Attachment A) using analytical data and/or process knowledge.
	3	ESG determines the ROCs for the project based on project details, site historical data, and process knowledge, or other documentation.
	4	If applicable, ESG coordinates with other groups (such as RPG) to facilitate cross-functional discussion to ensure that other regulatory considerations (e.g., 10 CFR 835 controls) are adequately evaluated based on the scope of work.
	5	ESG coordinates with project managers to determine if soil to be excavated is expected/desired to be cleared from DOE O 458.1 radiological control or disposed of as radiologically impacted waste.
Initial Assessment	6	ESG establishes sampling and analysis requirements, or for larger projects, ESG reviews and approves a project-specific Sampling and Analysis Plan. The project-specific Sampling and Analysis Plan must adequately characterize ROCs regardless of disposition of soil and ensure appropriate analytical laboratory analysis scheme.
	7	ESG identifies IFB criteria (i.e., BTVs for ROCs).
	8	If soil is to be reused and exceeds LBNL's IFB criteria, ESG identifies either the Berkeley Site Office–approved project DCGLs (per 10 CFR 835 requirements) or sitewide DCGLs for compliance with DOE O 458.1 requirements. Soil results must be below the applicable DCGL to be eligible to stay on site.

Sequence	Step	Radiological Soil Assessment Description
Site Characterization	9	Perform required radiological soil sampling in accordance with the approved Sampling and Analysis Plan. For smaller projects, this sampling may be performed by ESG personnel, though larger projects will most likely require a subcontractor to perform this work.
	10	ESG reviews and evaluates analytical data and compares results with BTVs and/or DCGLs, as applicable. For larger projects, project personnel will likely perform the data review and evaluation, though final review and approval is with ESG. ESG communicates the results of reviews with applicable personnel.
	11	ESG ensures that 40 CFR 61, Subpart H, NESHAP regulations are satisfied before beginning excavation or soil disturbance.
Soil Excavation and Disposition	12	If soil is determined to be less than IFB, document the decision; soil is classified as unrestricted reuse.
	13	If soil is determined to be greater than IFB but less than DCGLs, document the decision; soil is classified as restricted reuse.
	14	If soil is classified as unrestricted reuse, or in extraordinary cases restricted reuse, and is to be relocated from the project site to a different location at Berkeley Lab, obtain ESG approval and provide maps and details for tracking purposes.
	15	If determined to be greater than the DCGLs, ensure that sampling/characterization is sufficient to meet the chosen disposal facility's WAC and Department of Transportation classification requirements. Create waste profile for disposition and ship accordingly.

Note: BTV = background threshold value; CFR = Code of Federal Regulations; DCGL = Derived Concentration Guideline Level; DOE = U.S. Department of Energy; ESG = Environmental Services Group; EWRP = Environment, Waste & Radiation Protection; IFB = indistinguishable from background; LBNL = Lawrence Berkeley National Laboratory; NESHAP = National Emission Standards for Hazardous Air Pollutants; ROC = radionuclide of concern; WAC = waste acceptance criteria.

4.1 Scoping (Steps 1–5)

In general, the initial step for EWRP is to review the preliminary scope of work and schedule (provided by the Project) for the planned soil disturbance or excavation. The information submitted to EWRP should include an estimate of the volume of soil in question, the location of the soil, a summary of the known history of the soil and characteristics of the soil, the planned schedule and budget, and the preferred alternative for management of the soil (e.g., landfill disposal or return to excavation site). For planning purposes, LBNL's property is divided into four zones – non-impacted, low probability, moderate probability, and high probability for radiological constituents in soil above IFB (see radiological soil management zones on Figure A-1 in Attachment A). Additionally, Figures A-3 and A-4 indicate areas where there is a known tritium groundwater plume and known or suspected radiological concentrations in soil that require an evaluation for occupational concerns prior to disturbance, respectively. Depending on the project, work within these areas may require special consideration such as radiological control technician support. Potential ROCs should be identified based on process knowledge, project location/site information (Figure A-1), and/or sampling data, if available. Regulatory considerations, such as determining whether a formal release and clearance under 10 CFR 835 is required or whether specific requirements under DOE Order 458.1 are applicable, will also be determined. For small-scale soil disturbances in areas with no known radiological impact and no planned excess soil generation, a scoping meeting or email communications may be the only required step. Information included should summarize any historical site assessments and process knowledge from the *Summary of Radionuclide*

Investigations for the Lawrence Berkeley National Laboratory Environmental Restoration Program (LBNL, 2003) as applicable for the specific project in question.

