E.O. Lawrence Berkeley National Laboratory
University of California
Environmental Restoration Program

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Summary of Radionuclide Investigations

for

Lawrence Berkeley National Laboratory

ENVIRONMENTAL RESTORATION PROGRAM

September 2003

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A Joint Effort of
Environment, Health and Safety Division and
Earth Sciences Division
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LIST OF ABBREVIATIONS

AOC	Area of Concern
Berkeley Lab	Lawrence Berkeley National Laboratory
CAL-EPA	California Environmental Protection Agency
CAP	Corrective Action Process
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
CPT	Cone Penetrometer Test
DHS	California Department of Health Services
DOE	U.S. Department of Energy
DTSC	Cal-EPA Department of Toxic Substances Control
EH&S	Environment, Health and Safety Division
ERP	Environmental Restoration Program
FY	Fiscal Year (October 1 to September 30)
HHRA	Human Health Risk Assessment
HRS	Hazard Ranking System
HTO	Tritiated Water Vapor
HWHF	Hazardous Waste Handling Facility
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
NFA	No Further Action
NFI	No Further Investigation
NIH	National Institute of Health
NPL	National Priority List
NTLF	National Tritium Labelling Facility
OBT	Organically Bound Tritium
PCBs	Polychlorinated Biphenyls
pCi/L	picocuries per liter (10^{-12} curies per liter)
PRG	Preliminary Remediation Goal
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RL	Reporting Limit
RWQCB	Regional Water Quality Control Board

SWMU	Solid Waste Management Unit
UC	University of California
USEPA	U. S. Environmental Protection Agency
UST	Underground Storage Tank
VOCs	Volatile Organic Compounds

SECTION 1

INTRODUCTION

1.1 BACKGROUND

The Lawrence Berkeley National Laboratory (Berkeley Lab) Environmental Restoration Program (ERP) is part of a nationwide effort by the United States Department of Energy (DOE) to identify and clean up radionuclide and chemical releases at its facilities. In addition, Berkeley Lab operates under a Resource Conservation and Recovery Act (RCRA) Part B Permit, issued by the California Environmental Protection Agency (CAL-EPA) Department of Toxic Substances Control (DTSC). The Permit requires Berkeley Lab to investigate and address all releases of hazardous waste or hazardous constituents that may have occurred at the facility, in accordance with RCRA Corrective Actions Process (CAP) requirements. Therefore, most environmental investigations and cleanup activities at Berkeley Lab are conducted by the ERP under the CAP.

The five primary components of the RCRA corrective action process are:

- RCRA Facility Assessment (RFA)
- RCRA Facility Investigation (RFI)
- Interim Corrective Measures (ICMs)
- Corrective Measures Study (CMS)
- Corrective Measures Implementation (CMI)

Berkeley Lab conducted its RCRA Facility Assessment (RFA) in 1991 and 1992 (Berkeley Lab, 1992). The RFA identified Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs), and assessed whether there was a past or ongoing potential for the release of chemicals or wastes of concern from the identified SWMUs and AOCs. Although radionuclides and radioactive waste are not regulated under RCRA, the ERP included evaluation of radiological constituents in the RFA to comply with its DOE mission to identify and clean up areas of radionuclide and chemical releases at its facilities.

The RFA report (Berkeley Lab 1992), which was completed in September 1992, identified seven SWMUs and one AOC that were related to radioactive substances and waste (Table 1.1). The report noted in its findings that one SWMU (the Building 75 Former National Tritium Labelling Facility) had released, and was continuing to release tritium to the environment. The past potential for release from the other six SWMUs and one AOC was either not known or ranged from low to high. Except for the Building 75 Former National Tritium Labelling Facility and the Building 75A Former Radioactive Waste Storage Area (that was active at that time), the RFA determined there was no ongoing potential for release (Table 1.1).

The RFA also provided recommendations as to whether additional investigations were needed to determine if releases had actually occurred and to assess the magnitude and extent of contamination. The Building 4 Former Radioactive Waste Storage and Staging Area (SWMU 10-1) was recommended for no additional action. The remaining units were recommended for inclusion in the RCRA Facility investigation (RFI). The locations of the eight identified radiological units are shown on Figure 1-1.

Berkeley Lab began the RFI in 1992, with the primary objective of collecting adequate information to support corrective action decisions. This information included: 1) identification of the source and nature of hazardous wastes and hazardous constituents that had been released to the environment; and, 2) characterization of the magnitude and extent of releases that were identified. Berkeley Lab submitted its Draft Final RCRA Facility Investigation (RFI) Report to the DTSC on September 29, 2000 (Berkeley Lab 2000). DTSC reviewed the report and approved it on July 27, 2001 (DTSC 2001).

Concurrently with its RFI investigations, the ERP conducted investigations at the six radiological units (five SWMUs and one AOC) that the RFA report had recommended for investigation. At the request of the DOE, more detailed investigations were also carried out at the Building 4 Former Radioactive Waste Storage and Staging Area (SWMU 10-1). Investigations of these units were not included in the RFI report, since radionuclides and radioactive waste are not regulated under RCRA. The findings of these investigations are therefore contained in this report, which is being submitted to the DOE for review and approval. The final radiological unit, the Building 75A Former Radioactive Waste Storage Area (SWMU 3-9), was investigated in 1998 as

part of a separate process, closure of the Former Hazardous Waste Handling Facility (Buildings 75, 75A, and 69). The pertinent results of that investigation are also included in this report.

1.2 STATUS OF RADIOLOGICAL SWMUS AND AOCS

Reports describing the details of the site investigations and requesting no further action (NFA) status for the following radiological SWMUs and AOCs were previously submitted to the DOE for review and approval.

- AOC 1-7 Building 71 Radiation Release
- SWMU 10-2 Building 5 Former Decontamination Area
- SWMU 10-3 Building 5 Former Outdoor Radioactive Waste Storage Area
- SWMU 11-2 Building 74 Abandoned Aboveground Radioactive Waste Holding Tanks
- SWMU 11-3 Building 74 Six Inactive Aboveground Radioactive Waste Holding Tanks

These reports followed the general format of documents submitted as part of the RFI for units where chemicals of concern were non-radionuclides. The NFA request reports for these five units are referenced below and included in Appendix A. The results of the investigations described in those reports and the rationale for requesting NFA status are also summarized in Section 4 of this report.

- DOE (DOE 1998) approved NFA status for SWMU 11-2 and SWMU 11-3 based on a request report from Berkeley Lab dated June 25, 1998 (Berkeley Lab 1998a). NFA was approved "with the understanding that it did not release the structure, equipment, or area from any existing controls."

- DOE (DOE 1999) approved NFA status for AOC 1-7, SWMU 10-2, and SWMU 10-3 based on a request report from Berkeley Lab dated September 1999 (Berkeley Lab 1999). NFA was approved with the condition the "approval does not authorize release to the general public, and is only intended for Berkeley Lab's reuse of the subject areas."

As noted above, the Building 75A Radioactive Waste Storage Area (SWMU 3-9), was investigated during the closure certification process for the Former Hazardous Waste Handling Facility. Details of those investigations are included in the Closure Report for the Hazardous Waste Handling Facility (Buildings 75, 75A, and 69) (Berkeley Lab 1998b). The report on the

investigations conducted at the Building 4 Former Radioactive Waste Storage and Staging Area (SWMU 10-1) (Berkeley Lab 2003b) is contained in Appendix B of this report. The report contains the rationale for the site investigations, and a request that DOE concur with the finding that the investigations conducted in 2001 support the previous decision of NFA status for SWMU 10-1. Results of the investigations at SWMU 3-9 and SWMU 10-1 are also summarized in Section 4 of this report.

A detailed report of the investigations conducted at the former National Tritium Labelling Facility (NTLF) (SWMU 3-7), the sixth unit at which additional investigations were recommended in the RFA report (Berkeley Lab 1992), was postponed pending completion of investigations required by the United States Environmental Protection Agency (USEPA). The USEPA requested supplemental environmental sampling for tritium to support a final decision on whether to place Berkeley Lab on the National Priority List (NPL). The USEPA-required investigations have been completed, and a comprehensive discussion of all investigations conducted to evaluate SWMU 3-7 is included in Section 3 of this report.

1.3 PURPOSE OF REPORT

This report has been prepared with the following primary purposes:

1. to provide a comprehensive compilation of the results and conclusions of the radionuclide investigations conducted by the Berkeley Lab ERP

2. to request concurrence from the DOE that no additional investigation or remedial action is warranted to address human health issues or environmental concerns related to tritium releases from the former NTLF

3. to request concurrence from the DOE that investigations conducted in 2001 at the Building 4 Former Radioactive Waste Storage and Staging Area (SWMU 10-1) support the previous decision of no further action status for SWMU 10-1

1.4 PROJECT ORGANIZATION

Berkeley Lab is a multipurpose research facility managed by the University of California (UC) for the DOE. Berkeley Lab's various divisions manage and operate the laboratory facilities. Primary funding and oversight are provided by the DOE. Investigations of areas of

potential environmental contamination, including soil, surface water, and groundwater contamination, are conducted at Berkeley Lab under the Environmental Restoration Program (ERP). The ERP is part of Berkeley Lab's Environmental Services Group, which is in the Environment, Health and Safety (EH&S) Division.

Assessment, characterization, and any required cleanup of radionuclides at Berkeley Lab are conducted under the regulatory authority of the DOE. However, to keep the RCRA oversight agencies (DTSC, California Regional Water Quality Control Board [RWQCB], and City of Berkeley) informed on the status of radiological investigations, results of those investigations have been included in the ERP Quarterly Progress Reports. Results of radiological investigations conducted by the ERP are also presented at quarterly review meetings with the regulatory agencies. Participants at the quarterly meetings include representatives from the DOE, the RWQCB, the DTSC, the City of Berkeley, the City of Oakland, and UC. ERP documents, including quarterly reports and the requests submitted to DOE for NFA status of radiological units, are available for public review in the Information Repositories at the City of Berkeley Public Library and at the Berkeley Lab library in Building 50.

SECTION 2

DESCRIPTION OF THE SITE

2.1 FACILITY MANAGEMENT

Berkeley Lab is a national research facility that is located on University of California (UC) property. The facility is managed by UC, with primary funding and oversight provided by the DOE. Berkeley Lab's various divisions manage and operate the laboratory facilities. In general, the structures of Berkeley Lab are owned by DOE, while the land is owned by UC and leased to DOE. The property consists of 29 separately-leased parcels, with lease expiration dates ranging from 2003 through 2041. DOE renews its contract with UC to manage the site every 5 years, and expiring leases are renewed for the 5-year term of each contract renewal.

2.2 LOCATION

Berkeley Lab is located in the Berkeley/Oakland hills in Alameda County, California on approximately 200 acres of land above the UC Berkeley campus (Figure 2-1). The western three-quarters of the site are located in the City of Berkeley and the eastern quarter is in the City of Oakland (Figure 2-2). Berkeley Lab is located 3 miles east of San Francisco Bay.

2.3 LAND USE

Berkeley Lab began as a subatomic particle accelerator laboratory in 1931, when Ernest O. Lawrence established the Radiation Laboratory with the construction of the 27-Inch Cyclotron on the UC Berkeley campus. The laboratory was moved to its present location in 1940, when the 184-Inch Cyclotron was built on a hill overlooking the campus and the City of Berkeley. During a period of rapid growth between 1940 and 1946, the original hillside laboratory (Old Town area) became crowded with temporary wooden buildings hastily erected in response to national defense needs. Further development during the 1950's was more carefully planned, with the construction of permanent concrete and steel-frame structures east and west of the earlier buildings. From 1948 until 1972, Berkeley Lab was known as the Lawrence Radiation Laboratory and was funded by the U.S.

Atomic Energy Commission and its successor agencies. The name was changed to the Lawrence Berkeley Laboratory in 1972 and changed again in 1995 to the Ernest Orlando Lawrence Berkeley National Laboratory (Berkeley Lab).

A wide range of energy-related research activities have been conducted at Berkeley Lab, including research in nuclear and high-energy physics; accelerator research and development; and research in chemistry, geology, molecular biology, biomedicine, and materials. Berkeley Lab has developed and operated four large subatomic particle accelerators (the 184-inch Cyclotron, the Bevatron, the Super Heavy Ion Linear Accelerator [Hilac], and the 88-inch Cyclotron), several small accelerators, and radiochemical laboratories. Of the four large accelerators, only the 88-inch Cyclotron is currently operational; however, it has been recommended for closure. In addition, Berkeley Lab was the site of the National Tritium Labelling Facility (NTLF) until it ceased operations at the end of 2001. From its initial emphasis on high-energy and nuclear physics, Berkeley Lab has diversified to include materials sciences, chemistry, earth sciences, biosciences, and energy conservation research.

2.4 ADJACENT LAND USE

Berkeley Lab is bordered on the north by single-family homes and on the west by multi-unit dwellings, student residence halls, and private homes. The area to the west of Berkeley Lab is urbanized (Figure 2-3). To the northeast of Berkeley Lab are Tilden and Wildcat Parks, which are operated by the East Bay Regional Park District. Approximately one quarter of the parkland is developed with recreation facilities and a Botanical Garden.

2.5 METEOROLOGY

Characterized as Mediterranean, the climate at the site is influenced by the moderating effects of nearby San Francisco Bay and the Pacific Ocean to the west and the sheltering effects of the hills to the east of the site. These factors contribute to the cool, dry summers and relatively warm, wet winters. Comfortable outdoor conditions generally prevail throughout the year, although occasional hard freezes can occur in mid-winter and heat waves in summer. Predominant wind patterns have winds blowing from the southeast during the night and from the west during the day.

The winter storms (October through April) produce nearly all the precipitation the laboratory receives during the water year (October 1 to September 30). The annual average precipitation over the last 30 years was about 30 inches. Drought periods of several years duration are not uncommon, and neither are abnormally wet winters.

SECTION 3

THE FORMER NATIONAL TRITIUM LABELLING FACILITY (SWMU 3-7)

This section contains the results of investigations conducted by the ERP related to tritium releases from the former National Tritium Labelling Facility (NTLF) (SWMU 3-7), and summarizes the results of previously completed human health and environmental risk assessments. These investigations and assessments provide the basis for recommending that no additional investigation or remedial action is warranted to address human health issues or environmental concerns at the former NTLF. However, as discussed in Section 3.5, some additional action may be warranted to address regulatory policy and potential community concerns.

3.1 DESCRIPTION AND HISTORY OF THE FORMER NATIONAL TRITIUM LABELLING FACILITY

The former NTLF was formally established in 1982 and designated as a National User Facility for tritium labeling research and development, with funding provided by the National Institutes of Health (NIH). It was located in Building 75 and operated for almost 20 years until December 2001, when the NIH discontinued its funding.

Tritium labeling was performed inside a system of glove boxes, which trapped tritium to minimize its release to the environment. Tritium from fugitive losses in air drawn through the glove box ventilation system and the gaseous residual of tritiated water that was not trapped by the recovery system were directed through silica-gel traps, and then to the stack on the hillside west of Building 75. The location of the former NTLF and Building 75 hillside stack are shown on Figures 3-1 and 3-2.

In 1997, the Committee to Minimize Toxic Waste, a Berkeley-based community group, formally requested that the USEPA re-evaluate Berkeley Lab for possible listing as a Superfund site, based on levels of tritium in the environment surrounding Berkeley Lab. The principal

source of the tritium was the former NTLF. USEPA issued a preliminary Superfund evaluation report in July 1998, with a finding that Berkeley Lab was potentially eligible for the National Priorities List (NPL) based on tritium levels detected in ambient air. However, USEPA recognized that although the tritium levels in air sometimes exceeded Superfund screening criteria, they were well below its National Emission Standards for Hazardous Air Pollutants (NESHAPs). USEPA stated that while the operation of the NTLF resulted in detectable but small levels of tritium in nearby soil, groundwater, and surface water, the data did not show tritium activities in sufficient quantities to necessitate remedial action. Nevertheless, USEPA requested supplemental environmental sampling to support a final decision.

In September 1998, USEPA requested that supplemental samples of ambient air, soil, sediment, and surface water be collected to determine the nature and extent of tritium contamination in the environment surrounding Berkeley Lab. The supplemental data were required for the USEPA to make a final decision as to whether or not to place Berkeley Lab on the NPL as a Superfund site. The requested Hazard Ranking System (HRS) sampling began in April 2001 and was completed in May 2002. In July 2002, the USEPA announced that tritium levels in the environment at Berkeley Lab were well below federal health standards, and that no further action was required under the Federal Superfund program.

3.2 PHYSIOGRAPHY, SURFACE WATER HYDROLOGY, GEOLOGY, AND HYDROGEOLOGY

3.2.1 Physiography

The former NTLF was located in the Support Services Area of Berkeley Lab, which consists of the following three major subareas:

- the Building 69/75 complex area, which contains the central receiving area for Berkeley Lab and the Former Hazardous Waste Handling and Storage Facility (HWHF)
- the Building 76/78 Area to the southwest, which houses the motor pool and various fabrication, construction, and maintenance shops
- the Building 77/79 area to the south, which houses fabrication and maintenance shops

Prior to development, the steep, south-facing slopes of the Support Services Area were bisected by Chicken Creek Canyon, a major north-south-trending drainage. A map of the pre-construction topography (Figure 3-3) shows that two main tributaries occupied the area between the current locations of Buildings 69, 75, and 77. These tributaries and a third tributary to the east formerly passed beneath the current location of Building 77 and merged to form the main channel of Chicken Creek below Building 77.

These drainages were extensively altered during development of the Support Services Area. Grading activities created two principal flat sites for buildings and parking: the upper site comprises the Building 69/75 complex; the lower site comprises the Building 42/77/79 complex. Both sites required cuts up to 30 feet deep and fills up to 65 feet and resulted in filling of the upper reaches of the Chicken Creek tributaries. The current topography is shown on Figure 3-4.

3.2.2 Surface Water Hydrology

Two watersheds drain the Berkeley Lab site: Strawberry Canyon Watershed and Blackberry Canyon Watershed (Figure 3-5). The NTLF lies within the Strawberry Canyon Watershed, in which tributaries of Strawberry Creek carry runoff from the eastern part of the site southward into westward-flowing Strawberry Creek. These tributaries include Cafeteria Creek, Ravine Creek, Ten-Inch Creek, Chicken Creek, No Name Creek, Pineapple Creek, and Banana Creek (Figure 3-5). The Blackberry Canyon Watershed contains the westward-flowing North Fork Strawberry Creek, which carries runoff westward from the western part of the site. After North Fork Strawberry Creek merges with Strawberry Creek on the UC Berkeley campus, the water from the creeks eventually discharges to San Francisco Bay.

Surface water runoff in the developed portion of the Support Services Area is directed primarily into storm sewers that flow to Chicken Creek (Figure 3-6). The runoff is derived from several sources, including paved and unpaved areas, and the subhorizontal hillside drains (hydraugers) that extend into the hillsides above Buildings 69, 75, and 77 (Figure 3-7). Some surface runoff from the Support Services Area also flows to No-Name Creek and Ten-Inch Creek. Water from these three creeks flows into a storm sewer that lies along the former course of Strawberry Creek south of the property boundary, and ultimately discharges to San Francisco

Bay. In addition, some groundwater flowing from the Support Services Area may be intercepted by these three creeks.

3.2.3 Geology

As shown on the bedrock geologic map (Figure 3-8) and on cross sections A-A' through G-G' (Figures 3-9 through 3-15), three main bedrock units underlie the Support Services Area. Marine mudstones, sandstones, and shales of the Great Valley Group lie on the undeveloped lower slopes to the south. These strata are overlain to the north by nonmarine siltstones and fine-grained sandstones of the Orinda Formation. Over much of the northern and northeastern part of the Support Services Area, the Orinda Formation is overlain by rocks of the Moraga Formation, consisting primarily of interbedded massive andesite, volcanic breccia, and basalt to the northeast; and massive andesite, volcanic breccia, and volcaniclastic sandstones and siltstones to the northwest.

Exposures of the contact between the Great Valley Group and the overlying Orinda Formation are relatively poor in the Support Services Area. However, field relationships observed in the adjacent Old Town Area suggest that the contact is an (inactive) fault that dips at relatively low angles to bedding in the underlying and overlying units.

As shown on Figure 3-8, most exposures of Moraga Formation rocks are interpreted to represent ancient landslide deposits, based primarily on the geometry of contacts between the Moraga and Orinda Formations relative to bedding orientations.

Colluvium greater than 10 feet thick underlies most of the Building 69/75 complex and much of the area from Building 76 to Building 25, extending downslope to Building 42. Colluvial deposits also underlie Centennial Drive and the slope between the east end of Building 77 and Centennial Drive.

Hillside cuts and canyon filling activities resulted in placement of artificial fill up to 65 feet thick within the Support Services Area, as shown on Cross Sections A-A' through G-G' (Figure 3-9 through 3-15). Several boring logs from the Building 69/75 area record abundant organic debris (e.g. eucalyptus trees) at the base of the fill.

3.2.4 Hydrogeology

Shallow groundwater in the Support Services Area is present primarily in the Orinda Formation. In some areas, the water table extends into the lower part of the surficial units (i.e., alluvium, colluvium, and artificial fill). At these locations, the water table lies a short distance above the contact between the bedrock and surficial units, as shown on cross section A-A' (Figure 3-9).

Hydraulic conductivities of the Orinda Formation and colluvium in the Support Services Area are relatively low (Figure 3-16). Measurements of the yield of two wells screened in the Orinda Formation (MW75-97-5 and MW75-97-6), and one well screened in the Orinda formation and fill (MW75-99-7) in this area ranged from 26 to 76 gallons per day (gpd). These yields are well below the 200-gpd yield that is a criteria for consideration as a potential drinking water source under provisions of the RWQCB (see Section 3.5).

Since the Orinda Formation in most places crops out at the surface, or is overlain by only a thin veneer of generally unsaturated surficial materials, groundwater encountered in the Orinda Formation is interpreted to be unconfined. However, due to the variability of lithologies within the formation, it is likely that localized horizons may contain groundwater under confined conditions.

Groundwater in the Support Services Area generally flows southward following the topographic slope, as indicated by groundwater elevation contours that are generally parallel to the surface topographic contours (Figure 3-17). The horizontal component of the hydraulic gradient (dh/dl) ranges from approximately 0.1 to 0.3. Assuming a hydraulic conductivity (K) of 1×10^{-8} meters per second, which appears to be typical for the Orinda Formation, and an effective porosity (n_e) of approximately 0.25, Darcy's law ($v_x = K/n_e \times dh/dl$) indicates that the average linear groundwater velocity (v_x) would be approximately 0.4 meters/year (1.3 feet per year) within rocks of the Orinda Formation. The hydraulic conductivity could be an order of magnitude higher in the creek deposits, on the order of 4 meters per/year (13 feet/year). Deeper sections of the Orinda Formation, which have extremely low hydraulic conductivities in the adjacent Old Town Area, would probably have substantially lower groundwater velocities.

Groundwater elevation hydrographs from clustered shallow and deep wells were examined to evaluate the vertical component of the groundwater potentiometric gradient (Berkeley Lab 2000). Data were available from the following well pairs, which are relatively close to one another, near Building 75.

Well Pair	Unit(s) Screened	Water Level (feet)	Vertical Direction
MW91-4	Orinda Formation	860	Down
MW75-96-20	Orinda Formation	920	
MW91-4	Orinda Formation	860	Down
MW75-99-7	Artificial Fill/Orinda	960	

These data indicate that the vertical component of the hydraulic gradient is downwards near Building 75.

3.3 CONCEPTUAL HYDROGEOLOGIC AND CONTAMINANT TRANSPORT MODELS

The hydrogeologic information discussed above suggests the following conceptual model for groundwater flow in the Support Services Area. Groundwater flow primarily occurs within the Orinda Formation; however, the water table may also be found in overlying colluvium and fill, depending on the location and season. The flow direction is generally southwards, toward Chicken Creek, parallel to the slope of the overlying topography. Groundwater velocities are generally very low, on the order of 1 foot per year, in the Orinda Formation. However, velocities could be substantially greater where the water table is in the colluvium and alluvium that occupy the former upper Chicken Creek stream canyon. The near coincidence of the water table with the contact between Orinda Formation and colluvium/alluvium deposits in that area (cross section C-C', Figure 3-11) supports this hypothesis. The apparent vertical gradient observed in the well cluster near Building 75 suggests that some degree of flow may occur downwards into the Orinda Formation. However, groundwater flow within the Orinda Formation is likely to be of minor importance, as indicated by the relatively low values of hydraulic conductivity measured in the unit.

Some groundwater flow is captured by subdrains and hydraugers, particularly at the base of the slopes immediately north of Building 77 and the Building 69/75 complex (Figure 3-7). The captured water is routed through the storm drain system to Chicken Creek.

Following are the main characteristics of the conceptual model for contaminant transport in groundwater in the Support Services Area presented in the RFI Report (Berkeley Lab 2000).

- Plumes of groundwater contamination in the upper portion of the saturated zone are generally elongated along the direction of groundwater flow. This is consistent with advection being the predominant contaminant transport mechanism, as would be expected given the relatively steep groundwater gradients of the upper portion of the saturated zone.

- The Orinda Formation impedes the horizontal and vertical migration of contaminants in the groundwater.

3.4 NATURE AND EXTENT OF TRITIUM CONTAMINATION IN SOIL, SURFACE WATER, SEDIMENT, GROUNDWATER, AND SOIL WATER

3.4.1 Soil

The Berkeley Lab ERP has collected soil samples for tritium analysis during the following activities:

- Samples were collected since approximately 1991 from soil borings and borings drilled for monitoring well and lysimeter installations both in the Building 75/69 area, and in other areas potentially affected by tritium releases from the NTLF. These samples were collected to evaluate the magnitude and vertical extent of tritium contamination.

- From 1991 through 1999, approximately 185 shallow soil samples were collected to characterize the distribution of tritium in shallow soil.

- In April and May 2001, shallow soil samples were collected at 64 locations as part of the USEPA's HRS re-evaluation of Berkeley Lab. As part of this effort, 226 soil samples were analyzed for tritium, including 18 for total tritium (organically bound tritium plus tritiated water).

- In April 2002, 60 soil samples were collected from 24 locations in the vicinity of the underground section of the NTLF exhaust system. The purpose of the sampling was to evaluate whether potential leaks from the system or overflow from a sump adjacent to the exhaust blower were source(s) of tritium release to soil.

Soil sampling locations and tritium activities detected during these investigations are shown on Figure 3-18 (soil samples collected between 0 and 5 feet site wide), Figure 3-19 (soil samples collected between 0 and 5 feet near the former NTLF), Figure 3-20 (soil samples collected to evaluate the NTLF underground exhaust duct), Figure 3-21 (soil samples collected to evaluate the vertical extent of tritium sitewide), and Figure 3-22 (soil samples collected to evaluate the vertical extent of tritium near the former NTLF).

HRS Soil Sampling

The soil samples that best represent the magnitude and distribution of current tritium levels in the shallow soil (0 to 2 feet) at the site were collected in April and May 2001 as part of USEPA's HRS re-evaluation of Berkeley Lab. These samples were collected as part of a comprehensive program to characterize the levels of tritium in the shallow soil under the stringent quality assurance/quality control procedures required for HRS sampling.

Samples were collected at 64 locations up to a maximum distance of approximately 2,000 feet from the NTLF Hillside Stack. A systematic sampling approach was followed to delineate the extent of contamination. One suite of samples was collected at 36 locations dispersed in a radial pattern with respect to the stack. Three concentric rings were located at distances of 500, 1000, and 2,000 feet from the stack, and were divided into 36 segments by drawing radii at 30° intervals. One soil sample was collected from as close to the center of each segment as possible. A second suite of samples was collected at six locations approximately 2,000 feet from the Hillside Stack in the predominant downwind directions, and a third suite of samples was collected in a rectangular pattern near the base of the Hillside Stack. Ten additional locations were sampled in the primary downwind direction near the Lawrence Hall of Science, in areas that are accessible to the public. In response to a recommendation from the USEPA, samples were also collected at eight locations where elevated tritium activities had previously been detected in the soil near the Hillside Stack and in the area between the stack and the Lawrence Hall of Science. In addition, background samples were collected at two locations approximately 1 mile northeast of the NTLF.

Samples were collected at two depth intervals at each sampling location (0.5 to 1 foot and 1.5 to 2 feet) to assess whether tritium activities in the shallow soil were affected by seasonal variations

in moisture content. Single-point (discrete) samples were collected at all locations. In addition, ten-point composite samples were collected at seven locations to address concerns expressed by the City of Berkeley regarding the representativeness of discrete samples. These samples were collected in accordance with HASL-300 guidance from the DOE Environmental Measurements Laboratory. Analytical results were similar for both the discrete and composite samples.

A total of 238 soil samples were analyzed, including split and duplicate samples. Samples from all locations were analyzed for tritiated water (HTO). In addition, samples from five locations where soil tritium levels were historically highest were analyzed for total tritium (HTO plus organically bound tritium [OBT]).

HRS soil sampling locations and tritium activities (HTO) detected are included on Figure 3-18 and Figure 3-19. The variation in tritium activities with distance from the Hillside Stack is shown on Figure 3-23. The maximum tritium (HTO) activity (9.98 pCi/g) was detected immediately adjacent to the stack. Total tritium was detected at a maximum activity of 41.4 pCi/g at the same location, but was below the reporting limit (<5 pCi/g) in the other samples for which it was analyzed. Tritium activities decreased to levels below the reporting limit (<0.2 pCi/g) within approximately 450 feet of the stack. The five locations where tritium was detected at an activity greater than 1 pCi/g were within approximately 160 feet of the Hillside Stack. These results are consistent with the historical site data.

Summary of Soil Sampling Results

Except for two locations, tritium activities detected in soil were well below 100 pCi/g. The maximum tritium activity detected in soil was 177 pCi/g at a depth of 5 feet. The maximum tritium activity detected in the upper 2 feet of soil was 136 pCi/g. Both were detected west of Building 75, approximately 100 feet east of the stack (Figure 3-19).

3.4.2 Surface Water and Sediment

The potential for tritium in the air, soil, and groundwater to migrate to surface water and sediment was evaluated by sampling surface water and sediment in the creeks that transport

runoff from the site. Tritium activities detected in sediment and surface water samples collected by the Berkeley Lab ERP are included in Table 3.1 and Table 3.2, respectively.

The surface water and sediment samples that best represent the current magnitude and distribution of tritium activities at the site are those collected in 2001 and 2002. These samples were collected primarily for USEPA's HRS reevaluation of Berkeley Lab, as part of a comprehensive characterization program using the stringent quality assurance/quality control procedures required for HRS sampling. They are more representative of present site conditions than prior samples because they were collected during the final period of NTLF operations, when tritium emissions from the facility were generally lower than historical values.

For the HRS evaluation, surface-water and sediment samples were collected from creeks that transport runoff from the site. Samples were collected once during the rainy season (April 2001) to monitor the combination of base flow and surface runoff, and once during the dry season (August to September 2001) to monitor base flow conditions. The rainy season samples were collected at both upstream and downstream locations on Cafeteria, Ravine, Ten-Inch, Chicken, No-Name, and North Fork Strawberry Creek, and at single locations on Banana and Pineapple Creeks, which are relatively short. In addition, HRS surface water samples were collected monthly from Chicken Creek and North Fork Strawberry Creek during the rainy season (from October 2001 through April 2002) because: 1) they were the only creeks in which tritium had been detected in surface water samples collected by the ERP since 1993 and 2) the ERP sampling data had shown that historical tritium activities detected in the two creeks was a function of rainfall. The dry-season samples were collected at the same locations as the rainy-season samples, except that surface water samples could not be collected from Cafeteria, Ravine, or Ten-Inch Creek, which were dry. Additional (non-HRS) dry-season surface water samples were collected from Chicken Creek and North Fork Strawberry Creek in May, June, July, and September 2002 at the same locations as the HRS samples. HRS and historical surface water sampling locations are shown on Figure 3-24.

In addition to the on-site creek samples, HRS surface water and sediment samples were collected from Strawberry Creek on the UC Berkeley campus and at the outfall to San Francisco Bay (the HRS surface water target), once in the dry season (April 2001) and monthly from

September 2001 through April 2002. Background rainy and dry season HRS surface water and sediment samples were collected from two lakes outside the area influenced by the site (Lake Anza and Lake Temescal), about 1.5 miles north and south, respectively, of Berkeley Lab.

Surface water and sediment samples were generally analyzed for tritiated water (HTO); selected sediment samples collected from Chicken and North Fork Strawberry Creeks were also analyzed for total tritium (HTO and OBT). These creeks were selected because they were the locations where the highest tritium activities (HTO) had been detected in surface water, and therefore were the most likely to have the highest total tritium activities in sediment.

Except for a single sediment sample collected from Banana Creek in April 2001, tritium activities were below the reporting limit (RL) (0.2 pCi/g for HTO and 5 pCi/g for total tritium) in all of the HRS sediment samples. Tritium (HTO) was detected at the RL (0.2 pCi/g) in the Banana Creek sample, but was below the RL in the corresponding duplicate sample.

Except for Chicken Creek and North Fork Strawberry Creek, tritium activities were below the reporting limit (RL) (200 pCi/L) in all of the HRS surface water samples, including Strawberry Creek on the UC Berkeley campus, the outfall of Strawberry Creek to San Francisco Bay (the HRS surface water target), and the two background locations. The variations in tritium activities detected in the surface water samples collected from Chicken Creek and North Fork Strawberry Creek since January 1996 are shown on Figure 3-25 and Figure 3-26, respectively. These figures include data collected by both the Berkeley Lab Environmental Services Group and the Berkeley Lab ERP. Tritium activities detected in North Fork Strawberry Creek have been relatively low (approximately 400 pCi/L or less) since 1994, with tritium not detected (<200 or <300 pCi/L) in most samples. Tritium activities detected in Chicken Creek show a long-term decreasing trend with activities below 300 pCi/L since April 2002. During the seven times Chicken Creek was sampled from April 2002 to March 2003, tritium was not detected at the upstream sampling location (<200 or <300 pCi/L), and was only detected twice at the downstream location (247 pCi/L maximum). For comparison, the drinking water Maximum Contaminant level (MCL) for tritium is 20,000 pCi/L. Tritium activities detected in both creeks at the downstream sampling locations have generally been higher than activities detected at the upstream locations, although this relationship was not observed during every sampling period.

As can be seen on Figure 3-25, there has been a significant decrease in tritium activity detected in Chicken Creek since the former NTLF stopped operations in December 2001.

3.4.3 Groundwater

A plume of tritium-contaminated groundwater (The Building 75 Tritium Plume) extends southwards from near the former NTLF, beneath Building 77 and towards Chicken Creek (Figures 3-27 and 3-28a). A smaller area of tritium-contaminated groundwater is located near Building 71B (Figure 3-28b). Tritium activities detected in groundwater samples collected from monitoring wells, temporary groundwater sampling points, and slope stability wells are listed in Table 3.3. Tritium activities detected in hydrauger effluent are listed in Table 3.4, and Table 3.5 (for samples collected in March 2003). The hydrauger flow rates measured at the time of sampling are included in Table 3.5. Hydraugers are subhorizontal hillside drains that were installed for slope stability purposes. The source of the tritium in the groundwater was the former NTLF, which was closed in December 2001.

Building 75 Tritium Plume

Extent of Contamination

The locations of groundwater monitoring wells, temporary groundwater sampling points and hydraugers in the vicinity of the Building 75 Tritium Plume are shown on Figure 3-7. Tritium activities detected in groundwater samples collected from groundwater monitoring wells and temporary groundwater sampling points from July to December 2002 are shown on Figure 3-28a. This figure also shows tritium activities detected in samples of hydrauger effluent collected in March 2003. The tritium activities detected in the hydrauger effluent and the effluent flow rates from the hydraugers are listed in Table 3.5. Although one hydrauger (77-01-4) had a tritium activity slightly below the MCL, the flow rate was extremely low (approximately 0.3 gallons per day).

As described in Section 3.4.2, groundwater in the Corporation Yard area generally flows southwards (Figure 3-17). The groundwater migration pathways are primarily within two former tributaries of the Chicken Creek drainage which prior to development of the area flowed

southward between the current locations of Buildings 69 and 75 and merged to form the main channel of Chicken Creek below Building 77. The former tributaries are filled with compacted artificial fill.

Trends in Tritium Activities in Groundwater

Temporal variations in tritium activities detected in groundwater monitoring wells are shown on Figures 3-29 through 3-33. The only groundwater monitoring well in which tritium has been detected at an activity above the MCL (20,000 pCi/L) has been MW75-97-5. In 2002, tritium activities detected in MW75-97-5 ranged from approximately 22,000 to 26,000 pCi/L. Except for MW75-99-6, tritium activities detected in groundwater monitoring wells have remained relatively constant over time or have shown a decreasing trend. Long-term decreasing trends are evident in MW91-4, MW91-6, MW75B-92-24, and MW75-97-5. In addition, recent tritium activities in several wells monitoring the plume appear to be decreasing, a trend that may be related to closure of the NTLF. For well MW75-99-6, the tritium activity was initially below the minimum detectable activity (MDA) (<300 pCi/L) but subsequently increased to approximately 1,000 pCi/L. The well is located west of Building 75A near the upgradient margin of the plume. It is suspected that purging of the well prior to sampling may have caused tritium-contaminated groundwater from the plume margin to flow toward the well.

Potential Migration of Tritium-Contaminated Groundwater to Surface Water

As discussed in Section 3.4.2, tritium has been detected in surface water samples collected from Chicken Creek, with activities measured downstream being generally slightly higher than those measured further upstream. The main source of tritium-contaminated surface water at the head of the creek is effluent from a stormdrain line. The presence of higher tritium activities downgradient from this point suggests that tritium-contaminated groundwater derived from the Building 75 Tritium Plume may seep into the creek.

During the last half of 2002 and beginning of 2003, Berkeley Lab conducted extensive hydrogeological investigations at the leading edge of the plume to identify the migration pathway for tritium from the groundwater to the creek. The investigations included a geophysical resistivity survey, cone penetrometer test (CPT) borings, geological logging of auger borings, and the

installation of temporary groundwater sampling points (SB31-02-1, -2, -4, -5, -6, and -7). The investigations identified a relatively permeable sandstone horizon within the Orinda Formation at the leading edge of the plume. The sandstone horizon contains tritium-contaminated groundwater at a maximum activity of approximately 3,800 pCi/L (detected in temporary groundwater sampling point SB31-02-4). Based on the absence of tritium in three of the temporary sampling points (SB31-02-2, -6, and -7) upgradient from the sandstone unit, the tritium-contaminated groundwater in the sandstone unit appears to be isolated from the main body of the tritium plume (Figure 3-28a). If groundwater levels in the sandstone unit rise above the creek level during the rainy season, there is a potential for tritium-contaminated groundwater in the sandstone unit to flow to the creek.

Surface water samples were collected from several locations along Chicken Creek in February 2003. The sampling locations and tritium activities detected are shown on Figure 3-36. Two stormdrains and a subdrain discharge water at the head of Chicken Creek (Figure 3-36). Tritium was detected in the surface water sample collected from the creek near the discharge point of these drains at an activity of 670 pCi/L. At the time of sampling, only a small volume of water was observed discharging from the drains. Approximately 75 feet downstream, a 24-inch stormdrain discharges on the surface east of the creek. Tritium was not detected in the effluent from this stormdrain, or in two downstream surface water sampling locations. Tritium (1,756 pCi/L) was detected further downstream at a seep on the east side of the creek. The seep discharges tritium contaminated groundwater from the sandstone unit described above. Tritium was not detected in surface water samples collected at two locations downstream from the seep. These results indicate that the seep may be the source of the somewhat higher tritium activities that have been detected in Chicken Creek at the downstream sampling location (Figure 3-35).

Source identification

The source of the Building 75 Tritium Plume was the former NTLF, which has been closed.

Plume Characterization and Stability

The magnitude and extent of the Building 75 Tritium Plume have been characterized and the primary source of the contamination, the former NTLF, has been closed. The plume is stable in that tritium activities detected in wells monitoring the plume have remained relatively constant

over time or have decreased. Tritium has not been detected in downgradient monitoring wells MW31-97-18 or MW31-98-17, which are screened in artificial fill and Great Valley Group bedrock (Figures 3-7 and 3-28a).

Interim Corrective Measures and Plume Management

Several slope-stability wells in the area between Buildings 69 and 75 were abandoned to eliminate potential contaminant migration pathways to groundwater in the core area of the Building 75 plume (Berkeley Lab, 2000). The locations of the abandoned wells are shown on Figure 3-7.

Since it is not technically practical to separate tritium from groundwater, the most effective way to manage the plume is to implement measures that will further reduce the potential for plume migration. Four multi-level temporary groundwater sampling points were installed between Buildings 69 and 75 to assess the potential effectiveness of an Interim Corrective Measure (ICM) that was being considered to aid in plume management. The ICM would consist of groundwater extraction from wells located upgradient from the plume, which should reduce the volume of clean water entering the tritium plume area. All of the sampling points were dry for several days, indicating that the proposed ICM would not be effective.

Examination of subsurface utilities indicated that leakage of clean water from corroded metal stormdrains recharged groundwater in the Building 69/75 area. This artificial recharge would increase the potential for movement of tritiated groundwater. To prevent leakage of water from the stormdrains and eliminate the resultant artificial recharge of the groundwater, all corrugated-metal stormdrains in this area were lined with PVC casings. This measure should reduce the velocity, and corresponding downgradient migration, of tritiated groundwater.

Building 71B Area

Tritium has been detected in three monitoring wells near Building 71B (MW71-95-9, MW71B-98-13, and MW71B-99-3R) (Figure 3-28b). The contamination is limited to an area very close to the Building, and tritium activities are substantially lower than those detected in the Building 75 Tritium Plume. Tritium activities detected in these wells have been relatively low (770 pCi/L

maximum) and have shown a decreasing trend (Figure 3-34). The tritium is likely derived from surface runoff from the Lawrence Hall of Science area to the northeast of Building 71.

No plume management measures have been implemented in the Building 71B area due to the low tritium activities and declining trend.

3.4.4 Soil Water

Vacuum lysimeters were installed in the Corporation Yard area to monitor variations in tritium activities in the soil water with distance from the tritium stack and to monitor changes in activities over time. Twenty shallow lysimeters (VL-1 through VL-20) were installed at a depth of approximately 2 to 3 feet bgs. In addition, four borings near Buildings 75 and 75A (75-96-1 through 75-96-4) were instrumented with two lysimeters in the interval from 7.5 feet to 20 feet bgs. The locations of the lysimeters are shown on Figure 3-37. Tritium activities detected in soil water samples collected from the lysimeters are listed in Table 3.6. The variations in tritium activities detected in soil water over time are shown on Figure 3-38 and Figure 3-39 for the shallow and dual level lysimeters, respectively. As can be seen on Figure 3-38, tritium activity in soil water has shown a decreasing trend at most of the shallow lysimeter locations.

Vadose zone monitoring well VZM-TS-1 is located north of Building 75A near the site perimeter (Figure 3-37). The well instrumentation includes lysimeters at a number of depths between 4 and 55 feet bgs. Tritium has been detected in most soil-water samples collected from the well from near the surface (4.25 feet bgs) to 16.5 ft bgs (Table 3.7). Tritium has generally not been detected in samples collected from the lysimeters below 16.5 ft.

3.5 CONCLUSIONS

3.5.1 Risk-Based Considerations

In 1997, Berkeley Lab completed a human health risk assessment that evaluated potential risk to workers and the public from exposure to tritium emitted from the NTLF (McKone *et al.* 1997). This risk assessment considered exposure to multiple media (air, soil, and water) and transfer of tritium between media (for example, air to soil, air to groundwater, and soil to groundwater). It also evaluated various exposure scenarios and exposure-point concentrations, based on modeled

exposure concentrations. The risk assessment concluded that people who live near Berkeley Lab and most Berkeley Lab workers had a theoretical incremental lifetime cancer risk of $6x10^{-6}$ over a lifetime of exposure. For Berkeley Lab workers located near Building 75, the risk was estimated at $6x10^{-5}$. Berkeley Lab also evaluated the potential for ecological receptors to be adversely affected by exposure to tritium (Berkeley Lab 2002b). The ecological risk assessment concluded that exposure to tritium in environmental media at Berkeley Lab does not present a significant risk to ecological receptors.

The human health and ecological assessments both overestimate the potential risk, since the estimates were based on the assumption that the NTLF would continue to operate and emit tritium to the air over a lifetime of exposure. The NTLF has stopped operations, so tritium emissions have decreased significantly and will ultimately be eliminated. Furthermore, tritium activities in environmental media will decline as the tritium that is present decays.

An independent assessment was performed by SENES Oak Ridge Inc. on tritium-in-vegetation data collected as part of the HRS sampling program (Thomas *et al.* 2002). The assessment concluded that the maximum plausible human exposure to tritium contained in vegetation surrounding Berkeley Lab would result in a cancer risk that is "difficult to distinguish from zero".

Based on the low and declining level of risk presented by tritium in environmental media at Berkeley Lab, no additional investigation or remedial action is warranted to address human health or ecological concerns.

3.5.2 Regulatory Policy

In addition to risks to human health and ecological receptors, Berkeley Lab also considered regulatory policies and promulgated standards in deciding whether additional investigation or remedial action was warranted. The primary policy or standard applicable to the tritium-impacted groundwater and surface water is California State Water Resources Control Board Resolution No. 88-63. This policy specifies that all waters (surface and groundwater) of the State are considered suitable, or potentially suitable, for municipal or domestic water supply, and that beneficial use must be protected. For this reason, concentrations of contaminants in groundwater and surface water are typically compared to drinking water standards (MCLs). The

policy has three exceptions, including one that excludes locations where the water source does not provide sufficient water to supply a well capable of producing an average sustained yield of 200 gallons per day. Tritium activities detected in samples collected from groundwater monitoring wells have all been well below MCLs except for samples collected from one well MW75-97-5, where tritium has been detected at a maximum concentration of approximately 30,000 pCi/L. However, hydraulic tests of this well showed that it was unable to produce 200 gallons per day, indicating that Resolution No. 88-63 is not applicable to the well location.

As discussed in Section 3.4.3, tritium-contaminated groundwater appears to be a source of recharge to Chicken Creek. However, tritium activities detected in Chicken Creek show a long-term decreasing trend with activities below 300 pCi/L since the NTLF cleanup of laboratory space was completed. These levels are substantially lower than the drinking water MCL (20,000 pCi/L). Tritium activities detected in North Fork Strawberry Creek have been relatively low (approximately 400 pCi/L or less) since 1994, with tritium not detected (<200 or <300 pCi/L), since the NTLF cleanup of laboratory space was completed.

Since tritium activities are less than MCLs in the surface water and areas of groundwater where Resolution No. 88-63 might be applicable, no further investigation or remedial action is warranted to address regulatory policy pertaining to beneficial use of groundwater or surface water. However, to address potential community concerns, Berkeley Lab has been evaluating potentially applicable methods for reducing the migration of tritium-contaminated groundwater to surface water. To prevent the artificial recharge of groundwater from leaking stormdrains in the upgradient plume area, the corrugated-metal stormdrains in the Building 69/75 area were lined with PVC casings. This measure should reduce the velocity, and corresponding downgradient migration, of tritiated groundwater. Other measures that were being considered, such as extracting clean groundwater at the upgradient or downgradient edges of the plume, were determined to either not be effective or likely result in increased tritium activities in Chicken Creek.

3.5.3 Recommendations

Although no further investigations or remedial actions are warranted based on risks to human health or ecological receptors, or are required under applicable regulations or policies, Berkeley Lab recommends that the following actions be implemented:

Waste Management

To ensure that proper waste management practices are followed, formal procedures should be implemented for managing tritium-contaminated soil and water derived from construction activities and for minimizing potential risks to construction workers.

Tritium Monitoring

Groundwater and surface water should continue to be monitored for tritium to ensure that current conditions are maintained or improved (i.e. tritium activities remain below levels of concern) by verification of the following:

1. Tritium activities in surface water remain below levels of concern (MCLs)
2. Tritium does not migrate offsite in the groundwater
3. The groundwater plume remains stable or the magnitude and/or extent of contamination decreases

The NTLF has been closed, so the source of contamination has been removed, and residual tritium in the environment will decay naturally. Therefore, the three conditions listed above are also proposed as the criteria for requesting that routine monitoring of groundwater and surface water for tritium be discontinued after the long-term trends in these criteria have been well established. An additional five years of monitoring is proposed (until the end of 2008) to confirm these trends. Sampling from MW75-97-5 will continue beyond 2008, if tritium concentration in this well remains above MCL.

The schedule proposed for monitoring of tritium in groundwater and surface water is specified in the following table:

Proposed Groundwater and Surface Water Sampling Schedule for Tritium

Location	Frequency	Rationale
Groundwater		
MW75-97-5	Semiannually through 2008	Confirm tritium concentrations in groundwater in plume core area are stable or decreasing.
MWP-9	Semiannually through 2008	Confirm plume is stable.
MWP-10	Semiannually through 2008	Confirm plume is stable.
MW77-97-11	Semiannually through 2008	Confirm plume is stable.
MW31-98-17	Semiannually through 2008	Confirm tritium is not migrating offsite in groundwater.
Surface Water		
Chicken Creek Upstream and Downstream Locations	Monthly through February 2004 then semiannually through 2008.	Confirm tritium activities in surface water remain at the currently low levels or decrease.
North Fork Strawberry Creek Upstream and Downstream Locations	Monthly through February 2004 then semiannually through 2008.	Confirm tritium activities in surface water remain at the currently low levels or decrease.

SECTION 4

SUMMARY OF PREVIOUS REPORTS SUBMITTED TO DOE FOR RADIOLOGICAL SOLID WASTE MANAGEMENT UNITS (SWMUs) AND AREAS OF CONCERN (AOCs)

This section briefly summarizes the investigations at the six radiological Solid Waste Management Units (SWMUs) and one Areas of Concern (AOCs) that have been included in previous reports submitted to the DOE. Except for the Building 75A Former Radioactive Waste Storage Area (SWMU 3-9), those reports are included in Appendix A or Appendix B of this document. Results of the investigation at SWMU 3-9 are contained in the Closure Report for the Hazardous Waste Handling Facility (Berkeley Lab 1998b). The Report of Release and Decommissioning of Radioactive and Mixed Waste Units of the Former HWHF Building 75 Complex (Berkeley Lab 1998c) was included as Appendix C to the closure report.

4.1 BUILDING 71 RADIATION RELEASE (AOC 1-7)

Description and History

On July 3, 1959, an experiment failure resulted in the release of approximately 0.04 curies of curium-244 inside Building 71, the HILAC (heavy ion linear accelerator). The building was immediately closed for extensive decontamination. Testing of the building's roof indicated that curium activity was present. After the cleanup, regular testing was conducted inside the building, and contaminated parts of the structure were removed. After 1964, regular testing indicated no remaining radiation in the structure. The HILAC stopped operating in 1993.

Radionuclides of Potential Concern

The radionuclide of potential concern was curium-244. The half-life of curium-244 is approximately 19 years.