4.2 Initial Assessment (Steps 6–8)

During the initial assessment, all applicable data and information pertaining to the project (including process knowledge) are aggregated and used to categorize the potential radiological impact of the soil as it exists in situ. Categorization will then drive sampling and analysis requirements, as well as identify whether a radiological survey plan is required. Categorization also includes ensuring minimum detectable concentrations are sufficient to detect the applicable ROCs for the project. For larger scale projects (as determined by EWRP) and projects that require a formal release and clearance (under 10 CFR 835 or DOE Order 458.1 requirements), project-specific sampling and analysis plans are required.

IFB criteria (i.e., BTVs) are identified relative to the project ROCs, and soil categorization, along with other factors, may drive the decision of whether excavation of soil is required. Disposition pathways for soil should be identified, if applicable, and soil DCGLs (either soil replacement or project-specific, depending on the nature of the project) referenced to determine whether the soil has the potential to remain on site.

Nonradiological considerations are performed alongside radiological evaluations, and in many instances, nonradiological considerations will drive soil management decisions, especially in the presence of hazardous constituents in the soil.

4.3 Site Characterization (Steps 9–11)

Site characterization typically involves a historical assessment of any existing data, known impacts, site operations, or interviews with knowledgeable personnel, as well as sampling and analysis to determine the nature and extent of radiological impact present in an area where the soil will be disturbed. For larger or more complicated excavation activities, site characterization is performed under a written (and approved) Sampling and Analysis Plan that clearly defines the objectives and goals of the characterization to be performed.

If, during field work, areas of unexpected, elevated radioactivity are discovered, project-specific documents are customarily updated to reflect these identifications, and additional sampling and analysis beyond the initial assessment may be required.

Soil characterization data is customarily compared to project-specific DCGLs, sitewide DCGLs, or BTVs depending on the end state goal of the generated soil, but is also used to determine the potential for the emissions of radionuclides to the air, per National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations.

4.4 Soil Excavation and Disposition (Steps 12–15)

Soil excavation and disposition are performed according to written plans and procedures, the complexity of which is defined by the scope. Written documentation and records are subject to the requirements of Section 6.2 of this document. Disposition pathways are governed by characterization data. For soil that is determined to be IFB, disposal may be in any landfill; if greater than IFB, the soil will be classified and disposed of as low-level waste (LLW). If soil is greater than DCGLs, the characterization of the soil must be sufficient to meet a disposal facility's WACs, transportation classification requirements, etc.

On-site management of soil during excavation activities of larger projects must be performed according to a project-specific SMP that delineates how the soil will be stockpiled, tracked, characterized, and managed in the work area. Berkeley Lab or a subcontractor to Berkeley Lab prepares the project-specific SMP and coordinates soil management requirements with appropriate LBNL personnel. This plan delineates the specific criteria against which characterized soil will be evaluated to determine management pathways (e.g., reuse or disposal off-site). Soil that is classified as unrestricted reuse may be placed back in the project site or relocated to a different location within the LBNL main site, upon approval by ESG. Soil that is classified as restricted reuse may be placed back in the project site or, under extraordinary cases, may be relocated to a different location within the LBNL main site upon approval by ESG. All relocation of soil, regardless of disposition category, is subject to tracking by ESG and will require the project to provide detailed maps and pertinent information.

A project-specific Waste Management Plan may also be required for other types of waste, such as construction or demolition debris, that are to be generated by the project. On-site management of soil during excavation activities of smaller projects must be performed in accordance with the sitewide SMP.

5 Sampling Requirements

Comprehensive sampling and analysis criteria that meet disposition requirements will be decided during the initial assessment by EWRP staff. Individual program guidelines and requirements for sample collection are discussed in the subsections that follow.

5.1 Radionuclides of Concern

EWRP determines the ROCs for a given project during the project scoping stage. This determination should be informed from existing sources such as historical site assessments, process knowledge, facility radiological impact sheets, and/or analytical data. The ROCs for a given project may vary significantly based on the site location and historical activities performed. Figures A-1, A-3, and A-4 in Attachment A provide some guidance on potential ROCs or radiological hazards that may be present in on-site locations/areas.

5.2 Sampling for Stockpiles

Sampling and analysis results for the ROCs will be used to determine the disposition options. The minimum number of samples required for excavated or disturbed soil in developed areas of Berkeley Lab (see Figure A-2), when necessary, is provided in Table 5-1 and is consistent with the sitewide SMP requirements (for more details, see the sitewide SMP). For larger projects, a project-specific Sampling and Analysis Plan will likely be required.

Table 5-1. Stockpile Sampling Requirements

Soil Volume for Each Pile in cubic yards (yd^3)	Minimum Number of Samples*	Sample Type
<0.3 yd^3 (55 gallons)	1	4-point composite
0.3 to <200 yd^3	2	4-point composite
200 to <1,000 yd^3	2, plus 1 sample for each 250 yd^3	4-point composite
≥1,000 yd^3	4, plus 1 sample for each 500 yd^3	4-point composite

* Additional samples may be required at the discretion of ESG.

The following guidelines should be used for sample collection:

- Collect at least one “worst-case” sample (e.g., the most heavily stained area if one can be identified).
- Collect a minimum of two samples; collect only one sample, however, if there is only a very small volume of waste soil (e.g., less than 0.3 yd^3, or 55 gallons).
- All samples are composites that should represent the entire volume of waste.

5.3 In Situ Sampling

In certain project scenarios, in situ sampling may be preferable to stockpile sampling. In situ sampling may be performed via soil boring to characterize soils within the project area prior to excavation, rather than performing stockpile sampling following excavation activities. Because the objective of in situ sampling is to characterize radiological conditions across a defined area and depth interval, the number of required sample locations, their spatial distribution, and the selected depth intervals are dependent upon the size of the project area, the anticipated depth of impact, site history, and the level of statistical confidence required for characterization.

In situ radiological sampling designs should incorporate statistically representative sampling methodologies consistent with applicable guidance, including principles contained in the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM). Sampling locations are commonly established using systematic or randomized grid-based approaches, such as randomized-start triangular grids, to reduce spatial bias and provide representative coverage of the survey area. The required number of sample locations should be sufficient to support defensible characterization of the area of concern and may be determined using statistical design software or equivalent methodologies.

For smaller projects, ESG typically provides the number of borings, approximate boring locations, required depth intervals, and analytical suite for in situ sampling. For larger or more complex projects, the Subcontractor typically develops the in situ sampling design within the project Sampling and Analysis Plan, which is subject to ESG review and approval. For radiological constituents, common depth intervals may include surface soil to 2 feet below ground (ft bg), 2 to 4 ft bg, and 4 to 6 ft bg; however, alternate intervals may be required depending on project-specific conditions, operational history, or anticipated contaminant distribution.

5.4 Low-Level Waste Sampling

If soil concentrations exceed established DCGLs (as well as IFB criteria), the soil must be disposed of as LLW. For off-site disposal, sampling and characterization must be sufficient to meet the WAC for the selected disposition pathway. Preparation of waste profiles may require data that defines the maximum and average expected concentrations for each ROC that is representative of the waste soils. If necessary, at least one biased sample should be used to identify all expected waste constituents and the highest probable concentrations expected. Typically, WMG (or an authorized subcontractor) performs all applicable waste disposal functions, including waste characterization, disposal site verifications, waste packaging and load securement, transportation coordination, and compliance with U.S. Department of Transportation Hazardous Material Regulations and other regulations as required.

The preferred repository for LBNL radioactive waste soils is the Nevada Nuclear Security Site (NNSS). The NNSS WAC provide stringent certification, quality assurance, and verification requirements for characterization, packaging, preparation, shipment, and disposal of waste. Commercial radioactive waste repositories similarly define WAC that are required to meet their radioactive materials license and

other applicable requirements. In all cases, waste shipped to a facility must have been adequately characterized.

5.5 Imported Soil from Off-Site Locations

Depending on the project, it may be necessary to import soil and/or like material to Berkeley Lab from an off-site location. Imported material shall not be from a location with a known or potential history of radiological impact above LBNL IFB. If the radiological characterization of the imported material is unknown, sampling and radiological analysis may be required before the imported material is placed on site. Standard radiological analysis includes gross alpha and beta, as well as gamma spectroscopy, and the number of samples obtained shall be in accordance (unless specified otherwise by ESG) with Table 5-1 and LBNL's *Import Fill Plan*. Additionally, if the imported material is to be used at an on-site location with specific ROCs, such as the Old Town project, the imported material may be subject to analysis for the site-specific ROCs in addition to the standard radiological analysis, and the ESG Environmental Health Physicist shall be consulted. A *de minimis* volume of no more than 10 cubic yards may be imported from the approved non-impacted source location and placed on site without requiring radiological analysis. For additional details and requirements, see the *Import Fill Plan for the Lawrence Berkeley National Laboratory* (LBNL, 2023a).