Analytical Results

Soil

Between February 1993 and September 1996, a total of 36 soil samples were collected in the vicinity of Building 71 to characterize the magnitude and extent of curium-244 in the soil. Curium-244 was detected at a maximum activity of 2.6 pCi/g.

Groundwater

Groundwater samples were collected near or downgradient from Building 71, from eleven groundwater monitoring wells, one slope stability well, three subhorizontal drains (hydraugers), and a spring. No curium-244 was detected (<0.2 pCi/L). The wells sampled for curium-244 are listed in Table 4.1.

Sediment and Surface Water

North Fork Strawberry Creek drains the area of Building 71. No curium-244 was detected (<0.1 pCi/g) in two composite sediment samples collected from North Fork Strawberry Creek in April 1993. Curium-244 was detected at a maximum activity of 1.7 ± 0.3 pCi/g in sediment samples collected in August 1996 (Table 3.1).

Curium-244 was not detected (<0.2 pCi/L) in a surface water sample collected from North Fork Strawberry Creek in March 2000 (Table 3.2).

Status of Unit

DOE approved NFA status for the Building 71 Radiation Release (AOC 1-7) in September 1999 (DOE 1999), based on the following criteria included in Berkeley Lab's request for NFA status (Berkeley Lab 1999).

1. Curium-244 activities were all below the USEPA Region IX PRG for residential soil of 3.7 pCi/g (Dean, 1996). The USEPA has since increased the PRG for residential soil for curium-244 to 6.69 pCi/g.

2. Curium-244 was not detected in any of the groundwater samples collected near, or downgradient from, Building 71.

Since curium-244 had been detected in sediment samples collected from North Fork Strawberry Creek, AOC 1-7 was included in an Ecological Risk Assessment for Radionuclides completed by Berkeley Lab in January 2002 (Berkeley Lab 2002a). The ecological risk assessment concluded that exposure to curium-244 at the levels detected in environmental media at Berkeley Lab does not present a significant risk to ecological receptors.

4.2 BUILDING 5 FORMER DECONTAMINATION AREA (SWMU 10-2) AND BUILDING 5 FORMER OUTDOOR RADIOACTIVE WASTE STORAGE AREA (SWMU 10-3)

Description and History

From the 1940's until 1963, Building 5 (SWMU 10-2) was used as a radioactive waste accumulation area and an area for decontamination of radioactive-contaminated equipment. The Former Outdoor Radioactive Waste Storage Area (SWMU 10-3) consisted of the area outside Building 5, primarily on the north side of the building, and was used to transfer radioactive waste (sometimes mixed with chemical waste) to containers for temporary storage prior to offsite shipment and disposal.

In 1985, radionuclides (europium-152, europium-154, strontium-90, yttrium-90, and cesium-137) were detected in soil near the former outdoor storage area. Contaminated concrete, soil, and asphalt were removed (Berkeley Lab 1992).

Radionuclides of Potential Concern

The radionuclides of potential concern were strontium-90, cesium-137, europium-152, and europium-154. Yttrium-90 was not included because of its short half-life (2.7 days).

Analytical Results

Soil

Eight soil samples collected in 1992 were analyzed for the radionuclides of potential concern. Strontium-90, which was detected at a maximum activity of 0.080 pCi/g, was the only radionuclide

detected. The strontium-90 activity was consistent with residual activity from atmospheric testing. In 1995, soil samples were collected from seven borings north of Building 5. Gamma radiation, identified as naturally occurring potassium-40, and gross beta activity, reported as being consistent with naturally occurring potassium-40, were detected.

Groundwater

No radionuclides of potential concern were detected in groundwater samples collected in 1993 from monitoring well MW5-93-10 located west of Building 5; however gross alpha radiation was detected at a level of 15 ±10 pCi/L (Table 4.1). Because of the relatively high level of alpha radiation, the RWQCB requested that an additional groundwater sample be collected in 1999. Gross alpha radiation was measured at 3.4 ± 0.9 pCi/L. Results of gamma-spectrometric analysis by the Berkeley Lab Low-Background Facility indicated that natural radionuclides were present in the water in the range of activity that could cause the measured alpha levels. An additional sample was collected from MW5-93-10 in October 2000 (Table 4.1). No gross alpha radiation was detected (<5 pCi/L). Naturally occurring potassium-40 was the only gamma emitter detected. Gross beta radiation was detected as the result of the presence of potassium-40, which is both a beta and gamma emitter.

Strontium-90 was detected in a groundwater sample (1.7 ± 0.4 pCi/L) collected in 1993 from groundwater monitoring well MW91-9 located north of Building 5 (Table 4.1). However, neither of the duplicate groundwater samples collected in March 1997 contained strontium-90 (<0.74 pCi/L). No gross alpha radiation, gross beta radiation, or gamma emitters (potassium-40, natural uranium, radium-226, radium-228, cesium-137, or americium-241) were detected in a groundwater sample collected from MW91-9 in November 2000.

Groundwater samples were also collected in 1997 from three temporary groundwater sampling points (SB 5-97-6, -7, and -8) north of Building 5. No strontium-90, cesium-137, or gamma radiation was detected (Table 4.1).

Sediment

Surface runoff from the Building 5 area drains to North Fork Strawberry Creek. Neither strontium-90 nor cesium-137 was detected in sediment samples collected from North Fork Strawberry Creek in 1993 (Table 3.1).

Status of Unit

DOE approved NFA status for the Building 5 Former Decontamination Area (SWMU 10-2) and the Building 5 Former Outdoor Radioactive Waste Storage Area (SWMU 10-3) in September 1999 (DOE 1999), based primarily on the following criteria included in Berkeley Lab's request for NFA status (Berkeley Lab 1999). DOE noted that their approval did not authorize release of the area to the general public, and was only intended for Berkeley lab reuse of the subject areas.

1. Strontium-90, the only anthropogenic radionuclide detected, was detected at a maximum activity of 0.08 pCi/g, which was less than the PRG for residential soil of 14 pCi/g (Dean, 1996). The level is also below the USEPA revised PRG for residential soil for strontium-90 of 0.23 pCi/g . Strontium-90 is present in the environment as a result of past atmospheric testing.

2. Although strontium-90 was detected at a concentration of 1.7 pCi/L in a 1993 groundwater sample, it was not detected in a sample collected in 1997 (<0.74 pCi/L). The Maximum Contaminant Level (MCL) for drinking water for strontium-90 is 8 pCi/L.

3. Neither strontium-90 nor cesium-137 was detected in the sediment samples collected from North Fork Strawberry Creek.

4.3 BUILDING 74 INACTIVE ABOVEGROUND RADIOACTIVE WASTE STORAGE TANKS (SWMU 11-3)

Description and History

Six inactive aboveground liquid radioactive waste storage tanks are located on a concrete pad south of Building 74. Between approximately 1966 and 1972, two of the tanks (8-74 and 9-74) stored liquid waste that was generated from radioactive experiments conducted in the building. In the early 1970s, the contents of all of the tanks were pumped out and the tanks were decommissioned.

Radionuclides of Potential Concern

Radionuclides of potential concern included radioactive isotopes of strontium, plutonium, rubidium, and other elements, including carbon (^{14}C) and sulfur (^{35}S).

Analytical Results

In 1996, shallow soil samples were collected at three locations immediately south of the tanks and at two locations immediately beneath the concrete tank pad. In 1998, in accordance with recommendations from the DOE (DOE 1997), the Berkeley Lab ERP collected additional soil samples, and samples of the concrete pad and loose material on the concrete pad (mainly soil). At the same time, the Berkeley Lab Radiation Protection Group collected swipe samples from the exterior of Tanks 8-74 and 9-74, from exterior piping, and from the pump, as requested by DOE. They also sampled liquid within Tanks 8-74 and 9-74.

Soil Samples

Gross alpha radiation was detected in only one soil sample. Gross beta radiation was detected at a maximum activity of 16 $\pm$2 pCi/g. Total gamma radiation detected in 1996 was attributed to naturally occurring potassium-40. Gamma emitters quantified as potassium-40, thorium-232, and naturally occurring uranium were detected in 1998. Potassium-40 and thorium-232 are naturally occurring isotopes. Strontium-90 was not detected in the 1996 samples, and was not analyzed in the 1998 samples.

Loose Material and Concrete

Gross alpha radiation was not detected. Gross beta radiation (maximum 9 pCi/g) was detected in the loose material on the concrete and in one concrete sample. Potassium-40, thorium-232, naturally occurring uranium, beryllium-7, cesium-137, and americium-241 were detected in the concrete and/or loose material. Potassium-40, thorium-232, and beryllium-7 are naturally occurring isotopes. Cesium-137, americium-241, and cobalt-60 are present in the environment as a result of past atmospheric testing of nuclear weapons.

Swipe Samples

Gross alpha radiation (maximum 2.73 ± 0.27 disintegrations per minute per swipe) and gross beta radiation (maximum 5.8 disintegrations per minute per swipe) were detected in swipe samples. Gamma radiation was not detected.

Tank Liquids Samples

Gross alpha radiation (13 ± 8 pCi/L) was detected in the sample from Tank 9-74. Gross beta radiation (maximum 268 ± 11 pCi/L) was detected in samples from both tanks. Potassium-40 and cobalt-60 were detected in both tanks, and thorium-232 in Tank 9-74.

Status of Unit

In February 1997, Berkeley Lab requested NFA status for the Building 74 Inactive Aboveground Radioactive Waste Storage Tanks (SWMU 11-3) from the DOE. Upon review of the request, DOE requested additional work be conducted to support the NFA status request (DOE 1997). In 1998, Berkeley Lab performed additional sampling of environmental media and sampled the tank components and contents, as described above, in accordance with the DOE request. DOE approved NFA status for SWMU 11-3 in July 1998 based on the additional sampling results, which only showed the presence of low levels of radioisotopes that are commonly present as natural soil constituents or as a result of past atmospheric fallout. DOE's approval letter noted that the approval did not release the structure, equipment, or area from any existing controls (DOE 1998), and recommended that loose material and liquid in the tanks be disposed and that the tanks be secured.

4.4 BUILDING 74 ABANDONED RADIOACTIVE WASTE HOLDING TANKS (SWMU 11-2)

Description and History

Two single-walled tanks are located beneath Building 74. The tanks were designed to store wastewater generated from experiments conducted in the building: however, instead, the tanks functioned as part of the sanitary sewer system, receiving wastewater from sinks inside

Building 74. The tanks were active from 1964 until about 1976 when they were filled in place with sand.

Radionuclides of Potential Concern

No radioactive wastes were routed to the tanks.

Analytical Results

Soil samples were collected from two angled borings drilled beneath the tanks in 1996. No gross alpha radiation, gross beta radiation, or strontium-90 was detected. Detected gamma radiation was attributed to naturally occurring potassium-40.

Status of Unit

DOE approved NFA status for the Building 74 Abandoned Radioactive Waste Holding Tanks (SWMU 11-2) in July 1998 (DOE 1998) based on the soil sample results, which indicated that contaminants had not been released from the tanks. DOE noted, however, that the approval did not release the structure, equipment, or area from any existing controls.

4.5 THE BUILDING 75A FORMER RADIOACTIVE WASTE STORAGE AREA (SWMU 3-9)

The Building 75A Former Radioactive Waste Storage Area (SWMU 3-9) was recommended for no additional investigation in the RFA, based on an evaluation that both the past and ongoing release potential from the unit were low (Berkeley Lab 1992). However, extensive investigations at the Building 75A Former Radioactive Waste Storage Area were conducted in 1998, to obtain approval of closure certification for the Former Hazardous Waste Handling Facility (HWHF) (Buildings 75, 75A, and 69). Results of that investigation are described in detail in the Closure Report for the Hazardous Waste Handling Facility (Berkeley Lab 1998b) and Report of Release and Decommissioning of Radioactive and Mixed Waste Units of the Former HWHF Building 75 Complex, included as Appendix C to the closure report (Berkeley Lab 1998c). The results of the investigations are summarized below.

Description and History

Building 75A was constructed in the late 1980s. The floor and foundation curb walls are constructed of chemically resistant coating on reinforced concrete. The area inside Building 75A was divided into the following three areas:

1. B75A contained Mixed Waste Storage Units B75A-1 through B75A-7 and covered the northern half of the building. B75A was used to store overpacked containers and for repackaging containers. B75A-7 consisted of an area marked off on the floor that was periodically relocated within the building.

2. The Mixed Waste Staging Area (MWSA) was located in the southwest quarter of the building and was used for staging drums of waste ready for shipment.

3. B75AR, the radioactive waste room, was located in the southeast corner of the building and housed the compactor, the inactive scintillation-vial crusher, and an enclosure for sampling wastes.

Between April 21 and July 21, 1998, an extensive decommissioning and decontamination effort took place in the former HWHF, including Building 75A. Activities included disposal of waste inventory or transfer of waste inventory to the new Building 85 HWHF.

Radionuclides of Potential Concern

Radioactive and mixed waste.

Analytical Results

Soil Samples

From July to September 1997, 67 soil samples were collected at 27 locations at the Former HWHF (Building 75 and Building 75A) and analyzed for tritium and/or gross alpha, gross beta, and gamma radiation. Additional soil samples were collected in March 1998 at three locations inside Building 75A to investigate potential soil contamination in areas near drains in the building. Tritium was detected in almost all of the soil samples. The source of the tritium was most likely the former NTLF, which is discussed in Section 3 of this report. Gross alpha, gross beta, and gamma radiation were detected. The gamma radiation results were reported as consistent with naturally occurring isotopes, except americium-241 (0.071 pCi/g maximum),

zirconium-95 (0.051 pCi/g maximum), and cesium-137 (0.095 pCi/g). The detections of americium-241, zirconium-95, and cesium-137 were either not confirmed when the samples were reanalyzed by Berkeley Lab at lower detection levels, or are consistent with concentrations in soil resulting from past atmospheric nuclear testing.

Swipe Samples and Other Radiological Surveys

Extensive radiological surveys were conducted in the HWHF complex, including Building 75A by the Berkeley Lab Radiation Protection Group as part of closure activities. These surveys consisted of direct meter surveys, and swipes for alpha and beta/gamma contamination and for tritium. Based on results of the radiological surveys, all rooms, storage units, and equipment (except for parts of the compactor), either met DOE unrestricted release criteria or were decommissioned so that those portions could be reused by Berkeley Lab employees as appropriate.

Status of Unit

Building 75A was designated for reuse by the Berkeley Lab Radiation Protection Group.

4.6 THE BUILDING 4 FORMER RADIOACTIVE WASTE STORAGE AND STAGING AREA (SWMU 10-1)

Although the RFA Report (Berkeley Lab 1992) recommended that no additional work be performed at the Building 4 Former Radioactive Waste Storage and Staging Area (SWMU 10-1), Berkeley Lab was instructed by DOE to conduct additional investigations. Therefore, in January 2001, Berkeley Lab submitted a workplan to DOE describing the scope of proposed investigations needed to reassess the status of the unit (Berkeley Lab 2001a). On September 6, 2001, Berkeley Lab submitted a report to DOE describing the results of those investigations and providing documentation to support the conclusion that the no further action status of SWMU 10-1 should not be changed (Berkeley Lab 2001b). On October 2, 2001, DOE provided comments on the document. The report has been revised based on the DOE comments and is included as Appendix B to this document. A brief summary of that report is provided below.

Description and History

From the 1940's to the 1950's, part of Building 4 was used by Berkeley Lab's Nuclear Chemistry Division to conduct experiments involving radionuclides. Wastes from Building 4 were temporarily stored outdoors on the north side of the building.

Analytical Results

Soil Samples

A soil sample collected near Building 4 by DOE in 1986 contained gross alpha radiation at an activity above the background level (DOE 1998). To further evaluate this finding, in 2001 the ERP collected soil samples from 12 locations at the north side of Building 4. Samples were collected in the area where gross alpha activity had exceeded background levels in the 1986 DOE sample. Samples were also collected at four locations adjacent to the sanitary sewer line. These two areas were considered to have had the greatest potential for release of radionuclides to the environment.

Gross alpha radiation was only detected at one location. Gross beta radiation was reported as consistent with the amount of naturally occurring potassium-40 in the sample. Detected gamma emitters consisted of the naturally occurring radionuclides potassium-40, thorium-232, and uranium. The only synthetic radionuclides detected were cesium-137 and americium-241, which are present in the environment primarily as a result of fallout from past atmospheric testing. Two additional samples were collected adjacent to the location where gross alpha radiation had been detected. No gross alpha radiation was detected. The results indicated that the extent of soil in which gross alpha radiation exceeded the detection level was limited.

Video Survey

The integrity of the sewer line between Building 4 and the main sewer line branch was evaluated by conducting a video survey. No dislocations, breaks, or perforations were identified.

Status of Unit

The results of the 2001 investigations support the recommendation presented in the RFA (Berkeley Lab 1992) that the Building 4 Former Radioactive Waste Storage and Staging Area (SWMU 10-1) be given NFA status.

SECTION 5

SITEWIDE GROUNDWATER EVALUATION

5.1 RADIONUCLIDES IN GROUNDWATER

Groundwater samples were collected from 52 groundwater monitoring wells in 2000 and analyzed for gross alpha radiation, gross beta radiation, and gamma spectroscopy. The results are provided in Table 4.1. The locations of the wells are shown on Figure 5-1. The sampled wells were primarily located near current and former particle accelerators (Building 88, Building 51, Building 71, and Building 6); near Buildings 4, 5, 74, and 75A where radionuclides were handled; and near the site perimeter. No gross alpha radiation was detected (<5 pCi/L) in the 2000 samples. Gross beta radiation, which was detected in 23 samples at a maximum activity of 26 ±5 pCi/L, was the result of the presence of naturally occurring potassium-40, which is both a beta and gamma emitter. The MCL for gross beta is 50 pCi/L. Naturally occurring potassium-40 was the only gamma emitter detected, and was detected in 24 samples at a maximum activity of 16 ±5 pCi/L.

5.2 COLLOCATED CHEMICAL AND RADIOLOGICAL CONTAMINATION

As described in Section 5.1, except for naturally occurring potassium-40, no gross alpha radiation, gross beta radiation, or gamma emitters were detected during the site-wide evaluation of radionuclides in groundwater conducted in 2000 (Table 4.1). Except for strontium-90, which was detected in monitoring well MW91-9 in 1993 but was not confirmed in a subsequent sample (Table 4.1), tritium has been the only radionuclide detected in groundwater (Table 3.3). Areas of collocated chemical and tritium contamination in groundwater are shown on Figure 5-2. The figure shows the extent of the tritium plume based on the most recent data collected in 2002, the extent of volatile organic compounds (VOCs) in groundwater in the Support Services Area based on data collected in 2002, and wells in which both tritium and VOCs were detected in 2002.

Also indicated on the figure are wells in which VOCs were detected at concentrations above MCLs in 2002.

A second area of collocated chemical and tritium contamination in groundwater is located south of Building 71B. Both tritium and VOCs were detected in monitoring wells MW71B-98-13 and MW71B-99-3R in 2002. The locations of these two wells are shown on Figure 3-28b. Tritium was not detected in quarterly samples collected from these wells during the fourth quarter of fiscal year 2002 (FY02) or the first and second quarters of FY03 (July 2002 to March 2003).

SECTION 6

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LIST OF FIGURES

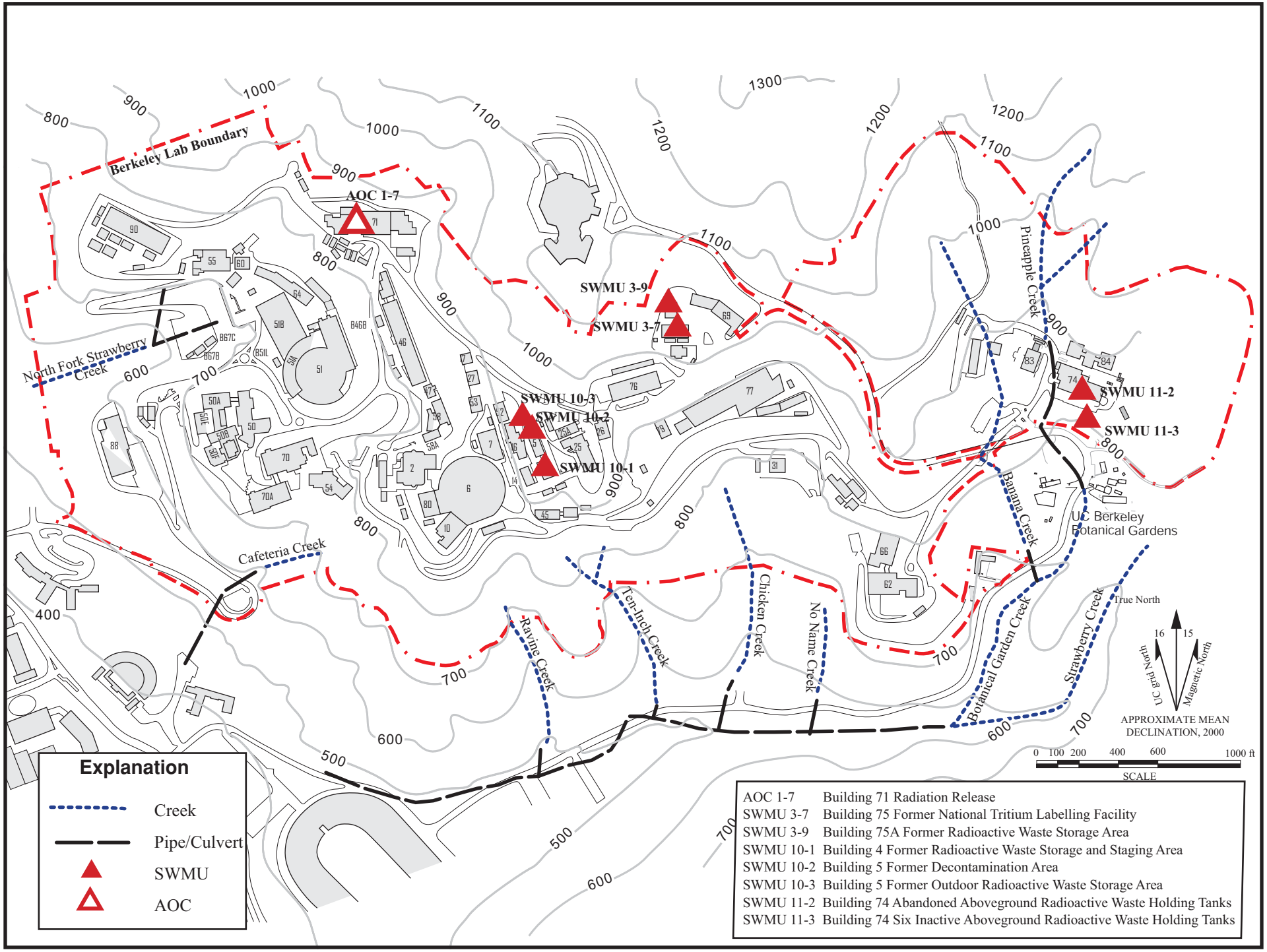


Figure 1-1. Location of Radiological SWMUs and AOCs, Lawrence Berkeley National Laboratory.

1-1creek&surf.ai
3/03

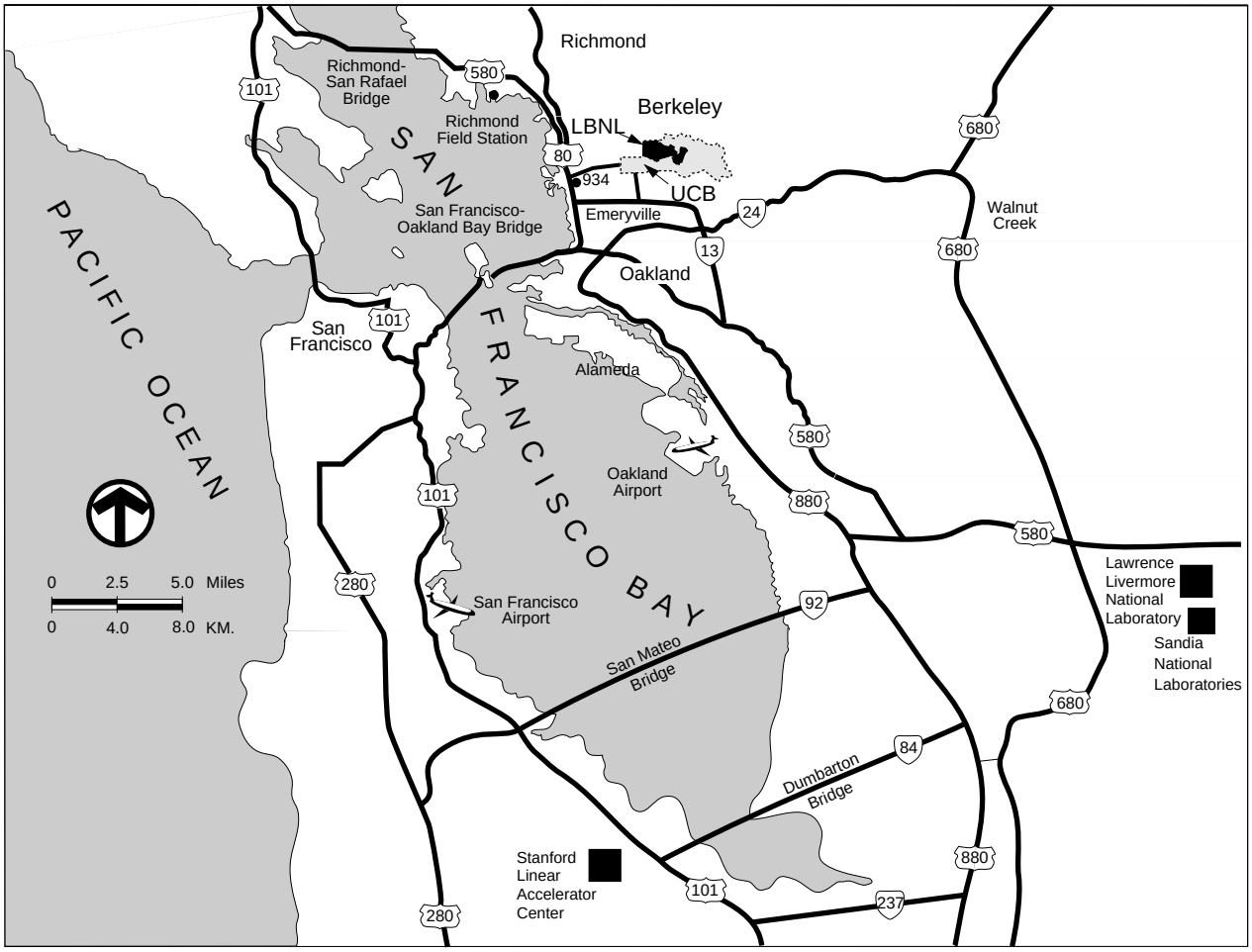


Figure 2-1. San Francisco Bay Area Map

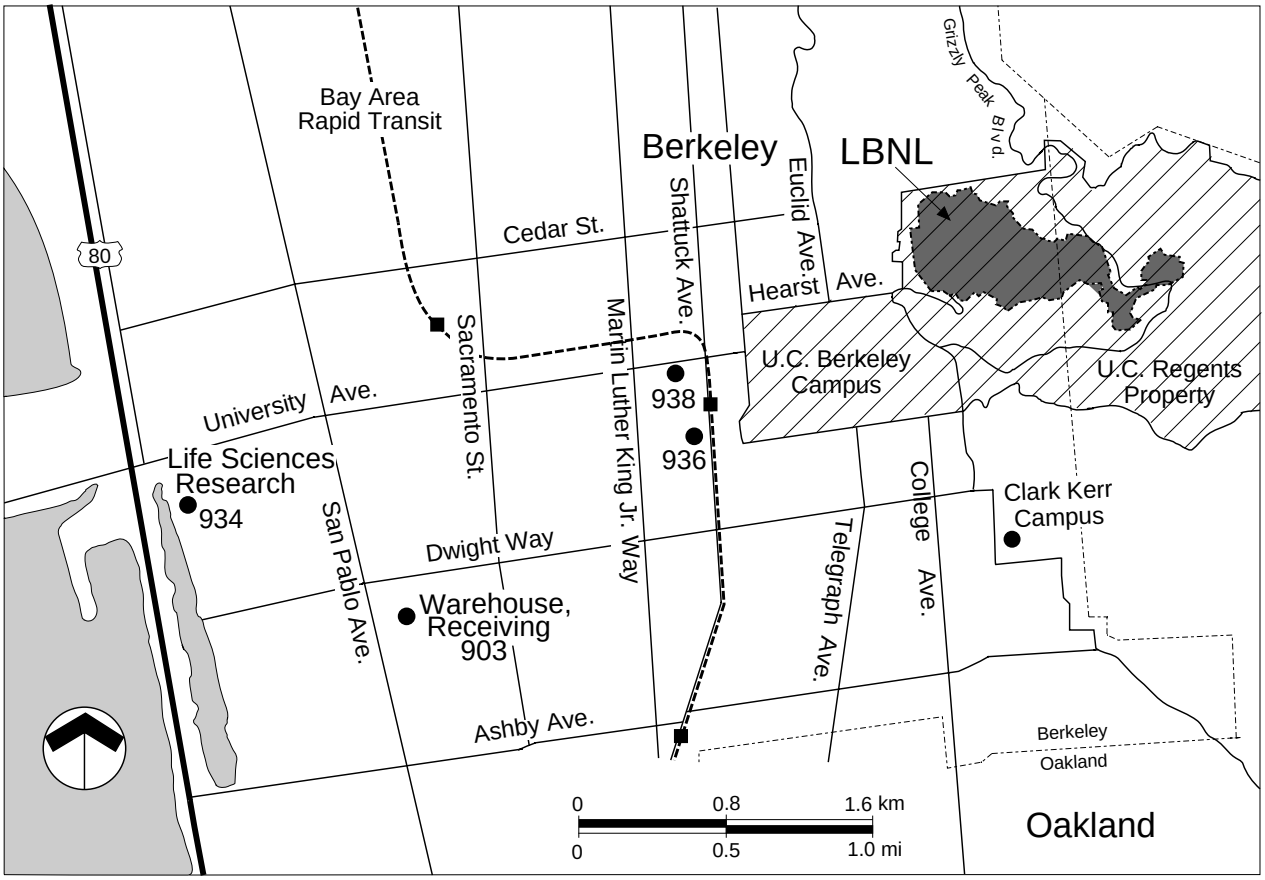


Figure 2-2. Vicinity Map

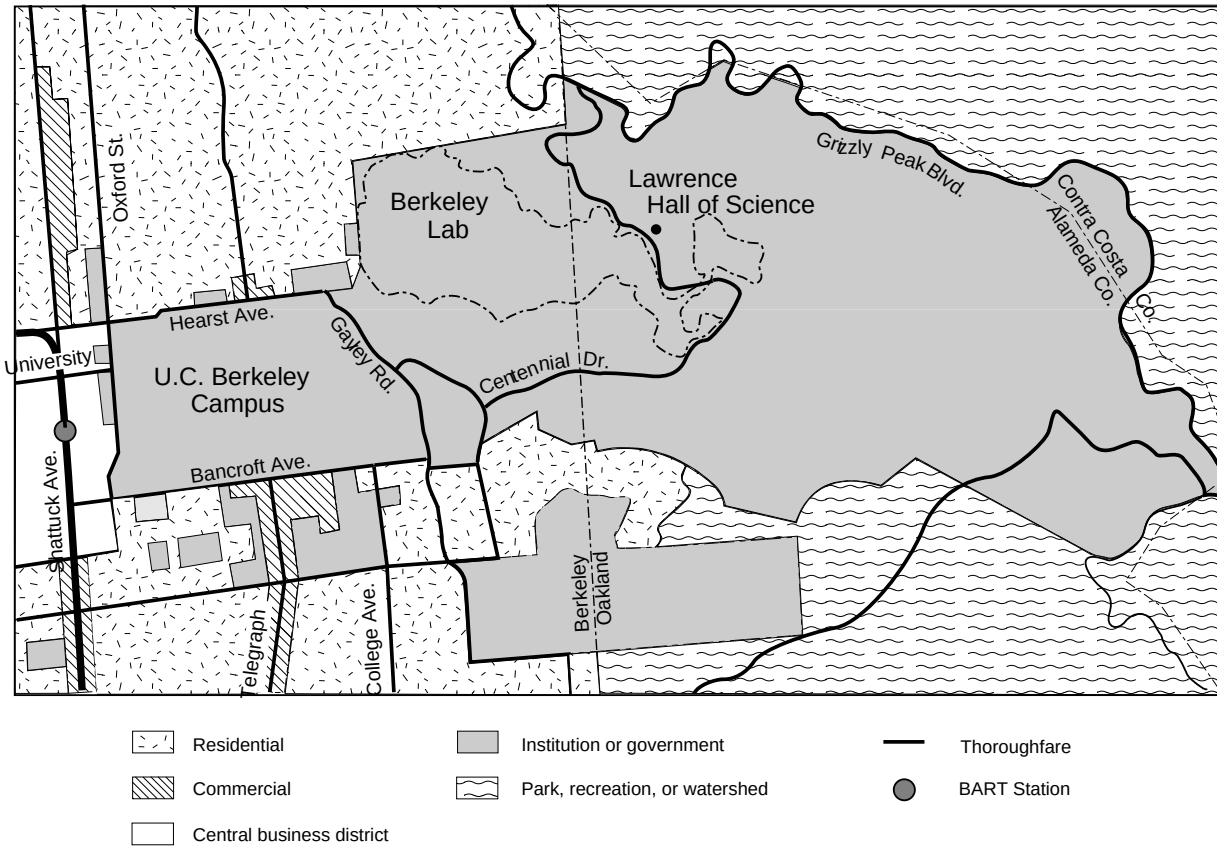


Figure 2-3. Adjacent Land Use

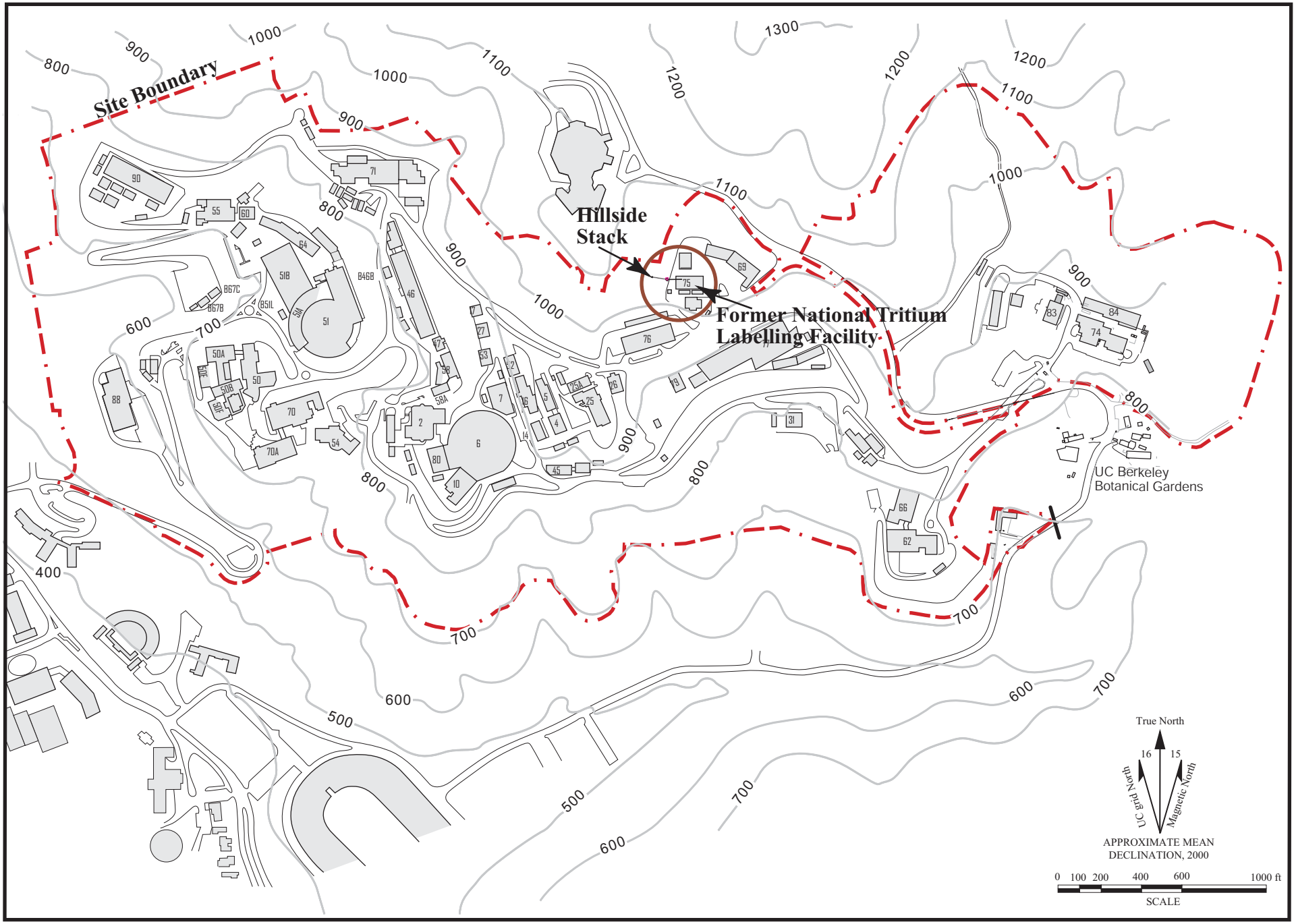
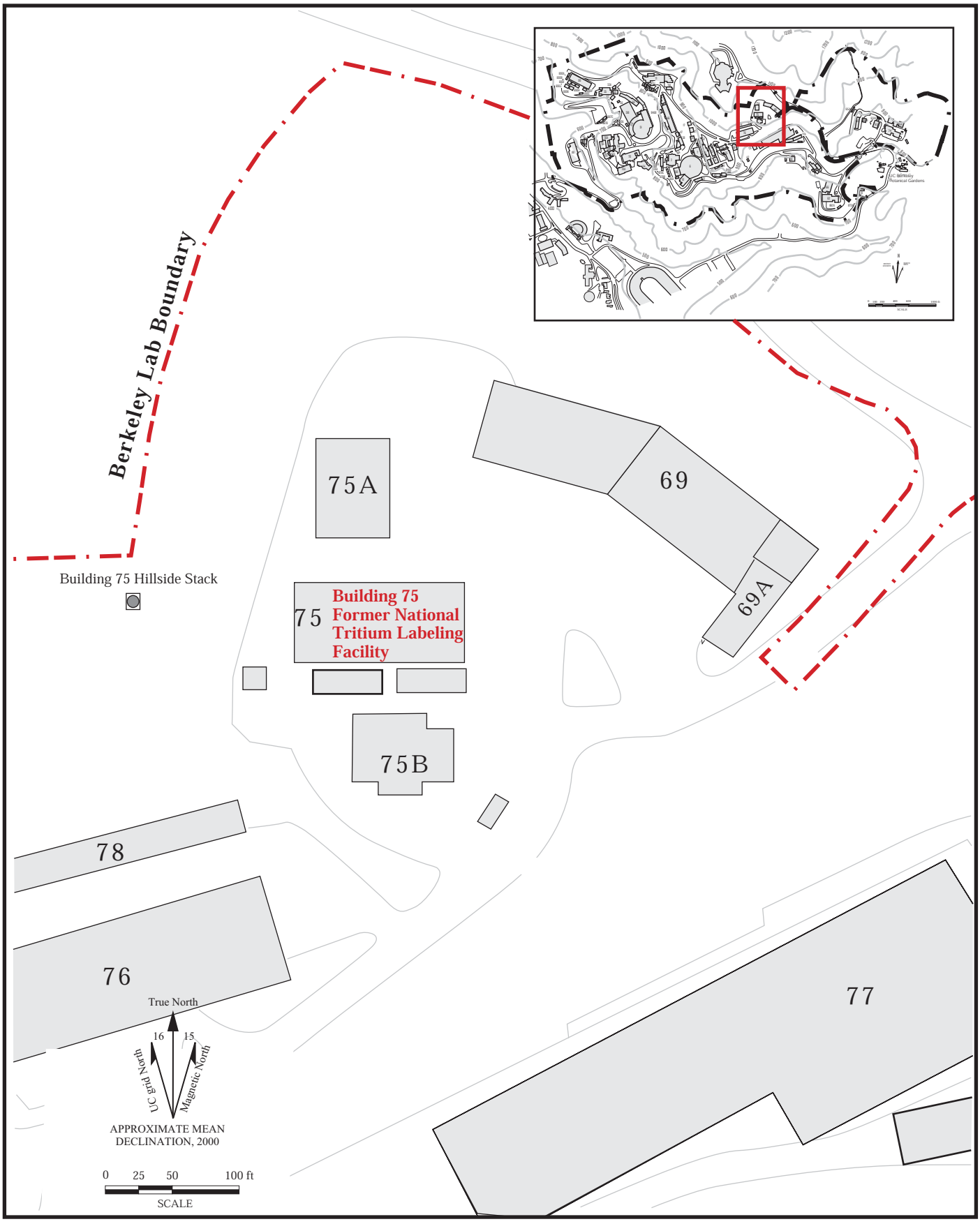


Figure 3-1. Location of the Former National Tritium Labelling Facility, Lawrence Berkeley National Laboratory.

3-1-sitemap.ai
3/03



3-2locntlf.ai
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Figure 3-2. Location of the Former National Tritium Labelling Facility, Support Services Area Area.

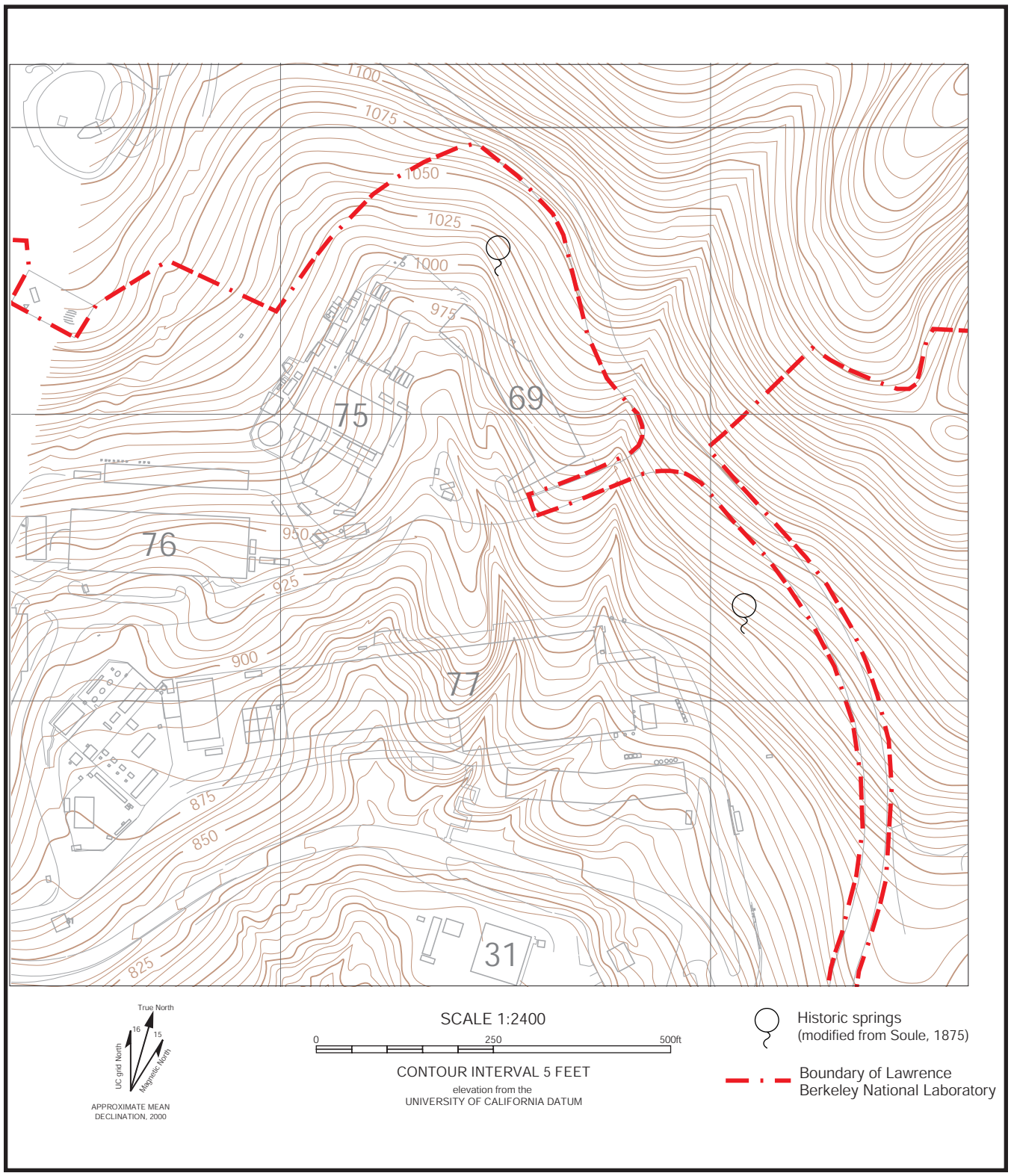
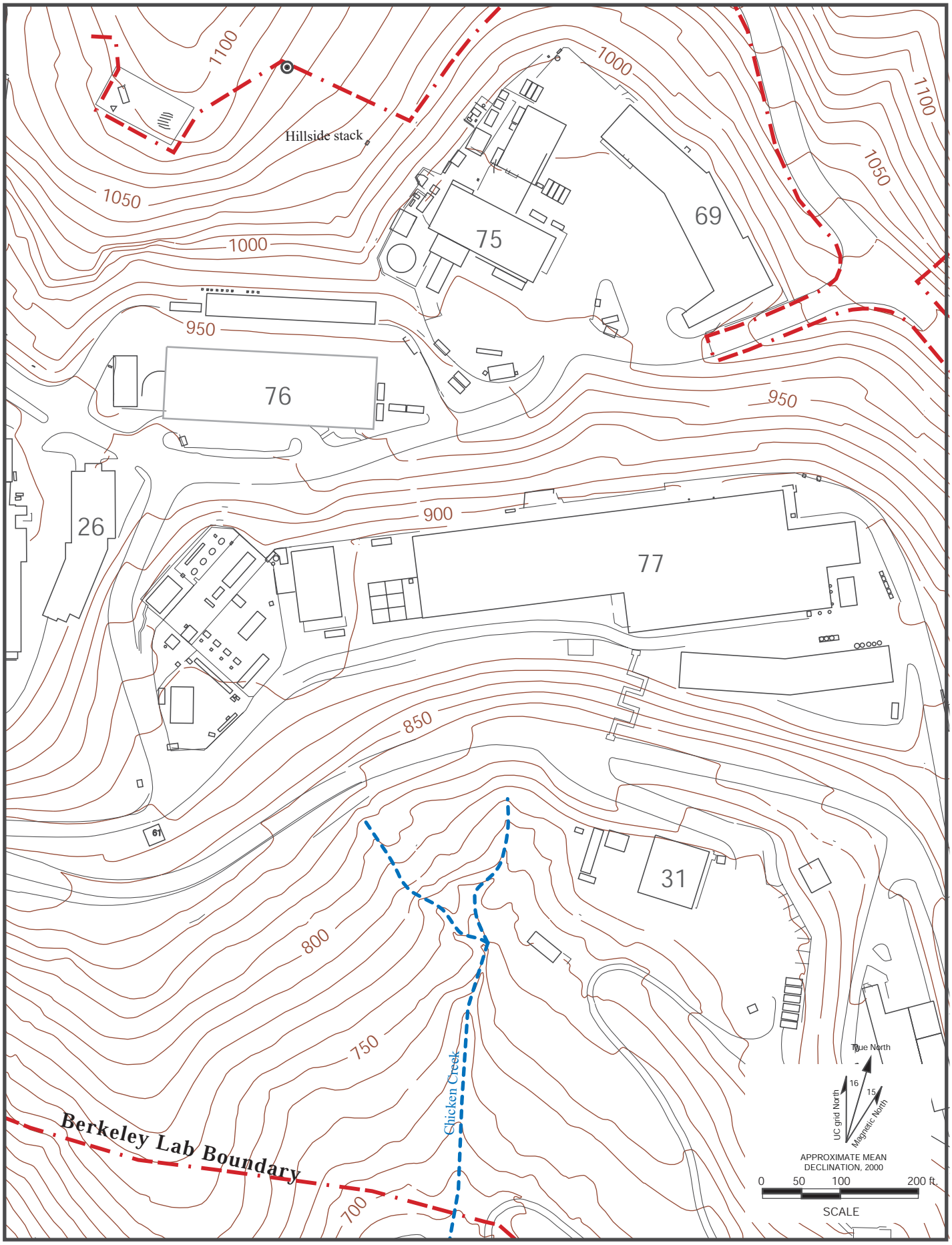


Figure 3-3. Pre-Development (1956) Topography of Support Services Area (modified from Hammon, Jensen, and Wallen, 1956).

3-3pretopography.ai
3/03



3-4,3-6support services.ai
3/03

Figure 3-4. Surface Topography in the Support Services Area.