5.6 Analytical Requirements

To analyze for selected ROCs, EWRP staff may select from the Lab Request Codes in Table 5-2 for most work performed on site and reference Figure A-1 in Attachment A for guidance. If a project's ROCs are not listed in either Table 5-2 or Figure A-1, additional analysis may be necessary. Analysis strategies should follow a risk-based approach in line with the following guidance:

- Gross alpha/beta analysis is generally included for all samples, though the analysis is not required for "Low Probability" areas identified on Figure A-1 unless ESG has determined otherwise.
- Gamma spectroscopy is generally included for all samples, though the analysis is not required for "Low Probability" areas identified on Figure A-1 unless ESG has determined otherwise.
- Tritium analysis should be included for samples whenever tritium concentrations above background may be suspected, such as the aggregation of soil, muck, and/or sediment from storm drain cleanout activities or for samples within the vicinity of the historic tritium plume area indicated on Figure A-3.
- Alpha spectroscopy should be included for samples that have the applicable analyte as an ROC, such as the former Old Town site, or areas where there is potentially activated concrete.
- Strontium-90 analysis is not generally performed but may be present in certain areas of the former Old Town site.

Analytical laboratories must have sufficient detection sensitivity to detect all ROCs at their respective BTV and/or DCGL, at a minimum (see Table 5-2), and be DOE Consolidated Audit Program accredited. Contracted analytical laboratories used by Berkeley Lab that meet these requirements include GEL, South Carolina; Eurofins, Missouri; and Pace, Tennessee. However, other analytical laboratories may also be considered so long as they meet the requirements. LBNL request codes are specific to Berkeley Lab–contracted analytical laboratories and thus are not to be used at a non-contract laboratory.

Table 5-2. Analytical Laboratory Methods, Reporting Limits, IFB BTVs, and DCGLs

ROC Analyte	Lab Request Code	IFB BTV (pCi/g)	Sitewide DCGL (pCi/g)	Background
Gross Alpha/Beta Analysis				
Gross Alpha	E900	*	†	‡
Gross Beta	E900	*	†	‡
Tritium Analysis				
Tritium (H-3)	E906EPSM	*	†	‡
Strontium Analysis				
Strontium-90	SR90:OT	*	†	‡
Lead Analysis				
Lead-210(1)	Pb210	*	†	‡
Alpha Spectroscopy				
Americium-241	Alpha_Spec-ESG	*	†	‡
Curium-242	Alpha_Spec-ESG	*	†	
Curium-244	Alpha_Spec-ESG	*	†	
Plutonium-238(2)	PUISO+PU242:OT	*	†	
Plutonium-239/240(2)	PUISO+PU242:OT	*	†	‡
Plutonium-242(2)	PUISO+PU242:OT	*	†	
Thorium-228	Alpha_Spec-ESG	*	†	‡
Thorium-230	Alpha_Spec-ESG	*	†	‡
Thorium-232	Alpha_Spec-ESG	*	†	‡
Uranium-233	Alpha_Spec-ESG	*	†	‡
Uranium-234	Alpha_Spec-ESG	*		
Uranium-235	Alpha_Spec-ESG	*	†	‡
Uranium-236	Alpha_Spec-ESG			
Uranium-238	Alpha_Spec-ESG	*	†	‡
Gamma Spectroscopy				
Actinium-227	Gamma_Spec-ESG	*	†	‡
Actinium-228	Gamma_Spec-ESG	*	†	‡
Americium-241	Gamma_Spec-ESG	*	†	
Americium-243	Gamma_Spec-ESG	*	†	
Barium-133	Gamma_Spec-ESG	*	†	
Berkelium-247	Gamma_Spec-ESG	*	†	
Beryllium-7	Gamma_Spec-ESG	*	†	‡
Bismuth-212	Gamma_Spec-ESG	*	†	‡
Bismuth-214	Gamma_Spec-ESG	*	†	‡
Cadmium-109	Gamma_Spec-ESG	*	†	
Californium-249	Gamma_Spec-ESG	*	†	
Cesium-134	Gamma_Spec-ESG	*	†	‡
Cesium-137	Gamma_Spec-ESG	*	†	‡