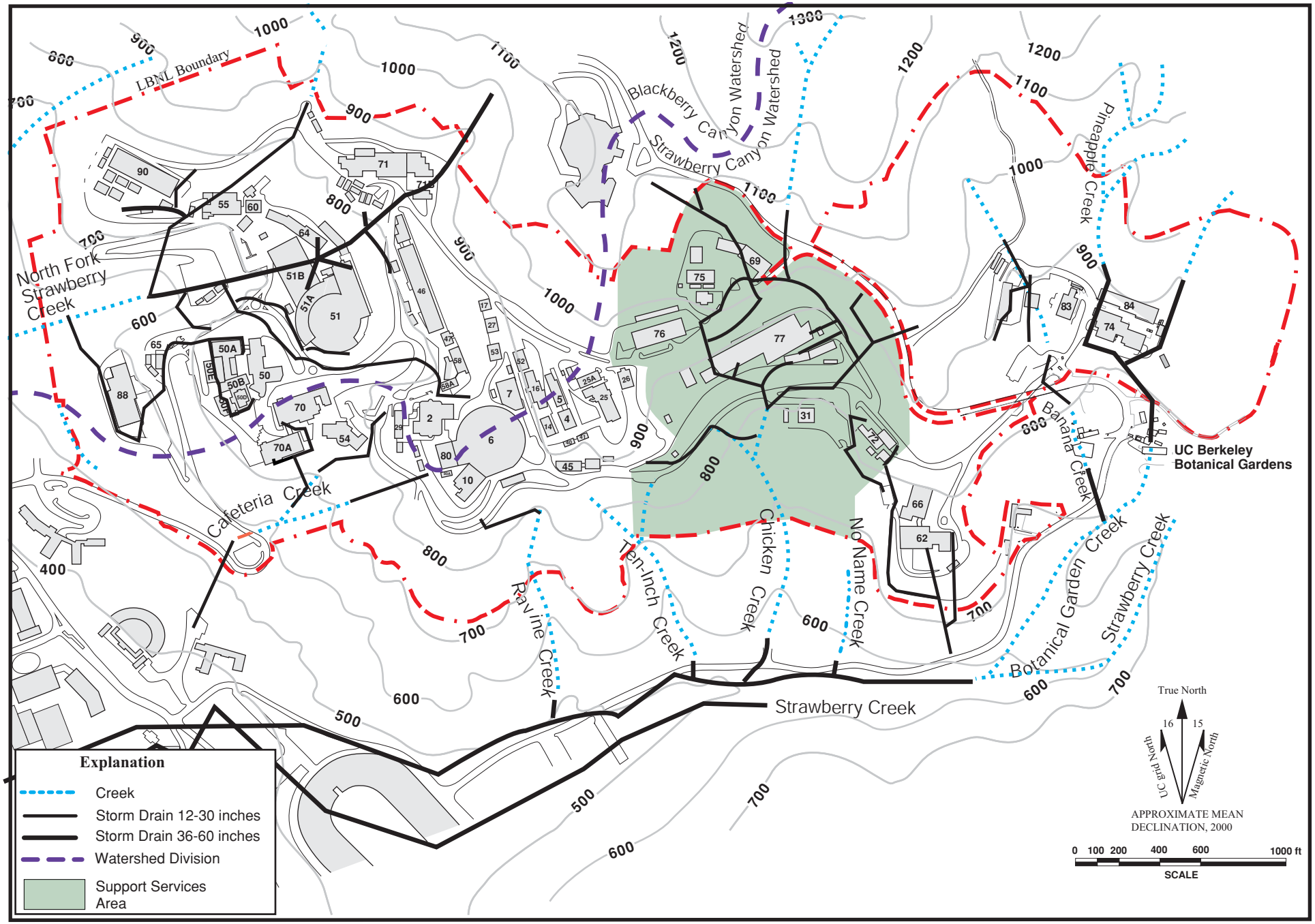
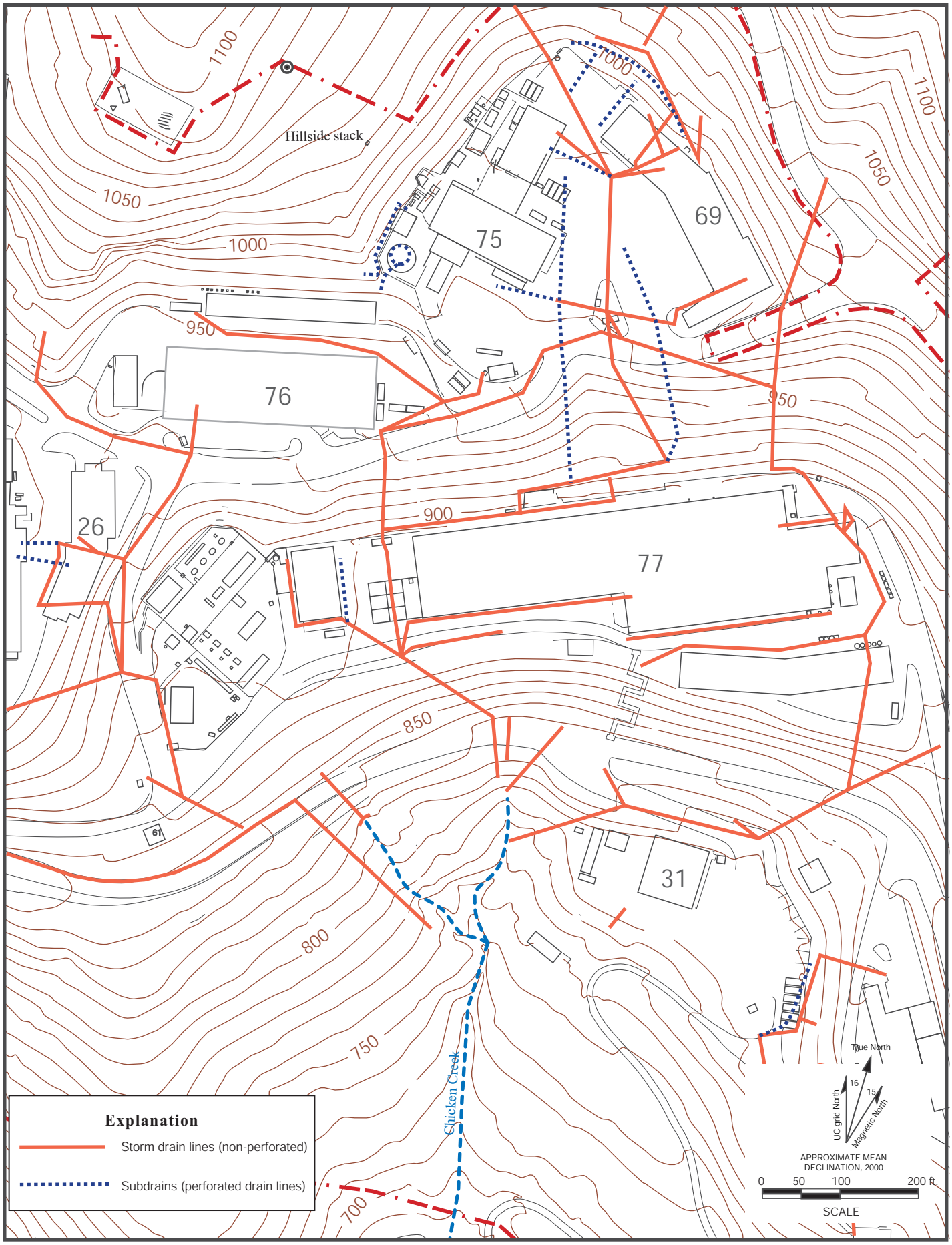


Figure 3-5. Berkeley Lab Surface Hydrology and Stormwater Drainage System.

3-5watershed.ai
3.03



3-4,3-6support services.ai
3/03

Figure 3-6. Locations of Stormdrains in the Support Services Area.

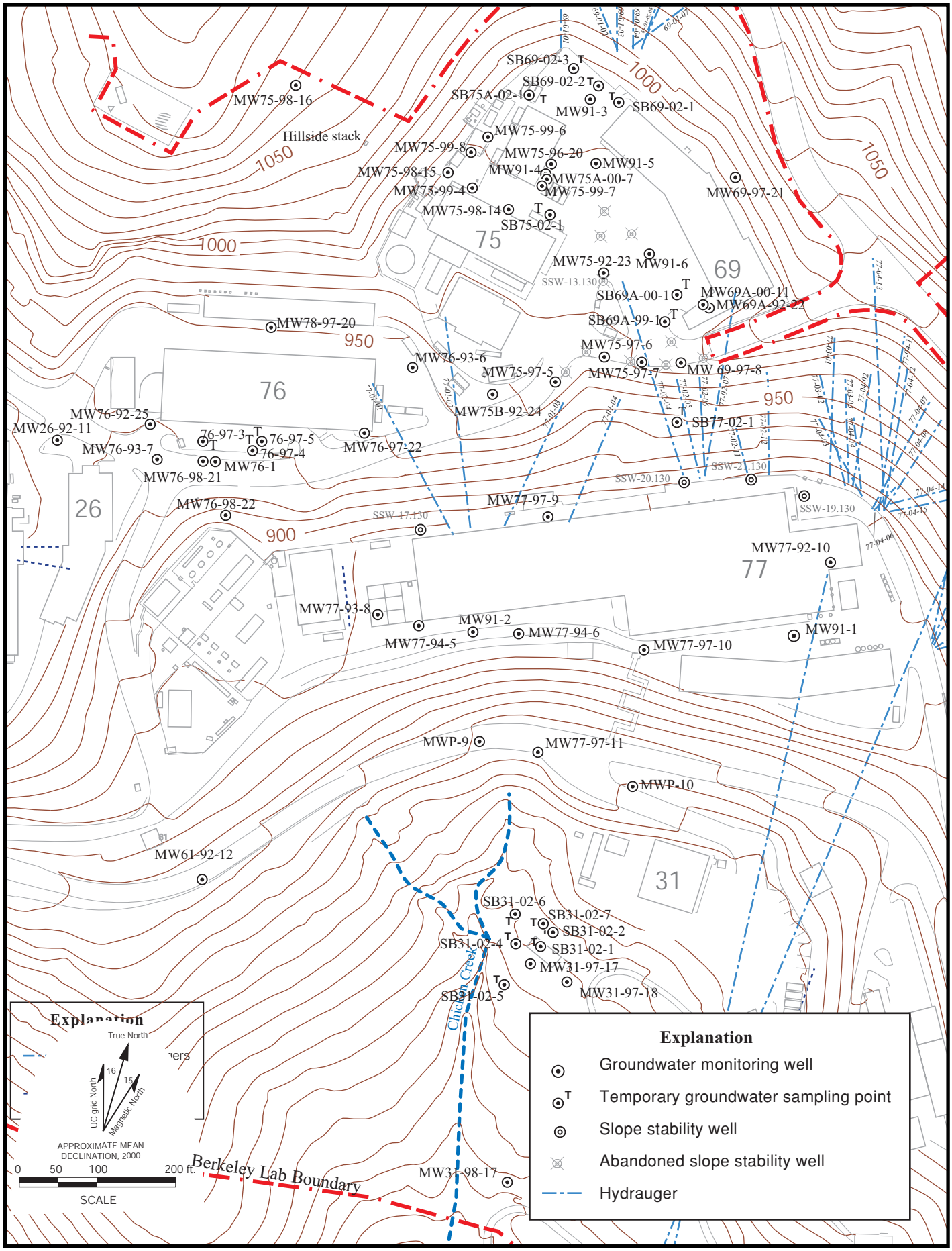


Figure 3-7. Locations of Wells and Hydraugers in the Corporation Yard Area.

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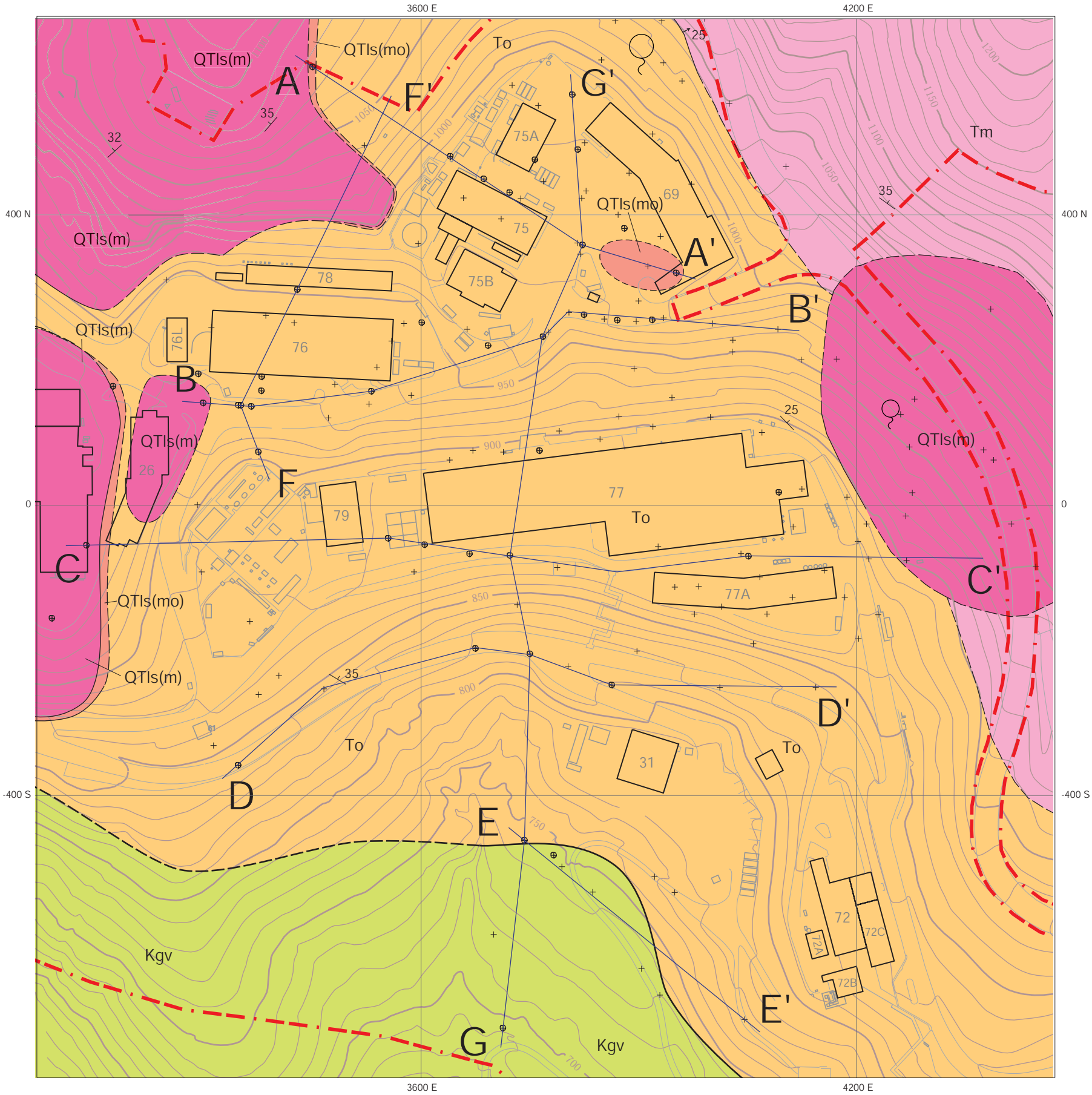
3/03



SCALE 1:1920

0 160 320ft

CONTOUR INTERVAL 10 FEET
UNIVERSITY OF CALIFORNIA DATUM

True North
16
15
UC grid North
Magnetic North

APPROXIMATE MEAN
DECLINATION, 2000

QTls(m) Paleolandslide Deposit Composed of Moraga Formation Rocks

QTls(mo) Paleolandslide Deposit (Mixed Unit)

Tm Moraga Formation

To Orinda Formation

Kgv Great Valley Group

Support Services area cross section

Boundary of Lawrence Berkeley National Laboratory

Environmental monitoring wells includes groundwater and soil gas wells and lysimeters

Soil borings includes slope indicators and slope stability wells

Historic springs (modified from Soule, 1875)

75 Contact, showing dip dashed where approximately located; dotted where concealed by other map units

35 Fault, showing dip dashed where approximately located; dotted where concealed; queried where inferred

60 Strike and dip of beds

revision: 9/26/2000

Figure 3-8. Support Services Area Bedrock Geologic Map.

C2.3-1 br map.ai
09/00

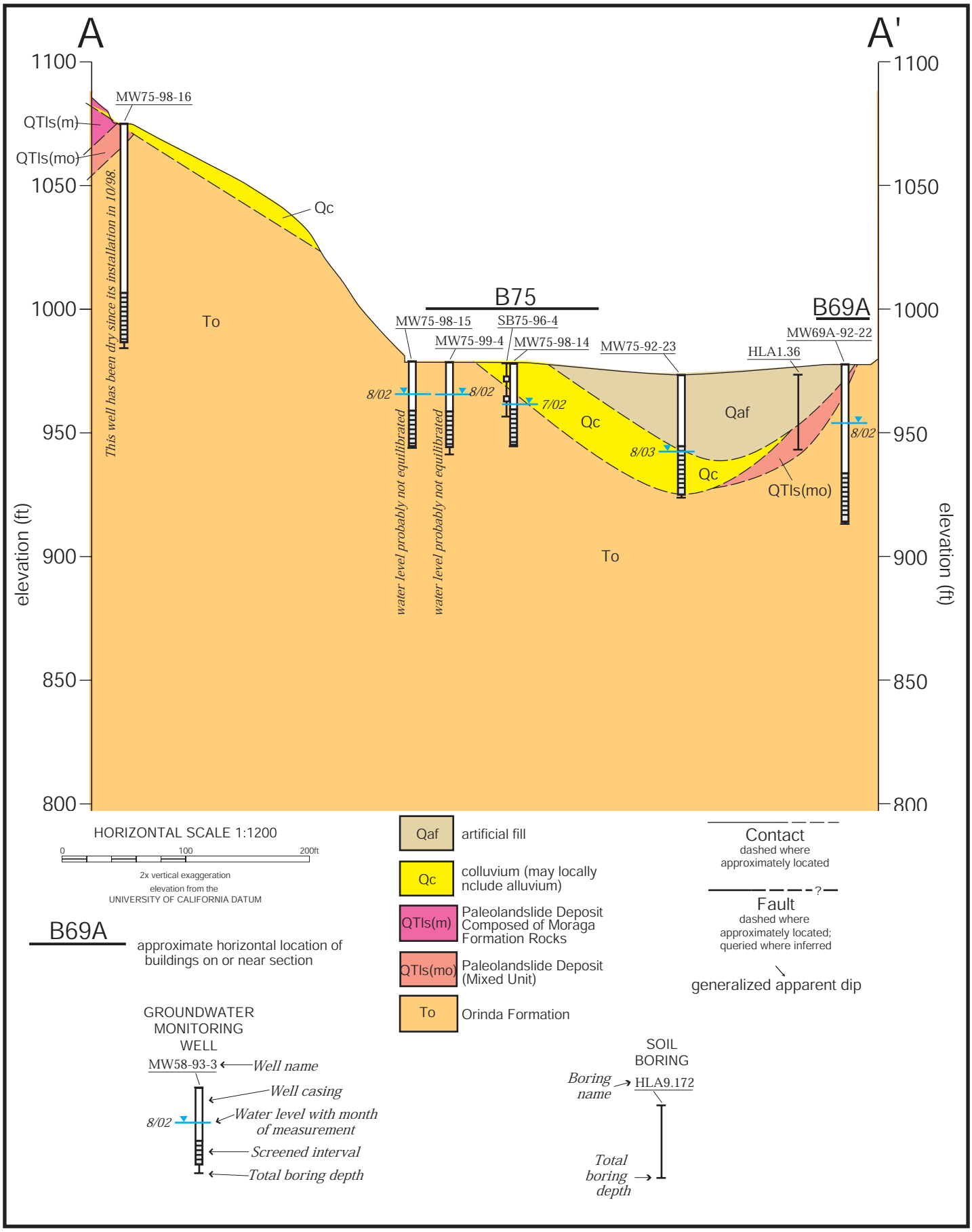


Figure 3-9. Support Services Area Cross Section A-A'.

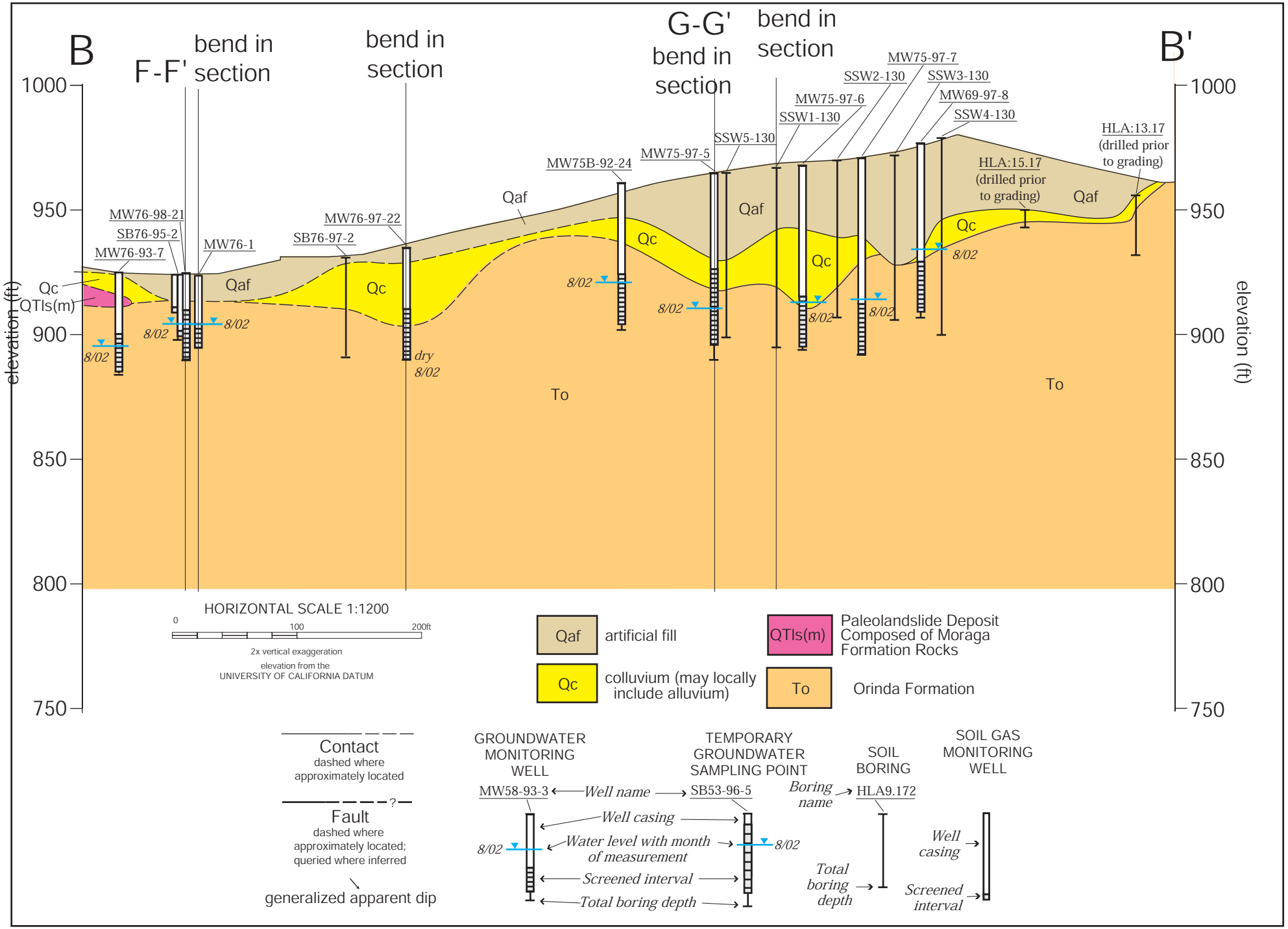
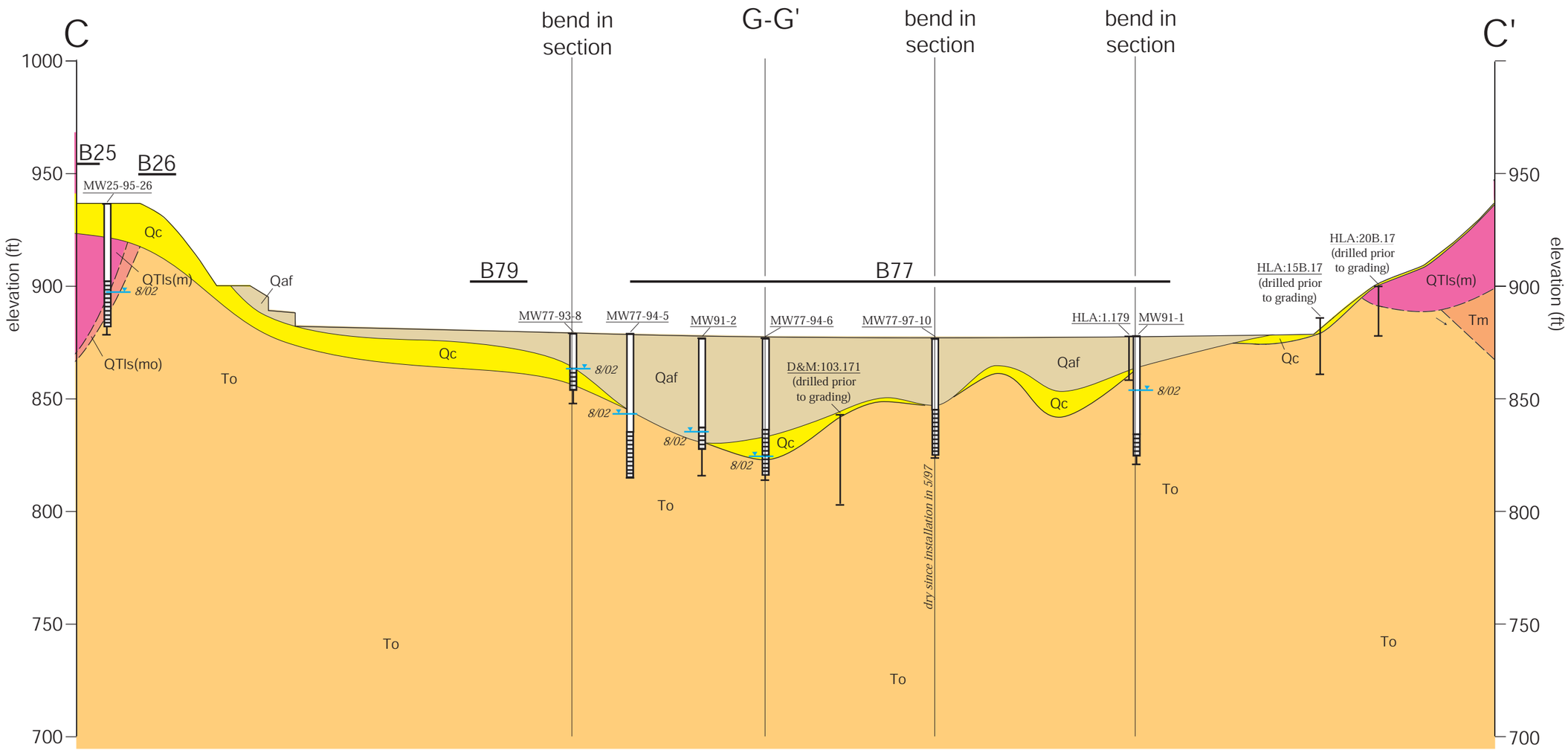


Figure 3-10. Support Services Area Cross Section B-B'.



HORIZONTAL SCALE 1:1200

0 100 200ft

2x vertical exaggeration

elevation from the UNIVERSITY OF CALIFORNIA DATUM

B77 — approximate horizontal location of buildings on or near section

1956 ground surface (modified from Hammon, Jensen, and Wallen, 1956)

Qaf	artificial fill
Qc	colluvium (may locally include alluvium)
QTls(m)	Paleolandslide Deposit Composed of Moraga Formation Rocks
QTls(mo)	Paleolandslide Deposit (Mixed Unit)
Tm	Moraga Formation
To	Orinda Formation

Contact — dashed where approximately located

Fault — dashed where approximately located; queried where inferred

generalized apparent dip

GROUNDWATER MONITORING WELL — MW58-93-3

TEMPORARY GROUNDWATER SAMPLING POINT — SB53-96-5

Well name; Well casing; Water level with month of measurement; Screened interval; Total boring depth; 8/02

SOIL BORING — HLA9.172

Boring name; Total boring depth

SOIL GAS MONITORING WELL

Well casing; Screened interval

Figure 3-11. Support Services Area Cross Section C-C'.

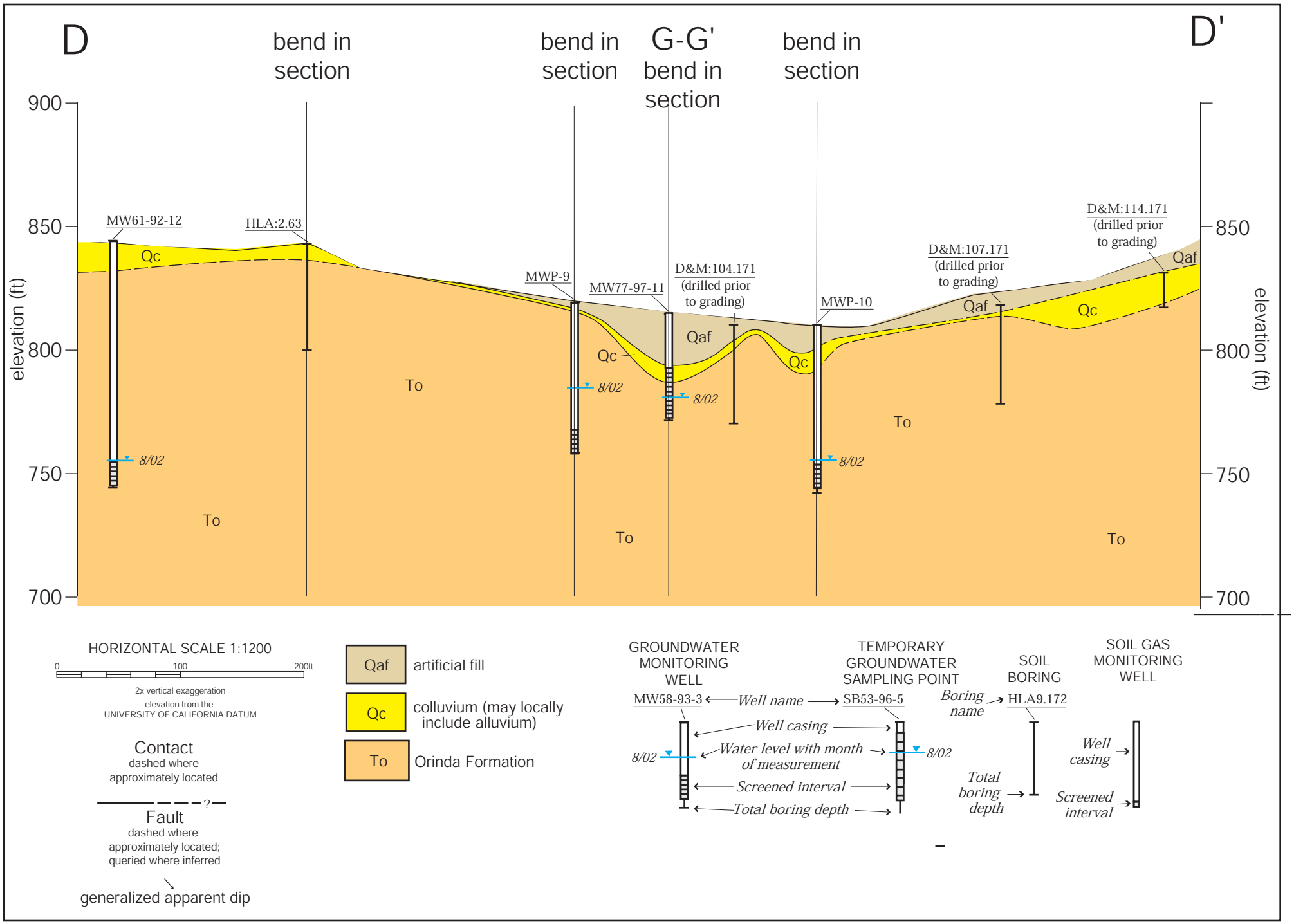


Figure 3-12. Support Services Area Cross Section D-D'.

3-1,C2.3-5 sec d.ai
3/03

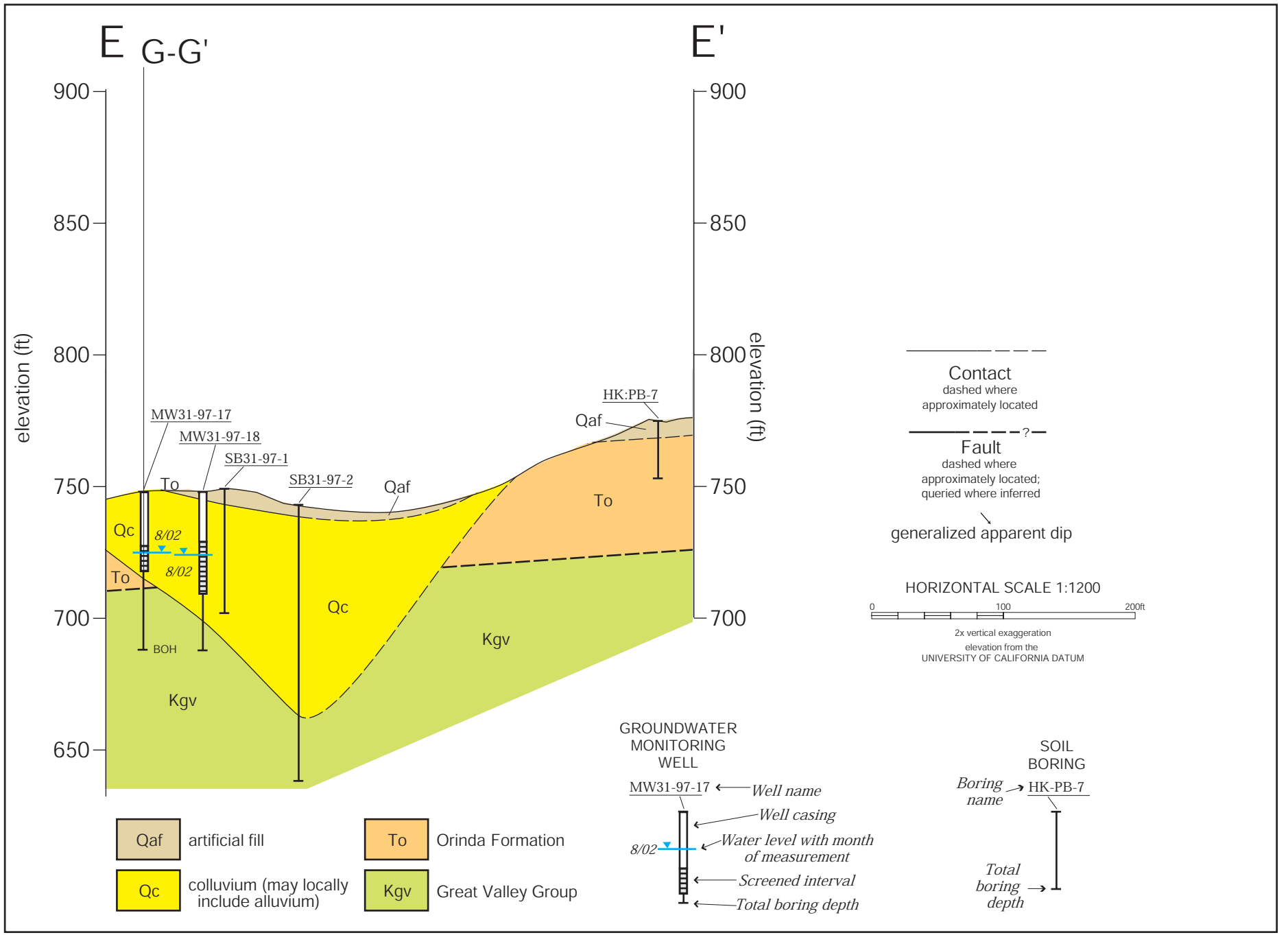


Figure 3-13. Support Services Area Cross Section E-E'.

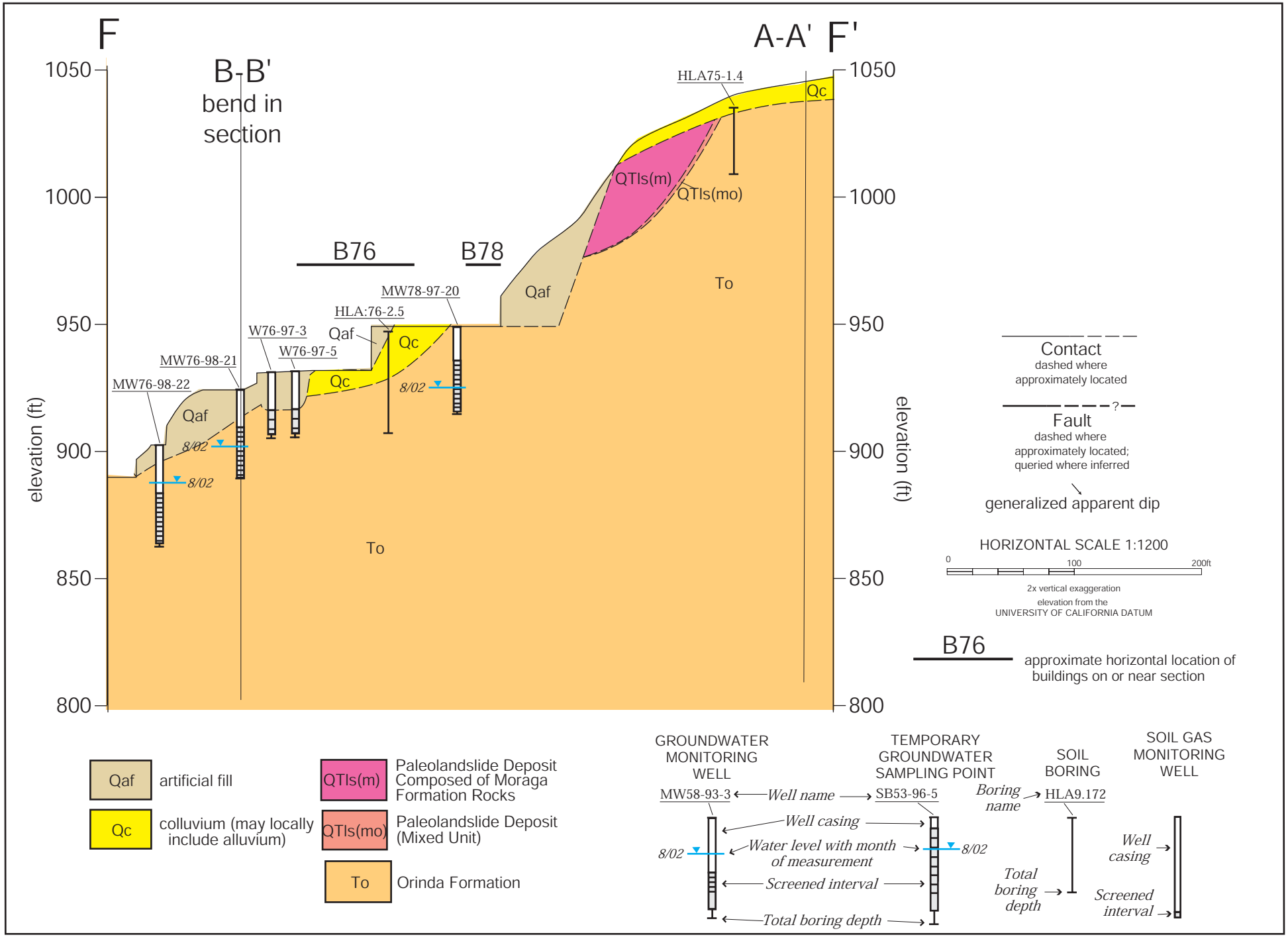


Figure 3-14. Support Services Area Cross Section F-F'.

3-14,C2.3-7 sec f.ai
3/03

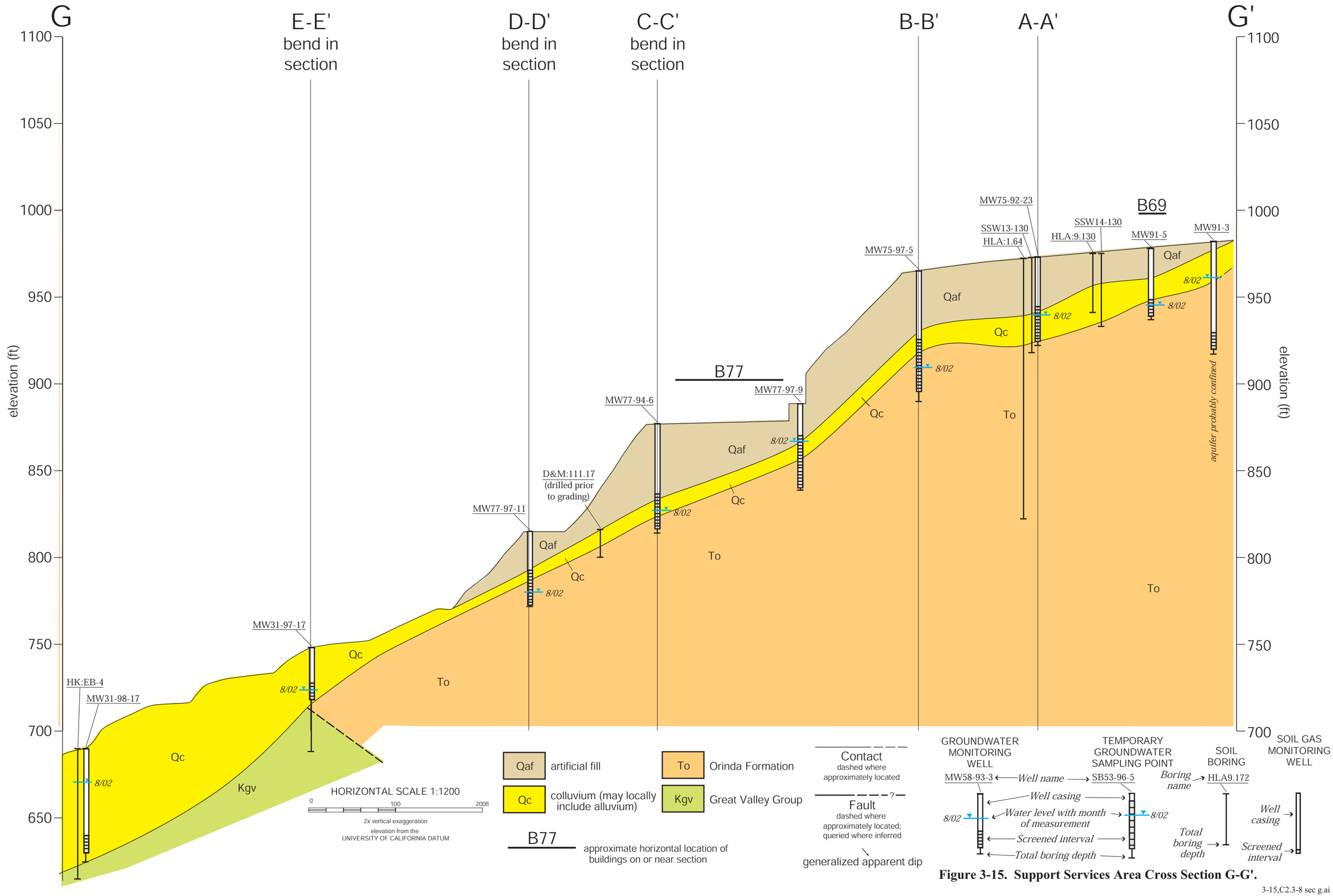


Figure 3-15. Support Services Area Cross Section G-G'.

3-15,C2.3-8 sec g.ai
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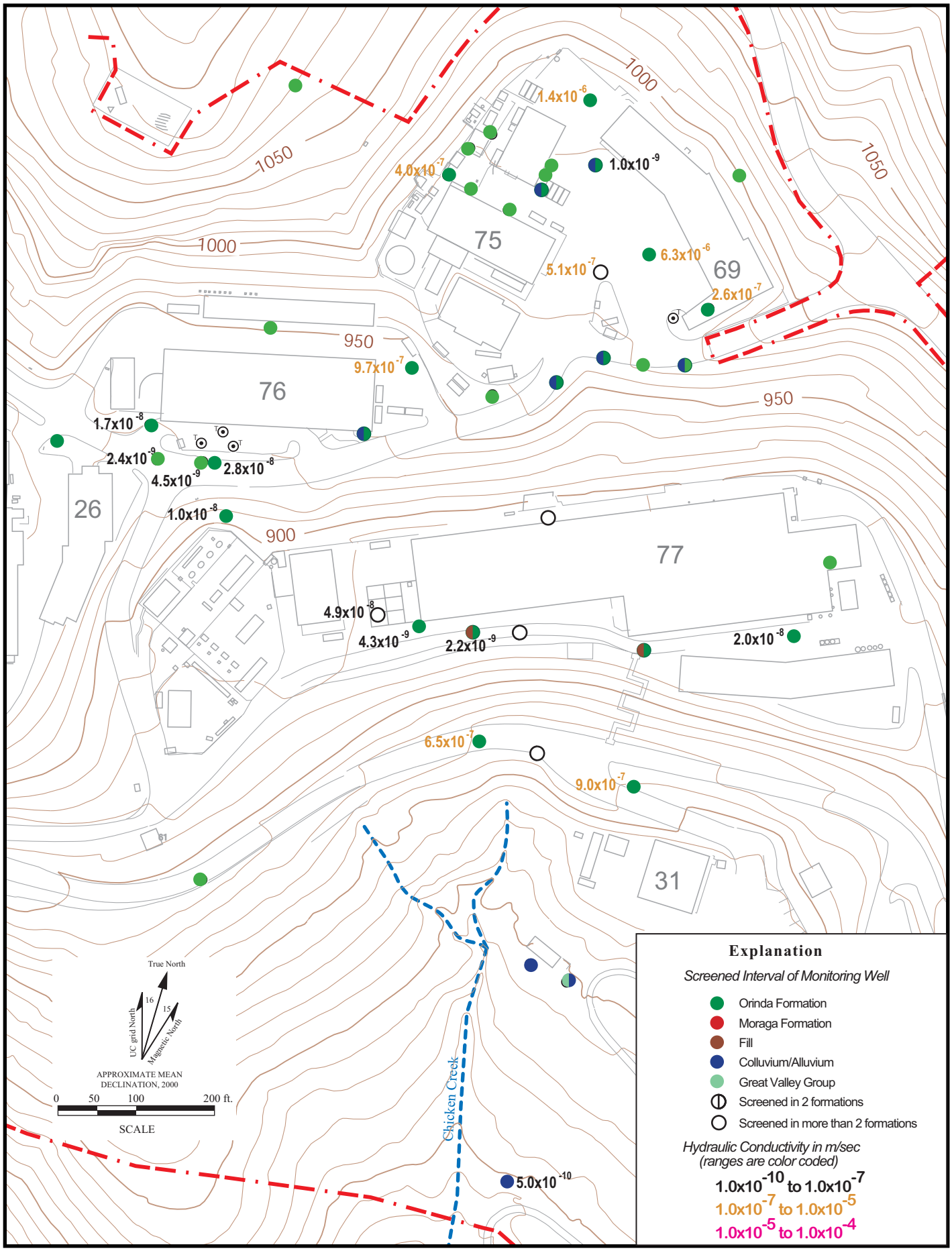

Figure 3-16. Support Services Area Well Locations Showing Hydraulic Conductivity Estimates Calculated from Slug Tests and Pumping Tests.

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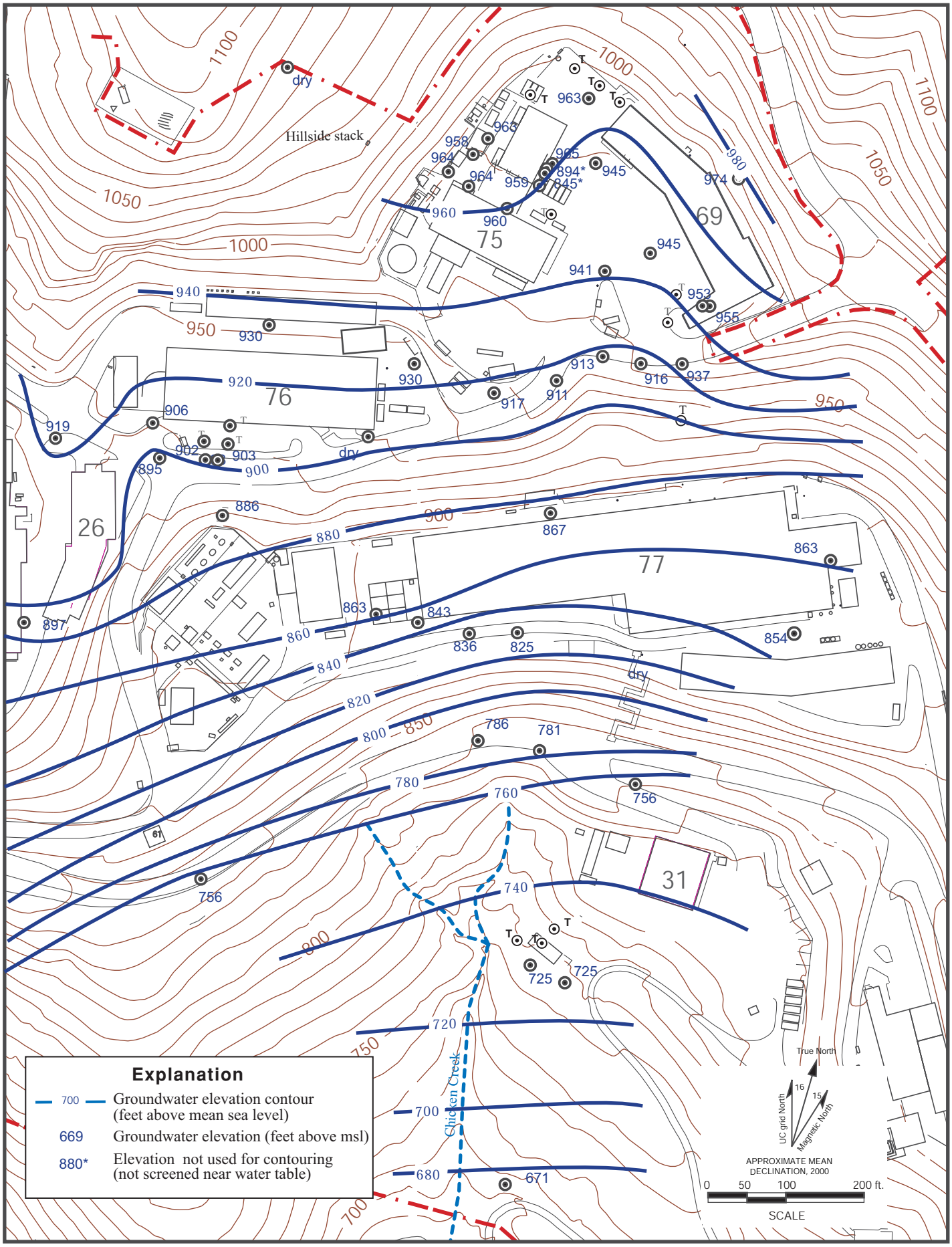
09/00



3-17-q4fy02support services.ai
12/02

Figure 3-17. Water Level Elevation Map of the Support Services Area, Fourth Quarter FY2002.

Berkeley Lab Boundary

Cyclotron Road

Centennial Drive

See figure 3-19 for details

UC Berkeley Botanical Gardens

True North

UC grid North

Magnetic North

APPROXIMATE MEAN DECLINATION, 2000

Explanation

- Groundwater monitoring well
- Lysimeter
- Soil Boring
- EPA HRS sampling location
- Shallow soil sampling location

0.5' 0.3 / 1.5' 0.3 — Depth (feet) Concentration tritium (pCi/g)

<0.2 — Not detected above reporting limit (<0.2 pCi/g)

Color Coding
(color coded for maximum detected concentration 0 to 5 feet)

- not detected
- 0.2 pCi/g to <1 pCi/g
- 1 pCi/g to <10 pCi/g
- 10 pCi/g to <100 pCi/g
- >100 pCi/g

0 250 500 1000
Scale in Feet

04tritsiteshallow.ai 11/98

Figure 3-18. Concentrations of Tritium Detected (pCi/g) in Shallow Soil Samples (Depth 0 to 5 feet), Lawrence Berkeley National Laboratory.