ROC Analyte	Lab Request Code	IFB BTV (pCi/g)	Sitewide DCGL (pCi/g)	Background
Cobalt-57	Gamma_Spec-ESG	*	†	
Cobalt-60	Gamma_Spec-ESG	*	†	
Europium-152	Gamma_Spec-ESG	*	†	
Europium-154	Gamma_Spec-ESG	*	†	‡
Europium-155	Gamma_Spec-ESG	*	†	‡
Lead-210	Gamma_Spec-ESG	*	†	‡
Lead-212	Gamma_Spec-ESG	*	†	‡
Lead-214	Gamma_Spec-ESG	*	†	‡
Manganese-52	Gamma_Spec-ESG	*	†	
Manganese-54	Gamma_Spec-ESG	*	†	‡
Neptunium-237	Gamma_Spec-ESG	*	†	
Niobium-94	Gamma_Spec-ESG	*	†	
Potassium-40	Gamma_Spec-ESG	*	†	‡
Promethium-146	Gamma_Spec-ESG	*	†	
Promethium-147	Gamma_Spec-ESG	*	†	
Protactinium-231	Gamma_Spec-ESG	*	†	‡
Protactinium-234m	Gamma_Spec-ESG	*	†	‡
Radium-224	Gamma_Spec-ESG	*	†	‡
Radium-226	Gamma_Spec-ESG	*	†	‡
Radium-228	Gamma_Spec-ESG	*	†	‡
Sodium-22	Gamma_Spec-ESG	*	†	
Thallium-208	Gamma_Spec-ESG	*	†	‡
Thorium-228	Gamma_Spec-ESG	*	†	‡
Thorium-229	Gamma_Spec-ESG	*	†	‡
Thorium-232	Gamma_Spec-ESG	*	†	‡
Thorium-234	Gamma_Spec-ESG	*	†	‡
Tin-126	Gamma_Spec-ESG	*	†	
Uranium-235	Gamma_Spec-ESG	*	†	‡
Uranium-238	Gamma_Spec-ESG	*	†	‡
Zirconium-95	Gamma_Spec-ESG	*	†	

pCi/g = picocuries per gram.

* Reference TP-5045, *Assessment Method for Radiological Release of Potentially Contaminated Soil and Sediment*.

† Reference DC-6021, *Lawrence Berkeley National Laboratory Sitewide Soil Replacement Derived Concentration Guideline Levels*, or project-specific DCGLs.

‡ Radionuclide that may also be found in a natural environment either as naturally occurring or manmade fallout.

(1) Pb-210 analysis via a gas flow proportional counting method for improved data quality.

(2) Plutonium analytes are not part of the standard analytical suite for alpha emitters used for environmental media but may still be used when necessary, and are therefore included in this table.

6 Soil Reuse and Disposal Decision Criteria

The disposition of excavated soil at Berkeley Lab falls into one of six categories based on the concentration of radiological contaminants. The six categories are summarized in Table 6-1.

Table 6-1. Soil Disposition Options

Disposition	Less Than or Equal to IFB	Greater Than IFB But Less Than DCGLs	Greater Than DCGLs
Unrestricted reuse in place	Allowed[1]	Not allowed	Not allowed
Unrestricted reuse with relocation	Allowed[1, 2]	Not allowed	Not allowed
Restricted reuse in place	N/A	Allowed[1, 3]	Not allowed
Restricted reuse with relocation	N/A	Allowed[1, 2,3,4]	Not allowed
Disposal off-site within California	Allowed	Not allowed	Not allowed
Disposal off-site outside of California	Allowed	Required	Required

Note: DCGL = derived concentration guideline level; IFB = indistinguishable from background; N/A = not applicable.

[1] Must also meet the sitewide SMP requirements for nonradiological constituents.

[2] Required approval and tracking by ESG.

[3] Must also meet sitewide DCGL unity rule requirements.

[4] Extraordinary circumstances required for approval.