3-3tritsiteshallow.ai 3/03

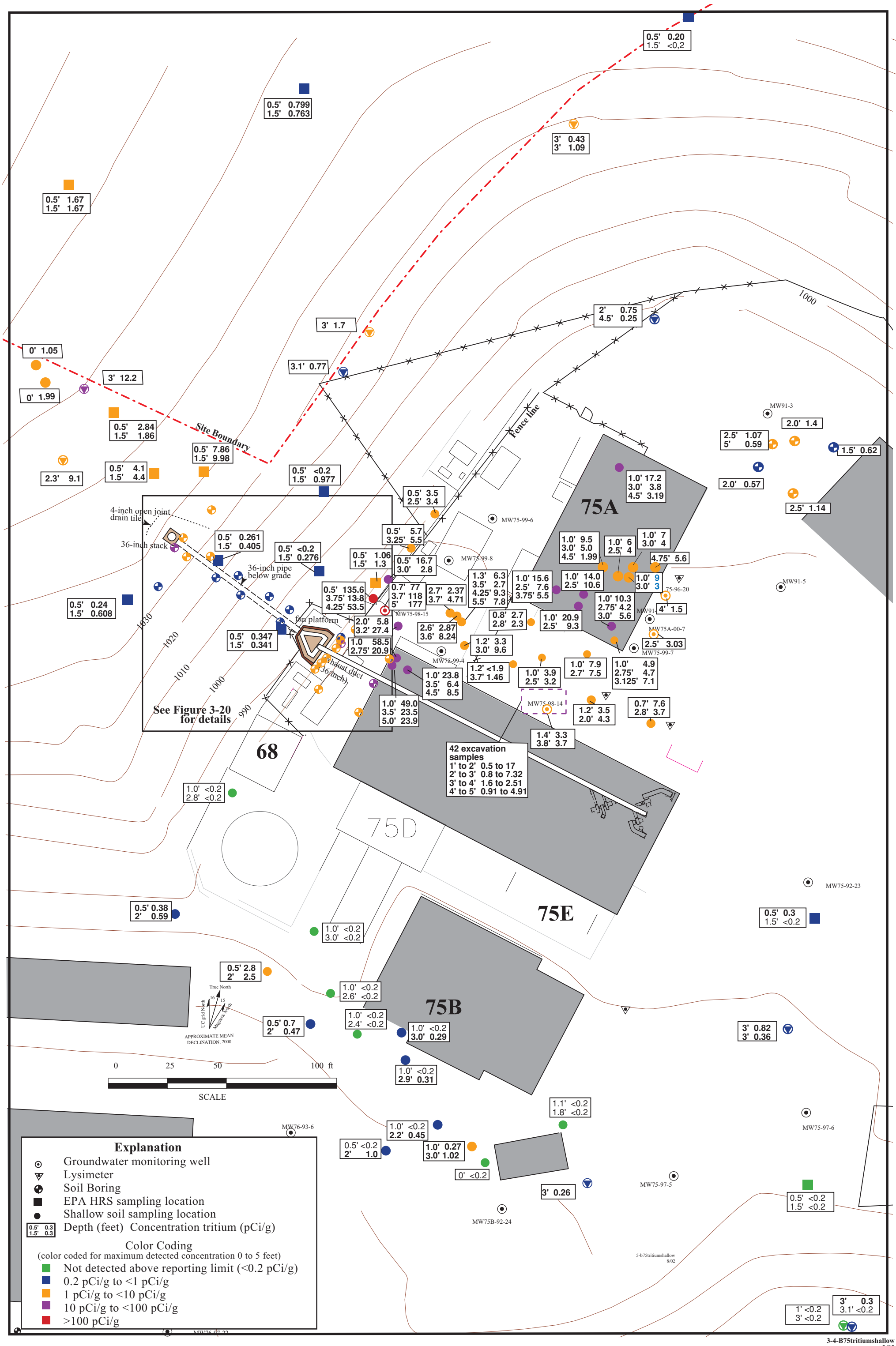


Figure 3-19. Concentrations of Tritium Detected (pCi/g) in Shallow Soil Samples (Depth 0 to 5 feet) in the Vicinity of the Former NTLF.

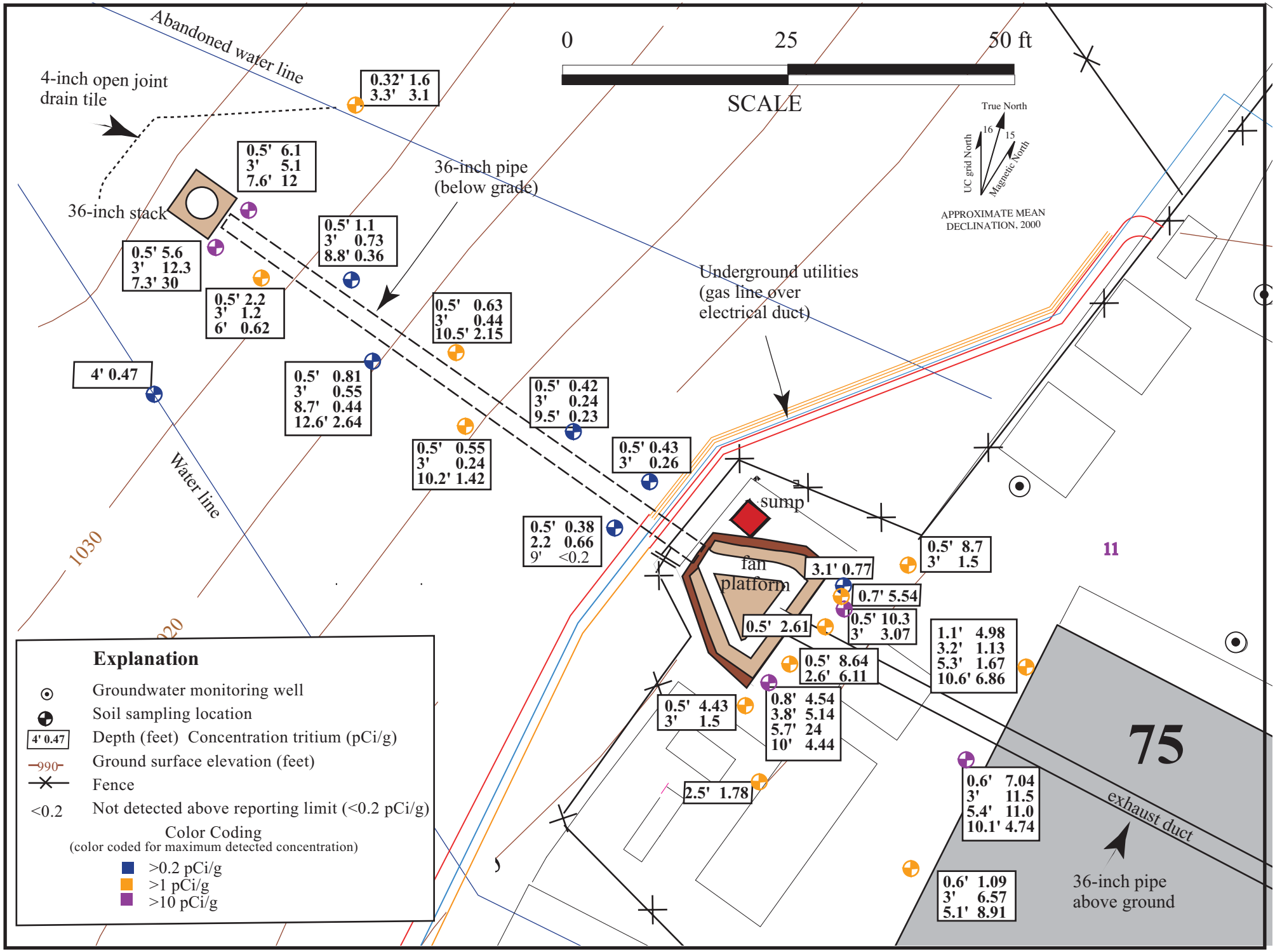


Figure 3-20. Concentrations of Tritium Detected (pCi/g) Building 75 Exhaust System, Former National Tritium Labelling Facility.

3-5-b75tritium.ai
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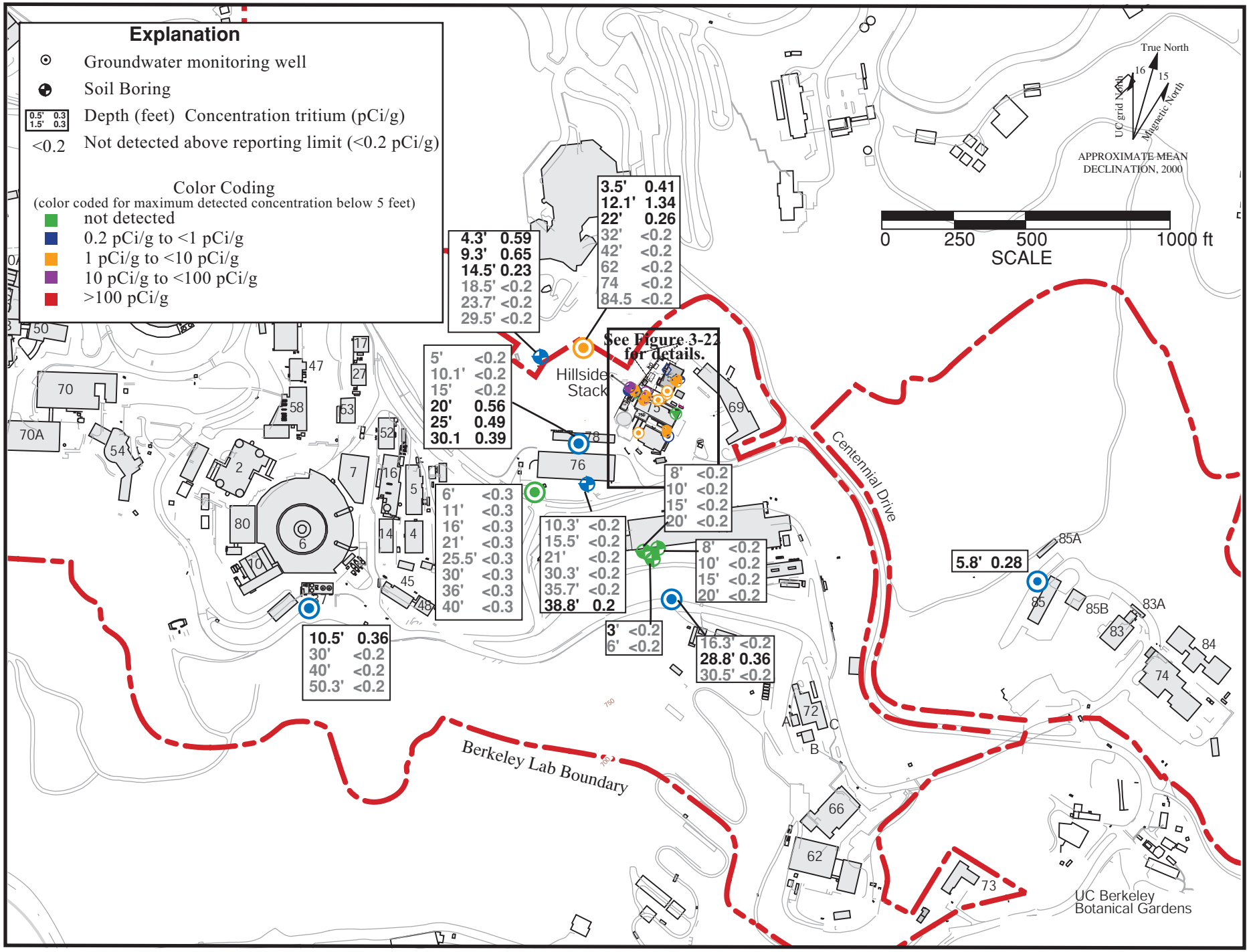

Figure 3-21. Concentrations of Tritium Detected (pCi/g) in Samples Collected to Evaluate the Vertical Extent of Tritium in the Soil, Lawrence Berkeley National Laboratory.

3-6-tritsitedeep.ai
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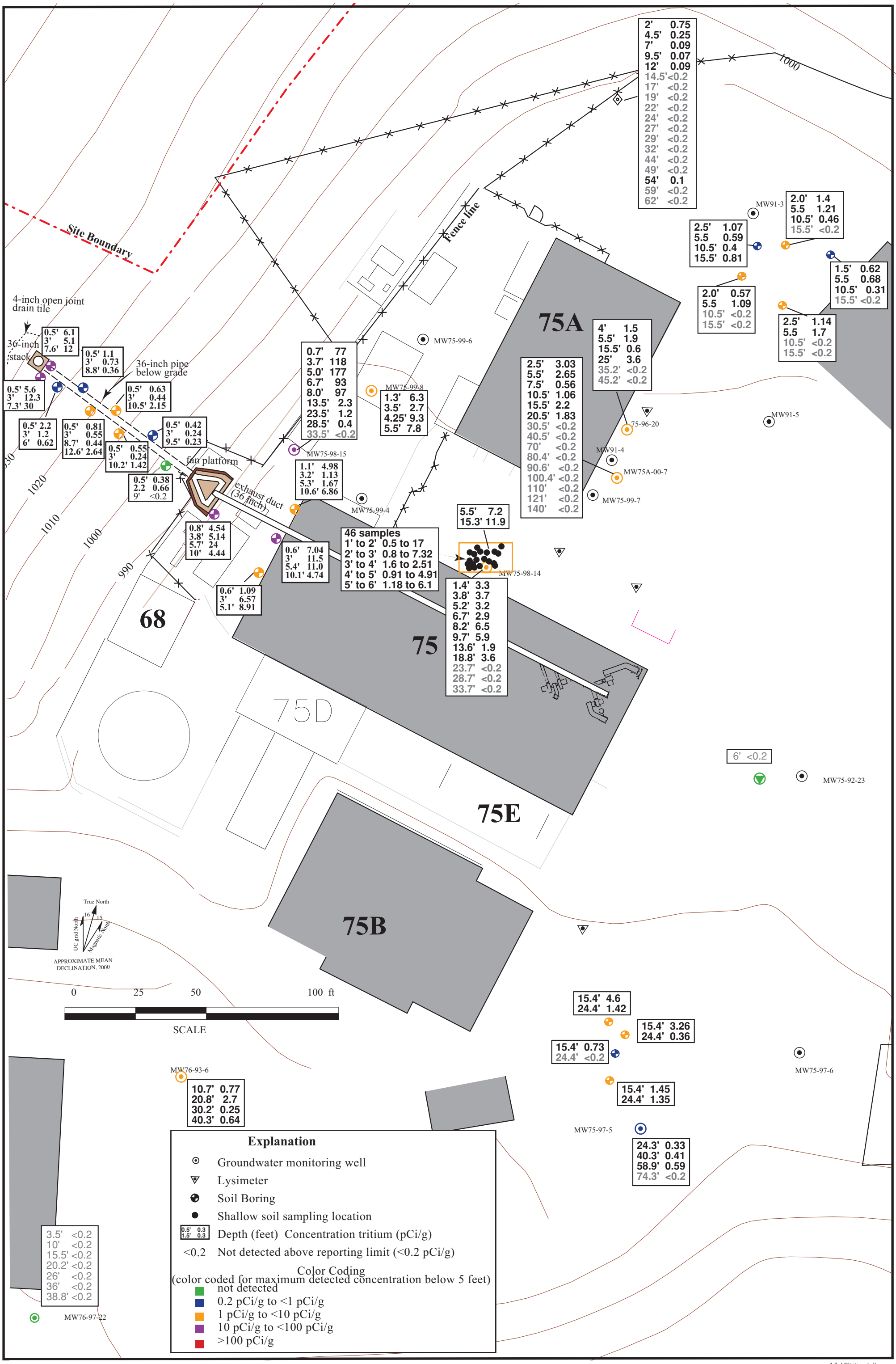
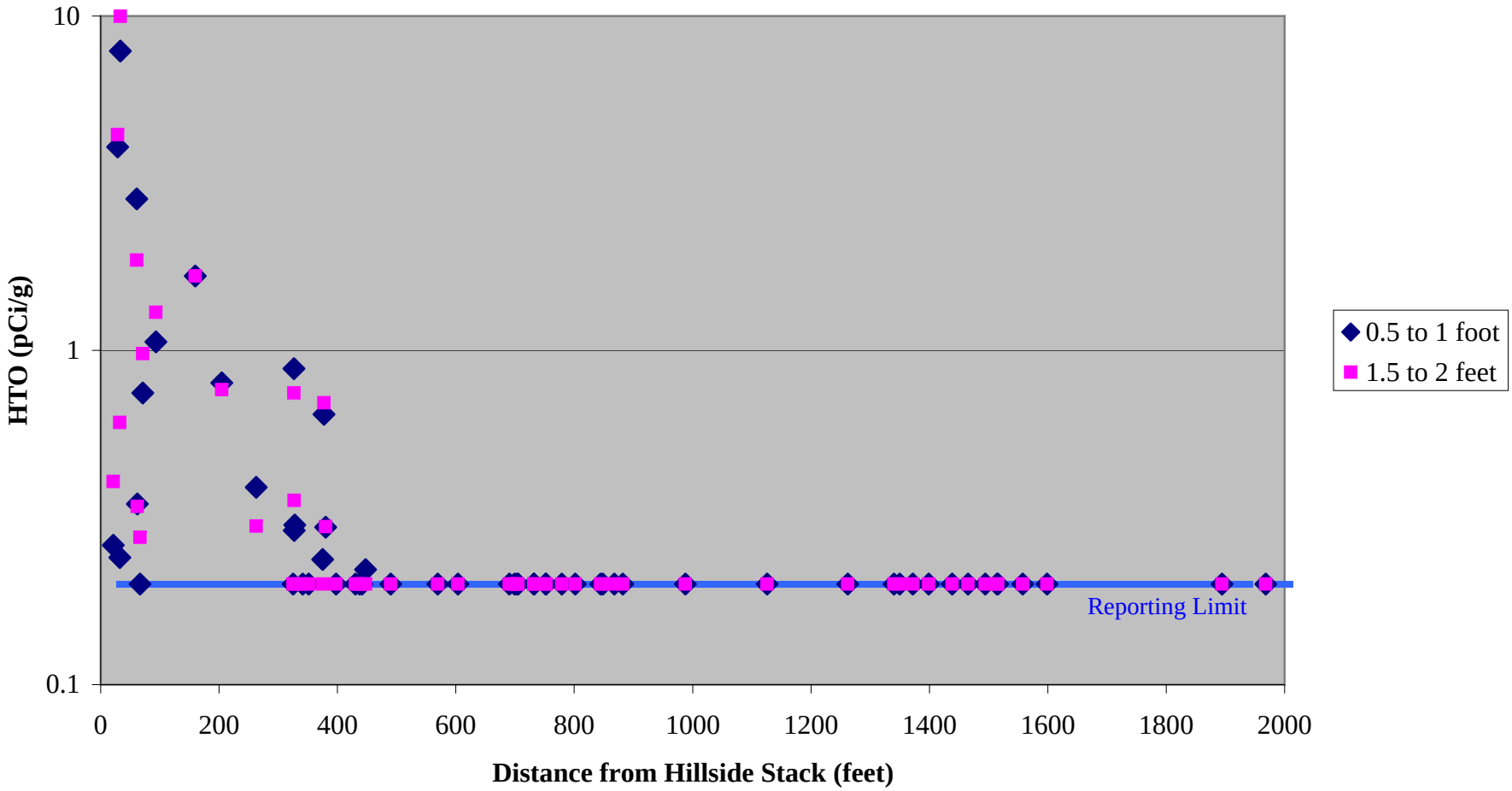
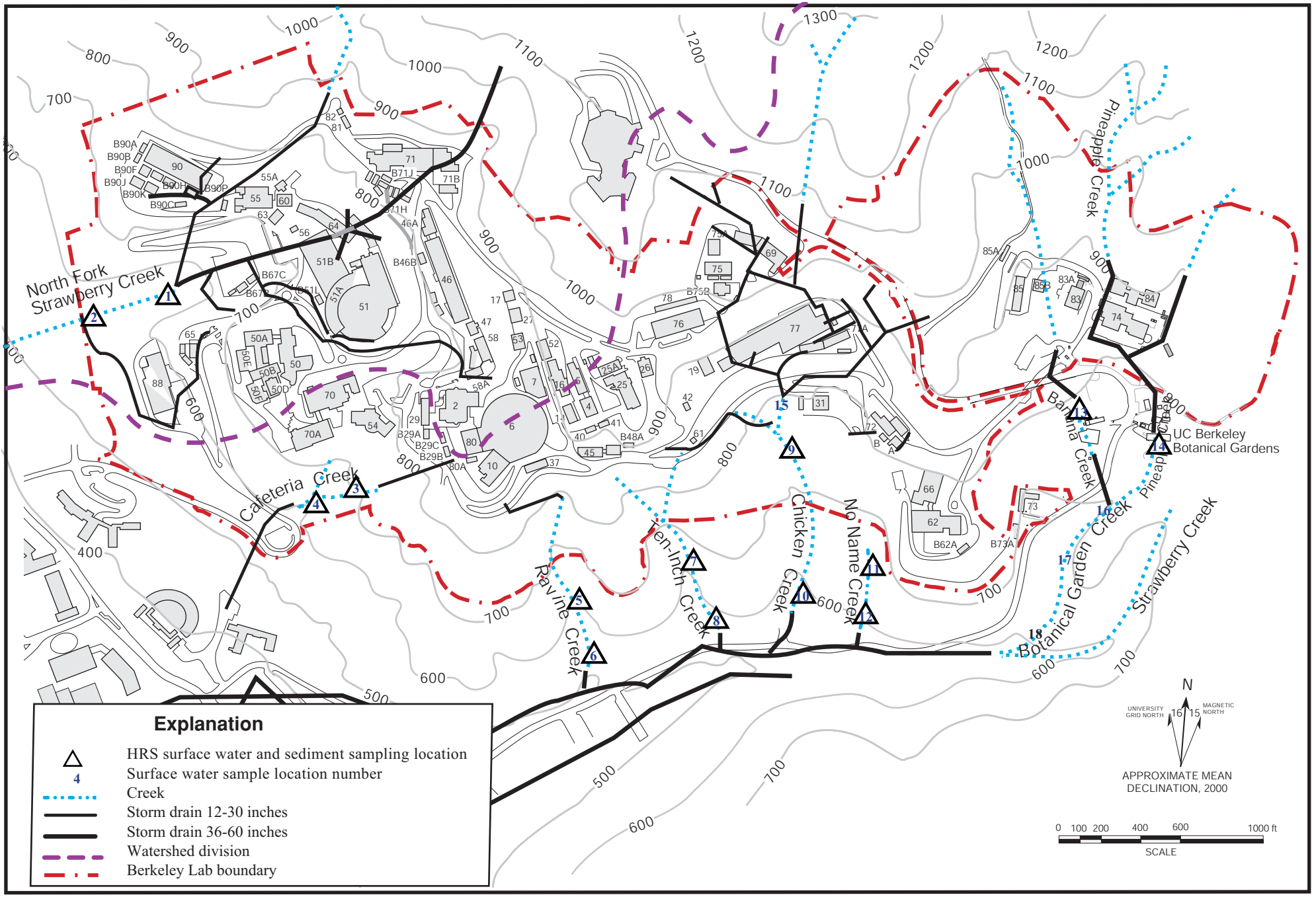


Figure 3-22. Concentrations of Tritium Detected (pCi/g) in Samples Collected to Evaluate the Vertical Extent of Tritium in the Soil in the Vicinity of the Former NTLF.

3-7--b75tritiumshallow
3/03

Figure 3-23
Variation in Concentration of Tritium in Soil with Distance from the Hillside Stack (HRS Sampling Results)





3-24surfwater06sed
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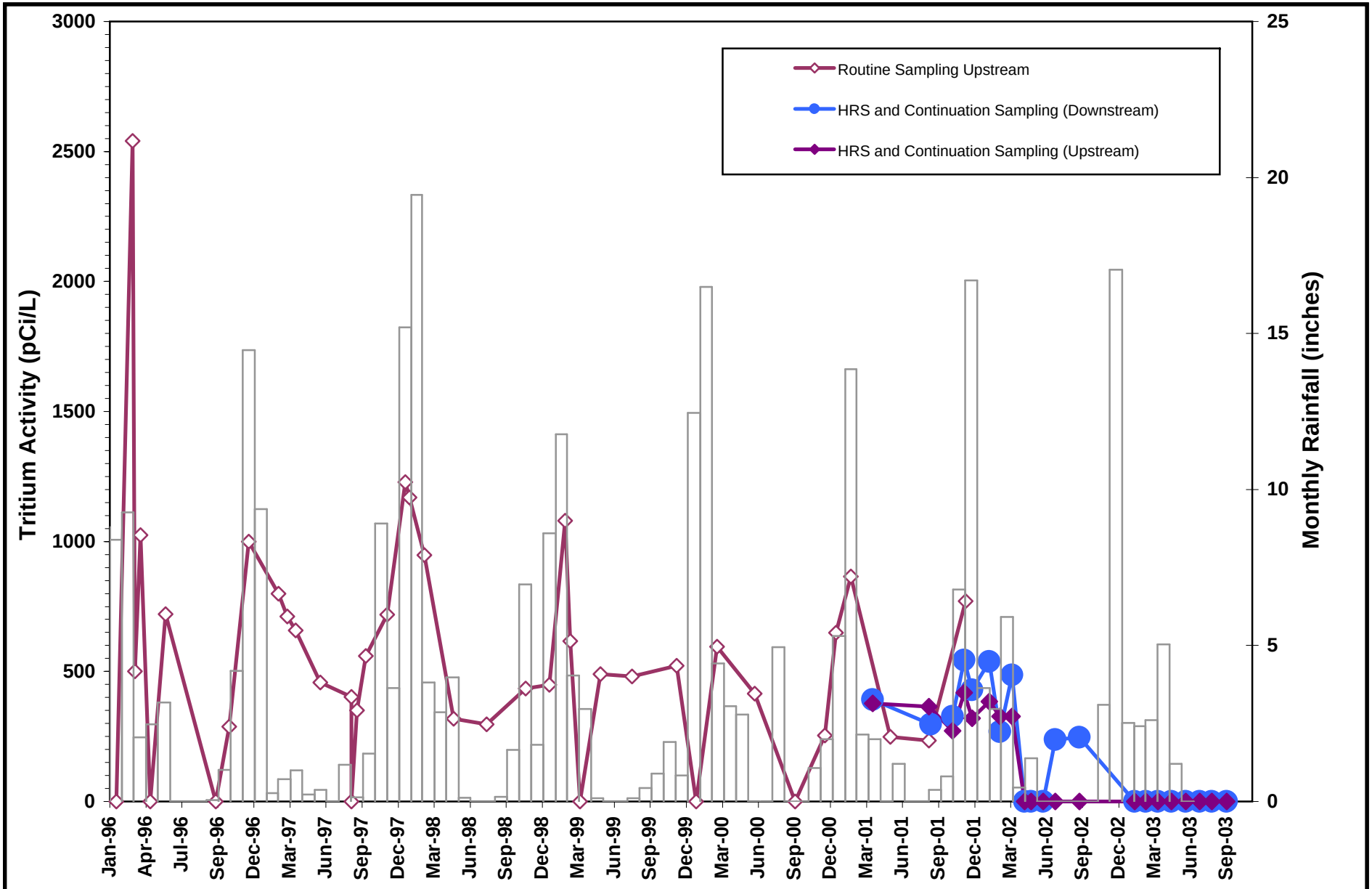
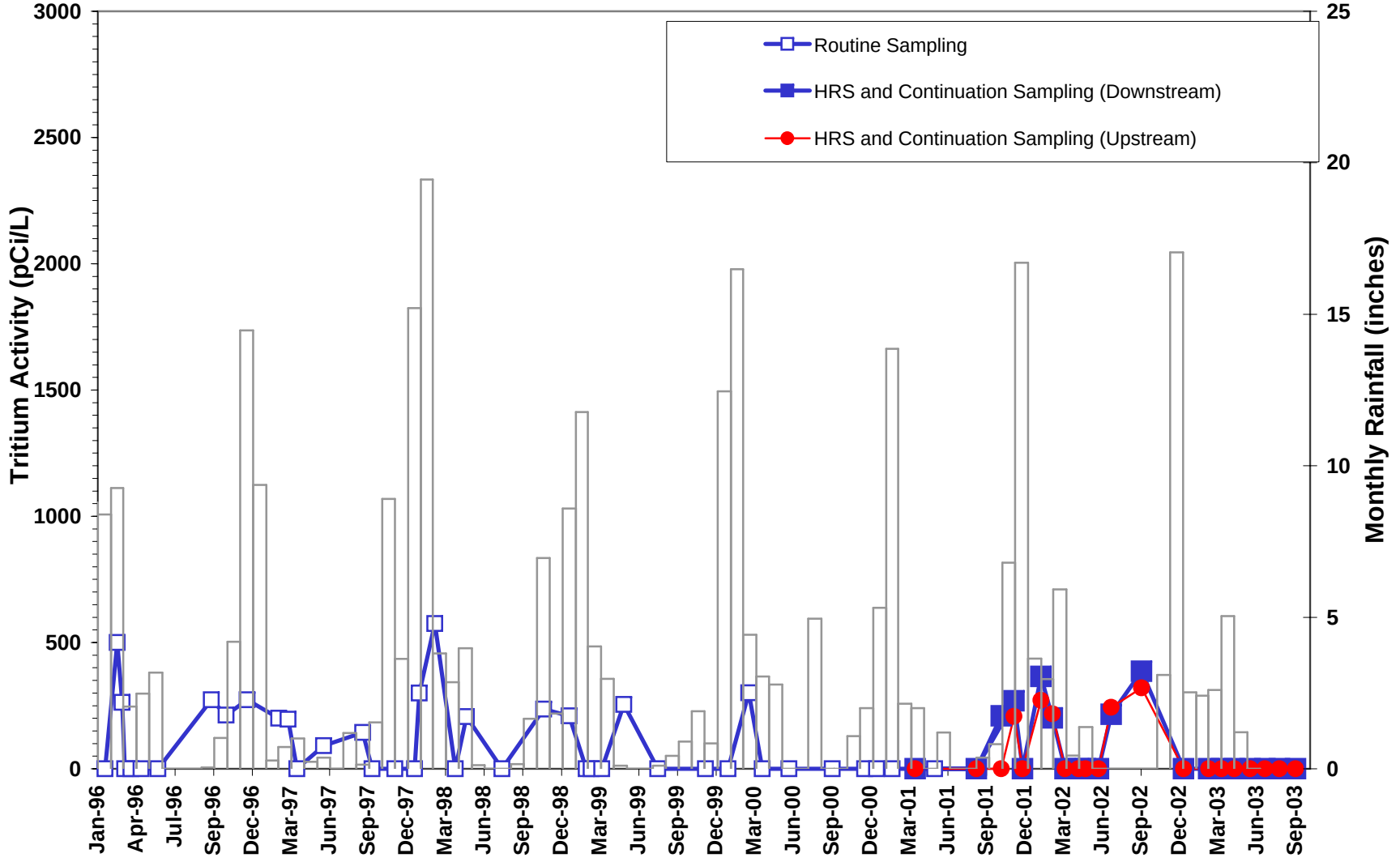
Figure 3-24. Locations of Surface Water Samples



Note: All tritium concentration points that are shown as 0 pCi/L are below reporting limits.

Figure 3-25. Concentration of Tritium in Chicken Creek.



Note: All tritium concentration points that are shown as 0 pCi/L are below reporting limits.

Figure 3-26. Concentration of Tritium in North Fork Strawberry Creek.

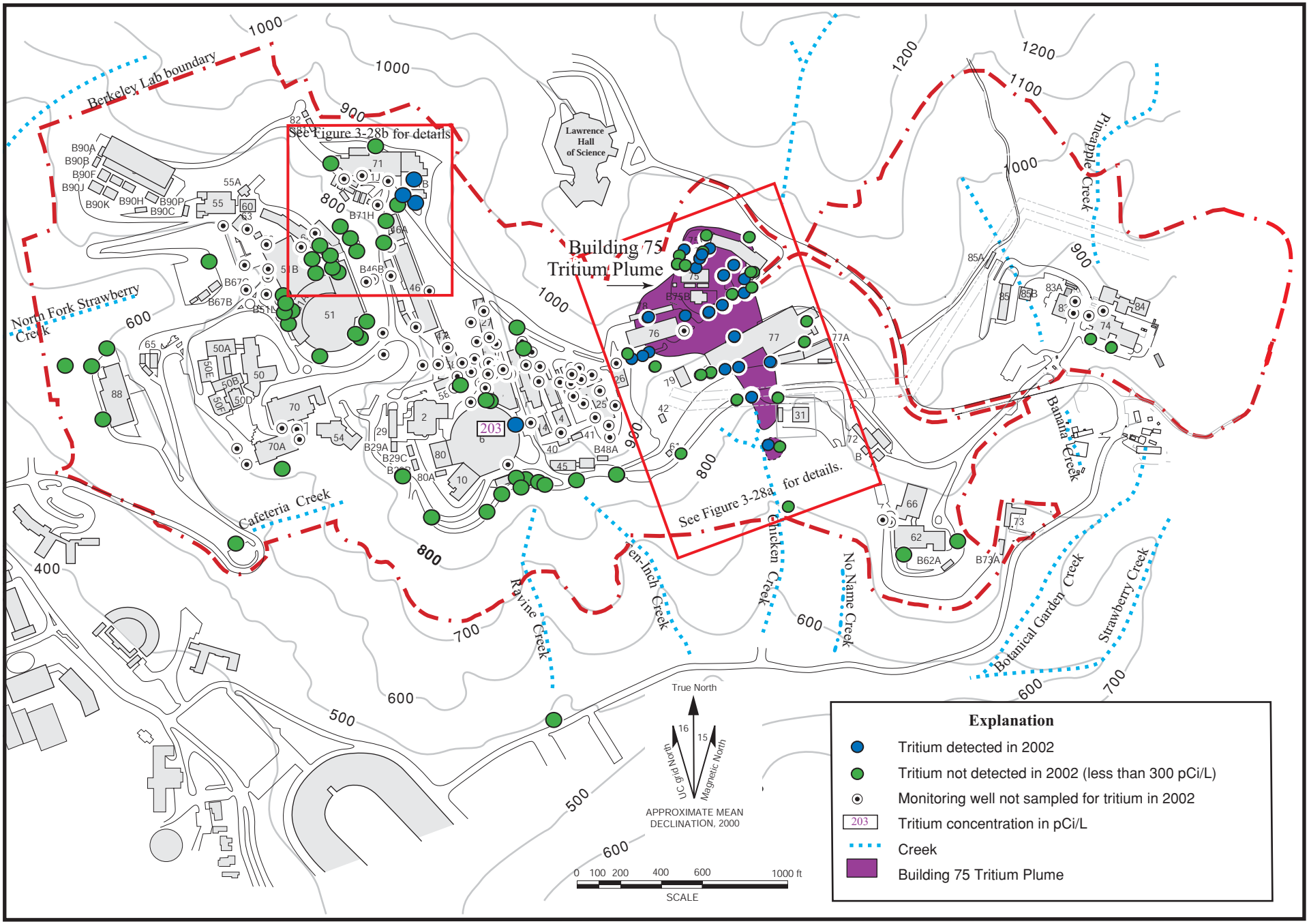


Figure 3-27. Concentrations of Tritium Detected (pCi/L) in Groundwater in 2002, Lawrence Berkeley National Laboratory.

3-27-tritiumwell2002.ai
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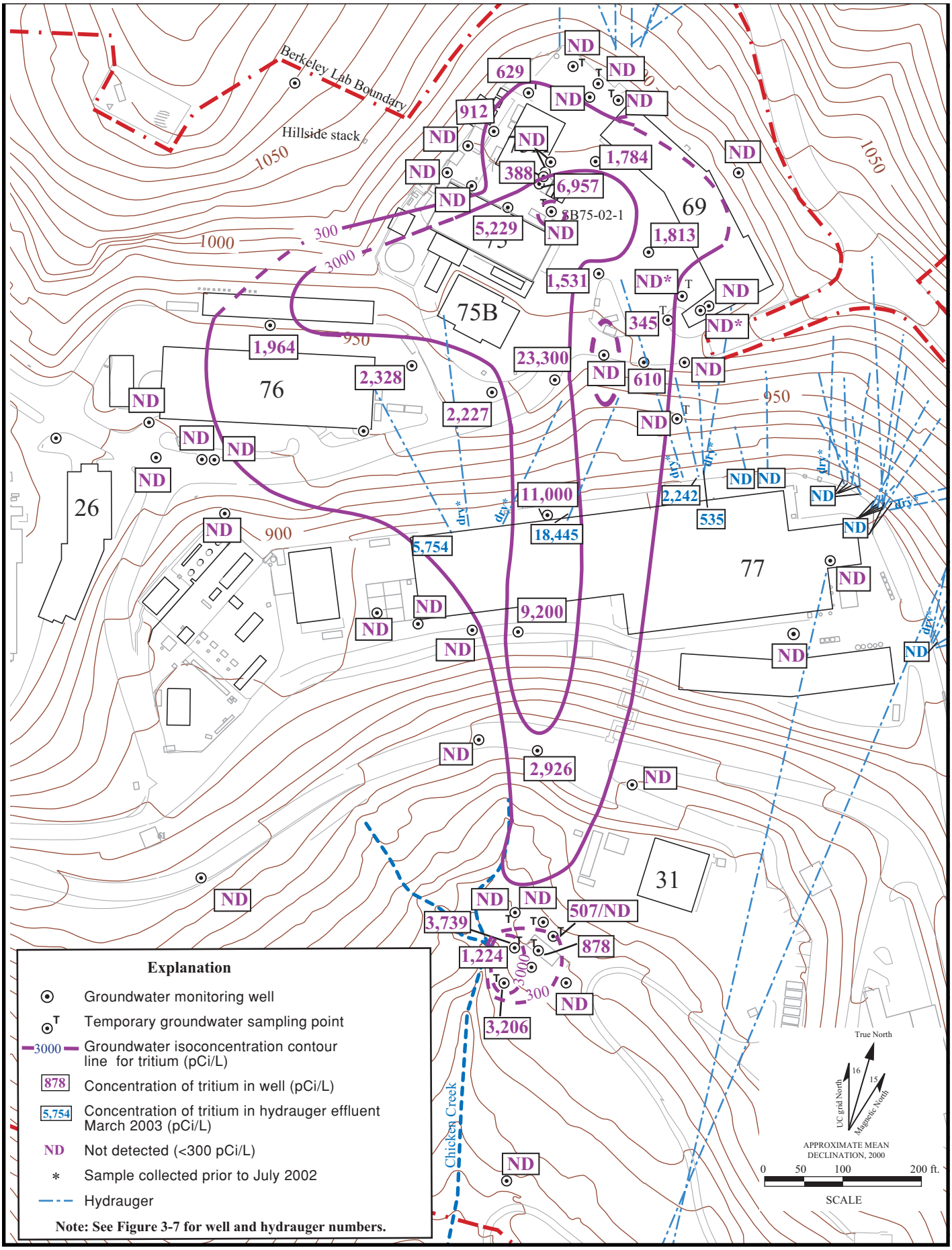

Figure 3-28a. Concentrations of Tritium Detected (pCi/L) in Groundwater, July to December 2002.

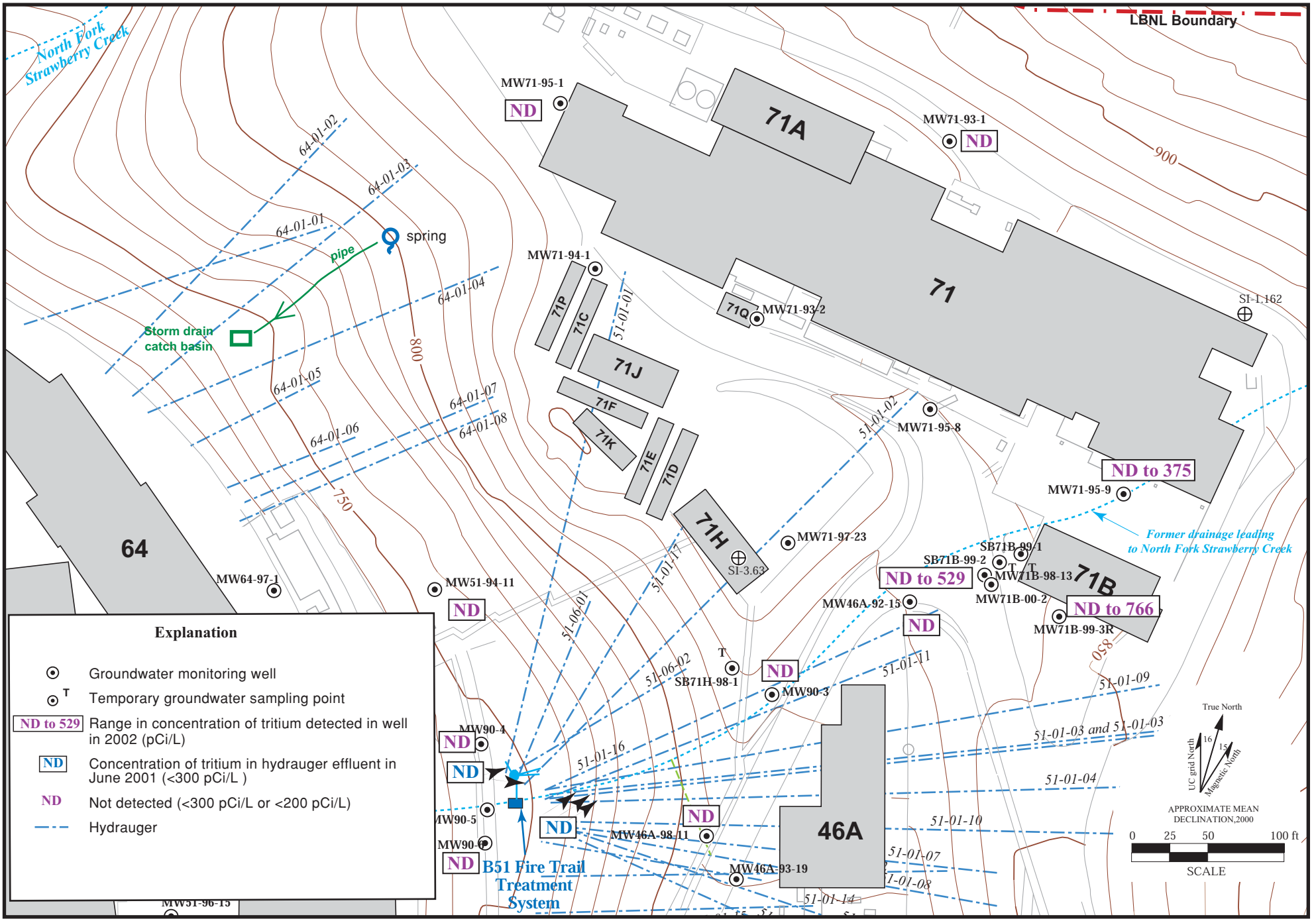

Figure 3-28b. Ranges in Concentrations of Tritium Detected (pCi/L) in Groundwater, Building 71 Area.

3-27A_B71base.ai
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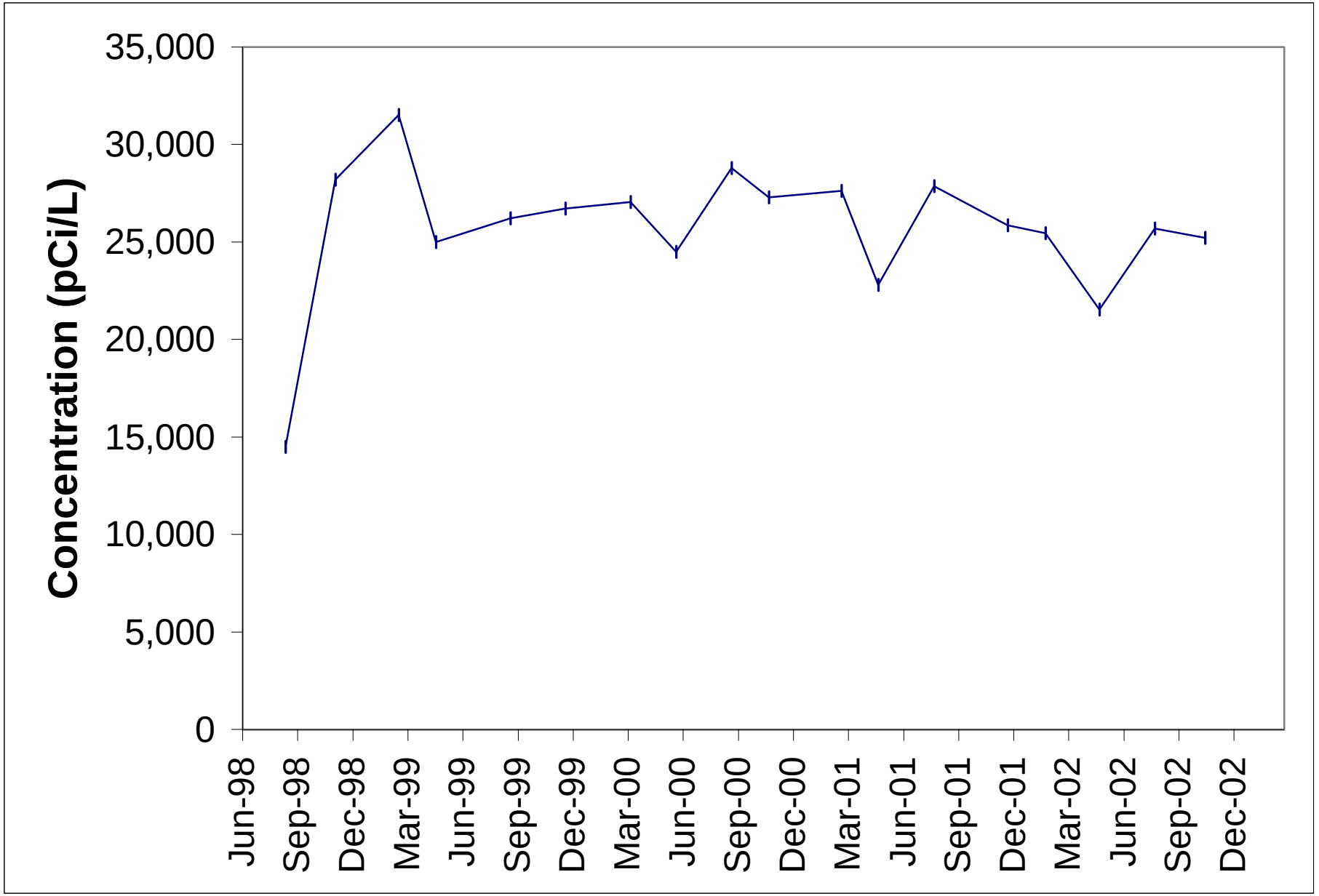

Figure 3-29. Tritium Concentrations in MW75-97-5 in the Tritium Plume Core Area

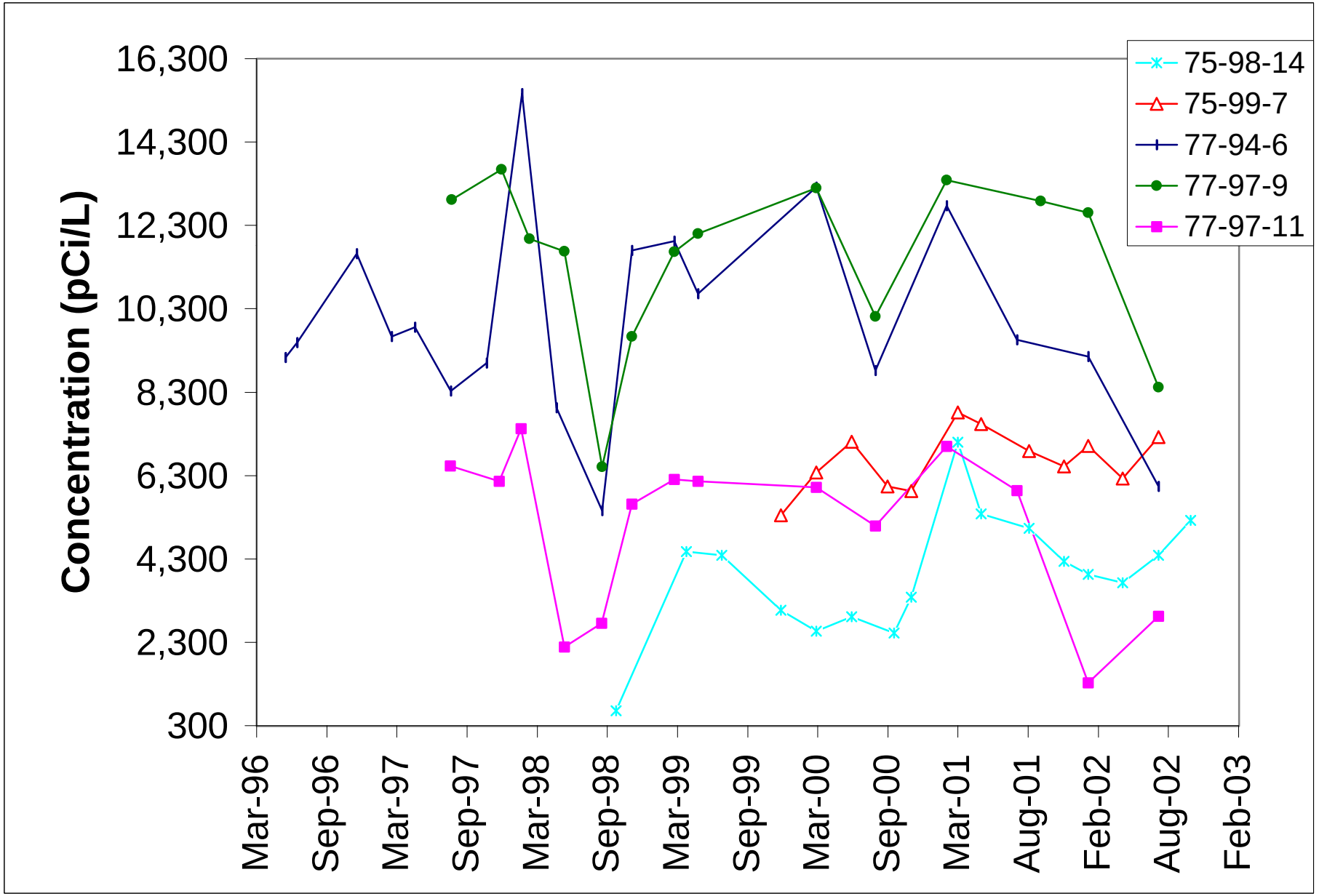

Figure 3-30. Tritium Concentrations in Wells in the Tritium Plume Core Area

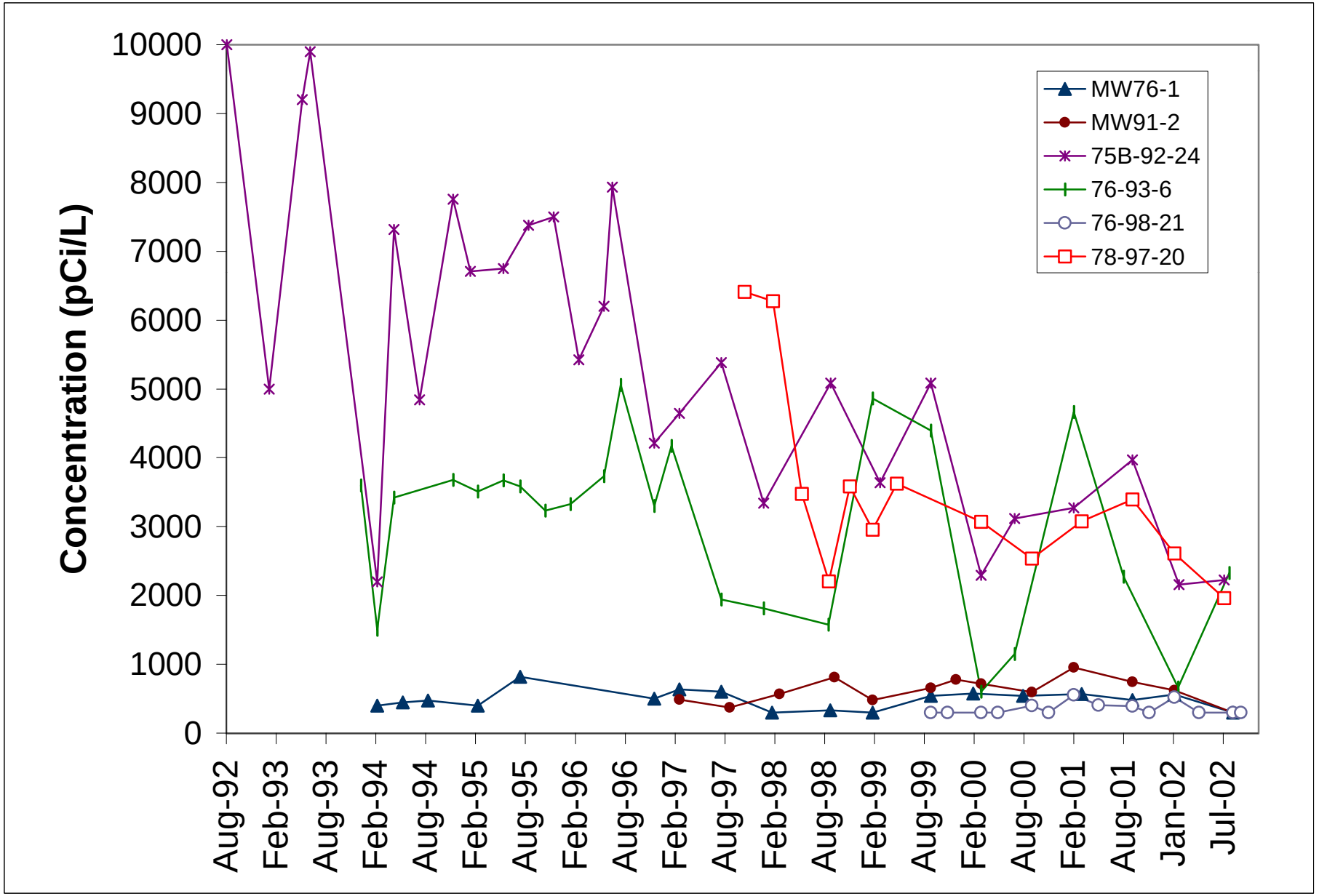

Figure 3-31. Tritium Concentrations in Wells Transgradient (west) of the Tritium Plume

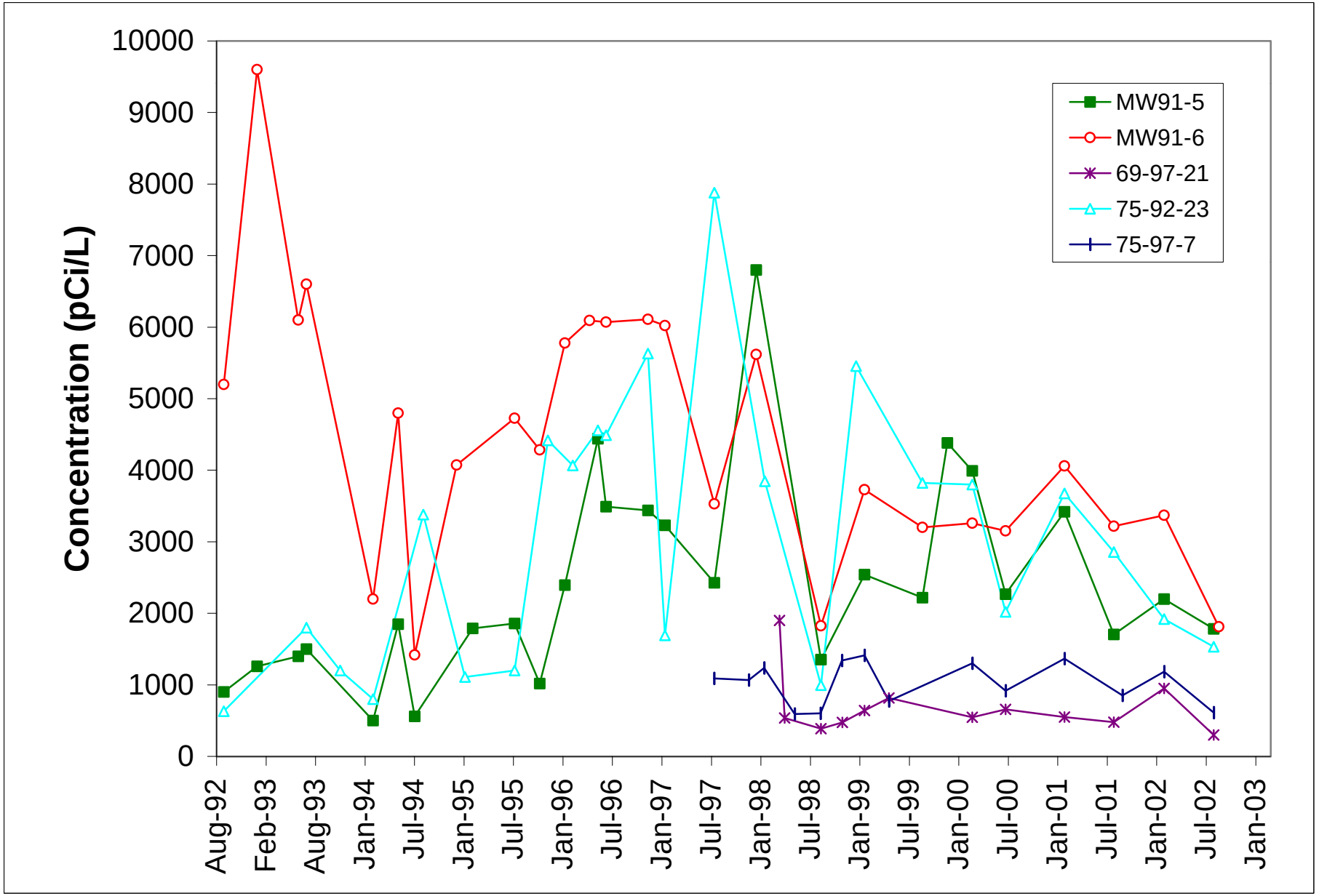

Figure 3-32. Tritium Concentrations in Wells Transgradient (east) of the Tritium Plume

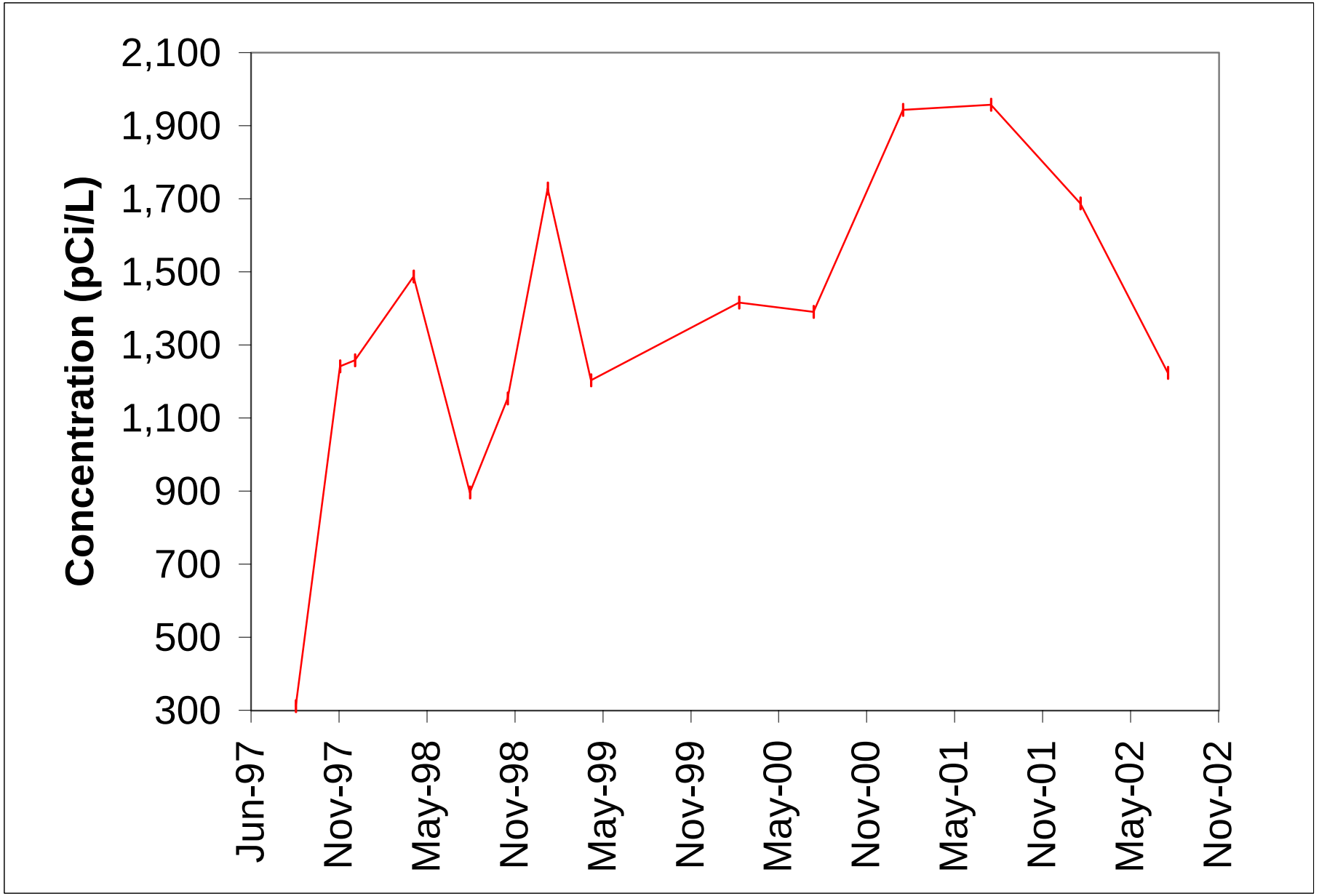

Figure 3-33. Tritium Concentrations in MW31-97-17 Downgradient of the Tritium Plume

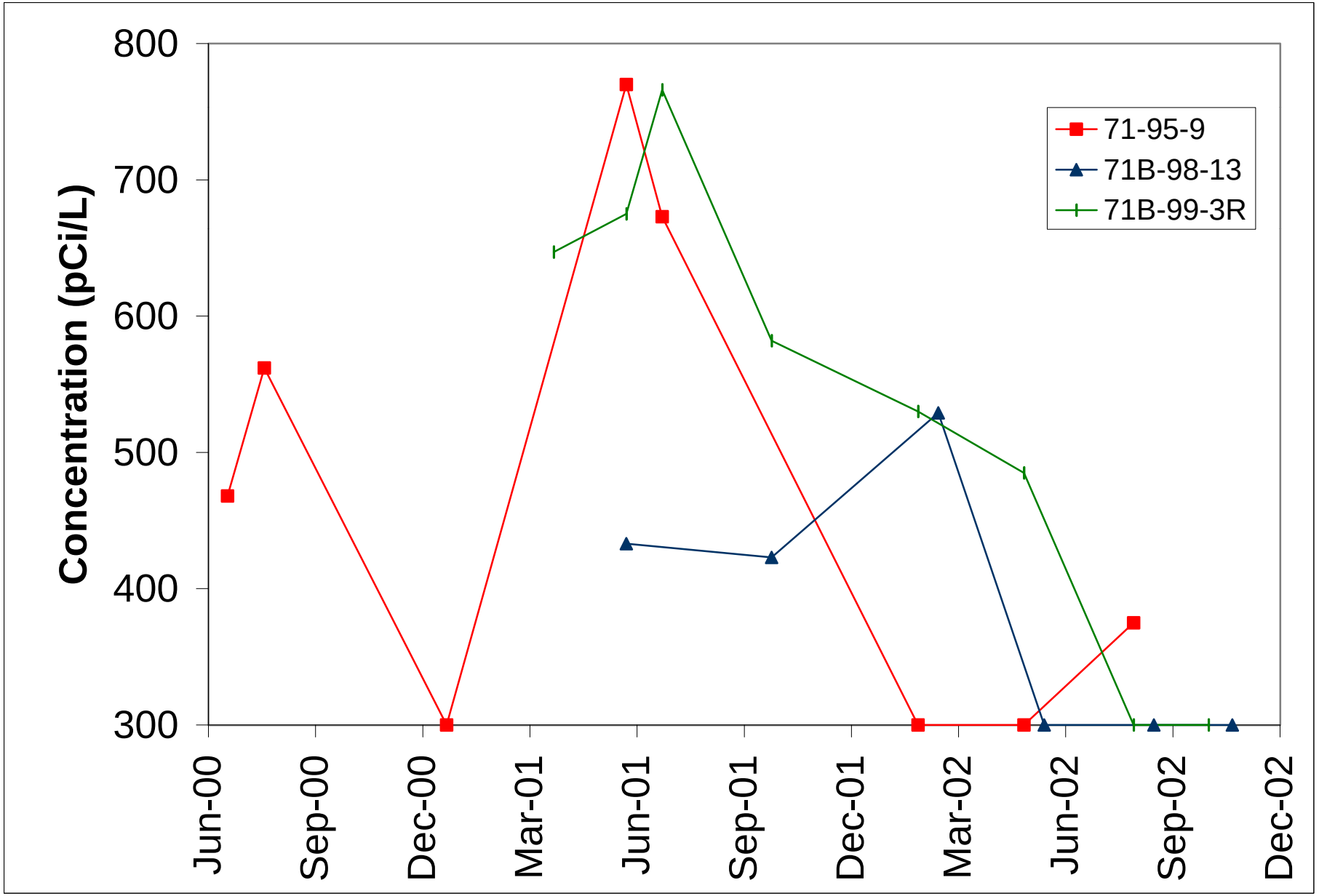

Figure 3-34. Tritium Concentrations in Wells Monitoring the Building 71B Tritium Plume

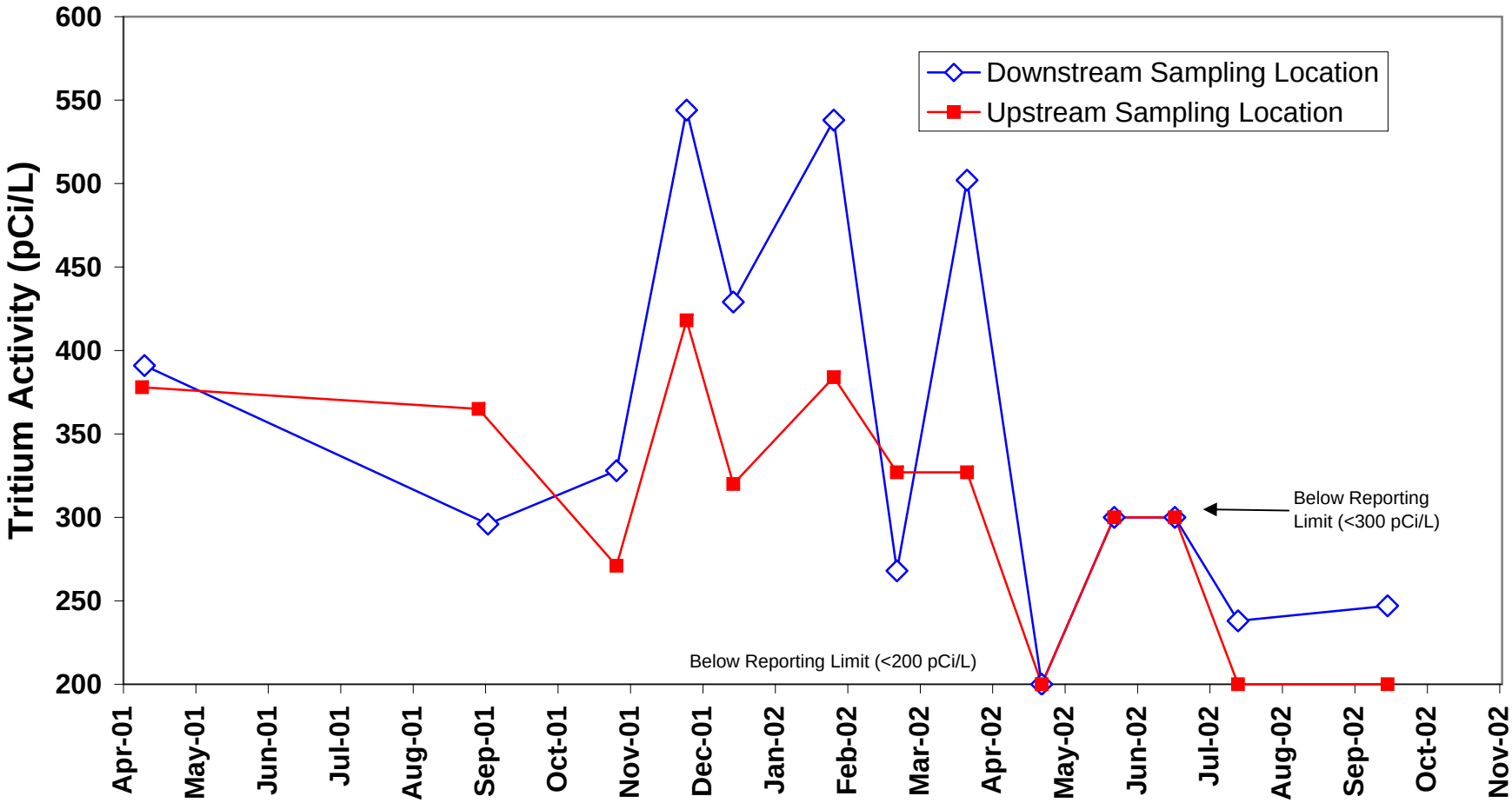

Figure 3-35. Maximum Tritium Activity Detected in Chicken Creek in Monthly Sampling (2001 to 2002).

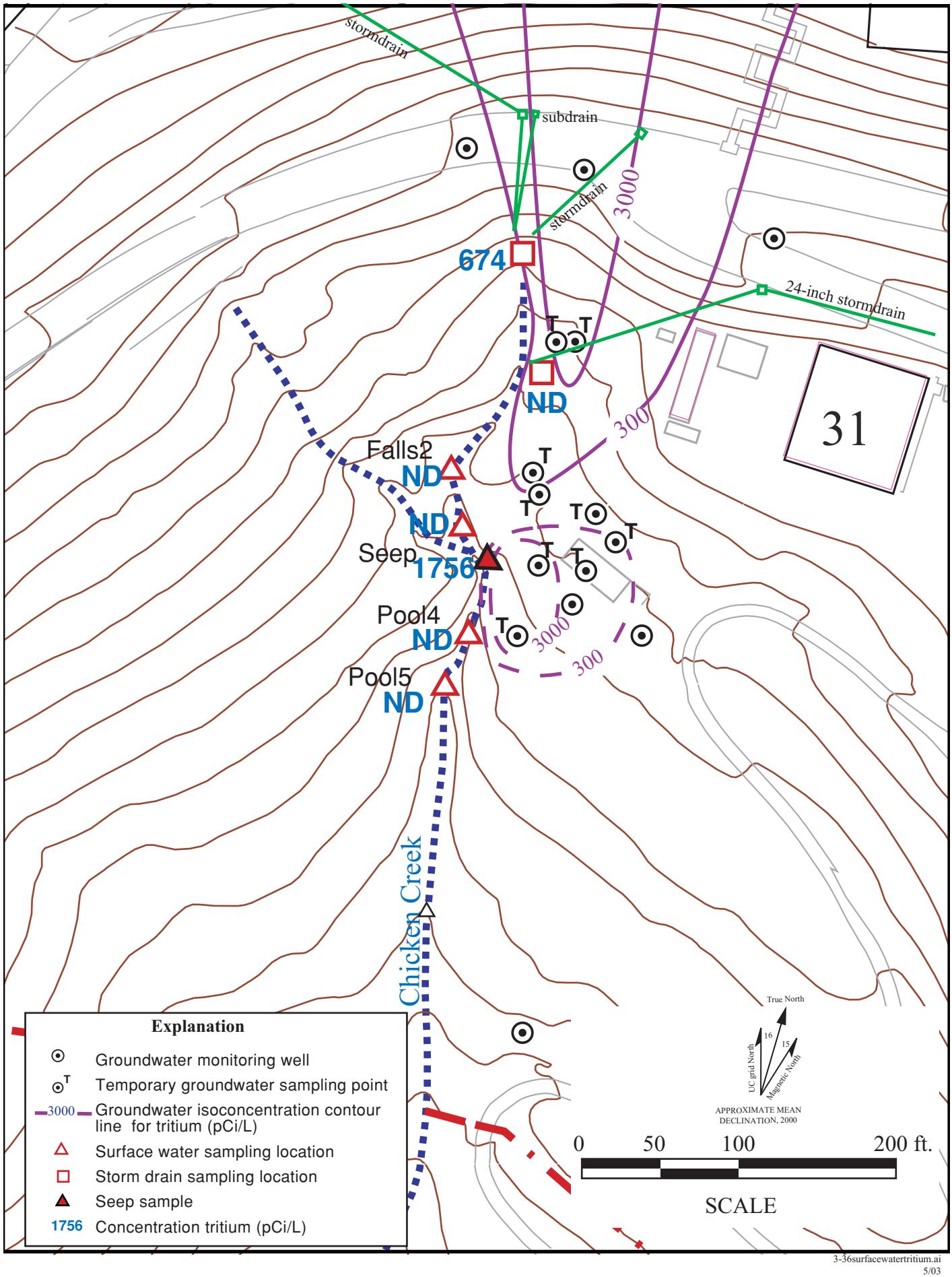

Figure 3-36. Concentrations of Tritium Detected in Surface Water Samples (pCi/L), February 2003.

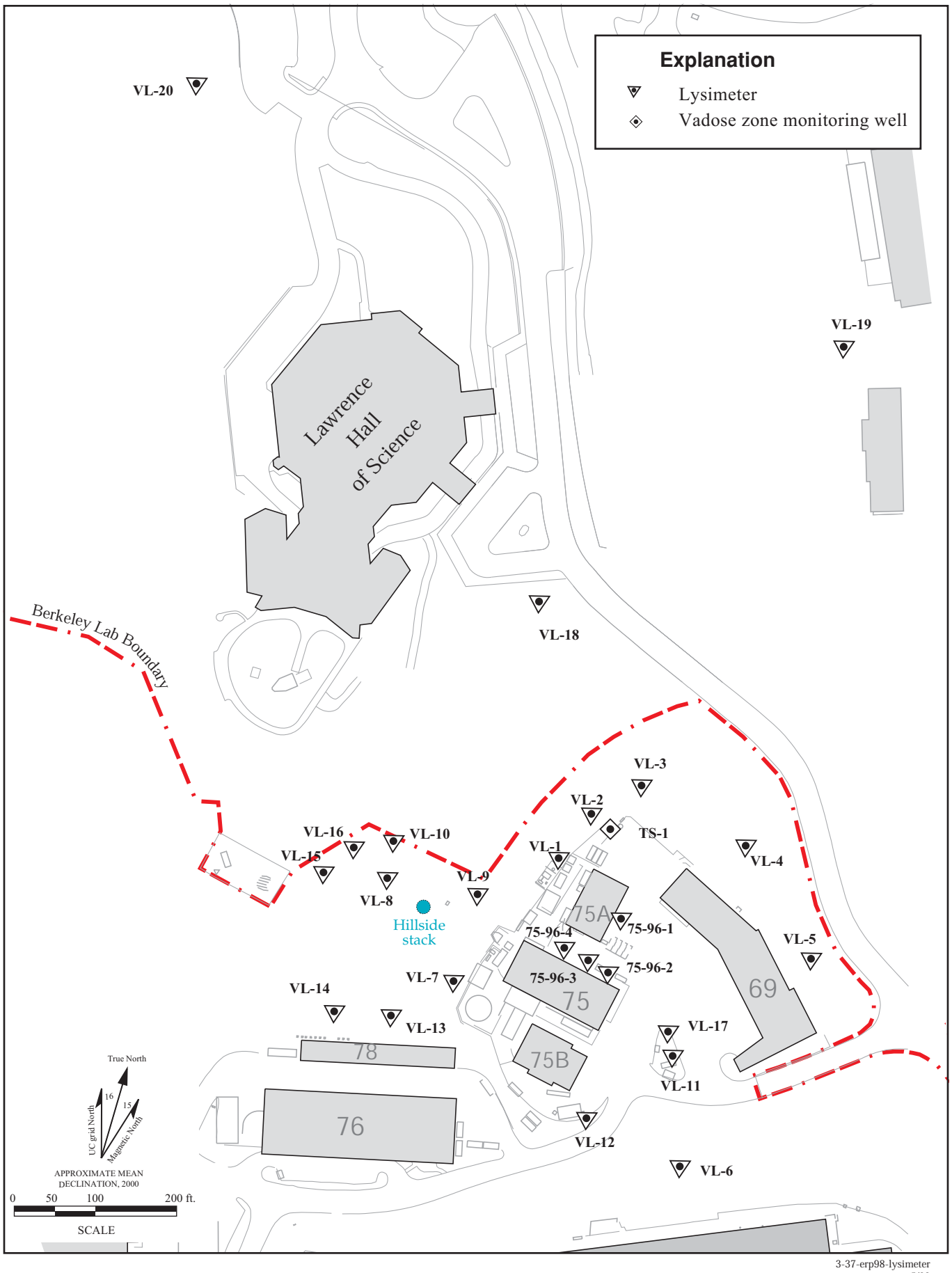

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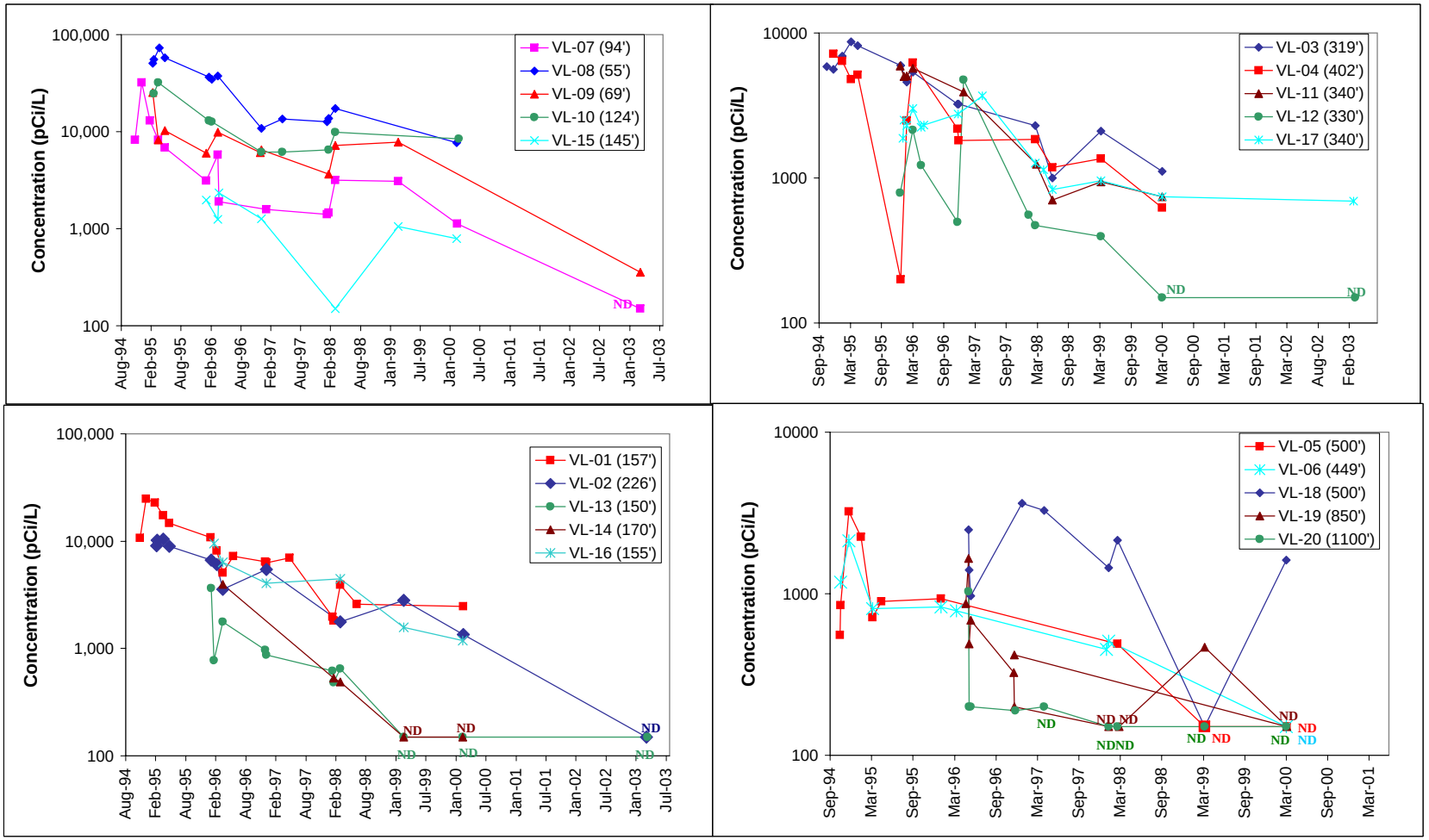
Figure 3-37. Locations of Lysimeters.



Note: Numbers in parentheses are distance from the Hillside Stack.
ND: Not Detected (<300 pCi/L). Shown at 1/2 the detection limit.

Figure 3-38. Concentrations of Tritium Detected in Soil Water Samples Collected from Shallow Lysimeters.

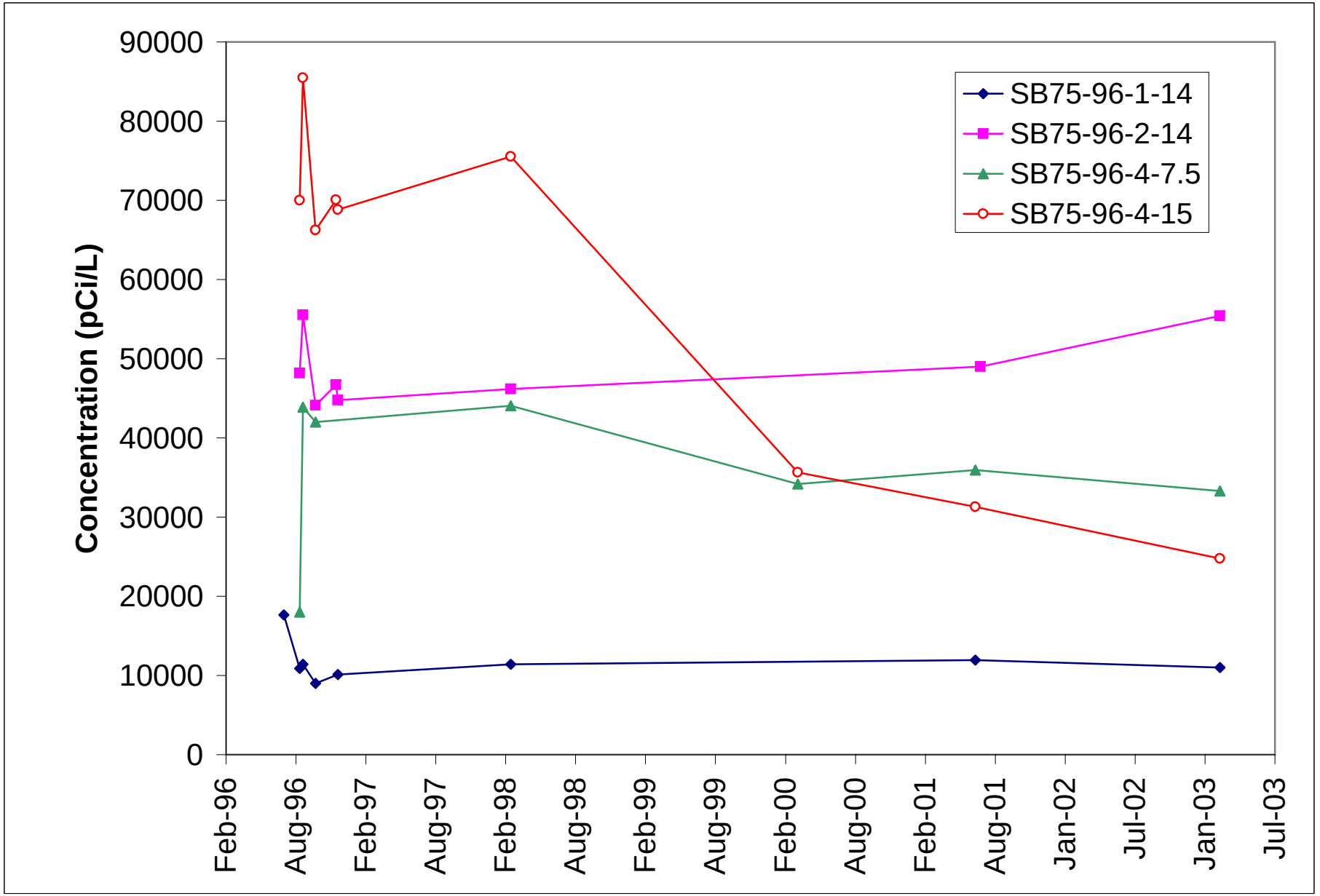
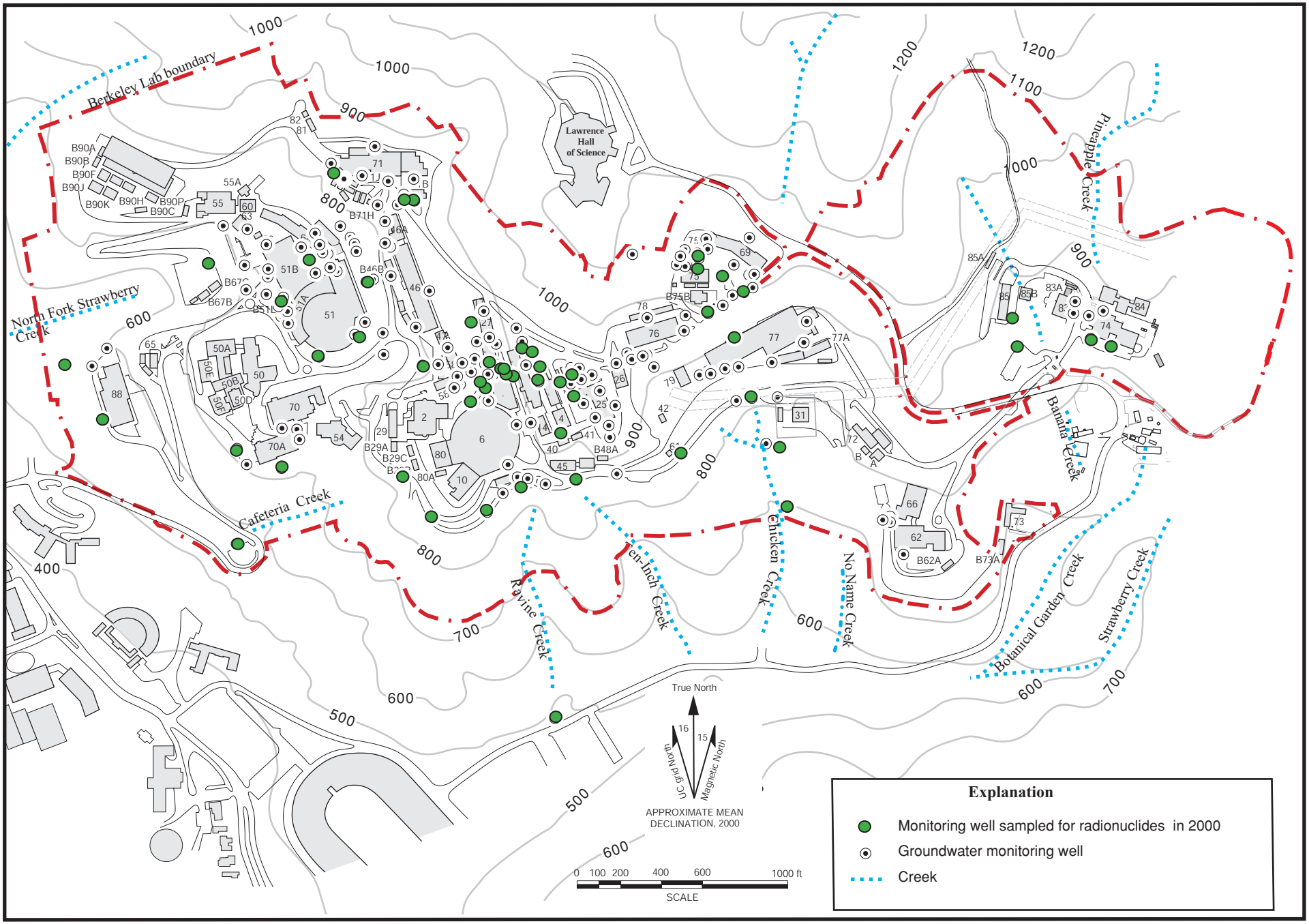


Figure 3-39. Concentrations of Tritium Detected in Soil Water Samples from Multi-Level Lysimeters Near Buildings 75 and 75A.



5-1-abg.ai
3/03

Figure 5-1. Locations of Groundwater Monitoring Wells Sampled for Radionuclides in 2000, Lawrence Berkeley National Laboratory.

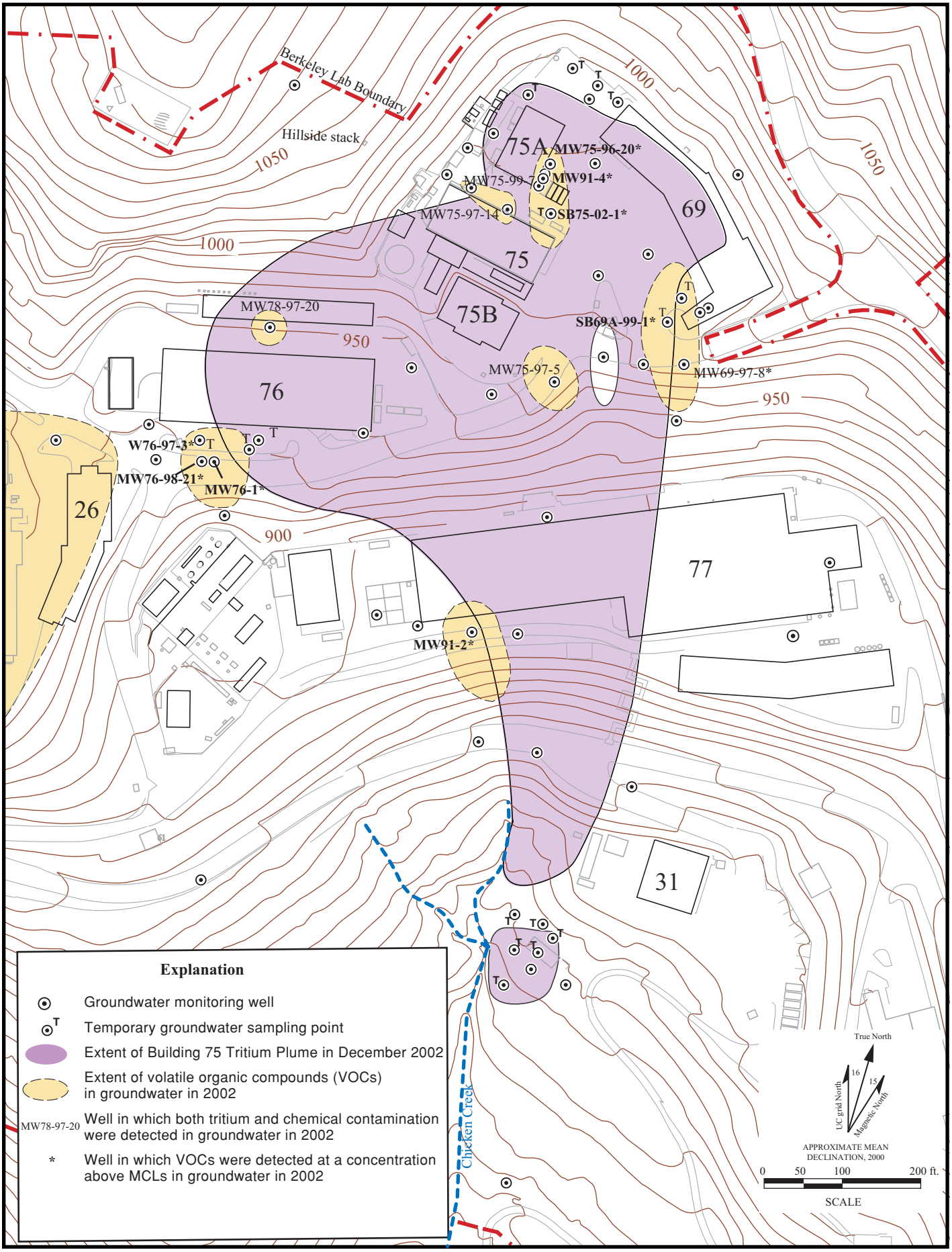


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Figure 5-2. Locations of Collocated Tritium and Chemical Contamination in Groundwater in 2002.

LIST OF TABLES

Table 1.1
Summary of RCRA Facility Assessment[1] Findings —
Release Potential and Recommendations Pertaining to Radionuclides

Berkeley Lab Unit Name	Radiological Constituents of Concern	Past Release Potential	Ongoing Release Potential	RFA Recommended Action
AOC 1-7 Building 71 Radiation Release	Curium-244	Moderate	None	Include in RFI
SWMU 3-7 Building 75 Former National Tritium Labelling Facility	Tritiated water	Known Release	Release	Include in RFI
SWMU 3-9 Building 75A Former Radioactive Waste Storage Area	Mixed transuranic, tritium, and induced wastes	Low	Low	None*
SWMU 10-1 Building 4 Former Radioactive Waste Storage and Staging Area	Radionuclides	High	None	None**
SWMU 10-2 Building 5 Former Decontamination Area	Radioactive wastes	Moderate	None	Include in RFI
SWMU 10-3 Building 5 Former Outdoor Radioactive Waste Storage Area	Radioactive waste	Known release	None	Include in RFI
SWMU 11-2 Building 74 Abandoned Aboveground Radioactive Waste Holding Tanks	Radioactive waste water	Not known	None	Include in RFI
SWMU 11-3 Building 74 Six Inactive Aboveground Radioactive Waste Holding Tanks	Radioactive animal waste	Moderate	None	Include in RFI

1 Berkeley Lab 1992

***** SWMU 3-9 was investigated during closure certification of the Former Hazardous Waste Handling Facility (Buildings 75, 75A, and 69)

******At the request of the DOE, this unit was also investigated during the RFI.

Table 3.1
Creek Sediment Sampling Results
Radiological Elements

Location	Sample ID	Date	HRS Sample	Tritium (pCi/g)	Total Tritium (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gamma (pCi/g) (1)	Curium 244 (pCi/g)	Uranium 235 (pCi/g)	Strontium 90 (pCi/g)	Cesium 137 (pCi/g)
North Fork Strawbery Creek	SSBC-1/2A/B-0.4	Apr-93		<700 (pCi/L)					<0.1		<1	<5
	SSBC-3/4A/B-0.8			<700 (pCi/L)					<0.1		<1	<5
	SS-NFStraw-96-1B-0	Aug-96				<12	9 ± 2	16 ± 4	1.1 ± 0.4			
	SS-NFStraw-96-2B-0					<17	7 ± 2	17 ± 3	0.7 ± 0.4			
	SS-NFStraw-96-3B-0					<10	11 ± 1	16 ± 4	0.3 ± 0.2			
	SS-NFStraw-96-4B-0					<12	5 ± 2	15 ± 2	<0.1			
	SS-NFStraw-96-5B-0					<10	11 ± 2	17 ± 2	1.7 ± 0.3			
	SS-NFStraw-01-DN-1	Apr-01		<0.2								
	SS-NFStraw-01-DN-1D			<0.2								
	SS-NFStraw-01-UP-1			<0.2	<5							
	SS-NFStraw-01-DN-2	Aug-01		<0.2								
	SS-NFStraw-01-DN-2D			<0.2								
	SS-NFStraw-01-UP-2			<0.2	<5							
Banana Creek	SS-Banana-96-1B-0	Aug-96				<13	10 ± 2	10 ± 2				
	SS-Banana-96-2B-0					<12	7 ± 2	8 ± 2				
	SS-Ban-01-1	Apr-01	X	0.20 ± 0.059								
	SS-Ban-01-1D		X	<0.2 (D)								
	SS-Ban-01-2	Aug-01	X	<0.2								
	SS-Ban-01-2D		X	<0.2								
Cafeteria Creek	SS-Cafe-96-1B-0	Aug-96				<10	20 ± 2	22 ± 4				
	SS-Cafe-96-2B-0					<13	16 ± 2	22 ± 4				
	SS-Cafe-01-DN-1	Apr-01	X	<0.2								
	SS-Cafe-01-UP-1		X	<0.2								
	SS-Cafe-01-DN-2	Sep-01	X	<0.2								
	SS-Cafe-01-UP-2		X	<0.2								
Chicken Creek	SSCH-1/2A/B-0.2	Apr-93		2500 ± 100 (pCi/L)					<0.1		<1	<5
	SS-Chick-96-1B-0	Aug-96		<0.2		<10	7 ± 1	10 ± 2				
	SS-Chick-96-2B-0			<0.2		<10	4 ± 2	8 ± 2				
	SS-Chick-96-3B-0			<0.2		<9	10 ± 2	11 ± 2				
	SS-Chick-96-4B-0			<0.2		<13	9 ± 2	13 ± 3				
	SS-Chick-96-5B-0			<0.2		<10	12 ± 2	13 ± 2				
	SS-Chick-01-DN-1	Apr-01	X	<0.2	<5							
	SS-Chick-01-DN-1D		X	<0.2	<5							
	SS-Chick-01-UP-1A		X	<0.2	<5							
	SS-Chick-01-UP-1B		X	<0.2	<5							
	SS-Chick-01-UP-1C		X	<0.2	<5							

Table 3.1 (Cont'd)
Creek Sediment Sampling Results
Radiological Elements

Location	Sample ID	Date	HRS Sample	Tritium (pCi/g)	Total Tritium (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gamma (pCi/g) (1)	Curium 244 (pCi/g)	Uranium 235 (pCi/g)	Strontium 90 (pCi/g)	Cesium 137 (pCi/g)
Chicken Creek	SS-Chick-01-UP-2A	Aug-01	X	<0.2	<5							
	SS-Chick-01-UP-2B		X	<0.2								
	SS-Chick-01-UP-2C		X	<0.2	<5							
	SS-Chick-01-DN-2	Sep-01	X	<0.2	<5							
	SS-Chick-01-DN-2D		X	<0.2	<5							
No Name Creek	SS-NoName-01-DN-1	Apr-01	X	<0.2								
	SS-NoName-01-UP-1		X	<0.2								
	SS-NoName-01-DN-2	Sep-01	X	<0.2								
	SS-NoName-01-UP-2		X	<0.2								
Pineapple Creek	SS-Pin-01-1	Apr-01	X	<0.2								
	SS-Pin-01-2	Aug-01	X	<0.2								
Ravine Creek	SS-Rav-96-1B-0	Aug-96				<12	19 ± 2	27 ± 5		0.03 ± 0.01		
	SS-Rav-96-2B-0					<11	20 ± 2	21 ± 4		0.04 ± 0.01		
	SS-Rav-96-3B-0					<10	15 ± 2	24 ± 4		0.04 ± 0.02		
	SS-Rav-96-4B-0					<12	23 ± 2	26 ± 3		0.04 ± 0.02		
	SS-Rav-96-5B-0					<10	12 ± 2	24 ± 4		0.02 ± 0.02		
	SS-Rav-01-DN-1A	Apr-01	X	<0.2								
	SS-Rav-01-DN-1B		X	<0.2								
	SS-Rav-01-DN-1C		X	<0.2								
	SS-Rav-01-UP-1		X	<0.2								
	SS-Rav-01-DN-2A	Aug-01	X	<0.2								
	SS-Rav-01-DN-2B		X	<0.2								
	SS-Rav-01-DN-2C		X	<0.2								
	SS-Rav-01-UP-2		X	<0.2								
Ten Inch Creek	SS-Ten Inch-98-1-0.0	Jan-98									<0.2	
	SS-Ten Inch-98-2-0.0										<0.2	
	SS-TenIn-01-DN-1	Apr-01	X	<0.2								
	SS-TenIn-01-UP-1		X	<0.2								
	SS-TenIn-01-DN-2	Sep-01	X	<0.2								
	SS-TenIn-01-UP-2		X	<0.2								

< = concentration less than minimum detectable activity (MDA)

= not analyzed

(1) - Gamma values are naturally occurring Potassium 40

Table 3.2
ERP Surface Water Radionuclide Sampling

Location*		Date	HRS Sample	Tritium (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)	Curium 244 (pCi/L)
North Fork Strawberry Creek	1	Apr-93		<700 <700 (D)				
	2	Aug-93		1700 ± 300 1800 ± 300 (D)	1 ± 2 2 ± 2 (D)	2 ± 3 0.4 ± 3 (D)	<0.1 <0.1 (D)	
		Oct-93		<700				
		Feb-94		<400 <400 (D)				
		Jan-95		<400				
		Jul-95		<400 <400				
		Jan-96		<400				
		Apr-96		<400				
		Apr-97		<400				
		Jan-98		<300				
		Apr-98		<300				
		Apr-99		<300				
		Jan-00		<300				
		Mar-00						<0.2
		Feb-01		<300				
		Apr-01	X	<200				
			X	<200 (D)				
	1		X	<200				
	2	Aug-01	X	<200				
			X	<200 (D)				
	1		X	<200				
	2	Oct-01	X	<200				
			X	209 ± 98 (D)				
	1		X	<200				
	2	Nov-01	X	269 ± 120				
			X	<200 (D)				
	1		X	207 ± 120				
			X	<200				
	2	Dec-01	X	<200				
	1		X	<200				
	2	Jan-02	X	365 ± 130				
			X	273 ± 110 (D)				
	1		X	271 ± 110				
	2	Feb-02		<300				
			X	201 ± 120				
	1		X	218 ± 120				
	2	Mar-02	X	<200				
			X	<200 (D)				
	1		X	<200				
	2	Apr-02	X	<200				
		May-02	X	<300				
	1		X	<300				
	1	Jun-02	X	<300				
	2		X	<300				
	1	Jul-02	X	243 ± 67				
	2		X	216 ± 67				
	1	Sep-02	X	320 ± 110				
			X	269 ± 110 (S)				
	2		X	386 ± 130				
			X	358 ± 120 (S)				