6.1 *De Minimis* Soil Special Case

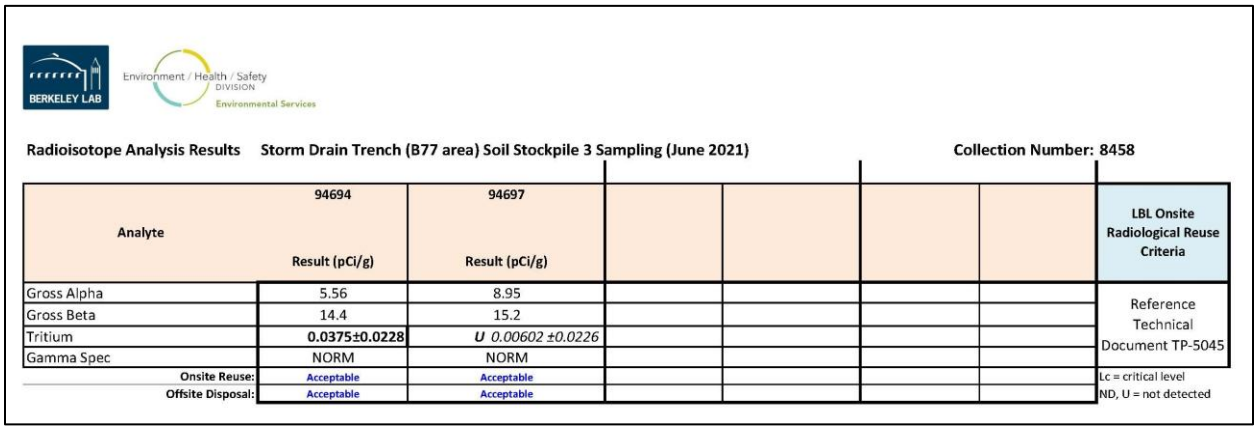
For work where there is a *de minimis* volume of soil (< 20 CY) that is to be put back in the same general excavation area from which it originated, this may be possible without radiological sampling so long as the location is outside of the "High Probability" (shaded red) areas in Figure A-1. This process still requires EWRP approval, must adhere to Berkeley Lab's sitewide SMP requirements, and is therefore evaluated on a case-by-case basis during the Scoping/Initial Assessment (see Table 4-1) phase of a project.

6.2 Soil Results Greater Than IFB

If any sample result exceeds the IFB criteria, then either the associated soil will be classified as contaminated or a second stage of verification may be performed. A second stage of verification involves three additional analyses at each sample location where the results exceeded the BTV. The laboratory may have sufficient sample for reanalysis in triplicate; otherwise, the collection of additional samples is required. If all three verification results are less than the BTV, the original result is deemed nonreproducible and invalid. It may then be discarded for the purpose of the IFB determination. Therefore, the area represented by these samples is determined to be IFB. If one of the additional results exceeds the BTV, the soil is confirmed as contaminated above background.

6.3 Record Keeping

Record keeping is required for all soil excavation projects, as discussed in Section 2, Roles and Responsibilities. A summary table of the soil analytical results that includes a comparison of the results to the unrestricted soil reuse and hazardous waste criteria is maintained. After EWRP staff compare radiological and nonradiological sample results with the appropriate assessment criteria, they will generate a record of the evaluation documenting the comparison, and it will be signed by the responsible reviewer. Figure 6-1 provides an example of an ESG-generated record of comparison, which is available to projects upon request. The record will be provided for generating waste profiles and documenting a DOE O 458.1 radiological release, such as a former radiologically controlled area, if applicable.



BERKELEY LAB

Environment / Health / Safety DIVISION
Environmental Services

Radioisotope Analysis Results **Storm Drain Trench (B77 area) Soil Stockpile 3 Sampling (June 2021)** **Collection Number: 8458**

Analyte	94694 Result (pCi/g)	94697 Result (pCi/g)					LBL Onsite Radiological Reuse Criteria
Gross Alpha	5.56	8.95					Reference Technical Document TP-5045
Gross Beta	14.4	15.2					
Tritium	**0.0375±0.0228**	*U 0.00602 ±0.0226*					
Gamma Spec	NORM	NORM					
Onsite Reuse:	Acceptable	Acceptable					Lc = critical level
Offsite Disposal:	Acceptable	Acceptable					ND, U = not detected

Figure 6-1. Example of comparison of analytical results with LBNL reuse and off-site disposal criteria

6.3.1 Soil Reuse

A summary table of the soil analytical results that includes a comparison of the results to the soil DCGLs, other screening levels, and hazardous waste criteria is maintained. Currently, soil contaminated with radiological constituents above IFB may be authorized (upon ESG determination) for soil reuse.