Table 3.2 (Cont'd)
ERP Surface Water Radionuclide Sampling

Location*		Date	HRS Sample	Tritium (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)	Curium 244 (pCi/L)
North Fork Strawberry Creek	1	Jan-03		<300				
				<300				
	2			<300				
	1	Mar-03		<300				
	2			<300				
Banana Creek	13	Apr-01	X	<200				
			X	<200 (D)				
		Aug-01	X	<200				
			X	<200 (D)				
Botanical Garden Creek	16	Aug-93		800 ± 300	2 ± 2	4 ± 3	<0.1	
		Oct-93		<700				
		Feb-94		<400				
	17	Jan-95		<400				
		Jul-95		<400				
		Jan-96		<400 <400				
		Apr-96		<400				
		Apr-97		<400				
		Jan-98		<300				
		Apr-99		<300				
		Jan-00		<300				
		Feb-01		<300				
		Feb-02		<300				
		Feb-03		<300				
Cafeteria Creek	4	Feb-94		<400				
		Jan-95		<400				
		Jan-96		<400				
		Apr-96		<400				
		Apr-97		<400				
		Jan-98		<300				
		Apr-99		<300				
		Jan-00		<300				
		Feb-01		<300				
		Apr-01	X	<200				
	3		X	<200				
	4	Feb-02		<300				
		Feb-03		<300				
Chicken Creek	15	Jan-7-93		<200 <200 (D)				
	9	Jan-25-93		2,100 ± 200 2,100 ± 200 (D)				
		Aug-93		1400 ± 300	2 ± 2	<3	<0.1	
		Oct-93		<700				
		Feb-94		500 ± 200				
		Jan-95		4840 ± 520				
		Jul-Aug 95		432 ± 137				
		Jan-96		<400				
		Apr-96		<400				
		Apr-97		658 ± 85				
		Jan-98		1229 ± 163				
		Apr-99		<300				
		Jan-00		<300				
		Feb-01		855 ± 223				

Table 3.2 (Cont'd)
ERP Surface Water Radionuclide Sampling

Location*		Date	HRS Sample	Tritium (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)	Curium 244 (pCi/L)
Chicken Creek	9	Apr-01	X	233 ± 130				
			X	378 (S)				
			X	316 ± 199 (S)				
	10	Apr-01	X	391 ± 140				
			X	290 ± 130 (D)				
	9	Aug-01	X	<200				
			X	365 ± 94 (S)				
			X	<200 (S)				
	10	Sep-01	X	296 ± 110				
			X	269 ± 110 (D)				
		Oct-01	X	277 ± 100				
			X	328 ± 110 (D)				
	9		X	<200				
			X	271 (S)				
			X	<200 (S)				
	10	Nov-01	X	544 ± 140				
			X	373 ± 140 (D)				
	9		X	260 ± 120				
			X	334 (S)				
			X	418 ± 131 (S)				
	10	Dec-01	X	429 ± 130				
	9		X	320 ± 110				
	10	Jan-02	X	538 ± 120				
			X	413 ± 130 (D)				
	9		X	261 ± 110				
			X	354 ± 91 (S)				
			X	384 ± 128 (S)				
	10	Feb-02		<300				
			X	268 ± 120				
	9	Feb-02	X	327 ± 120				
	10	Mar-02	X	502 ± 130				
			X	487 ± 130 (D)				
	9		X	238 ± 85				
			X	283 ± 88 (S)				
			X	327 ± 108 (S)				
	10	Apr-02	X	<200				
			X	<200				
		May-02	X	<300				
	9		X	<300				
	10	Jun-02	X	<300				
	9		X	<300				
	10	Jul-02	X	238 ± 66				
	9		X	<200				
	10	Sep-02	X	247 ± 110				
			X	<200 (S)				
	9		X	<200				
			X	<200 (S)				
		Feb-03		<300				
		Mar-03		<300				
	10			<300				
No Name Creek	12	Feb-94		<400				
		Jan-95		<400				

Table 3.2 (Cont'd)
ERP Surface Water Radionuclide Sampling

Location*		Date	HRS Sample	Tritium (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)	Curium 244 (pCi/L)
No Name Creek	12	Jul-Aug 95		<400				
		Jan-96		<400				
		Apr-96		<400				
		Apr-97		<400				
		Jan-98		<300				
		Apr-99		<300				
		Jan-00		<300				
		Feb-01		<300				
		Apr-01	X	<200				
	11		X	<200				
	12	Sep-01	X	<200				
	11		X	<200				
	12	Feb-02		<300				
		Feb-03		<300				
Pineapple Creek	14	Apr-01	X	<200				
		Aug-01	X	<200				
Ravine Creek	6	Feb-94		<400				
		Jan-95		<400				
		Jul-Aug 95		<400				
		Jan-96		<400				
		Apr-96		<400				
		Apr-97		<400				
		Jan-98		<300				
		Apr-99		<300				
		Jan-00		<300				
		Feb-01		<300				
		Apr-01	X	<200				
			X	<200 (S)				
			X	<300 (S)				
	5		X	<200				
	6	Feb-02		<300				
		Feb-03		<300				
Ten Inch Creek	8	Jul-Aug 95		<400				
		Apr-96		<400				
		Jan-98		<300				
		Apr-99		<300				
		Jan-00		<300				
		Feb-01		<300				
		Apr-01	X	<200				
	7		X	<200				
	8	Feb-02		<300				
		Feb-03		<300				

*See Figure 3-24 for sampling location
(D) = Duplicate sample
(S) = Split sample

Table 3.3
Tritium Results from Groundwater Monitoring Wells, Temporary Wells, and Slope Stability Facilities
(Concentrations in pCi/L)
MCL = 20,000 pCi/L

Area	Well No.	FY92 Qtr 4	FY93 Qtr 2	FY93 Qtr 3	FY93 Qtr 4	FY94 Qtr 1	FY94 Qtr 2	FY94 Qtr 3	FY94 Qtr 4	FY95 Qtr 1	FY95 Qtr 2	FY95 Qtr 3	FY95 Qtr 4	FY96 Qtr 1	FY96 Qtr 2	FY96 Qtr 3	FY96 Qtr 4	FY97 Qtr 1	FY97 Qtr 2	FY97 Qtr 3	FY97 Qtr 4	FY98 Qtr 1	FY98 Qtr 2	FY98 Qtr 3	FY98 Qtr 4	FY99 Qtr 1	FY99 Qtr 2	FY99 Qtr 3	FY99 Qtr 4	FY2000 Qtr 1	FY2000 Qtr 2	FY2000 Qtr 3	FY2000 Qtr 4	FY2001 Qtr 1	FY2001 Qtr 2	FY2001 Qtr 3	FY2001 Qtr 4	FY2002 Qtr 1	FY2002 Qtr 2	FY2002 Qtr 3	FY2002 Qtr 4	FY2003 Qtr 1
Groundwater Monitoring Wells																																										
1	MW90-3							<400													<300				<300											<300			<300	<300	<300	
	MW90-4							<400*																																<200		
	MW90-6							<700																																	<200*	
	46A-92-15				<300*		<400 <400 (D)	<400													<300	<300		<300				<300*				<300			530 376	<300	<300	<300	
	71-93-1							<400													<300				<300				<300				<300							<300	
	71-93-2							<400																												<300						
	46A-93-19							<400																																		
	51-94-11																																							<200		
	71-95-1																							<300																<200*	
	71-95-8																																			<300						
	71-95-9																																468 562		<300*	770	673		<300	<300	375	
	71B-98-13																																			433		423 255 (D)	529	<300	<300	<300
	71B-99-3R																																			647 675 476	766	582 568 446 471 (D)	530	485	<300	<300
	71B-00-2																																			<300						
	46A-98-11																																								<200*	
2	MW90-2							<400																																		
	MW91-7							<400																																		
	MW91-8							<400																																		
	MW7-1							<400																																		
	7-92-16																																							<200		
	7-92-19							<400																																		
	27-92-20							<400																																		
	6-93-4							<400																																		
	53-93-9							<400																																		
	53-93-16-42'							<400																																		
	53-93-16-69'							<400					<400																														
	6-95-14																																								<200 <200		
3	MW91-3	<700	<700*	<700*	<300*		<400*	<400*										<400			<300		<300		<300		<300		<300			<300			<300		<300		<300		
	MW91-4	12,000* 4000*	5400* 5900* (D)	1700	2000*	1400	800	1372*	821		1030	958	606 <400 (D)	1015	779	1078	680	2270	830		524		887		725		828		923		1347				632		690		741		<300	
	MW91-5	900*	1260*	1400*	1500*		1260*	1849*	560		1790		1856	1018	2394	4439	3490	3440	3230		2427		6798*		1352		2542		2218	4381*	3991		2269		3419*		1706		2200		1784	
	MW91-6	5300*	9600*	6100*	6600*		7500*	4797*	1417		4074		4728	4284	5779	6094	6070	6110	6020		3528		5618*		1825		3728		3202		3260		3153		4059*		3218		3369		1813	
	69A-92-22						<400*	<400*										<200	<400		<300		<300		<300		<300		<300*		<300*		<300		<300*		<300		<300		
	75-92-23	630 460 (D)	<700* <700* (D)		1800*	1200	1200* 800		3380		1110		1202	4417 4239 (D)	4066	4556	4490	5630	1690		6013 7880 (D)		3845		994		5456		3823		3799		1894 2020 (D)		3676*		2855		1920		1531	
	75B-92-24	10,000*	5000* 5000* (D)	9200*	9900*		8700* 2200	7318*	4843	7640 7755 (D)	6710	6745	6896 7378 (S)	7497	5345 5424 (S)	6203	7930	4210	4645		5383		3339*		5082		3637		5082		2294		3118		3274*		3970		2160		2227	
	75-96-20																		257 <400 (D)	<300	<300	<300 <300 (D)	<300	<300	<300	<300	<300	<300			<300		<300		<300		<300		<300		<300	
	75-97-5																								14,487 12,291 (D)	21,807 28,200 (D) 27,012	31,503* 26,549	24,991	24,700 26,211 (S)	26,720 24,500 (D)	27,047	18,556 24,500 (D)	26,672 28,800 (D)	26,162 27,300 (D)	27,618 25,900 (D)	22,810 21,900 (D)	27,866 25,900 (D)	25,857 23,900 (D)	25,442 24,600 (D)	21,541 22,700 (D)	25,698 24,500 (D)	25,215 23,300 (D)
	75-97-6																				<300 <96 (D)	<300	<300	<300	<300	<300	<300	<300			<300*		<300		<300*			<300 <200 (D)	<300		<300	
	75-97-7																				966 1090 (D)	1067	1237	591	602	1339	1411	775			1301*		918		1366*		853		1184		610	
	69-97-8																						<300		<300 <300 (D)	454 <300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
	69-97-21																					<300*	1126 1900	538 504	387	441 476 (D)	641	818			546		657		549		478		949		<300	
	75-98-14																									656*		4481*	4383 4100 (D)	3066	2563*	1990 2910 (D)	2524	3383	7136	5383	5034	4245	3929	3723	4381	5229
	75-98-15																								<300*		<300 <200 (D)	<300	<300	537 <300*	<300	<300	<300	<300	<300	<300	<300	<300 <200 (D)	<300 <200 (D)	<300	<300	<300	<300
	75-99-4																													<300 <200 (D) <300	<300	<300	<300	<300	<300	<300	<300	<300 <200 (D)	<300	<300	<300	<300
	75-99-6																														<300 <200 (D)	<300	<300	<300	<300	<300	<300	<300 <200 (D)	<300	839	1323	1531	912
	75-99-7																													5347 4320 (D)	6375	5047 7110 (D)	6040 5840 (D)	5605 5930 (D)	7818	7536	6885	6521 6350 (D)	7013	6225	7218	6957 6450 (D)

Table 3.3 (Cont'd)
Tritium Results from Groundwater Monitoring Wells, Temporary Wells, and Slope Stability Facilities
(Concentrations in pCi/L)
MCL = 20,000 pCi/L

Area	Well No.	FY92 Qtr 4	FY93 Qtr 2	FY93 Qtr 3	FY93 Qtr 4	FY94 Qtr 1	FY94 Qtr 2	FY94 Qtr 3	FY94 Qtr 4	FY95 Qtr 1	FY95 Qtr 2	FY95 Qtr 3	FY95 Qtr 4	FY96 Qtr 1	FY96 Qtr 2	FY96 Qtr 3	FY96 Qtr 4	FY97 Qtr 1	FY97 Qtr 2	FY97 Qtr 3	FY97 Qtr 4	FY98 Qtr 1	FY98 Qtr 2	FY98 Qtr 3	FY98 Qtr 4	FY99 Qtr 1	FY99 Qtr 2	FY99 Qtr 3	FY99 Qtr 4	FY2000 Qtr 1	FY2000 Qtr 2	FY2000 Qtr 3	FY2000 Qtr 4	FY2001 Qtr 1	FY2001 Qtr 2	FY2001 Qtr 3	FY2001 Qtr 4	FY2002 Qtr 1	FY2002 Qtr 2	FY2002 Qtr 3	FY2002 Qtr 4	FY2003 Qtr 1
3	75-99-8																														<300 <200 (D)	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
	75A-00-7																																			<300*		388					<300 <200 (D)
	69A-00-11																																	<300	<300	<300	<300	<300	<300	<300	<300	<300
4	MW76-1						<400	443	472 <381		<400		818					499	634		601		<300		331		<300		544		573*		538		567		481		561		<300	
	76-92-25							<400*													<300		<300		<300		<300		<300	<300*	<300*		<300		<300*		<300		<300		<300	
	76-93-6					<400*	3600* 1500 1200 (D)	3420*		3676	3210 3280 (D) 3510 (S)	3671	3584	3232	3328 3281 (D)	3730	5060 3081 (D)	3300	4170		1942		1815		1577		4864		4397		605		1148		4665		2271		660		2328	
	76-93-7							<400											<400	<300	<300	<300	<300		<300	549* <300	<300	<300			<300		<300		<300		<300		882	<300	<300	
	78-97-20																					4720 6410 (D) 4902	6272	3478	2202	3586	2953	3622			3067*		2535		3076		3396		2608		1964	
	76-98-21																												<300	<300	<300	<300	399	<300	553	404	391	<300	518	<300	<300	<300
	76-98-22																										<300 145 (D)	<300	<300	<300	<300	<300	<300	<300	<300	418	503	535	<300	<300	<300	<300	<300
5	MW91-1				<300*		500* <200								<400	<80	<400	<400	<400	<300		<300		<300		<300*		<300			<300		<300		<300*		<300		<300*		<300	
	MW91-2				<300*		<400*	<400							<400	508	<400	<400	487		369		571		812		482		654	779*	719		597		952		743		619		<300	
	MWP-9				<300*		<400	<400	<400		<400	<400	<400	<400	<400	<400	<130	<200	<400	<400 <90 (S)	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300*	<300*	<300*	<300	<300*	<300	<300	<300	<300	<300*	<300	<300	<300
	MWP-10				<300*		<400	<400*	<400		<400	<400	<400	<400	<400	<400	<130	<200	<400	<300 <94 (S)	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300*	<300*	<300*	<300	<300	<300	<300	<300 <200	<300	<300*	<300	<300	<300
	77-92-10							<400										<99	<400		<300		<300		<300		<300		<300		<300*		<300		<300		<300		<300*		<300	
	61-92-12							<400								<81	<400	<400		<300	<300	<300	<300	<300	<300	<300	<300	<300 <300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
	77-93-8							<400								<400	<400		<400		<300		<300		<300		<300		<300*		<300		<300		<300*		<300		<300*		<300	
	77-94-5															<400	<400	<400	<300		792 <300	<300	<300		<300		<300	<300	<300		<300		<300		<300*		<300		<300*		<300	
	77-94-6															9136	9494	11,626	9630 9962 (D)	9858 12,420 (D)	8324	8998	15,462	7927	5457	10,000 11,700 (D)	11,928	10,657			13,223*		8818		12,777*		9558 9560 (D)		9153 9110 (D)		6038 9200 (D)	
	77-97-9																				10,307 12,920 (D)	13,640	11,984	11,676	6509	9631	11,668	12,100			13,195*		10,110		13,386*			12,882 12,000 (D)	12,304 12,600 (D)		8417 11,000 (D)	
	77-97-11																				5132 6530 (D)	6167	7426*	2182	2636 2759 (D)	4837 5620 (D)	6202	6164			6018*		5088		6998*		5936		1330		2926	
	31-97-17																				311*	998 1241	1258	1487	896	1153	1728	1203			1416		1390		1943*		1957		1687		1224	
	31-97-18																				<300*	<300 <300		<300	<300	<300	<300	<300	<300	<300*	<300*	<300	<300	<300	<300	<300	<300	<300	<300*	<300	<300	<300	<300
	31-98-17																									<300*			<300 <200 (D)	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
6	88-92-4						<200	<400																																<200 <200			
	88-93-11A															<400	<400	<400											<300	<300	<300	<300	<300	<300	<300	<300	<300	<300 <200	<300	<300	<300	<300	<300
	88-93-13							<400																																<200			
	88-96-4																																							<200			
7	46-93-12							<400																																			
	58-96-12																																									<200*	
8	MWP-2							<400*	<400		<400	<400	<400	<400	<400	<400	<130	<400	<300 <92 (S)	<300 <89 (S)	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
	70-92-7							<400																																			
	OW3-225							<400 <400 (D)	<400		<400	<400	<400	<400	<400	<400	<130 <400 (D)	<200	<400	<400 <92 (S)	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300 <200 (D)	<300	<300	<300	<300	<300
9	51-92-2																																							<200			
	51-92-3-12'																																							<200			
	51-92-3-32'																																							<200			
	51-92-3-42'																																							<200			
	51-92-3-52'																																							<200			
	51-92-3-62'																																							<200 <200			
	51-96-15																																							<200			
	51-96-16																																							<200			
	51-96-18																																							<200			
	51-96-19																																							<200			
	51-97-16																																							<200			

Table 3.3 (Cont'd)
Tritium Results from Groundwater Monitoring Wells, Temporary Wells, and Slope Stability Facilities
(Concentrations in pCi/L)
MCL = 20,000 pCi/L

Area	Well No.	FY92 Qtr 4	FY93 Qtr 2	FY93 Qtr 3	FY93 Qtr 4	FY94 Qtr 1	FY94 Qtr 2	FY94 Qtr 3	FY94 Qtr 4	FY95 Qtr 1	FY95 Qtr 2	FY95 Qtr 3	FY95 Qtr 4	FY96 Qtr 1	FY96 Qtr 2	FY96 Qtr 3	FY96 Qtr 4	FY97 Qtr 1	FY97 Qtr 2	FY97 Qtr 3	FY97 Qtr 4	FY98 Qtr 1	FY98 Qtr 2	FY98 Qtr 3	FY98 Qtr 4	FY99 Qtr 1	FY99 Qtr 2	FY99 Qtr 3	FY99 Qtr 4	FY2000 Qtr 1	FY2000 Qtr 2	FY2000 Qtr 3	FY2000 Qtr 4	FY2001 Qtr 1	FY2001 Qtr 2	FY2001 Qtr 3	FY2001 Qtr 4	FY2002 Qtr 1	FY2002 Qtr 2	FY2002 Qtr 3	FY2002 Qtr 4	FY2003 Qtr 1
9	51-98-5																																							<200		
	51-99-1																																							<200		
	51-00-1																																							<200		
	51-00-9																																								<200	
	51-00-10																																								<200	
	51A-01-10A																																							<200		
	51A-01-11																																							<200		
	51L-01-6																																							<200		
	51L-01-7																																							<200		
10	MW91-9							<400											<400																						
	26-92-11				<300*		<400	<400										<400																							
	5-93-10							<400																																		
	25-93-15							<400*																																		
	16-95-3																	<400																						
	25-95-27																																						<300	<300	<300	<300	<300
	4-96-2																	<400																								
	MWP-8				<300*			<400*	<400 <400 (D)		<400	<400	<400	<400	<400	<400	<140	<400	<400	<400 135 (S)	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
	52-94-10																			<300			<300				<300							<300				<300 288 (D)			<300	
	52-95-2B																			<300				<300				<300							402	398		<300	<300		
	52A-98-8B																																					<300					
	52-98-9																																					<300					
11	74-92-13				<300*		<200	<400 <400*																																		
	83-92-14				<300*			<400																																		
	P15 (B33A)				<300*																																					
	74-94-7							<400*								<400 <400 (D)	<400	434					<300	<300		<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
	74-94-8															<400	<400	<400											<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
13	62-92-26															<400				<300	<242	<300	<300*	<300	<300*		<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
	62-92-27							<400*								<400				<300	<242	<300	<300	<300	<300		<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
	MW62-B1A							<400*																																		
	MW62-B2							<400*																																		
	62-95-16															<400	<400	<400																								
14	MWP-4							<400	<400		<400	<400	<400	<400	<400	<400	<89	<200	<400	<400 <91 (S)	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
	MWP-5							<400*	<400		<400	<400	<400	<400	<400	<400	<140	<200	<400	<400 <93 (S)	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
	MWP-6						<400	<400*	<400		<400	<400	<400	<400	<400	<400	<89	<200	<400	<400 <92 (S)	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
	MWP-7							<400	<400		<400	<400	<400	<400	<400*	<400*	212 433	<200 <200 (D)	<400 240 (D)	<300* 179 (S)*	717 169 (D)	<300 <300 (S)	<300	<300*	<300*	701* <300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
	37-92-6							<400										<400				<300		<300*					<300			<300								<300		
	6-92-17							<400 <400 (D)																																203		
	37-92-18							<400*														<300							<300			<300					<300 <200 (D)			<300	
	37-92-18A							<400														<300							<300			<300				<300 <200			<300	
	37-93-5				<700*			<400										100				<300							<300			<300				<300 <200			<200	<300	
	37-94-9							<400														<300							<300			<300				<300			<200	<300	
15	MWP-1							<400*	<400		<400	<400	<400	<400	<400	<400	132 <95	<200	<400	<400 <93 (S)	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
OS	CD-92-28				<300		<400	<400	<400		<400	<400	<400	<400	<400	<400	<88	<200	<400	<400 <92 (S)	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300 <200 (D)	<300	<300 <300 408	<300 <200 (D)		<300	<300	

Temporary Wells

1	SB71B-99-1																																			373					
	SB71B-99-2																																			<300					
2	SB6-96-1																																						<200		
	SB7-97-1																																						<200		
3	SB69A-99-1																																			829*		484	1,057			820	482		345	
	SB69A-00-1																																								<300			
	SB69-02-1-20'																																											<300
	SB69-02-1-35'																																											<300
	SB69-02-2-35'																																											<300

Table 3.3 (Cont'd)
Tritium Results from Groundwater Monitoring Wells, Temporary Wells, and Slope Stability Facilities
(Concentrations in pCi/L)
MCL = 20,000 pCi/L

Area	Well No.	FY92 Qtr 4	FY93 Qtr 2	FY93 Qtr 3	FY93 Qtr 4	FY94 Qtr 1	FY94 Qtr 2	FY94 Qtr 3	FY94 Qtr 4	FY95 Qtr 1	FY95 Qtr 2	FY95 Qtr 3	FY95 Qtr 4
3	SB69-02-3-40'												
	SB75-02-1												
	SB75A-02-1-20'												
	SB75A-02-1-40'												
5	SB31-02-1												
	SB31-02-2												
	SB31-02-4												
	SB31-02-5												
	SB31-02-6												
	SB31-02-7												
	SB77-02-1												
9	SB51-98-4												
	SB51-96-6												
Slope Stability/Indicator Facilities													
3	SSW1-130	<700*	<700* <700* (D)	<700*	400*		<400*		<400* <400* <376* (D)				
	SSW3-130												
	SSW4-130												
	SSW5-130												
	SSW9-130	5200*	5800* 5600* (D)	5300*	6000*		4900*		3563* 4722*(D)			4213*	
	SSW13-130	19,000* 18,000* 19,000*(D)	27,500* 27,030*(D)		31,100* 27,100*		26,600*		20,185* 27,920*(D)			33,753*	
	SSW15-130	2600*	5100* 4900* (D)	8400*	9120*		3800*						
	SSW16-130	<700*	<700* <700* (D)	<700*	500*		1100* 500		<400* 400 <380 (D)				
4	SI2-64		<700*										
5	SSW17-130										<400		
	SSW19-130							89*	1120 1470 (D)	958	2600 2310 (D)		
	SSW20-130							1149*	1875 1211 (D)	1216	1610		
	SSW21-130							<400*			780		
	SI4-64												
Quality Assurance Samples													
	Trip Blank				<300		<400 <400	778					
	Rinse Blank	<700 <700 (D)			<300 <300 (D)		<400 <400	<400 <400	<400 <400		<400 <400	<400 <400	<400

Area	Well No.	FY96 Qtr 1	FY96 Qtr 2	FY96 Qtr 3	FY96 Qtr 4	FY97 Qtr 1	FY97 Qtr 2	FY97 Qtr 3	FY97 Qtr 4	FY98 Qtr 1	FY98 Qtr 2	FY98 Qtr 3	FY98 Qtr 4	FY99 Qtr 1	FY99 Qtr 2	FY99 Qtr 3	FY99 Qtr 4
3	SB69-02-3-40'																
	SB75-02-1																
	SB75A-02-1-20'																
	SB75A-02-1-40'																
5	SB31-02-1																
	SB31-02-2																
	SB31-02-4																
	SB31-02-5																
	SB31-02-6																
	SB31-02-7																
	SB77-02-1																
9	SB51-98-4																
	SB51-96-6																
Slope Stability/Indicator Facilities																	
3	SSW1-130	<400* <400* (D)	<400*	<400*	471*	367*		539*									
	SSW3-130							959*									
	SSW4-130							<300*									
	SSW5-130							34,542*									
	SSW9-130	2764*	2707*	3755* 3336* (S)	3560* 3241 (D)	3280*		2389*	2114*								
	SSW13-130	31,764*	33,348*	33,148*	33,300*	35,800* 35,100* (D)		31,862* 35,000* (D)	28,334* 37,000* (S)								
	SSW15-130	8681*	8362*	9762*	12,170*	9540* 9730* (S)		7934*	6188*								
	SSW16-130	927*	1192*	1071*	950*	672*		706*	<300*								
4	SI2-64									518							
5	SSW17-130	1074	3224*	6026*	4170*	2030*		8070*	7494*	9779*				5530*		6672* 6010*	6518*
	SSW19-130	1148	965*	1326* 1188* (D)	625*	112*		789* 734* (S)	678*	484*				448*		<300*	525*
	SSW20-130	994	773* 799* (S)	1417*	1200*	1210*		1211*	761*	1122*				953*		825*	1142*
	SSW21-130	612	534*	561*	433*	249*		<300*	<300*	<300*				<300*		<300*	<300*
	SI4-64					<400*											
Quality Assurance Samples																	
	Trip Blank																
	Rinse Blank	<400 <400	<400 <400	<400 <400 <400 <400 <400 <400	<400	<200 <400 <97 <95 <96 <96	<92 2330 (1) <300	<400 <300 <300	<300 <300 <300 <300 <300 <300	<300	<300	<300 <300 <300 <300 <300 <300	<300 <300 <300 <300	<300 <300 <300 <300	<300 <300 <300 <300	<300 <300 <300 <300 <300 <300	<300 <300

Area	Well No.	FY2000 Qtr 1	FY2000 Qtr 2	FY2000 Qtr 3	FY2000 Qtr 4	FY2001 Qtr 1	FY2001 Qtr 2	FY2001 Qtr 3	FY2001 Qtr 4	FY2002 Qtr 1	FY2002 Qtr 2	FY2002 Qtr 3	FY2002 Qtr 4	FY2003 Qtr 1
3	SB69-02-3-40'													<300
	SB75-02-1													<300 <300
	SB75A-02-1-20'													629
	SB75A-02-1-40'													<300
5	SB31-02-1													359 878
	SB31-02-2													507 <300
	SB31-02-4													3283 3739
	SB31-02-5													3206
	SB31-02-6													<300
	SB31-02-7													<300
	SB77-02-1													<300
9	SB51-98-4												<200	
	SB51-96-6											<200	<200	
Slope Stability/Indicator Facilities														
3	SSW1-130													
	SSW3-130													
	SSW4-130													
	SSW5-130													
	SSW9-130													
	SSW13-130													
	SSW15-130													
	SSW16-130													
4	SI2-64													
5	SSW17-130		2683*	3109* 4440* (D)	3509* 3590* (D)							2,559*	1,302*	
	SSW19-130		731*		591*		621*		610*			<300*	<300*	
	SSW20-130		1087*		1003*				1400*			<300*	932*	
	SSW21-130		<300*		<300*		<300*		<300*			<300*	<300*	
	SI4-64													
Quality Assurance Samples														
	Trip Blank													
	Rinse Blank	<300 <300 <300	<300 <300 <300 <300	<300 <300	<300 <300 <300 <300 <300 <300	<300 <300 <300	<300 <300 <300 <300 <300 <300	<300 <300	<300 <300 <300 <300 <300 <300 <300 <300 <300	<300 <300 <300 <300	<300 <300 <300 <300 <300 <300 <300 <300	<300 <300 <300 <200 <200 <200	<300 <300 <300 <300 <300	<300 <300 <300

MCL = Maximum contaminant level for drinking water determined by California DTSC
* - Grab samples
(D) - Duplicate sample
(S) - Split sample
(1) - Detection is due to sampling or laboratory error

[blank box] = Not Sampled
[shaded box] < = Less than minimum detectable activity (MDA)

Table 3.4
Hydrauger Tritium Results
(Concentrations in pCi/L)

Location	Dec-92	Mar-93	Feb-94	Mar-94	Oct-95	Apr-96	Jun-96	Mar-98	Aug-98	Jan-00	Jan-01	Jun-01	Mar-03
37-01-01									<300				
51-01-01				<200					<300			<300	
51-01-02				<200					<300			<300	
51-01-03				<200					<300			<300	
51-01-03A				<200					<300			<300	
51-01-04				<200					<300			<300	
51-05-01									<300				
54-01-03									<300				
54-01-04									<300				
54-01-05									<300				
54-01-06									<300				
54-01-07									<300				
64-01-01									<300				
77-01-01						<400	12,541 ± 320	11,776 ± 240	5163 ± 147		7866 ± 395		5754 ± 334
77-01-02*	32,700 ± 2000	20,090 ± 2000 20,300 ± 2000											
77-01-04											17,679 ± 553		18,445 ± 546
77-02-05	6900 ± 500		2100 ± 300			3474 ± 437		4389 ± 155	1911 ± 99	2229 ± 169	2627 ± 267		2242 ± 240
77-02-06			500 ± 200			555 ± 247							535 ± 103
77-02-07	<200					<400		<300					
77-02-11			<400			<400			<300				<300
77-02-12	300 ± 50		<400			<400			<300				<300
77-02-PVC outlet						2382 ± 380							
77-03-01	<200		<400			<400		<300	<300	<300	<300		
77-03-02											<300		<300
77-03-03						491 ± 233		<300	<300		548 ± 201		<300
77-04-02						<400		<300					<300
77-04-03						<400			<300		408 ± 196		<300
77-04-04	650 ± 100		<400			<400			<300	<300	<300		<300
77-04-06	740 ± 100					<400			<300	<300	<300		<300
77-04-07	830 ± 100		<400			<400			<300	<300	<300		<300
77-04-08	900 ± 200		<400			<400			<300	<300	<300		<300
77-04-11										<300			<300
77-04-12													<300
77-04-13						<400		<300					<300
77-04-14													<300
77-04-09 to 04-13											<300		
77-05-01	700 ± 100					1066 ± 288		<300	<300		<300		<300
Chicken Creek 1					<400				<300				
Chicken Creek 2					<400				<300				

All analyses by LBNL

* - This hydrauger no longer flows

< = less than minimum detectable activity

Table 3.5
Results of Hydrauger Sampling and Flow Rates March 2003

Location	Concentration of Tritium (pCi/L)	Flow Rate (Liters/Minute)	Flow Rate (Gallons/Day)
77-01-1	5754	0.148	56.26
77-01-2		dry	dry
77-01-3		dry	dry
77-01-4	18,445	0.001	0.32
77-02-4		dry	dry
77-02-5	2242	1.500	570.24
77-02-6	535	0.000	0.14
77-02-7		dry	
77-02-11	<300	0.041	15.59
77-02-12	<300	0.008	2.94
77-03-1		dry	dry
77-03-2	<300	0.400	152.06
77-03-3	<300	0.200	76.03
77-04-2	<300	0.008	2.93
77-04-3	<300	0.008	2.92
77-04-4	<300	1.360	517.02
77-04-6	<300	0.046	17.49
77-04-7	<300	2.000	760.32
77-04-8	<300	1.580	600.65
77-04-11	<300	0.124	47.14
77-04-12	<300	0.048	18.25
77-04-13	<300	0.033	12.55
77-04-14	<300	0.286	108.73
77-04-15		dry	dry
77-05-1	<300	0.012	4.56
77-05-4		dry	dry

Table 4.1
Groundwater Sampling Results for Radionuclides
(Concentrations in pCi/L)

						Gamma Spectroscopy									
			Gross Alpha	Gross Beta**	Gamma	Potassium 40	Uranium natural	Radium 226	Radium 228	Cesium 137	Americium 241	Europium 152	Europium 154	Strontium 90	Curium 244
		MCL:	15	50		NS	20	5*		NS	NS			8	
Area	Well No.	Date													
1	MW90-3	Dec-98													<0.2
	MW90-4	Dec-98													<0.2
	MW90-5	Dec-98													<0.2
	MW90-6	Dec-98													<0.2
	46A-92-15	May-93													<0.1
		Dec-98													<0.2
	46A-93-19	Dec-98													<0.2
	51-94-11	Dec-98													<0.2
	71-93-1	Oct-93													<0.6
		Dec-98													<0.2
	71-93-2	Dec-98													<0.2
	71-94-1	Jun-95	<6	<6	<33										
		Dec-98													<0.2
	71-95-1	Nov-00	<5	<5		<5	<3	<1	<3	<1	<1				
		Dec-98													<0.2
	71-95-8	Dec-98													<0.2
	71-95-9	Dec-98													<0.2
	71-97-23	Dec-98													<0.2
	71B-98-13	Sep-00	<5	<5		<4	<3	<1	<3	<1	<1				
	71B-99-3	Dec-99													<0.2
		Sep-00	<5	<5		<4	<3	<1	<3	<1	<1				
2	MW90-2	Sep-00	<5	<3		<4	<3	<1	<3	<1	<1				
	7-92-19	Sep-00	<5	<3		<4	<3	<1	<3	<1	<1				
	27-92-20	Sep-00	<5	<5		<4	<3	<1	<3	<1	<1				
	6-93-4	Sep-00	<5	<3		<4	<3	<1	<3	<1	<1				
	53-93-16-69'	Sep-00	<5	<5		<4	<3	<1	<3	<1	<1				
	7-94-3	Sep-00	<5	<5		<4	<3	<1	<3	<1	<1				
	52B-95-13	Sep-00	<5	<3		<4	<3	<1	<3	<1	<1				
	7B-95-25	Sep-00	<5	<3		<4	<3	<1	<3	<1	<1				
3	75-92-23	Nov-00	<5	<5		<5	<3	<1	<3	<1	<1				
	75B-92-24	Nov-00	<5	<5		<5	<3	<1	<3	<1	<1				
	75-97-7	Oct-00	<5	8 ± 1		8 ± 5	<3	<1	<3	<1	<3				
	75-98-14	Sep-00	<5	9 ± 2		12 ± 4	<3	<1	<3	<1	<1				
	75-99-7	Sep-00	<5	<5		6 ± 4	<3	<1	<3	<1	<1				
5	61-92-12	Nov-00	<5	7 ± 1		6 ± 3	<3	<1	<3	<1	<1				
	77-97-9	Nov-00	<5	8 ± 1		14 ± 5	<3	<1	<3	<1	<1				
	77-97-11	Nov-00	<5	<5		<5	<3	<1	<3	<1	<1				
	31-97-18	Oct-00	<5	6 ± 1		8 ± 5	<3	<1	<3	<1	<3				
	31-98-17	Oct-00	<5	12 ± 2		12 ± 5	<3	<1	<3	<1	<1				
6	88-93-11A	Nov-00	<5	26 ± 5		16 ± 5	<3	<1	<3	<1	<1				
	88-93-13	Oct-00	<5	5 ± 1		9 ± 5	<3	<1	<3	<1	<3				
7	58A-94-14	Sep-00	<5	<5		<4	<3	<1	<3	<1	<1				
8	MWP-2	Oct-00	<5	7 ± 1		7 ± 4	<3	<1	<3	<1	<3				
	70A-96-14	Oct-00	<5	6 ± 1		9 ± 4	<3	<1	<3	<1	<3				
	OW3-225	Oct-00	<5	<5		<5	<3	<1	<3	<1	<1				
9	51-92-2	Nov-00	<5	16 ± 1		12 ± 5	<3	<1	<3	<1	<1				
	51-95-17	Nov-00	<5	12 ± 1		8 ± 4	<3	<1	<3	<1	<1				
	51-96-16	Sep-00	<5	<3		<4	<3	<1	<3	<1	<1				
	51-97-16	Nov-00	<5	<5		<5	<3	<1	<3	<1	<1				
	51-99-1	Nov-00	<5	13 ± 2		9 ± 4	<3	<1	<3	<1	<1				

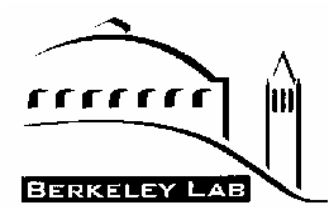
Table 4.1 (Cont'd)
Groundwater Sampling Results for Radionuclides
(Concentrations in pCi/L)

						Gamma Spectroscopy									
			Gross Alpha	Gross Beta**	Gamma	Potassium 40	Uranium natural	Radium 226	Radium 228	Cesium 137	Americium 241	Europium 152	Europium 154	Strontium 90	Curium 244
		MCL:	15	50		NS	20	5*		NS	NS			8	
Area	Well No.	Date													
10	MWP-8	Oct-00	<5	8 ± 1		10 ± 5	<3	<1	<3	<1	<1				
	MW91-9	May-93	5 ± 4	22 ± 4	<3										
		Aug-93												1.7 ± 0.4	
		Mar-97												<0.74 <4 (S)	
		Nov-00	<5	<5		<5	<3	<1	<3	<1	<1				
	5-93-10	Oct-93	15 ± 10	23 ± 4	<200					<10	<0.6	<10	<10	<1	
		Jun-94			<10										
		Aug-99	3.4 ± 0.9			<17									
		Oct-00	<5	5 ± 1		8 ± 5	<3	<1	<3	<1	<3				
	4-96-2	Nov-00	<5	6 ± 1		6 ± 4	<3	<1	<3	<1	<1				
	16-94-13	Sep-00	<5	<5		<4	<3	<1	<3	<1	<1				
	52-95-2B	Sep-00	<5	<3		<4	<3	<1	<3	<1	<1				
	25A-95-15	Sep-00	<5	<5		<4	<3	<1	<3	<1	<1				
	25A-98-1	Sep-00	<5	<5		<4	<3	<1	<3	<1	<1				
	25A-98-3	Sep-00	<5	<5		<4	<3	<1	<3	<1	<1				
	52A-98-8B	Sep-00	<5	<3		<4	<3	<1	<3	<1	<1				
11	74-94-7	Nov-00	<5	6 ± 1		7 ± 5	<3	<1	<3	<1	<1				
	74-94-8	Nov-00	<5	<5		<5	<3	<1	<3	<1	<1				
	85-95-1	Oct-00	<5	11 ± 1		10 ± 5	<3	<1	<3	<1	<1				
	85-96-2	Nov-00	<5	<5		<5	<3	<1	<3	<1	<1				
14	MWP-4	Oct-00	<5	15 ± 2		10 ± 4	<3	<1	<3	<1	<1				
	MWP-5	Oct-00	<5	8 ± 1		16 ± 5	<3	<1	<3	<1	<1				
	MWP-6	Oct-00	<5	6 ± 1		6 ± 4	<3	<1	<3	<1	<1				
	MWP-7	Nov-00	<5	<5		<5	<3	<1	<3	<1	<1				
	37-93-5	Oct-93	<10	27 ± 4	<200										
15	MWP-1	Oct-00	<5	11 ± 2		7 ± 5	<3	<1	<3	<1	<1				
OS	CD-92-28	Oct-00	<5	8 ± 1		9 ± 4	<3	<1	<3	<1	<1				
Temporary Wells and Borings															
1	SB71H-98-1	Dec-98													<0.2
9	Firetrail Well	Nov-95	<6	<6	<30										
	SB51-96-6	Apr-96	<2	<2	<40										
	SB51-96-8	Apr-96	<2	<2	<40										
	SB51-96-12	Apr-96	<2	<2	<40										
10	SB5-97-6	Mar-97	6 ± 2	<2	<10					<6				<4	
	SB5-97-7		5 ± 2	3 ± 1	<10					<6				<4	
	SB5-97-8		9 ± 4	3 ± 1	<10					<6				<4	
Slope Stability Facilities															
1	SI1-162	Jun-93													<0.1
Quality Assurance Samples															
	Rinse Blank	Jul-96	<6	<3	<30										
		Nov-96	<8	<4	<10										
		Nov-97	<5	<8	<8										
		Nov-98													<0.2

All analyses by LBNL Radiation Analytical Measurement Laboratory
MCL: Maximum contaminant level for drinking water (determined by California Department of Health Services)
< = Less than minimum detectable activity
*MCL is for Ra 226+Ra 228
**Detections are due to potassium 40, which emits both gamma and beta
(S) = Split sample
NS: Not Specified

APPENDIX A1

Request for No Further Action (NFA) Status for SWMU 11-2 and SWMU 11-3 for the Lawrence Berkeley National Laboratory Environmental Restoration Program, June 1998.



E.O. Lawrence Berkeley National Laboratory
University of California
Environmental Restoration Program

United States Department of Energy

REQUEST FOR NO FURTHER ACTION (NFA) STATUS FOR SWMU 11-2 and SWMU 11-3

for the

Lawrence Berkeley National Laboratory

ENVIRONMENTAL RESTORATION PROGRAM

June 1998

REQUEST FOR
NO FURTHER ACTION (NFA)
FOR
SWMU 11-2 and SWMU 11-3

for the

Lawrence Berkeley National Laboratory

ENVIRONMENTAL RESTORATION PROGRAM

A Joint Effort of
Environment, Health and Safety Division and
Earth Sciences Division
Lawrence Berkeley National Laboratory
University of California
Berkeley, CA 94720

and

Parsons Engineering Science, Inc.
Oakland, California

June 1998

This work was done at the Lawrence Berkeley Laboratory operated by the University of California for the U. S. Department of Energy under contract DE-AC03-76SF00098.

CONTENTS

LIST OF ABBREVIATIONS

DOE	United States Department of Energy
DPM/Swipe	Disintegrations per minute per swipe
DTSC	State of California Environmental Protection Agency, Department of Toxic Substances Control
EPA	United States Environmental Protection Agency
LBNL	Lawrence Berkeley National Laboratory
MDA	Method detection amount
mg/kg	Milligrams per kilogram
NFA	No Further Action
pCi/g	Picocuries per gram
pCi/L	Picocuries per liter
PRGs	Preliminary Remediation Goals
RCRA	Resource, Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SB	Soil boring
SWMU	Solid Waste Management Unit

SECTION 1
INTRODUCTION

1.1 OBJECTIVE

The objective of this report is to request approval for No Further Action (NFA) status for the following Solid Waste Management Units (SWMUs) at the Lawrence Berkeley National Laboratory (LBNL):

- Building 74 Inactive Aboveground Radioactive Waste Storage Tanks (SWMU 11-3)
- Building 74 Abandoned Radioactive Waste Holding Tanks (SWMU 11-2).

This request for NFA status is part of the Resource Conservation and Recovery Act (RCRA) corrective action process, and the focus of this process is potential releases of contamination to the environment. Review and approval of NFA status requests for these SWMUs is the responsibility of the United States Department of Energy (DOE), because radioactive wastes were handled or were potentially handled at these units. Approval of NFA status would indicate that no additional environmental investigations would be required at these SWMUs under the RCRA corrective action process. Any implementation of site controls or demolition, which were recommended for consideration by DOE (DOE, 1997), would be completed outside the scope of the RCRA corrective action process. **Figure 1** is a map of LBNL with the locations of SWMU 11-2 and SWMU 11-3.

1.2 BACKGROUND

LBNL operates under a RCRA Part B Hazardous Waste Handling Facility Permit, which was issued by the California Department of Toxic Substances Control (DTSC) on May 4, 1993. In accordance with this Permit, LBNL is required to investigate and address all releases of hazardous waste that may have occurred at its facility. Both of the potentially radioactive waste sites addressed by this report were identified as SWMUs during the RCRA Facility Assessment (RFA) (LBNL, 1992), and both SWMUs were investigated during the RCRA Facility Investigation (RFI) phase of the RCRA corrective action process.

In February 1997, LBNL requested NFA status for SWMU 11-2 and SWMU 11-3 (LBNL, 1997a) from the DOE, based on information gathered during the RFA and RFI. Upon review, DOE requested additional work at SWMU 11-3 (no additional work was recommended for SWMU 11-2) to support the NFA status request and to justify any future release of the unit from radiological controls for either restricted or unrestricted use (DOE, 1997). Based on the DOE recommendations, which were incorporated into a workplan approved by DOE (LBNL, 1997b), LBNL performed additional environmental sampling in 1998.

SECTION 2
SITE DESCRIPTION AND HISTORY

SWMUs 11-2 and 11-3 are located in the area of Building 74 (**Figure 2**), which is the site of the Life Sciences Functional Area, formerly known as the East Canyon Research Area. The Human Genome Laboratory, a national research facility, was recently constructed in the area. Following are descriptions and histories of SWMUs 11-2 and 11-3.

2.1 BUILDING 74 INACTIVE ABOVEGROUND RADIOACTIVE WASTE STORAGE TANKS (SWMU 11-3)

2.1.1 Site Description

Six inactive tanks are located downslope and south of Building 74 within and adjacent to the LBNL perimeter (**Figure 2**). The tanks are single-walled and sit on a rectangular concrete pad in a side-by-side configuration of two rows (**Figure 3a**). An asphalt berm, six inches high, borders the southern portion of the pad. The berm is incomplete due to deterioration. The other three sides of the pad are bordered by a concrete retaining wall that is built into the hillside that slopes to the south and east. An asphalt-covered driveway is immediately south of the asphalt berm.

The general piping system of the tanks, shown on **Figure 3a**, includes two waste lines from Building 74 (the routing of the lines from Building 74 to the tanks is shown on **Figure 2**). A detailed view of the present piping configuration at the tanks are schematically represented on **Figure 3b**. Tanks 8-74 and 9-74 are connected with an inactive "hot waste line" that originates in the former metabolic chamber in Building 74, where radioactive experiments were conducted (location of the chamber is shown on **Figure 2**). The hot waste line runs through a strainer box at the northwest corner of the concrete pad (**Figures 3a and 3b**) prior to connecting with Tanks 8-74 and 9-74. These two tanks are labeled "Caution Radioactive Waste" on their outer walls. The hot waste line is elevated approximately 8 feet above the concrete tank pad, and connections are near the tops of the two tanks. Overflow ports at the tops of these tanks are capped. The lines that exit the two tanks originate at the base of the tanks and run along the concrete tank pad

to an electric-powered pump, which distributed contents to an elevated "boom" for offloading and disposal (**Figure 3a and 3b**).

The other four tanks, Tanks 5-74, 6-74, 7-74, and 10-74, are connected to an inactive "acid waste line" that originates in Building 74 (**Figure 2**) and runs through a strainer dump sump at the northwest corner of the concrete pad adjacent to the hot line strainer box (**Figures 3a and 3b**). The acid waste line is elevated approximately 8 feet above the concrete tank pad, and connections to the four tanks are near the tops of the tanks. Overflow ports at the tops of these tanks are connected to elevated pipes that are routed to vertical pipes for connection to the exiting acid waste line that lies along the concrete tank pad. Connections to the exiting line are also via pipes emanating from the base of the four tanks. The exiting line leaves the tank pad through the western concrete wall and is routed to the sanitary sewer system (**Figures 2, 3a, and 3b**).

2.1.2 Site History

Tanks 8-74 and 9-74 were used to store liquid waste between approximately 1966 and 1972 that was generated from radioactive experiments conducted in the former metabolic chambers of Building 74. Routing of the wastes was through the hot waste line which connected the former metabolic chambers to the tanks. Radioactive isotopes of strontium, plutonium, rubidium, and other elements, including carbon (^{14}C) and sulfur (^{35}S), were used for these experiments. All liquid wastes were contained within the metabolic chamber in Building 74 prior to disposal to the tanks.

The contents from the two hot waste tanks were periodically tested for radioactivity. If the contents were not found to contain radioactivity, then they were disposed of directly to the sanitary sewer. If the contents were found to be radioactive, then they were pumped through an elevated boom to a disposal truck. In the early 1970s, the contents of all of the tanks were reportedly pumped out and the tanks were decommissioned. Environmental sampling was performed at the site in 1992, 1996, and 1998 (see Section 3). The sampling in 1998 was done in accordance with recommendations by DOE in 1997 (DOE, 1997), which were incorporated into the workplan approved by DOE (LBNL, 1997b).

2.2 BUILDING 74 ABANDONED RADIOACTIVE WASTE HOLDING TANKS (SWMU 11-2)

2.2.1 Site Description

Two single-walled tanks are located beneath the floor of Room 105 in Building 74. **Figure 2** shows the locations of the tanks within Building 74, and **Figure 4** gives both a detailed map view and cross-section view of the tanks. The tanks are approximately 7 feet from the south wall of the building, and the bottoms of the tanks are approximately 7 feet below the base of the building floor. A manhole 9 feet deep is between the tanks and the building wall. The tanks and the manhole are connected to the sanitary sewer lines (**Figures 2 and 4**).

2.2.2 Site History

The two tanks were emplaced below ground in 1964 outside Building 74. The building was later expanded over the tank location. The tanks were originally designed to store wastewater generated from experiments conducted in Building 74. An engineering drawing (No. 4B74P018, dated January 1964) made prior to tank emplacement indicates that acid waste from Building 74 was to be pumped into these tanks. During the period of tank use, wastes from all sinks within Building 74 were routed to the tanks. No radioactive wastes were routed to the tanks. Instead, the tanks essentially functioned as part of the sanitary sewer system. No secondary containment was implemented. The tanks were active until about 1976 and then were filled in place with sand for abandonment prior to the Building 74 expansion. An environmental investigation of the tanks was conducted in 1996 (see Section 3). No further surveys (i.e., environmental sampling) were recommended by DOE in 1997 (DOE, 1997).

SECTION 3
SAMPLING RESULTS

During environmental investigations at SWMU 11-2 and SWMU 11-3, several samples of various media were collected for laboratory analysis. The analytical data are presented in the tables attached to this report. **Tables 1a** through **1f** contain all results of sampling at SWMU 11-3, and **Tables 2a** and **2b** have the sampling results for SWMU 11-2. Some of these results are also presented on figures in this report. **Figures 5a, 5b, 5c, and 5d** show some of the analytical results for samples collected at SWMU 11-3. **Figure 6** shows locations of soil samples collected at SWMU 11-2.

The following discussions outline sampling activities and analytical results for SWMU 11-2 and SWMU 11-3. Justifications are also given for NFA status requests. The work performed did not include implementation of site controls or demolition, which were recommended for consideration by DOE (DOE, 1997), but are outside the scope of the RCRA corrective action process.

3.1 BUILDING 74 INACTIVE ABOVEGROUND RADIOACTIVE WASTE STORAGE TANKS (SWMU 11-3)

3.1.1 Sampling Activities

Three soil samples were collected in June 1992 at three locations (SB74-92-14, SB74-92-15A, and SB74-92-15B on **Figure 5a**) in the vicinity of the six tanks as part of the RFA. The samples were collected between 2 and 3 feet bgs and analyzed for metals (EPA Method 6010) and organic compounds (EPA Method 8240). SB74-92-14 and SB74-92-15A were located adjacent to the concrete surface drain about 10 feet south of the tank pad. SB74-92-15B was located adjacent to the strainer box and strainer dump sump on the slope north of the tank retaining wall.

In June 1996 as part of the RFI, two angled borings were drilled immediately south of the asphalt berm near Tank 10-74 (SB74T-96-1 and SB74T-96-1A on **Figure 5a**). Both borings met

auger refusal and could not be completed to the proposed depth. Shallow soil samples were collected from a maximum depth of 3 feet from the attempted borings. Also, shallow soil samples were collected from a third location immediately south of the asphalt berm near Tank 8-74 (SB74T-96-2 on **Figure 5a**). Samples from the three borings were analyzed for gross alpha radiation, gross beta radiation, gamma radiation, strontium-90, and metals (EPA Method 6010).

In September 1996, as part of continuing RFI activities, two holes were cut in the concrete at locations between the tanks near the center of the pad (SB74T-96-3 and SB74T-96-4 on **Figure 5a**). Three soil samples were collected at both locations from depths of approximately 1 to 3 feet below the concrete. All samples were analyzed for metals (EPA Method 6010), gross alpha radiation, gross beta radiation, gamma radiation, and strontium-90.

In February 1998, samples of soil, concrete, loose material on the concrete (mainly soil), and liquid within Tanks 8-74 and 9-74 were collected. Also, swipe samples were collected from the exterior of Tanks 8-74 and 9-74, from the exterior of piping connected to these two tanks, and from the pump and associated piping. Samples collected from piping exteriors were at locations where leaking was most likely to have occurred. All swipe samples and samples of liquid within tanks were collected by the LBNL Radiation Protection Group. All of the February 1998 samples were collected in response to recommendations made by DOE (DOE, 1997) in their review of LBNL's request of NFA status for SWMU 11-2 and SWMU 11-3 (LBNL, 1997a). Sampling was performed according to protocols specified in the DOE-approved workplan (LBNL, 1997b). All sampling locations are shown on **Figure 5a**, and the different sample types are distinguishable by symbology as explained on the figure. All of the samples were analyzed for gross alpha radiation, gross beta radiation, and gamma radiation. Specific gamma radioisotopes were identified where gamma radiation was detected.

3.1.2 Analytical Results

3.1.2.1 Soil Samples

Soil sample analytical results for radionuclides are given in **Tables 1a and 1b**. Gross alpha radiation was detected in only one soil sample at the site: 8 ± 5 pCi/g in SB74TK-98-1 (**Figure 5b**). Gross beta radiation was detected in 14 of the 22 soil samples analyzed for

radionuclides. Detected concentrations ranged from 5 ± 1 pCi/g to 16 ± 2 pCi/g (**Figure 5c**). Gamma radiation was detected in all of the 22 soil samples analyzed for radionuclides. Detected concentrations of gamma radiation for the 1996 soil samples (**Table 1a**) were reported as total gamma and ranged from 6 ± 1 pCi/g to 18 ± 2 pCi/g. These total gamma results were determined by the analytical laboratory to be from naturally-occurring potassium-40. The gamma radiation results for the 1998 soil samples (**Table 1b**) were reported as individual gamma isotopes. The isotopes identified were potassium-40, thorium-232, and naturally-occurring uranium, and all three isotopes were detected in each 1998 soil sample. **Figure 5d** shows the gamma radiation analytical results. Maximum detected concentrations of the gamma isotopes are 9.7 ± 0.9 pCi/g potassium-40, 0.31 ± 0.06 pCi/g thorium-232, and 1.2 ± 0.5 pCi/g naturally-occurring uranium. No strontium-90 was detected in any of the soil samples (**Table 1a**).

Cadmium and lead were the only metals detected in soil samples at concentrations above the maximum background concentrations at LBNL (**Table 1c**). These detections were in the soil samples detected during the RFA in 1992 (SB74-92-14, SB74-92-15A, and SB74-92-15B on **Figure 5a**). Maximum concentrations were 4.5 mg/kg cadmium and 84 mg/kg lead. The RFA soil samples were also analyzed for organic compounds; none were detected (**Table 1d**).

3.1.2.2 Samples of Loose Material and Concrete

Analytical results of loose material and concrete samples collected in 1998 at the site are given in **Table 1b**. Gross alpha radiation (**Figure 5b**) was not detected in any of the loose material or concrete samples. Gross beta radiation (**Figure 5c**) was detected in 3 of the 5 samples of loose material (maximum 9 ± 2 pCi/g) and in one of the two concrete samples (12 ± 2 pCi/g). Gamma radioisotopes (**Figure 5d**) were identified in all of the loose material and concrete samples. These isotopes were potassium-40 (in all samples), thorium-232 (all concrete samples and 4 of 5 loose material samples), naturally-occurring uranium (one concrete sample and two loose material sample), beryllium-7 (one concrete sample and one loose material sample), cesium-137 (both concrete samples), and americium-241 (both concrete samples).

3.1.2.3 Swipe Samples

Analytical results of the 14 swipe samples collected in 1998 are given in **Table 1e**. Gross alpha radiation was only detected in swipe samples collected on the pump and on the piping near the offloading boom (**Figure 5b**) at concentrations of 1.82 $\pm$ 0.21 disintegrations per minute per swipe (DPM/Swipe) and 2.73 $\pm$ 0.27 DPM/Swipe, respectively. Gross beta radiation (**Figure 5c**) was detected in only three swipe samples: one sample from the exterior of Tank 8-74 (5.8 DPM/Swipe), one sample from piping near Tank 9-74 (3.9 $\pm$ 0.32 DPM/Swipe), and one sample from piping near the pump (4.5 $\pm$ 0.37 DPM/Swipe). Gamma radiation was not detected in any of the swipe samples.

3.1.2.4 Tank Liquids Samples

The analytical results of liquid collected from Tanks 8-74 and 9-74 (the tanks that were formerly connected to the hot waste line) are given on **Table 1f**. Gross alpha radiation (**Figure 5b**) was detected in the sample from Tank 9-74 (13 $\pm$ 8 pCi/L). Gross beta radiation (**Figure 5c**) was detected in samples from both tanks (180 $\pm$ 27 and 268 $\pm$ 11 pCi/L). Gamma radioisotopes (**Figure 5d**) were identified in samples from both tanks: potassium-40 (maximum 339 $\pm$ 83 pCi/L) and cobalt-60 (maximum 16 $\pm$ 6 pCi/L) in both tanks, and thorium-232 (18 $\pm$ 8 pCi/L) in Tank 9-74.

3.1.3 Interpretation of Results

3.1.3.1 Radionuclides

Detections of gross alpha and gross beta radiation were reported at concentrations near the Method Detection Amount (MDA), and therefore may be due to naturally-occurring radiation. Several gamma radioisotopes were detected. Potassium-40, thorium-232, and uranium-235 are all naturally-occurring, and their detected concentrations were all relatively low (i.e., near the MDA) and consistent with amounts normally found in the environment. Other gamma radioisotopes detected (beryllium-7, cesium-137, americium-241, and cobalt-60) are not naturally-occurring, but their presence at the site may not be due to contamination from the storage tanks (cobalt-60 was not found outside of the tanks). Beryllium-7 is cosmogenic (i.e.,

produced from atmospheric processes). Cesium-137, americium-241, and cobalt-60 are known to be present in the environment in small quantities due to past atmospheric testing of atomic weapons. Their detected concentrations were all relatively low (i.e., near the MDA).

3.1.3.2 Metals and Organic Compounds

Cadmium and lead were the only metals detected in soil at concentrations above the maximum background concentrations for these metals at LBNL (2.7 mg/kg cadmium and 16.1 mg/kg lead). The maximum detected concentrations of these metals (4.5 mg/kg cadmium and 84 mg/kg lead) were below the USEPA Region IX Preliminary Remediation Goals (PRGs) for cadmium (9 mg/kg) and lead (130 mg/kg) as defined for a residential soil scenario. PRGs are concentration goals for individual constituents for specific media (i.e., soil, water, and air) in combination with specific land uses. Many of the PRGs are based on potential risks to human health. As approved by the DTSC, LBNL uses USEPA Region IX PRGs and California-modified PRGs (EPA, 1996) as a screening tool for the evaluation of future action at a site. Since the maximum detected concentrations of cadmium and lead are below their PRGs, no further action addressing metals in soil is necessary. Also, since no organic chemicals were detected in soil samples at the site, no further action is warranted for these constituents.

3.2 BUILDING 74 ABANDONED RADIOACTIVE WASTE HOLDING TANKS (SWMU 11-2)

3.2.1 Sampling Activities

Two borings (SB74-96-1 and SB74-96-2 on **Figure 6**) were drilled at a 45-degree angle beneath the tanks in June 1996 as part of RFI activities. Soil samples were collected from 4 locations in each boring at linear depths between 20 to 36 feet (between approximately 14 and 25 feet bgs). Soil samples from all depths were analyzed for organic compounds (EPA Method 8260) and pH. Samples collected from the bottom three locations (linear depths of approximately 25, 30, and 35 feet) were also analyzed for gross alpha radiation, gross beta radiation, gamma radiation, and strontium-90.

3.2.2 Analytical Results

Soil sample analytical results for radionuclides are given in **Table 2a**. Gross alpha radiation and gross beta radiation were not detected in any of the samples. Gamma radiation was detected in all 6 samples analyzed for radionuclides at concentrations ranging from 3 $\pm$ 2 pCi/g to 18 $\pm$ 8 pCi/g. These gamma radiation detections were determined by the analytical laboratory to be from naturally-occurring potassium-40. Also, no strontium-90 was detected in any of the samples. No organic chemicals were detected in any of the soil samples collected (**Table 2b**). Based on these soil sample results, no release of contaminants has occurred from the tanks, and no further action is necessary.

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LBNL (1997b). *Workplan for Investigation at the Building 74 Six Inactive Aboveground Radioactive Waste Holding Tanks (SWMU 11-3).* Lawrence Berkeley National Laboratory Environmental Restoration Program, Lawrence Berkeley National Laboratory, Berkeley, California. November 1997.

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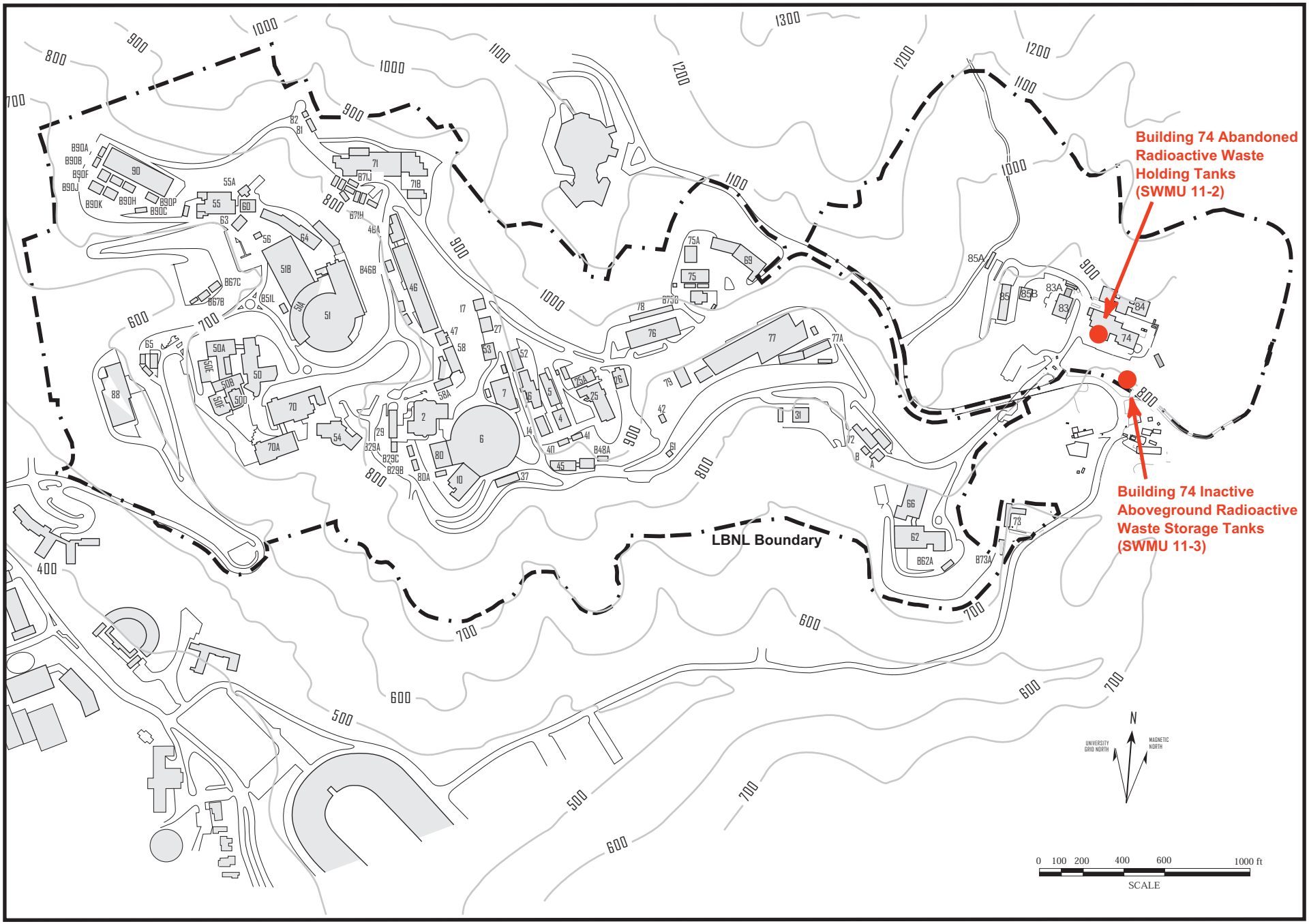

Figure 1. Site Location Map and Topography, Lawrence Berkeley National Laboratory (LBNL).

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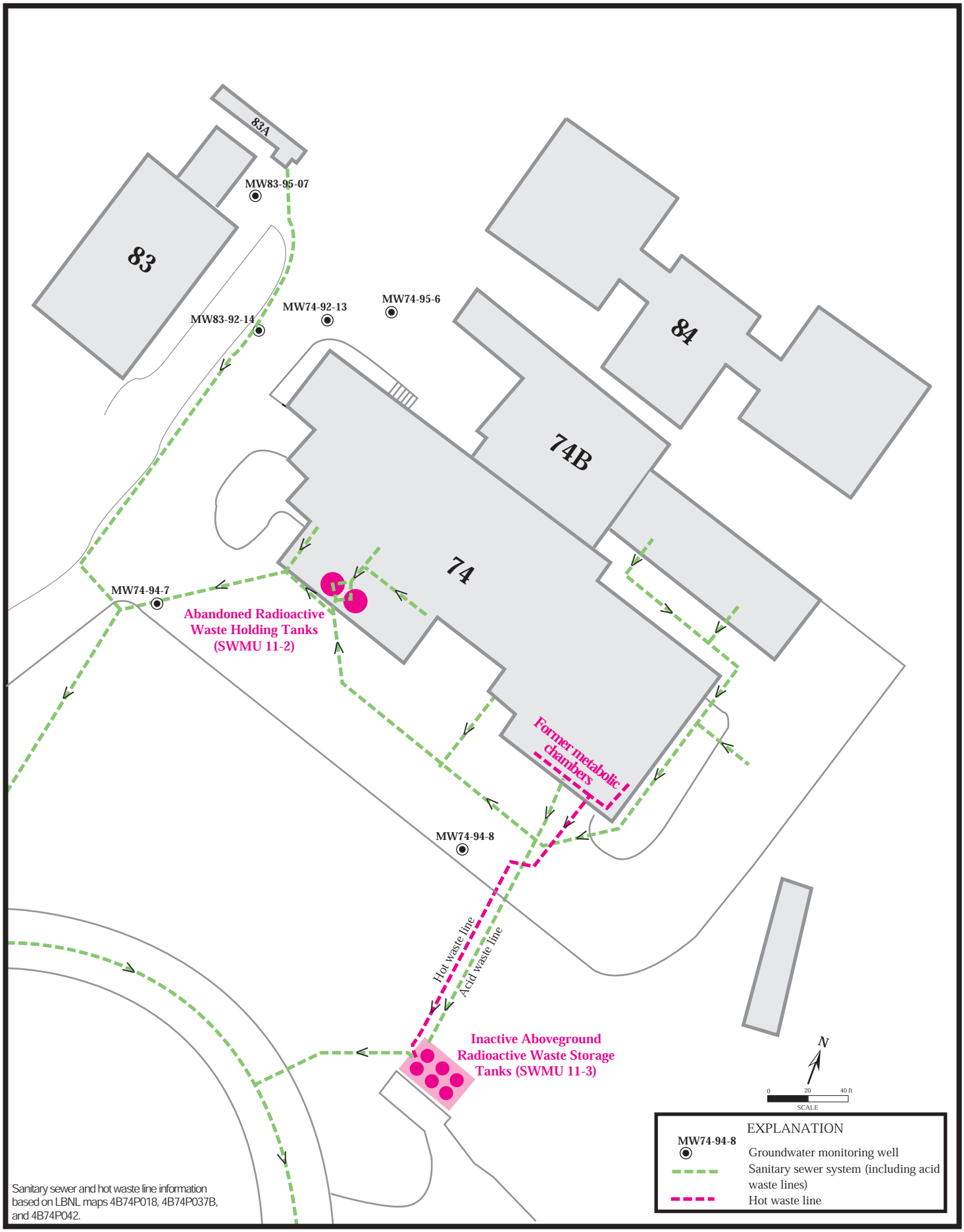

2-B74Area.ai
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Figure 2. Site Map, Building 74 Area and Location of Abandoned Radioactive Waste Holding Tanks (SWMU 11-2) and Inactive Aboveground Radioactive Waste Storage Tanks (SWMU 11-3).

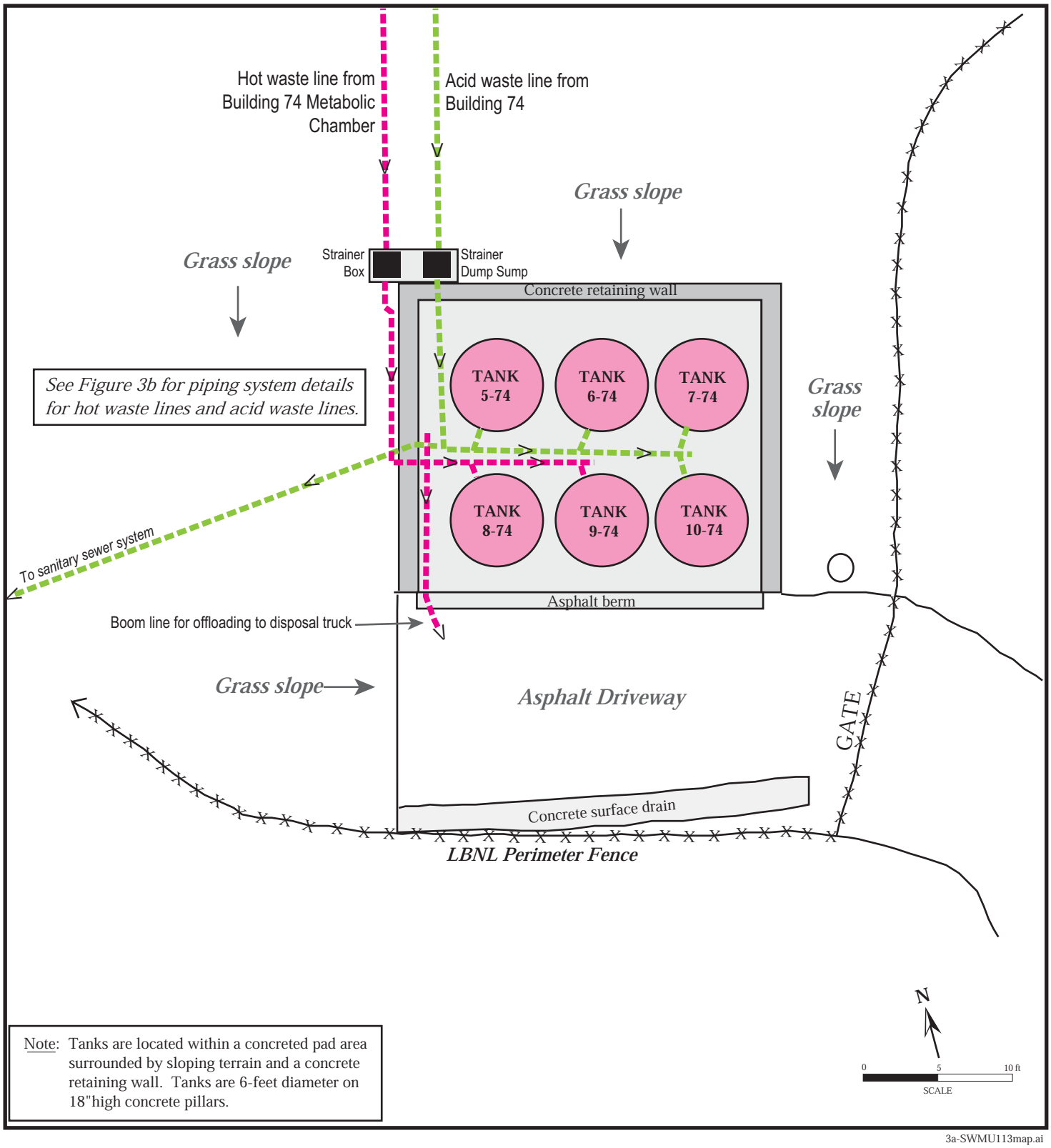

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Figure 3a. Site Map, Building 74 Inactive Aboveground Radioactive Waste Storage Tanks (SWMU 11-3).

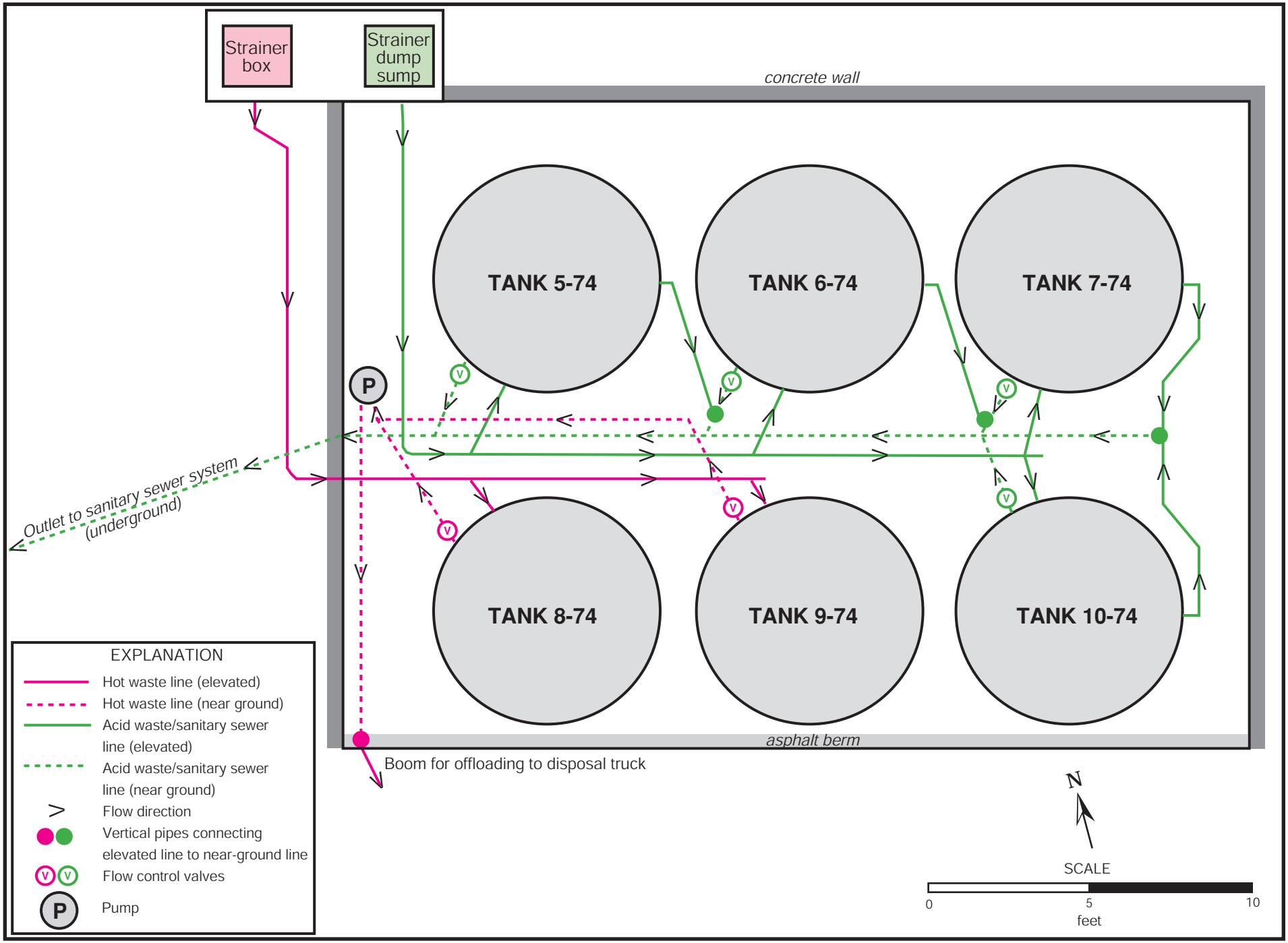

Figure 3b. Detailed Map of Piping System at Building 74 Inactive Aboveground Radioactive Waste Storage Tanks (SWMU 11-3).

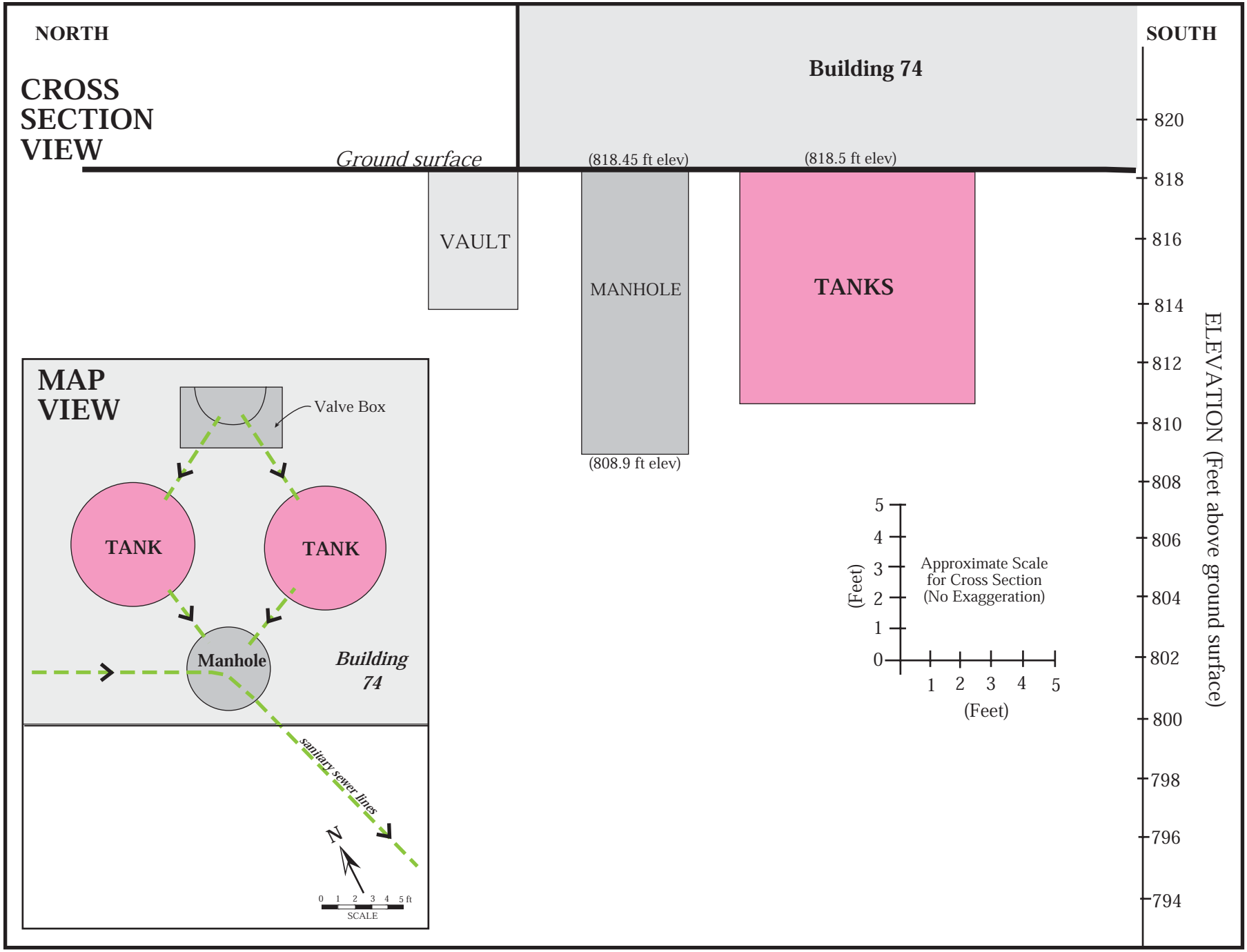

Figure 4. Site Map and Cross Section View, Building 74 Abandoned Above Ground Radioactive Waste Holding Tanks (SWMU 11-2).

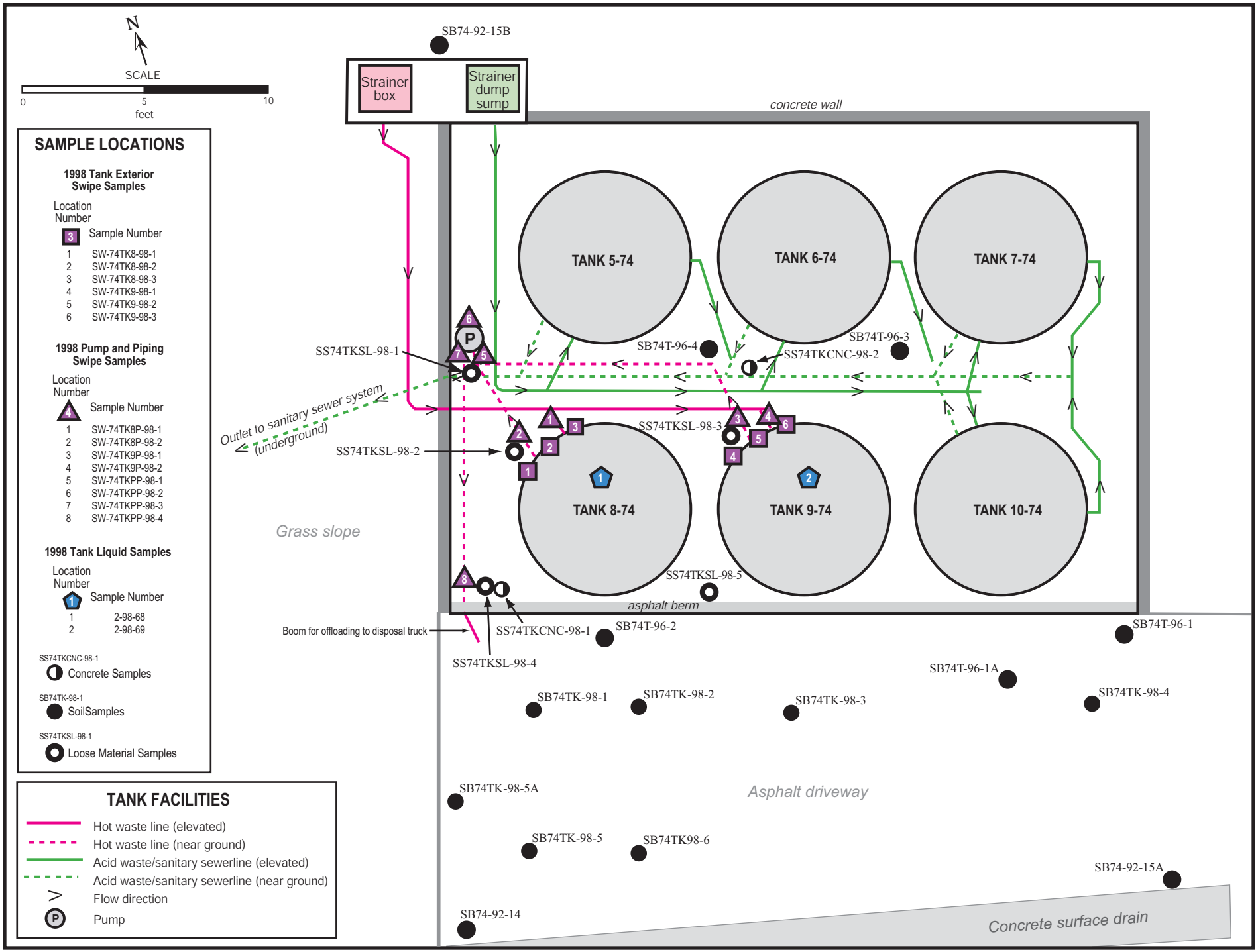

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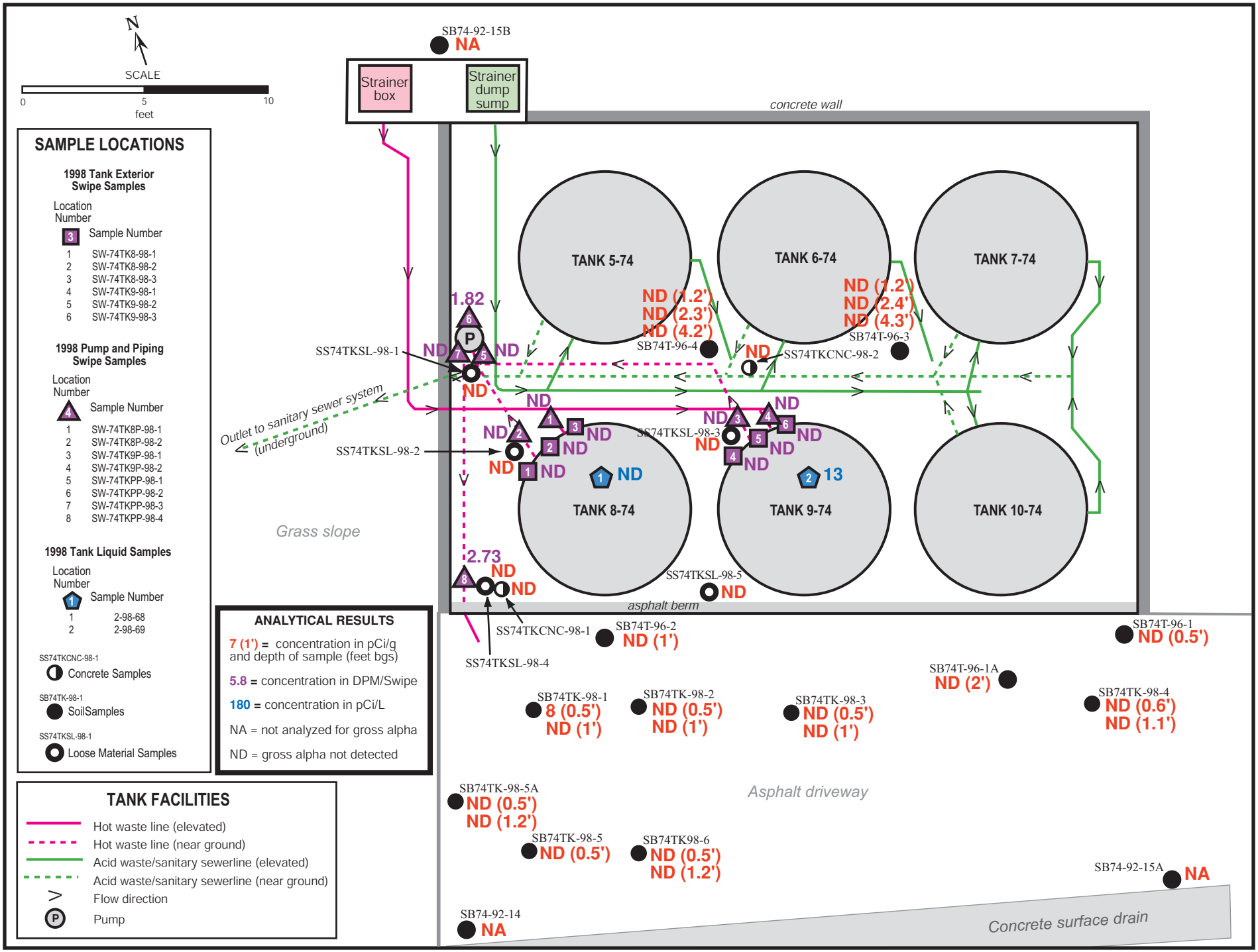
Figure 5a. Sample Locations, Building 74 Inactive Aboveground Radioactive Waste Storage Tanks (SWMU 11-3).



5b-alpha.ai
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Figure 5b. Gross Alpha Analytical Results, Building 74 Inactive Aboveground Radioactive Waste Storage Tanks (SWMU 11-3).

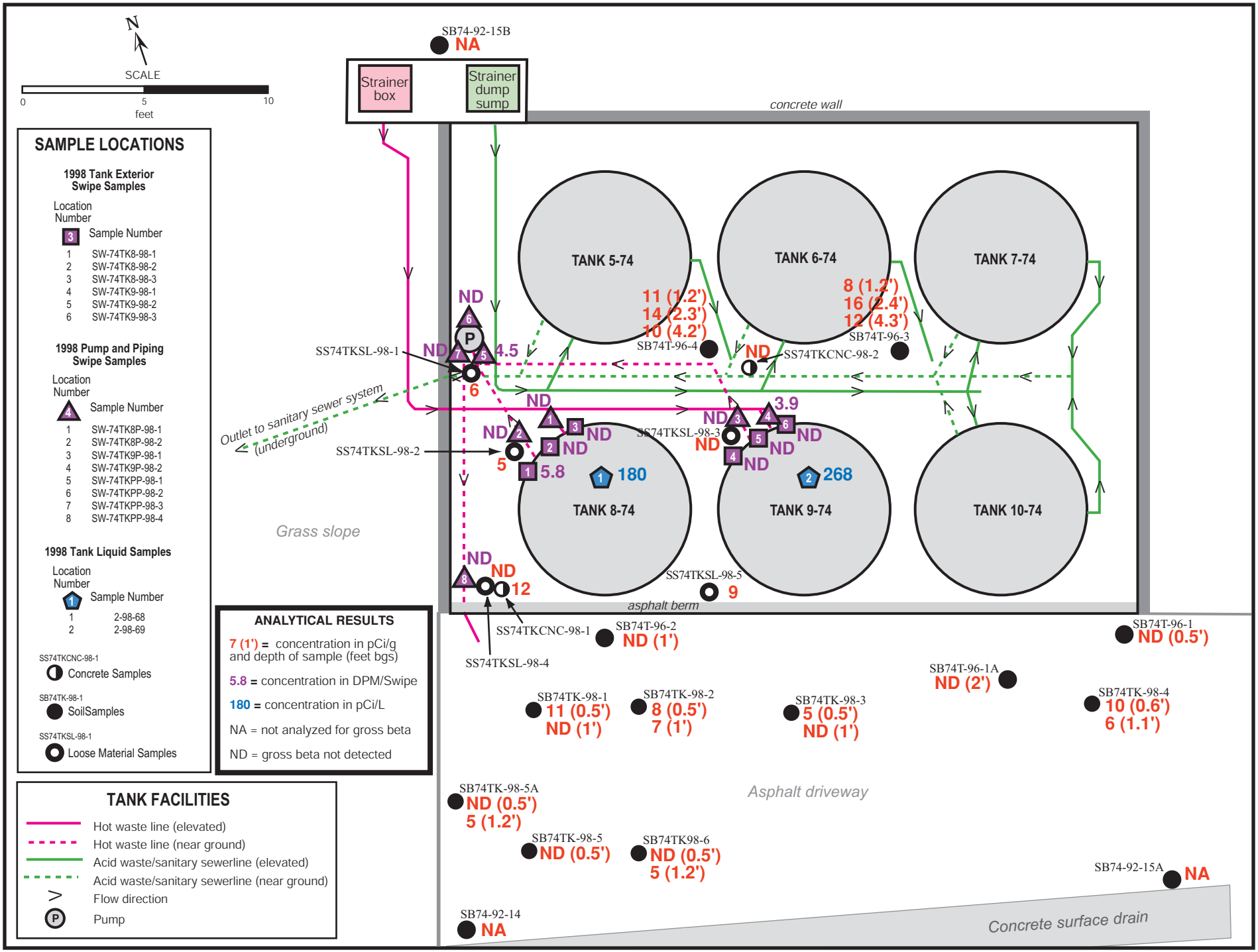

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Figure 5c. Gross Beta Analytical Results, Building 74 Inactive Aboveground Radioactive Waste Storage Tanks (SWMU 11-3).

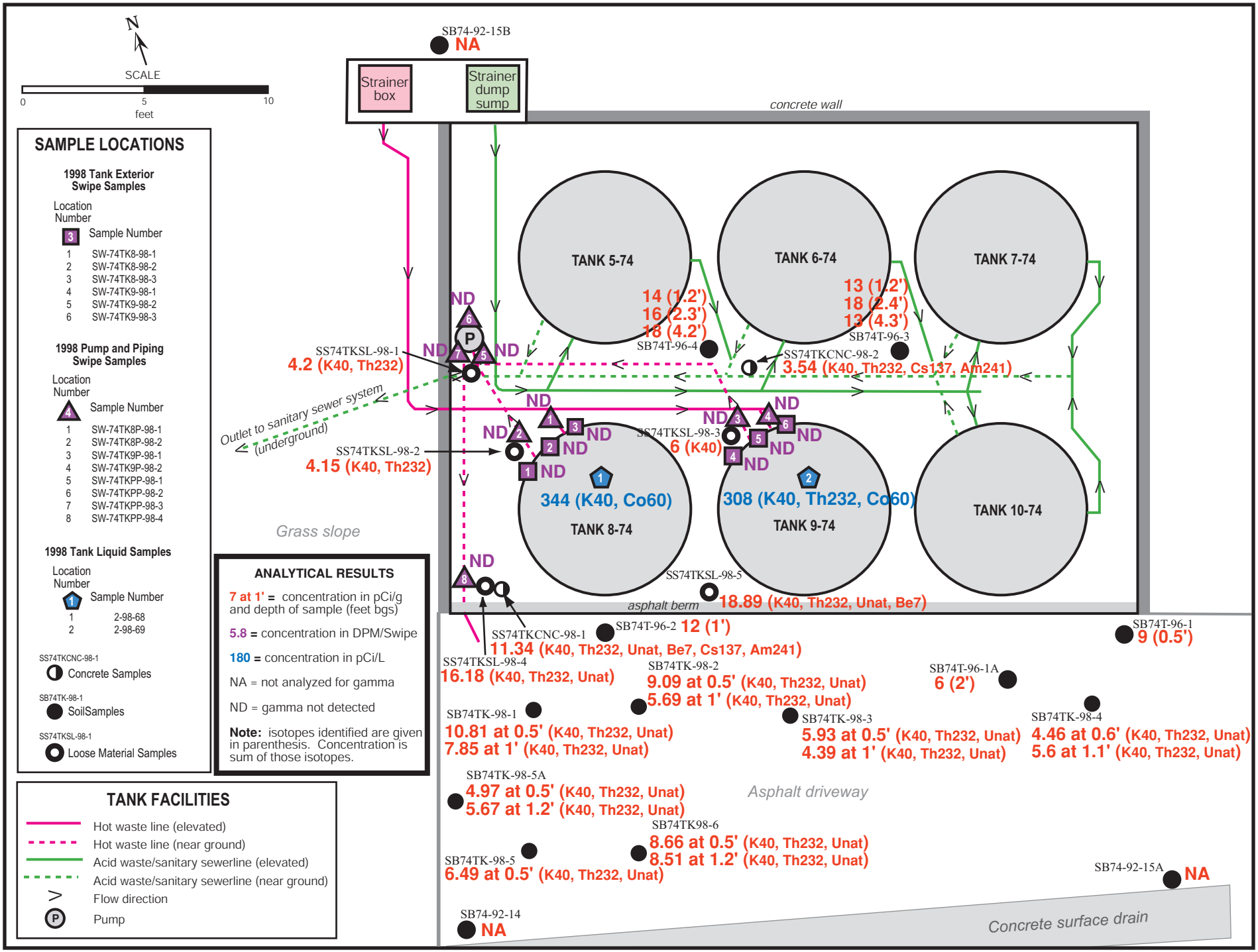

Figure 5d. Gamma Analytical Results, Building 74 Inactive Aboveground Radioactive Waste Storage Tanks (SWMU 11-3).

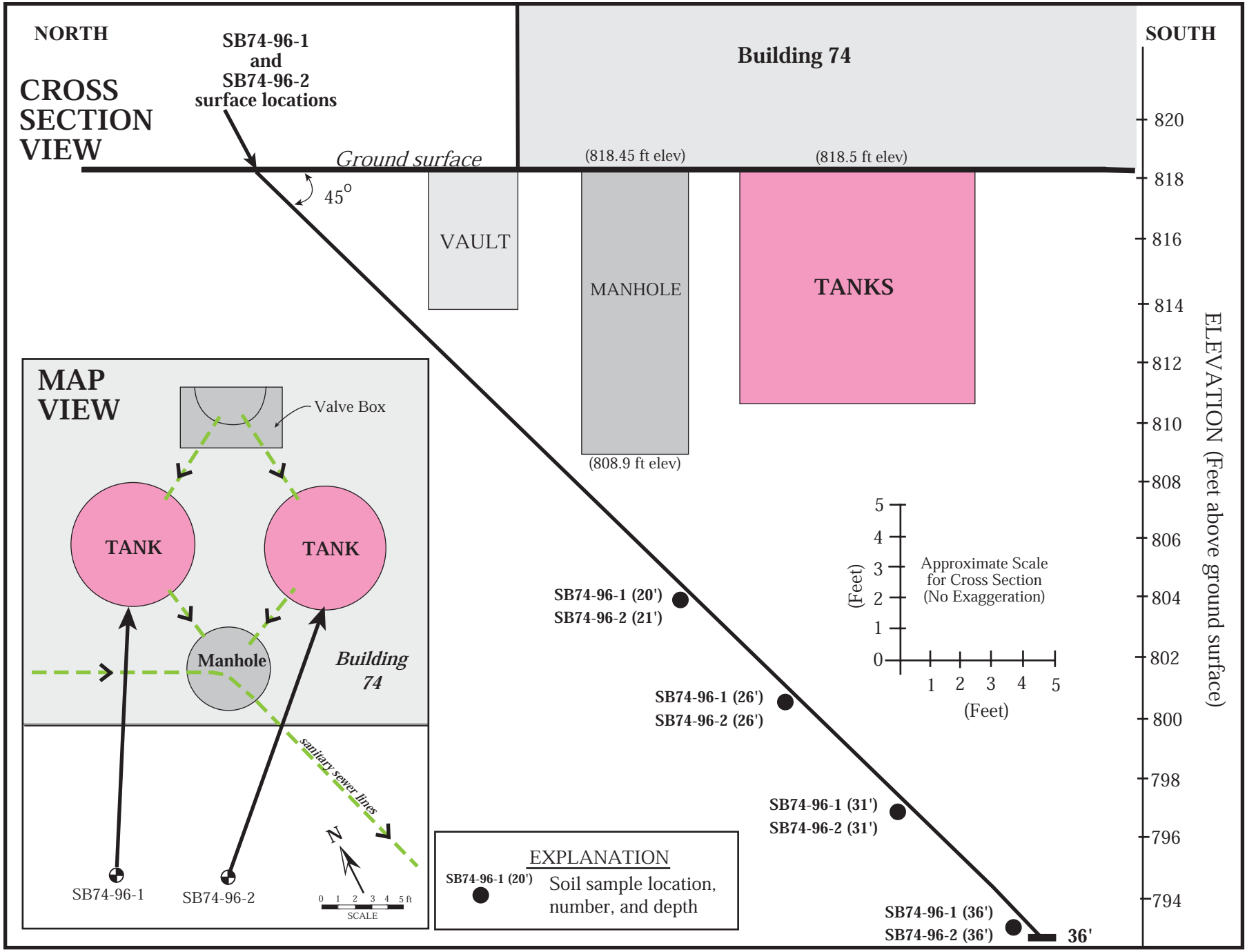

Figure 6. Site Map and Cross Section with Soil Sampling Locations, Building 74 Abandoned Above Ground Radioactive Waste Holding Tanks (SWMU 11-2).

6-SmplLocs.ai
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Table 1a.