For soil reuse, the following records should be maintained:

- Maps, tables, and text describing the sample locations and depths and extent of excavation(s)
- Digital copies and electronic data deliverables of all analytical records
- Maps and survey coordinates in California State Plane or North American Datum 1983 system showing soil reuse areas
- Photo documentation (photographs and dates) of soil reuse activities that clearly shows the geometry and location of soil reuse areas in relation to identifiable permanent landmarks
- Any additional records that may be required for projects requiring approval from DOE

6.3.2 Disposal

For projects for which soil is disposed of off-site, the following records are maintained by both ESG and WMG (as applicable to the scope of the group), in accordance with EHS Procedure 873, *Management of Non-HWHF Waste*:

- Approved waste profile documentation provided by the disposal facility
- Hazardous and nonhazardous waste manifest forms, including Bills of Lading and completed Nuclear Regulatory Commission Forms 540/541
- Land Disposal Restriction forms
- Certificates of Disposal
- Tracking spreadsheet with a summary of the soil analytical results
- Digital copies and electronic data deliverables of all analytical records
- Any additional documents as required by WMG

7 References

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Attachment A – Figures

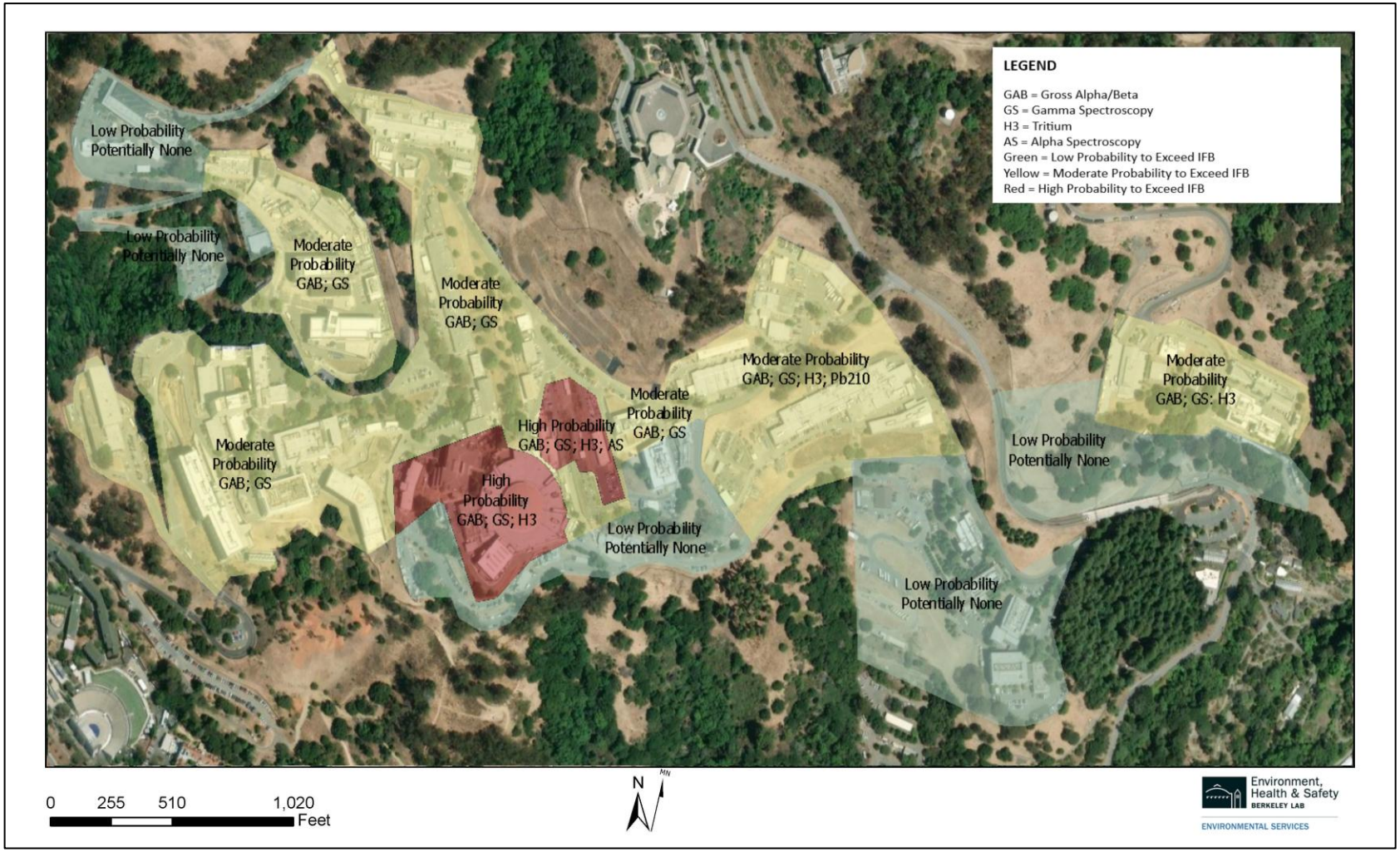

Figure A-1. Map Showing Radiological Soil Management Zones, Lawrence Berkeley National Laboratory

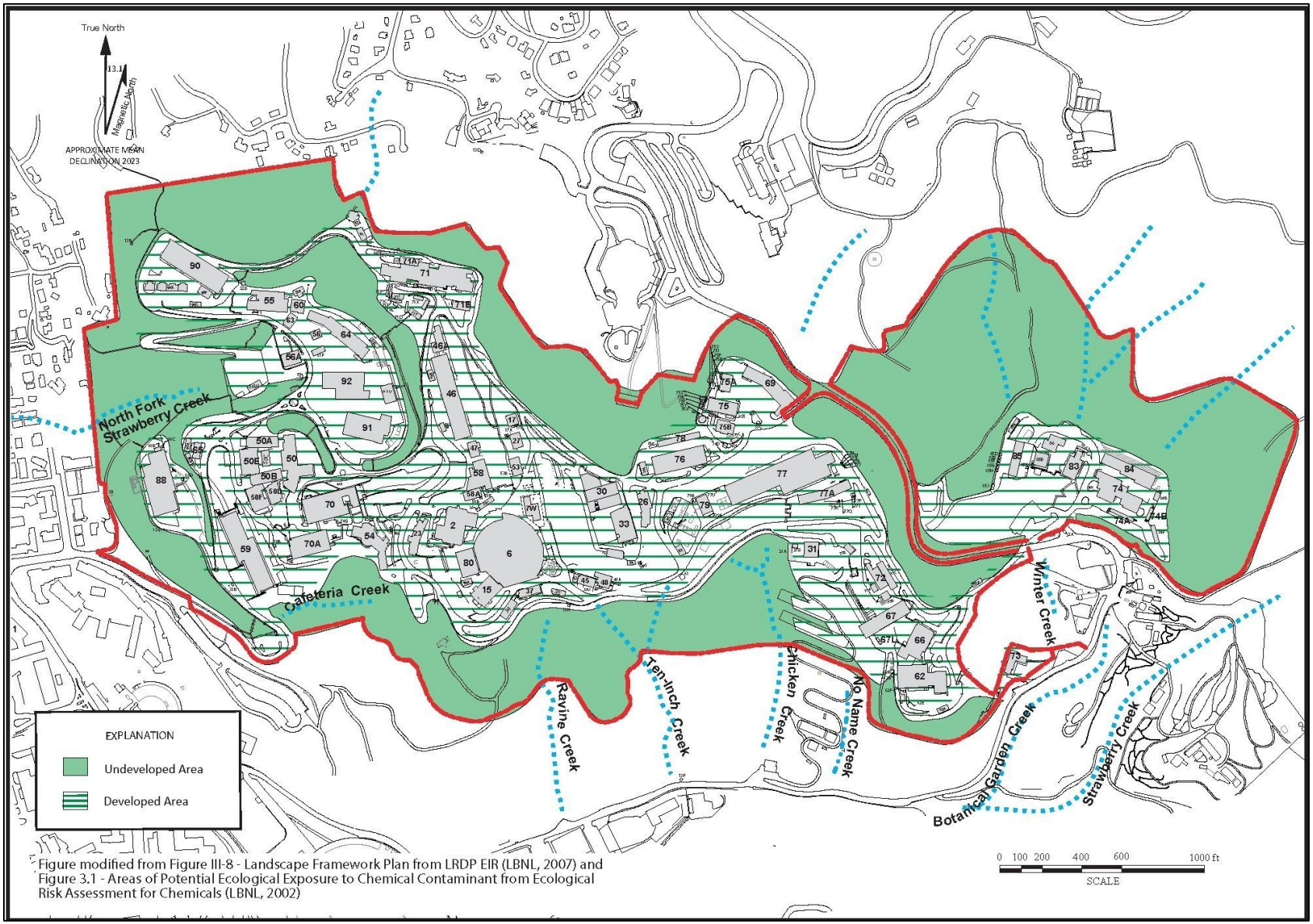

Figure A-2. Map of Developed and Undeveloped Areas, Lawrence Berkeley National Laboratory

Figure A-3. Map of Groundwater Tritium Impact, Lawrence Berkeley National Laboratory

Figure A-4. Map of Potential Radiological Soil Impact Areas, Lawrence Berkeley National Laboratory