Results of Radionuclides Analyses: 1996 Soil Samples

Building 74 Abandoned Aboveground Radioactive Waste Holding Tanks (SWMU 11-3)

Sample Type and Number	DATE	Gross Alpha	Gross Beta	Gamma	Strontium-90
		All results are in units of picocuries per gram (pCi/g)			
SB74T-96-1-0.5	**Jun 96**	ND (<12)	ND (<12)	**9 ± 2**	ND (<0.1)
SB74T-96-1A-2.0	**Jun 96**	ND (<12)	ND (<12)	**6 ± 1**	ND (<0.1)
SB74T-96-2-1.0	**Jun 96**	ND (<12)	ND (<12)	**12 ± 1**	ND (<0.1)
SB74T-96-3-1.2	**Sep 96**	ND (<9)	**8 ± 2**	**13 ± 1**	ND (<0.2)
SB74T-96-3-2.4	**Sep 96**	ND (<9)	**16 ± 2**	**18 ± 2**	ND (<0.1)
SB74T-96-3-4.3	**Sep 96**	ND (<8)	**12 ± 1**	**13 ± 2**	ND (<0.1)
SB74T-96-4-1.2	**Sep 96**	ND (<10)	**11 ± 2**	**14 ± 2**	ND (<0.1)
SB74T-96-4-2.3	**Sep 96**	ND (<11)	**14 ± 2**	**16 ± 2**	ND (<0.1)
SB74T-96-4-4.2	**Sep 96**	ND (<10)	**10 ± 2**	**18 ± 2**	ND (<0.1)

Note: All gamma results were determined to be from naturally-occurring K-40

ND = not detected (method detection amount in parenthesis).

Analyses performed by Lawrence Berkeley Laboratory Analytical Services Group.

Table 1b.

Analytical Results of Samples of Loose Material, Concrete, and Shallow Soil: 1998 Samples
Building 74 Abandoned Aboveground Radioactive Waste Holding Tanks (SWMU 11-3)

Sample Type and Number	DATE	Gross Alpha	Gross Beta	Gamma Isotopes Identified					
				K-40	Th-232	U-natural	Be-7	Cs-137	Am-241
				All results are in units of picocuries per gram (pCi/g)					
Loose Material									
SS-74TKSL-98-1-0.0	**Feb 98**	ND (<7)	**6 ± 1**	**4 ± 2**	**0.2 ± 0.1**	NI	NI	NI	NI
SS-74TKSL-98-2-0.0	**Feb 98**	ND (<7)	**5 ± 1**	**4 ± 1**	**0.15 ± 0.09**	NI	NI	NI	NI
SS-74TKSL-98-3-0.0	**Feb 98**	ND (<7)	ND (<6)	**6 ± 2**	NI	NI	NI	NI	NI
SS-74TKSL-98-4-0.0	**Feb 98**	ND (<7)	ND (<5)	**7 ± 1**	**0.18 ± 0.06**	**9 ± 1**	NI	NI	NI
SS-74TKSL-98-5-0.0	**Feb 98**	ND (<7)	**9 ± 2**	**8 ± 1**	**0.29 ± 0.26**	**10 ± 1**	**0.6 ± 0.3**	NI	NI
Concrete									
SS-74TKCNC-98-1-0.0	**Feb 98**	ND (<7)	**12 + 2**	**9.7 ± 0.9**	**0.3 ± 0.1**	**0.8 ± 0.4**	**0.4 ± 0.2**	**0.04 ± 0.02**	**0.10 ± 0.05**
SS-74TKCNC-98-2-0.0	**Feb 98**	ND (<7)	ND (<4)	**3.1 ± 0.5**	**0.27 ± 0.07**	NI	NI	**0.05 ± 0.03**	**0.12 ± 0.05**
Shallow Soil Samples									
SB74TK-98-1-0.5	**Feb 98**	**8 ± 5**	**11 ± 2**	**9.7 ± 0.9**	**0.31 ± 0.3**	**0.8 ± 0.4**	NI	NI	NI
SB74TK-98-1-1.0	**Feb 98**	ND (<7)	ND (<5)	**6.6 ± 0.7**	**0.25 ± 0.04**	**1.0 ± 0.6**	NI	NI	NI
SB74TK-98-2-0.5	**Feb 98**	ND (<7)	**8 ± 2**	**7.6 ± 0.8**	**0.29 ± 0.05**	**1.2 ± 0.5**	NI	NI	NI
SB74TK-98-2-1.0	**Feb 98**	ND (<7)	**7 ± 2**	**4.6 ± 0.6**	**0.19 ± 0.04**	**0.9 ± 0.6**	NI	NI	NI
SB74TK-98-3-0.5	**Feb 98**	ND (<7)	**5 ± 1**	**4.8 ± 0.6**	**0.23 ± 0.03**	**0.9 ± 0.6**	NI	NI	NI
SB74TK-98-3-1.0	**Feb 98**	ND (<7)	ND (<4)	**3.4 ± 0.5**	**0.19 ± 0.04**	**0.8 ± 0.5**	NI	NI	NI
SB74TK-98-4-0.6	**Feb 98**	ND (<7)	**10 ± 2**	**3.5 ± 0.4**	**0.16 ± 0.03**	**0.8 ± 0.4**	NI	NI	NI
SB74TK-98-4-1.1	**Feb 98**	ND (<7)	**6 ± 1**	**4.6 ± 0.6**	**0.10 ± 0.04**	**0.9 ± 0.6**	NI	NI	NI
SB74TK-98-5-0.5	**Feb 98**	ND (<7)	ND (<4)	**5.3 ± 0.6**	**0.19 ± 0.03**	**1.0 ± 0.5**	NI	NI	NI
SB74TK-98-5A-0.5	**Feb 98**	ND (<7)	ND (<5)	**4.1 ± 0.5**	**0.17 ± 0.03**	**0.7 ± 0.4**	NI	NI	NI
SB74TK-98-5A-1.2	**Feb 98**	ND (<7)	**5 ± 1**	**4.8 ± 0.5**	**0.17 ± 0.03**	**0.7 ± 0.4**	NI	NI	NI
SB74TK-98-6-0.6	**Feb 98**	ND (<7)	**7 ± 2**	**7.6 ± 0.8**	**0.26 ± 0.05**	**0.8 ± 0.7**	NI	NI	NI
SB74TK-98-6-1.0	**Feb 98**	ND (<7)	ND (<4)	**7.2 ± 0.9**	**0.31 ± 0.06**	**1.0 ± 0.9**	NI	NI	NI

Note: Results of Th-232 and U-natural were calculated with the decay products of the natural uranium and thorium chains.

ND = not detected (method detection amount in parenthesis).

NI = not identified during gamma analysis.

Analyses performed by Lawrence Berkeley Laboratory Analytical Services Group.

Table 1c.

Soil Sampling Results for Metals
Building 74 Abandoned Aboveground Radioactive Waste Holding Tanks (SWMU 11-3)
All results are in units of milligrams per kilogram (mg/kg)

		Sb	As	Ba	Be	Cd	Cr	CrVI	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	Tl	V	Zn
Maximum Background Concentrations		5.5	19.1	323.6	1.0	2.7	99.6		22.2	69.4	16.1	0.4	7.4	119.8	5.6	1.8	27.1	74.3	106.1
USEPA Region 9 PRGs		31	0.38*	5300	0.14	38	210	30	4600	2800	400	6.5*	380	1500	380	380		540	23000
California Modified PRGs						9		0.2*			130			150					
Boring / Sample Number	**Date**																		
SB74-92-14-3.0	**Jun 92**	*< 1*	2.5	77	0.23	4.5	*< 0.5*	NA	7.8	10	11	0.07	*< 0.25*	34	*< 0.5*	*< 0.25*	*< 2*	18	40
SB74-92-15A-2.0	**Jun 92**	1.1	5.4	77	0.23	3.4	34	NA	12	19	31	0.12	0.5	42	*< 0.5*	*< 0.25*	*< 2*	31	99
SB74-92-15B-3.0	**Jun 92**	1.2	4.8	77	0.24	3.3	53	NA	11	16	84	*< 0.05*	0.55	34	*< 0.5*	*< 0.25*	*< 2*	34	66
SB74T-96-1-1.0	**Jun 96**	*< 10*	2.1	93	*< 1*	*< 1*	54	NA	8.7	25	5.8	*< 0.2*	5	33	1.8	*< 2*	*< 10*	47	76
SB74T-96-1A-3.0	**Jun 96**	*< 10*	2.7	67	*< 1*	*< 1*	36	NA	8.3	30	*< 5*	*< 0.2*	*< 5*	32	1.8	*< 2*	*< 10*	54	60
SB74-96-2-1.5	**Jun 96**	*< 10*	2.2	120	*< 1*	*< 1*	36	NA	12	45	*< 5*	*< 0.2*	*< 5*	43	2	*< 2*	*< 10*	48	71
SB74T-96-3-1.2	**Sep 96**	*< 10*	3.7	98	*< 1*	1.2	68	NA	16	27	*< 5*	*< 0.2*	*< 5*	92	1.3	*< 2*	*< 10*	46	73
SB74T-96-3-2.4	**Sep 96**	*< 10*	4.9	98	*< 1*	1.2	72	NA	14	31	5.1	*< 0.2*	*< 5*	107	1.4	*< 2*	*< 10*	44	71
SB74T-96-3-4.3	**Sep 96**	*< 10*	*< 1*	59	*< 1*	*< 1*	54	NA	10	39	*< 5*	*< 0.2*	*< 5*	72	*< 1*	*< 2*	*< 10*	67	68
SB74T-96-4-1.2	**Sep 96**	*< 10*	5.0	139	*< 1*	1.4	64	NA	16	34	*< 5*	*< 0.2*	*< 5*	99	1.2	*< 2*	*< 10*	54	66
SB74T-96-4-2.3	**Sep 96**	*< 10*	5.4	111	*< 1*	*< 1*	69	NA	17	45	*< 5*	*< 0.2*	*< 5*	95	1.2	*< 2*	*< 10*	50	77
SB74T-96-4-4.2	**Sep 96**	*< 10*	5.6	99	*< 1*	*< 1*	74	NA	14	35	6.1	*< 0.2*	*< 5*	101	1.2	*< 2*	*< 10*	49	66
Standard Deviation (σ)						1.18					22.2								
Number of samples						12					12								
Kσ						0.669					12.5								
Mean (X_{av})						1.75					14.4								
95% UCL = X_{av} + Kσ						**2.42**					**27.0**								

*The PRG value for As is the cancer endpoint PRG (non-cancer endpoint PRG=22 mg/kg). The PRG for Cr assumes that detected Cr is 100% CrVI for screening purposes.
The PRG for Hg is for methyl(organic) mercury.

**Background concentrations derived from LBNL Soil Disposal Plan and from Shacklette and Borngen (1984).

NA	= Not analyzed
<5	= Not detected (reporting limit shown)
25	= Concentration above background but below PRG.
40	= Concentration above both background and PRG.

Table 1d.

Soil Sampling Results for Organic Compounds

Building 74 Abandoned Aboveground Radioactive Waste Holding Tanks (SWMU 11-3)

	Boring / Sample Numbers and Dates		
	SB74-92-14-3.0	**SB74-92-15A-2.0**	**SB74-92-15B-3.0**
	June 1992	**June 1992**	**June 1992**
Chemical Analyte (EPA Method 8240)	***All results are in units of milligrams per kilogram (mg/kg)***		
Acetone	<0.1	<0.1	<0.1
Benzene	<0.005	<0.005	<0.005
Bromodichloromethane	<0.005	<0.005	<0.005
Bromoform	<0.005	<0.005	<0.005
Bromomethane	<0.005	<0.005	<0.005
2-Butanone	<0.1	<0.1	<0.1
Carbon disulfide	<0.005	<0.005	<0.005
Carbon tetrachloride	<0.005	<0.005	<0.005
Chlorobenzene	<0.005	<0.005	<0.005
Chloroethane	<0.005	<0.005	<0.005
2-Chloroethylvinylether	<0.005	<0.005	<0.005
Chloroform	<0.005	<0.005	<0.005
Chloromethane	<0.005	<0.005	<0.005
Dibromochloromethane	<0.005	<0.005	<0.005
1,1-DCA	<0.005	<0.005	<0.005
1,2-DCA	<0.005	<0.005	<0.005
1,1-DCE	<0.005	<0.005	<0.005
cis-1,2-DCE	<0.005	<0.005	<0.005
trans-1,2-DCE	<0.005	<0.005	<0.005
1,2-Dichloropropane	<0.005	<0.005	<0.005
cis-1,3-Dichloropropene	<0.005	<0.005	<0.005
trans-1,3-Dichloropropene	<0.005	<0.005	<0.005
Ethylbenzene	<0.005	<0.005	<0.005
2-Hexanone	<0.05	<0.05	<0.05
Methylene chloride	<0.005	<0.005	<0.005
4-Methyl-2-Pentanone	<0.05	<0.05	<0.05
Styrene	<0.005	<0.005	<0.005
1,1,2,2-PCA	<0.005	<0.005	<0.005
PCE	<0.005	<0.005	<0.005
Toluene	<0.005	<0.005	<0.005
1,1,1-TCA	<0.005	<0.005	<0.005
1,1,2-TCA	<0.005	<0.005	<0.005
TCE	<0.005	<0.005	<0.005
Trichlorofluoromethane	<0.005	<0.005	<0.005
Vinyl acetate	<0.05	<0.05	<0.05
Vinyl chloride	<0.005	<0.005	<0.005
Total xylenes	<0.005	<0.005	<0.005

Table 1e.

Analytical Results of 1998 Swipe Samples
Building 74 Abandoned Aboveground Radioactive Waste Holding Tanks (SWMU 11-3)

Sample Type and Number	DATE	Gross Alpha	Gross Beta	Gamma
		All results are in units of disintegrations per minute per swipe (DPM/Swipe)		
Exterior of Tanks 8-74 and 9-74				
SW-74TK8-98-1	**Feb 98**	ND (<1.29)	**5.8**	ND (<3)
SW-74TK8-98-2	**Feb 98**	ND (<1.29)	ND (<3.8)	ND (<3)
SW-74TK8-98-3	**Feb 98**	ND (<1.29)	ND (<3.8)	ND (<3)
SW-74TK9-98-1	**Feb 98**	ND (<1.29)	ND (<3.8)	ND (<3)
SW-74TK9-98-2	**Feb 98**	ND (<1.29)	ND (<3.8)	ND (<3)
SW-74TK9-98-3	**Feb 98**	ND (<1.29)	ND (<3.8)	ND (<3)
Exterior of Tank Piping				
SW-74TK8P-98-1	**Feb 98**	ND (<1.29)	ND (<3.8)	ND (<3)
SW-74TK8P-98-2	**Feb 98**	ND (<1.29)	ND (<3.8)	ND (<3)
SW-74TK9P-98-1	**Feb 98**	ND (<1.29)	ND (<3.8)	ND (<3)
SW-74TK9P-98-2	**Feb 98**	ND (<1.29)	**3.9 $\pm$ 0.32**	ND (<3)
Exterior of Pump and Piping				
SW-74TKPP-98-1	**Feb 98**	ND (<1.29)	**4.5 $\pm$ 0.37**	ND (<3)
SW-74TKPP-98-2	**Feb 98**	**1.82 $\pm$ 0.21**	ND (<3.8)	ND (<3)
SW-74TKPP-98-3	**Feb 98**	ND (<1.29)	ND (<3.8)	ND (<3)
SW-74TKPP-98-4	**Feb 98**	**2.73 $\pm$ 0.27**	ND (<3.8)	ND (<3)

Note: Gamma results were determined using the Pb-214 peak which is a member of the decay chain of naturally-occurring U-238.
ND = not detected (method detection amount in parenthesis).
Analyses performed by Lawrence Berkeley Laboratory Analytical Services Group.
Quality control samples (blanks and spikes) were analyzed for gross alpha and gross beta and results were found to be acceptable by the laboratory.

Table 1f.

Analytical Results of 1998 Tank Liquids Samples

Building 74 Abandoned Aboveground Radioactive Waste Holding Tanks (SWMU 11-3)

Sample Type and Number	DATE	Gross Alpha	Gross Beta	Gamma Isotopes Identified		
				K-40	Th-232	Co-60
		All results are in units of picocuries per liter (pCi/L)				
Tank 8-74						
2-98-68	**Feb 98**	ND (<4)	**180 ± 27**	**339 ± 83**	NI	**5 ± 4**
Tank 9-74						
2-98-69	**Feb 98**	**13 ± 8**	**268 ± 11**	**274 ± 76**	**18 ± 8**	**16 ± 6**

Note: Results of Th-232 were calculated with the Pb-212 daughter peak and were considered naturally-occurring Th-232.

ND = not detected (method detection amount in parenthesis).

NI = not identified during gamma analysis.

Analyses performed by Lawrence Berkeley Laboratory Analytical Services Group.

Table 2a.

Results of Radionuclides Analyses of Soil Samples

Building 74 Abandoned Radioactive Waste Holding Tanks (SWMU 11-2)

Sample Type and Number	DATE	Gross Alpha	Gross Beta	Gamma	Strontium-90
		All results are in units of picocuries per gram (pCi/g)			
SB74-96-1-25.5	**Jun 96**	ND (<12)	ND (<12)	**7 ± 1**	ND (<0.1)
SB74-96-1-30.5	**Jun 96**	ND (<12)	ND (<12)	**7 ± 1**	ND (<0.1)
SB74-96-1-35.5	**Jun 96**	ND (<12)	ND (<12)	**7 ± 1**	ND (<0.1)
SB74-96-2-25.5	**Jun 96**	ND (<12)	ND (<12)	**6 ± 1**	ND (<0.2)
SB74-96-2-30.5	**Jun 96**	ND (<12)	ND (<12)	**3 ± 2**	ND (<0.1)
SB74-96-2-35.5	**Jun 96**	ND (<12)	ND (<12)	**18 ± 8**	ND (<0.1)

Note: All gamma results were determined to be from naturally-occurring K-40

ND = not detected (method detection amount in parenthesis).

Analyses performed by Lawrence Berkeley Laboratory Analytical Services Group.

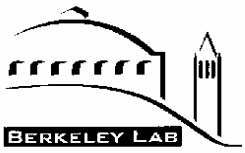
Table 2b.

Soil Sampling Results for Organic Compounds and pH
Building 74 Abandoned Radioactive Waste Holding Tanks (SWMU 11-2)

	Boring / Sample Numbers and Dates							
	SB74-96-1-20.0	**SB74-96-1-26.0**	**SB74-96-1-31.0**	**SB74-96-1-36.0**	**SB74-96-2-21.0**	**SB74-96-2-26.0**	**SB74-96-2-31.0**	**SB74-96-2-36.0**
	June 1996	**June 1996**	**June 1996**	**June 1996**	**June 1996**	**June 1996**	**June 1996**	**June 1996**
Chemical Analyte (EPA Method 8260)	*All results are in units of milligrams per kilogram (mg/kg)*							
Benzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Bromobenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Bromochloromethane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Bromodichloromethane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Bromoform	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Bromomethane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
n-Butylbenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
sec-Butylbenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
tert-Butylbenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Carbon tetrachloride	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Chlorobenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Chloroethane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Chloroform	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Chloromethane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
2-Chlorotoluene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
4-Chlorotoluene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Dibromochloromethane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,2-Dibromo-3-Chloropropane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,2-Dibromoethane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Dibromomethane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,2-Dichlorobenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,3-Dichlorobenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,4-Dichlorobenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Dichlorodifluoromethane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,1-DCA	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,2-DCA	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,1-DCE	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
cis-1,2-DCE	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
trans-1,2-DCE	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,2-Dichloropropane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,3-Dichloropropane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
2,2-Dichloropropane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,1-Dichloropropene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
cis-1,3-Dichloropropene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
trans-1,3-Dichloropropene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ethylbenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Hexachlorobutadiene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Isopropylbenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
p-Isopropyltoluene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Methylene chloride	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
n-Propylbenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Styrene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,1,1,2-PCA	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,1,2,2-PCA	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
PCE	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Toluene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,2,3-Trichlorobenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,2,4-Trichlorobenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,1,1-TCA	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,1,2-TCA	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TCE	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Trichlorofluoromethane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,2,3-Trichloropropane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,1,2-Trichloro-1,2,2-Trifluoroethane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,2,4-Trimethylbenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,3,5-Trimethylbenzene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Vinyl chloride	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total xylenes	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH (Method SW-9040)	9.00	7.70	7.85	9.25	8.35	8.28	7.99	9.15

APPENDIX A2

Request for No Further Action (NFA) Status for Building 71 Radiation Release, Building 5 Former Decontamination Area, Building 5 Former Outdoor Radioactive Waste Storage Area for the Lawrence Berkeley National Laboratory Environmental Restoration Program, October 1999.



E.O. Lawrence Berkeley National Laboratory
University of California
Environmental Restoration Program

United States Department of Energy

REQUEST FOR NO FURTHER ACTION (NFA) STATUS

FOR

BUILDING 71 RADIATION RELEASE, BUILDING 5 FORMER DECONTAMINATION AREA, AND BUILDING 5 FORMER OUTDOOR RADIOACTIVE WASTE STORAGE AREA

for the

Lawrence Berkeley National Laboratory

ENVIRONMENTAL RESTORATION PROGRAM

October 1999

REQUEST FOR
NO FURTHER ACTION (NFA) STATUS

FOR
BUILDING 71 RADIATION RELEASE,
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ENVIRONMENTAL RESTORATION PROGRAM

A Joint Effort of
Environment, Health and Safety Division
and
Earth Sciences Division
Lawrence Berkeley National Laboratory

October 1999

This work was done at the Lawrence Berkeley Laboratory operated by the University of California for the U. S. Department of Energy under contract DE-AC03-76SF00098.

CONTENTS

LIST OF ABBREVIATIONS

AOC	Area of Concern
bgs	below ground surface
Berkeley Lab	Lawrence Berkeley National Laboratory
CAL-EPA	California Environmental Protection Agency
CAP	Corrective Actions Process
CMS	Corrective Measures Studies
DCE	dichloroethene
DHS	California Department of Health Services
DOE	U.S. Department of Energy
DTSC	Cal-EPA Department of Toxic Substances Control
ERP	Environmental Restoration Program
mg/kg	milligrams per kilogram
NA	Not Analyzed
ND	not detected
NFA	No Further Action
NFI	No Further Investigation
PCE	tetrachloroethene (perchloroethene)
pCi/g	picocuries per gram (10^{-12} curies per gram)
pCi/L	picocuries per liter (10^{-12} curies per liter)
PRG	Preliminary Remediation Goal
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RWQCB	Regional Water Quality Control Board
SWMU	Solid Waste Management Unit
TCE	trichloroethene
USEPA	U. S. Environmental Protection Agency
VOCs	volatile organic compounds

SECTION 1

INTRODUCTION

1.1 BACKGROUND

The Lawrence Berkeley National Laboratory (Berkeley Lab) Environmental Restoration Program (ERP) is part of a nationwide effort by the United States Department of Energy (DOE) to identify and clean up areas of radioactive and hazardous waste releases at its facilities. In addition, Berkeley Lab operates under a Resource Conservation and Recovery Act (RCRA) Part B Permit, issued by the California Environmental Protection Agency (CAL-EPA) Department of Toxic Substances Control (DTSC). The Permit requires Berkeley Lab to investigate and address all releases of hazardous waste or hazardous constituents that may have occurred at the facility, in accordance with RCRA Corrective Actions Process (CAP) requirements. There is no authority under RCRA to regulate the release of radionuclides; however, the Berkeley Lab ERP has been investigating and addressing potential releases of radionuclides concurrently with its RCRA required investigations, and in accordance with the guidelines of the CAP. The DTSC is the lead regulatory agency for the CAP. The DOE is the lead regulatory agency for areas of radionuclide contamination at Berkeley Lab.

Berkeley Lab is currently near the end of its RCRA Facility Investigation (RFI). The RFI consists of investigating solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) previously identified as having had a potential for past releases of chemical contaminants to the environment (Berkeley Lab, 1992) and characterizing the magnitude and extent of any releases that are corroborated. The final component of the RFI is determining which SWMUs and AOCs should be included in the Corrective Measures Studies (CMS). The regulatory oversight agencies for the RCRA CAP at Berkeley Lab (DTSC, Regional Water Quality Control Board, and City of Berkeley) have the authority for approving when the extent of chemical contamination has been sufficiently characterized and which SWMUs or AOCs should be included in the CMS.

A similar process has been followed for SWMUs and AOCs identified as having had a potential for past release of radiological contaminants. To be consistent with the RCRA CAP approach, Berkeley Lab has requested that DOE approve when the extent of radiological contamination (if any) at a SWMU or AOC has been sufficiently characterized and which of those SWMUs or AOCs should be included in a CMS.

In accordance with the DTSC approved procedure for chemical releases, SWMUs and AOC are approved for No Further Action (NFA) status when the extent of contamination has been sufficiently characterized and concentrations of contaminants in soil are within Berkeley Lab background levels or below USEPA Region IX Preliminary Remediation Goals (PRGs) for residential soil (USEPA, 1998). Background levels for metals in soil at Berkeley Lab are included in Table 4. When the extent of contamination has been sufficiently characterized and concentrations of contaminants in soil are above both Berkeley Lab background levels and PRGs for residential soil, the SWMU or AOC is approved for No Further Investigation (NFI) status. No additional environmental investigations are required for SWMUs and AOCs approved for NFA or NFI status. SWMUs or AOCs approved for NFI status, however, will be included in the human health and ecological risk assessments, the initial phase of the CMS. SWMUs and AOCs approved for NFA status will not be included in the human health risk assessment but will be evaluated in the site-wide ecological risk assessment because the screening process (comparison to PRGs) only addresses potential risk to human health. DOE has previously applied the same methodology for granting NFA or NFI approvals for SWMUs and AOCs at the Berkeley Lab.

1.2 PURPOSE AND SCOPE

The purpose of this report is to obtain approval from DOE for NFA status for the following two SWMUs and one AOC that were identified during the RCRA Facility Assessment (RFA) (Berkeley Lab, 1992) as having had a potential or known past release of radioactive contaminants to the environment.

- AOC 1-7: Building 71 Radiation Release
- SWMU 10-2: Building 5 Former Decontamination Area
- SWMU 10-3: Building 5 Former Outdoor Radioactive Waste Storage Area.

The approval of NFA status for these units would mean that the extent of radiological contamination (if any) has been sufficiently characterized and they will not be included in a CMS. Any site controls, demolition, or similar activities that might be requested by DOE would be outside the authority of the ERP. The locations of these units are shown on Figure 1 (AOC 1-7) and Figure 2 (SWMU 10-2 and SWMU 10-3).

SECTION 2

DESCRIPTION OF UNITS AND SAMPLING RESULTS

2.1 INTRODUCTION

Analytical results for the various environmental media sampled are included in the attached tables referenced below. Sampling locations and analytical results are shown on the attached figures. The ERP has established Standard Operating Procedures and a Quality Assurance Program Plan that specify sample collection and handling requirements.

	Building 71 Radiation Release	**Building 5 Former Decontamination Area**	**Building 5 Former Outdoor Radioactive Waste Storage Area**
Unit Number	AOC 1-7	SWMU 10-2	SWMU 10-3
Contaminant of Potential Concern	curium-244	radionuclides and solvents	radionuclides and solvents
Soil	Table 1	Table 2 (radionuclides) Table 3 (organics)	Table 2 (radionuclides) Table 3 (organics) Table 4 (metals)
Sediment	Table 5	Table 5	Table 5
Groundwater	Table 6	Table 6	Table 6

The site histories and descriptions included in the following sections were generally summarized from discussions included in the RFA Report (Berkeley Lab, 1992).

2.2 AOC 1-7: BUILDING 71 RADIATION RELEASE

Site Description and History

On July 3, 1959, an experiment failure resulted in the release of approximately 0.04 curies of curium-244 inside Building 71, the Hilac (heavy ion linear accelerator) (Garden and Dailey, 1959). The exhaust fans were on at the time of the incident and may have distributed some curium-244 outside the building. The exhaust fans were subsequently turned off (personal communication from James Haley). The building was immediately closed for three weeks of extensive decontamination. Testing of the building's roof indicated that curium activity was

present. After the clean up, regular testing was conducted inside the building and contaminated parts of the structure were removed. After 1964, regular testing indicated no remaining radiation in the structure. The location of the unit is shown on Figure 1. The Hilac is no longer operational.

Contaminants of Potential Concern

The contaminant of potential concern is curium-244. The half life of curium-244 is approximately 19 years.

Soil Sampling

Activities of curium-244 measured in soil are listed in Table 1. Soil sampling locations and curium-244 activities detected are shown on Figures 3a and 3b. In February 1993, nine surface soil samples (SS71NE-1 through SS71NE-9) were collected from undisturbed soil northeast of Building 71 near the Berkeley Lab property line (Figure 3b). This location was selected for sampling since it was considered to be the most likely area to have been affected by the release from the building. Curium-244 was detected in six of the nine samples at a maximum activity of 0.38 pCi/g. In August 1995, nine additional shallow soil samples were collected at five locations (SS-71NE-95-1 through SS-71NE-95-5) northeast of Building 71, in the same area as the February 1993 samples (Figure 3b). Samples were collected from 1 to 3 feet below ground surface (bgs) to help evaluate the extent and vertical distribution of the curium-244. Samples were analyzed for curium-244 and for gross alpha, gross beta, and gamma radiation. Curium-244 was detected in two of the samples (1.7 pCi/g and 0.21 pCi/g). Gamma radiation was detected in two of the samples at a maximum activity of 0.09 ± 0.02 pCi/g.

In June 1996, in response to comments from the California Department of Health Services (DHS), 15 shallow soil samples (SS-71RAD-1 through SS-71RAD-15) were collected at 0.5 feet bgs from areas of exposed soil surrounding Building 71 (Figure 3a). Curium-244 was detected at a maximum activity of 2.1 pCi/g in sample SS-71RAD-1 located west of Building 71. In September 1996, three additional shallow soil samples (0.5 feet bgs) were collected from the vicinity of SS71-RAD-1 to help evaluate the magnitude and extent of the curium-244

contamination in the area. Curium-244 was detected at a maximum activity of 2.6 pCi/g in these samples.

Groundwater Sampling

Groundwater samples have been collected from eleven groundwater monitoring wells, one slope stability well, and three drains (hydraugers) in the area of, or downgradient from, the curium release and analyzed for curium-244. The locations of these wells and hydraugers are shown on Figure 3a. Groundwater analytical results for curium-244 are included in Table 6 and discussed below.

In 1993, groundwater samples were collected from monitoring wells MW46A-92-15 and MW71-93-1 and slope indicator well SI1-162. No curium-244 was detected (<0.1 or <0.6 pCi/L). In November 1998, groundwater samples were collected from monitoring wells MW90-5, MW46A-92-15, MW71-93-1, MW71-93-2, MW46A-93-19, MW51-94-11, MW71-95-1, MW71-95-8, MW71-95-9, and MW71-97-23. Curium-244 was not detected (<0.2 pCi/L).

In August 1998, samples of the effluent from three hydraugers (64-01-01, 51-01-01, and 51-01-02) that drain the slope south of Building 71 were analyzed for curium 244. The locations of the hydraugers are shown on Figure 3a. Curium-244 was not detected (<0.2 pCi/L).

Sediment Sampling

Sediment sampling locations and curium-244 activities measured are shown on Figure 4. Sediment sampling results for radionuclides, including curium-244 are listed in Table 5. North Fork Strawberry Creek drains the area of Building 71, where the curium release occurred. In April 1993, two composite samples (each composite consisted of two distinct samples) were collected at approximately 0.4 to 0.8 feet bgs from sediment of North Fork Strawberry Creek. The two samples for the first composite were collected from each of the two storm drain sediment basins. Samples for the second composite were collected from the creek bed immediately outside the Berkeley Lab site boundary. Analyses of the composite samples included curium-244 and other radionuclides. No radionuclides were detected (<0.1 pCi/g for curium-244). In August 1996, five additional sediment samples were collected from North Fork

Strawberry Creek. Sample analyses included curium-244. Curium-244 was detected in four of the five samples at activities ranging from 0.3 ± 0.2 to 1.7 ± 0.3 pCi/g.

Recommended Action

No Further Action (NFA) status is requested for the Building 71 Radiation Release (AOC 1-7) for the following reasons:

1. Curium-244 activities were below the USEPA Region IX Preliminary Remediation Goal (PRG) for residential soil of 3.7 pCi/g (Dean, 1996) in all 36 soil samples collected.
2. Curium-244 activities were below the PRG for residential soil of 3.7 pCi/g in all seven sediment samples collected from the creek downstream of Building 71.
3. Curium-244 was not detected in the 17 groundwater samples collected from 12 wells and 3 hydraugers in the area of, or downgradient from, the curium-244 release.
4. The area inside Building 71 affected by the accidental release was thoroughly decontaminated (Garden and Dailey, 1959).

To support the recommendation for NFA status, a table summarizing the results of sampling for curium-244 in soil and sediment is presented below. The maximum curium-244 activity measured in the 36 soil samples that were collected in the Building 71 area (2.6 pCi/g) is below the PRG for residential soil (3.7 pCi/g) (Dean, 1996). The average curium-244 activity in those samples is approximately 10% of the PRG. The maximum curium-244 activity measured in sediment samples is also below the PRG. If the recommendation for NFA status is approved, AOC 1-7 will not be included in the human health risk assessment; however, it will be included in the ecological risk assessment because of the detection of curium-244 in sediment samples collected from North Fork Strawberry Creek.

Summary of Curium-244 Results in Soil and Sediment

	Soil (pCi/g)	Sediment (pCi/g)
Preliminary Remediation Goal (PRG)	3.7[(a)]	3.7[(a)]
Maximum Activity	2.6	1.7
Average Activity	0.39	0.58
Median Activity	0.1	0.3
Standard Deviation	0.59	0.62
Number of Samples	36	7

[(a)] Dean (1996).

2.3 SWMU 10-2: BUILDING 5 FORMER DECONTAMINATION AREA SWMU 10-3: BUILDING 5 FORMER OUTDOOR RADIOACTIVE WASTE STORAGE AREA

Site Description and History

Building 5 was used as a radioactive waste accumulation area and an area for decontamination of radioactive-contaminated equipment. These activities began sometime in the 1940's and continued to 1963. The Former Outdoor Radioactive Waste Storage Area (SWMU 10-3) was located on the north side of Building 5 and was used to transfer radioactive waste (sometimes mixed with chemical waste) to containers for temporary storage prior to offsite shipment and disposal. Radionuclides in the waste included strontium-90, yttrium-90, cesium-137, and europium-152 and europium-154. The chemical constituents of the wastes included salts such as chlorides and nitrites, organic compounds, solvents, and acids such as hydrochloric acid.

In 1985, radioactive contamination was detected in soil near the former outdoor storage area (europium-152, europium-154, strontium/yttrium-90, and cesium-137). Contaminated concrete, soil, and asphalt were removed.

Contaminants of Potential Concern

The contaminants of potential concern are radionuclides including strontium-90, yttrium-90, cesium-137, europium-152, and europium-154 and organic solvents.

Soil Sampling

Concentrations of radionuclides, organic analytes and pH, and metals detected in soil samples collected at SWMU 10-2 and SWMU 10-3 are listed in Table 2, Table 3, and Table 4, respectively. Sampling results are discussed below.

RFA Soil Sampling

During the RFA, eight shallow soil samples collected at the former radioactive waste storage area (SS5-01-2C through SS5-08-2C). Dibromochloromethane (0.016 mg/kg maximum), tetrachloroethylene (PCE) (0.028 mg/kg maximum), trans-1,2-dichloroethene (DCE)(0.020 mg/kg maximum), and total xylenes (0.092 mg/kg maximum) were detected. All concentrations were below the PRG for residential soil. These eight samples were reanalyzed in 1993 for the radionuclides americium-241, europium-152, europium-154, strontium-90, and cesium-137. Strontium-90 was detected in four of the samples at a maximum activity of 0.080 pCi/g. The activity that was measured is consistent with residual activity from fallout. No other radionuclides were detected. The PRG for residential soil for strontium-90 is 14 pCi/g (Dean, 1996).

RFI Sampling Results

In September 1993, monitoring well MW5-93-10 was installed west of Building 5 to determine if a dead-ended “contaminated sewer” line coming out of Building 5 had affected soil or groundwater. Soil samples were collected at approximately 5-foot intervals to a depth of 35 feet from the boring for the well. Analyses of the upper three samples included gross alpha, gross beta, and gamma radiation. A trace concentration of Freon-11 (0.004 mg/kg) was the only organic analyte detected in the soil. Metals were detected at concentrations within Berkeley Lab background levels or below PRGs. Gross alpha and gamma radiation were not detected. Gross beta radiation was detected in all three samples at activities ranging from 14 ± 3 to 24 ± 5 pCi/g.

From April to June 1995, soil samples were collected to a maximum depth of 15 feet bgs from seven borings (SB5-95-1 through SB5-95-7) in the area of SWMU 10-3 north of Building 5. SB5-95-1 was drilled through the raised concrete platform ramp at Building 5 and sampled to 15 feet. SB5-95-3 through SB5-95-7 were located north of the concrete platform in an area that may have been used for temporary storage of wastes prior to offsite disposal. Samples were analyzed for volatile organic compounds (VOCs) and selected samples from SB5-95-1, SB5-95-2 and SB5-95-3 for metals and pH. Samples collected from these borings were analyzed for gross alpha, gross beta, and gamma radiation. Low concentrations (< 0.1 mg/kg) of trichloroethene (TCE), PCE, and cis-1,2- DCE were detected in 8 of the 15 samples. All concentrations were below PRGs for residential soil. Metals were detected at concentrations within the Berkeley Lab background levels or below PRGs. Gamma radiation (identified as naturally occurring potassium-40) was detected at a maximum activity of 9 ± 1 pCi/g and gross beta (reported as being consistent with naturally occurring potassium-40) was detected at a maximum activity of 9 ±2 pCi/g. Gross alpha radiation was not detected.

A well designated as a slope stability well (SSW-6.37) is located in the area of the units. In April 1996, samples (SSW6-37-96) were collected from sediment in the well from 25 to 37.5 feet bgs. Samples were analyzed for gross alpha, gross beta, and gamma radiation; strontium 90; cesium-137; europium 152; and europium 154; VOCs; and metals. No strontium 90, cesium-137, europium 152; or europium 154 was detected. Gross alpha radiation was not detected. Gross beta (19 ± 5 pCi/g maximum activity) and gamma radiation (15 ± 1 pCi/g maximum activity) were detected. No VOCs were detected. Metals were detected at concentrations within Berkeley Lab background levels or below PRGs.

Groundwater

Activities of radionuclides detected in groundwater samples collected at SWMU 10-2 and SWMU 10-3 are included in Table 6. Groundwater samples collected from MW5-93-10 in October 1993 were analyzed for gross alpha, gross beta, and gamma radiation; americium-241; strontium 90; cesium-137; europium 152; and europium 154. No americium-241, strontium 90, cesium-137, europium 152, or europium 154 was detected. Gross alpha radiation (15 ± 10 pCi/L) and gross beta radiation (23 ± 4 pCi/L) were detected. The Maximum Contaminant Level

(MCL) for drinking water for gross alpha and gross beta activity are 15 pCi/L and 50 pCi/L, respectively. At the request of the Regional Water Quality Control Board (RWQCB), an additional groundwater sample was collected from MW5-93-10 in August 1999 and analyzed for gross alpha radiation. The sample was also analyzed for gamma radiation. Gross alpha radiation was measured at 3.4 ± 0.9 pCi/L. No gamma radiation was detected (<17 pCi/L). Results of gamma-spectrometric analysis by the Berkeley Low Background Facility of the groundwater sample collected from MW5-93-10 in August 1999 indicate that natural radionuclides were present in the water in the range of activity that can explain the alpha results.

Groundwater samples collected from MW91-9 in August 1993 and March 1997 were analyzed for strontium-90. Strontium-90 was detected in the 1993 sample (1.7 ± 0.4 pCi/L) but was not detected in duplicate samples collected in 1997 (<0.74 pCi/L). Grab water samples were also collected from three temporary wells (SB5-97-6, SB5-97-7, and SB5-97-8) installed approximately 100 feet north of Building 5 (east of Building 52A) in March 1997 and analyzed for gross alpha, gross beta, and gamma radiation; strontium-90; and cesium-137. No strontium-90, cesium-137, or gamma radiation was detected. Gross alpha and gross beta radiation were detected at maximum activities of 9 ± 4 pCi/L and 3 ± 1 pCi/L, respectively.

Halogenated hydrocarbons have been consistently detected in groundwater samples from MW5-93-10 and MW91-9. Based on the concentrations of contaminants detected in groundwater monitoring wells, however, the source is not located in the area of Building 5. Groundwater sampling results are reported to the Regional Water Quality Control Board (RWQCB) on a quarterly basis. The RWQCB is the regulatory agency with oversight authority for hazardous constituents in the groundwater and is evaluating the status of groundwater plumes at Berkeley Lab.

Sediment Sampling

Surface runoff from the Building 5 area is directed through the Berkeley Lab storm drain system to North Fork Strawberry Creek. Sediment sampling results potentially related to SWMU 10-2 and SWMU 10-3 are included in Table 5. In April 1993, two 2-point composite sediment samples were collected at approximately 0.4 to 0.8 feet bgs from sediment of North

Fork Strawberry Creek. The two points for the first composite were collected from each of the two storm drain sediment basins. The second composite sample consisted of points from the creek bed immediately outside the Berkeley Lab site boundary. Sample analysis included strontium-90 and cesium-137. Neither strontium-90 nor cesium-137 were detected (<1 pCi/g and 5 pCi/g, respectively).

Recommended Action

No Further Action (NFA) status is requested for the Building 5 Former Decontamination Area (SWMU 10-2) and the Building 5 Former Outdoor Radioactive Waste Storage Area (SWMU 10-3) for the following reasons:

1. The magnitude and extent of contamination in the soil have been characterized and concentrations of all contaminants detected in soil are below PRGs for residential soil. Strontium-90 was the only anthropogenic radionuclide detected at these units. However, its maximum detected activity was 0.08 pCi/g, which is less than 1% of the PRG for residential soil (14 pCi/g). The activity that was measured is consistent with the expected residual activity from fallout. A table summarizing the results of sampling for strontium-90 in soil is presented below.
2. Although strontium-90 was detected in a 1993 groundwater sample (1.7 ± 0.4 pCi/L), its presence was not confirmed in subsequent sample collected in 1997 (<0.74 pCi/L). The drinking water standard (MCL) for strontium-90 is 8 pCi/L. No other radionuclides have been detected in groundwater at these units.
3. Surface runoff from the Building 5 area is directed through the Berkeley Lab storm drain system to North Fork Strawberry Creek. Neither strontium-90 nor cesium-137 were detected in sediment samples collected from North Fork Strawberry Creek.

Summary of Strontium-90 Results

	Soil (pCi/g)
Preliminary Remediation Goal (PRG)	14 [(a)]
Maximum Activity	0.08
Average Activity	0.01
Median Activity	0.001
Standard Deviation	0.025
Number of Samples	8

[(a)] Dean (1996).

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Haley, J. (1999). February 8, 1999, Personal Communication, telephone conversation between Iraj Javandel (Berkeley Lab) and James Haley (Berkeley Lab).

Berkeley Lab (1992). *RCRA Facility Assessment (RFA) at the Lawrence Berkeley Laboratory, Revision 1.* Lawrence Berkeley Environmental Restoration Program, Lawrence Berkeley Laboratory, Berkeley, California. October 30, 1997.

LIST OF FIGURES

MW76-93-7 Groundwater monitoring well

SB76-94-01 Soil boring

L-3 Vacuum lysimeter

SS-10-95-7BS-2 Shallow soil sample location

SI-8.107 Slope indicator well

ND (or <) Not detected

B 17 Surface structure (e.g., buildings, etc.)

Sanitary sewer line

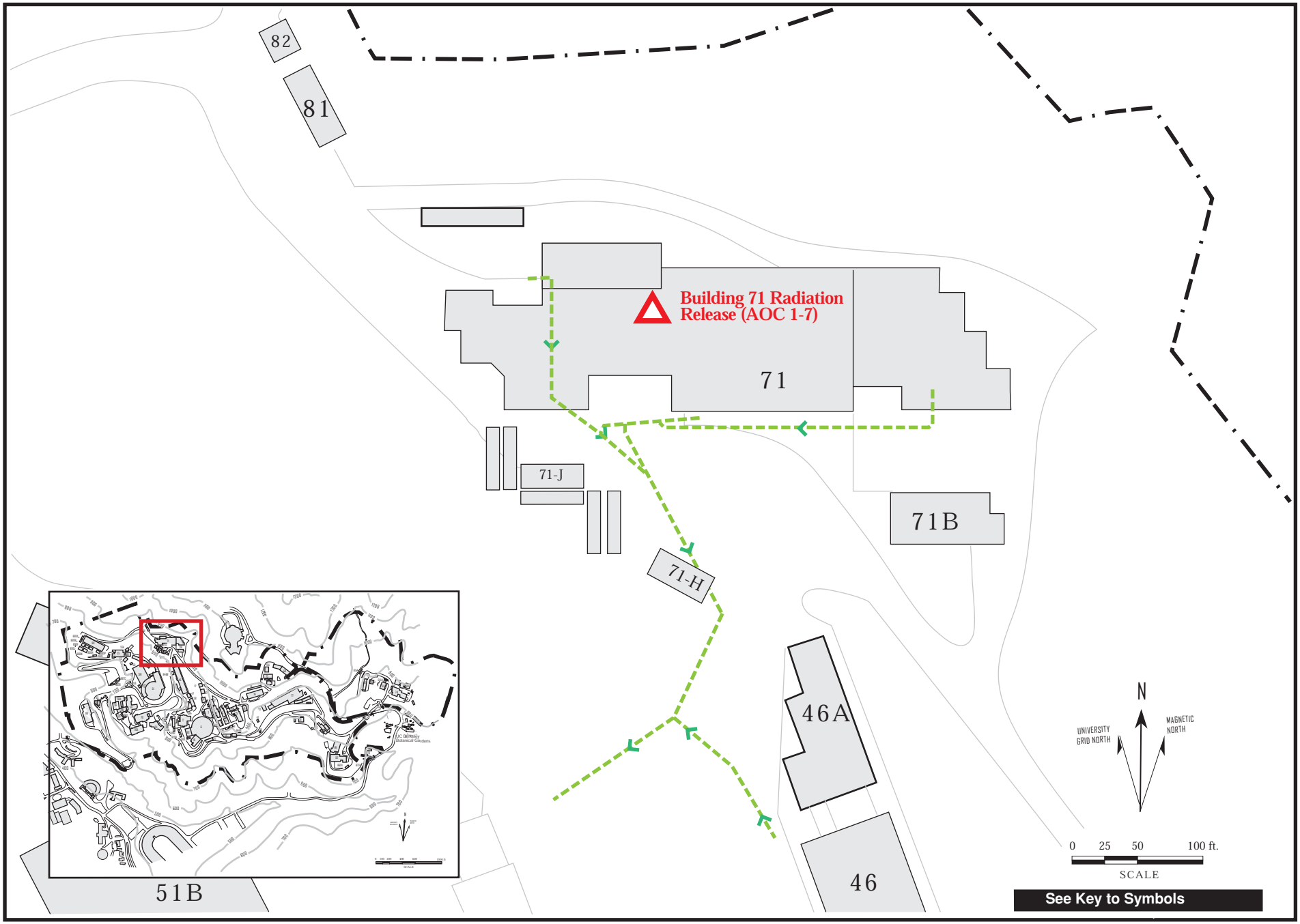
Storm drain line

LBNL site boundary

Fence

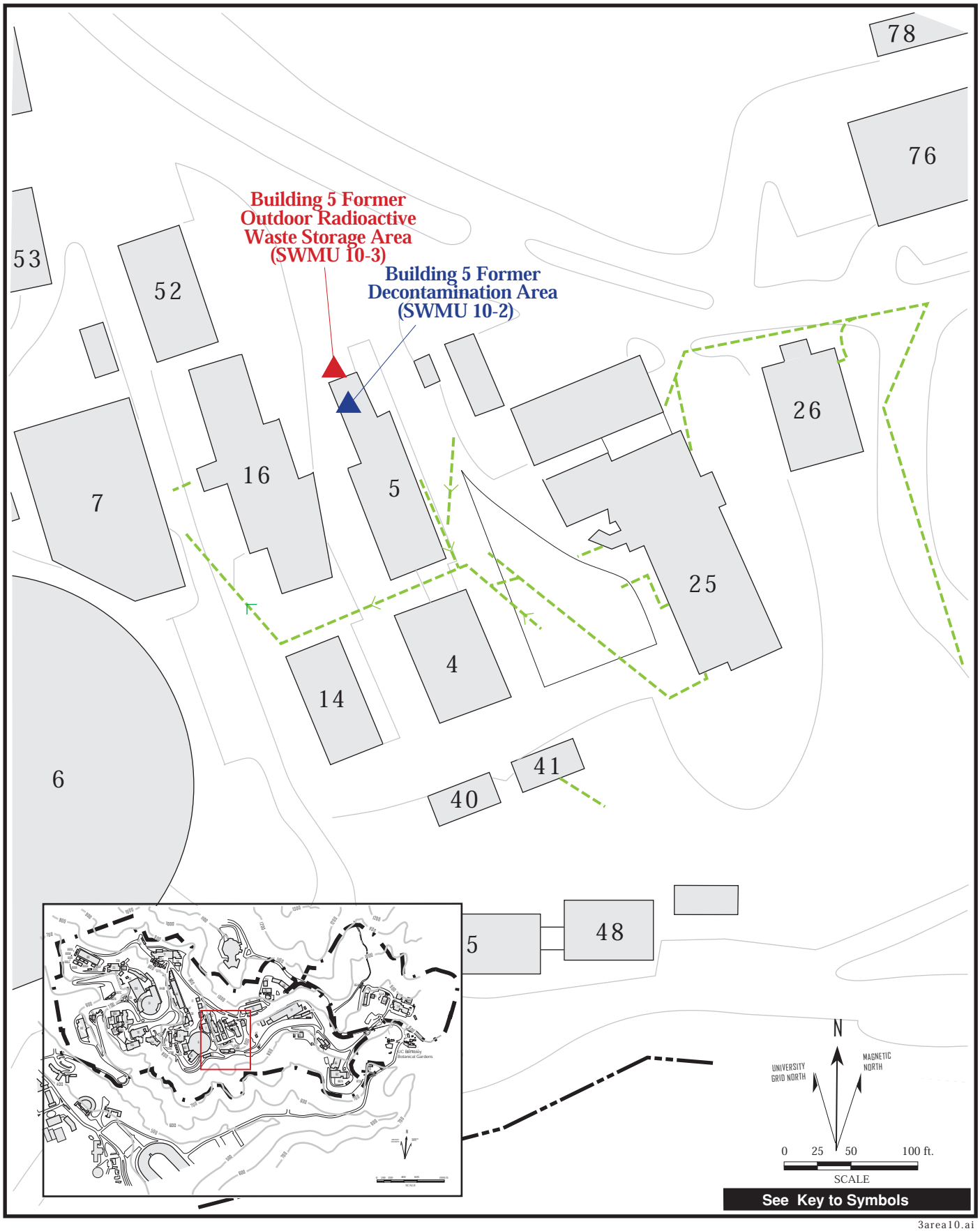
NOTES:
All other symbols used are explained on the figures.

Key to Symbols Used on Figures



1Area1.ai
11/98

Figure 1. Location of Area of Concern 1-7, Building 71 Radiation Release



3area10.ai
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2. Locations of Solid Waste Management Units 10-2 and 10-3, Building 5 Former Decontamination Area and Former Outdoor Radioactive Waste Storage Area

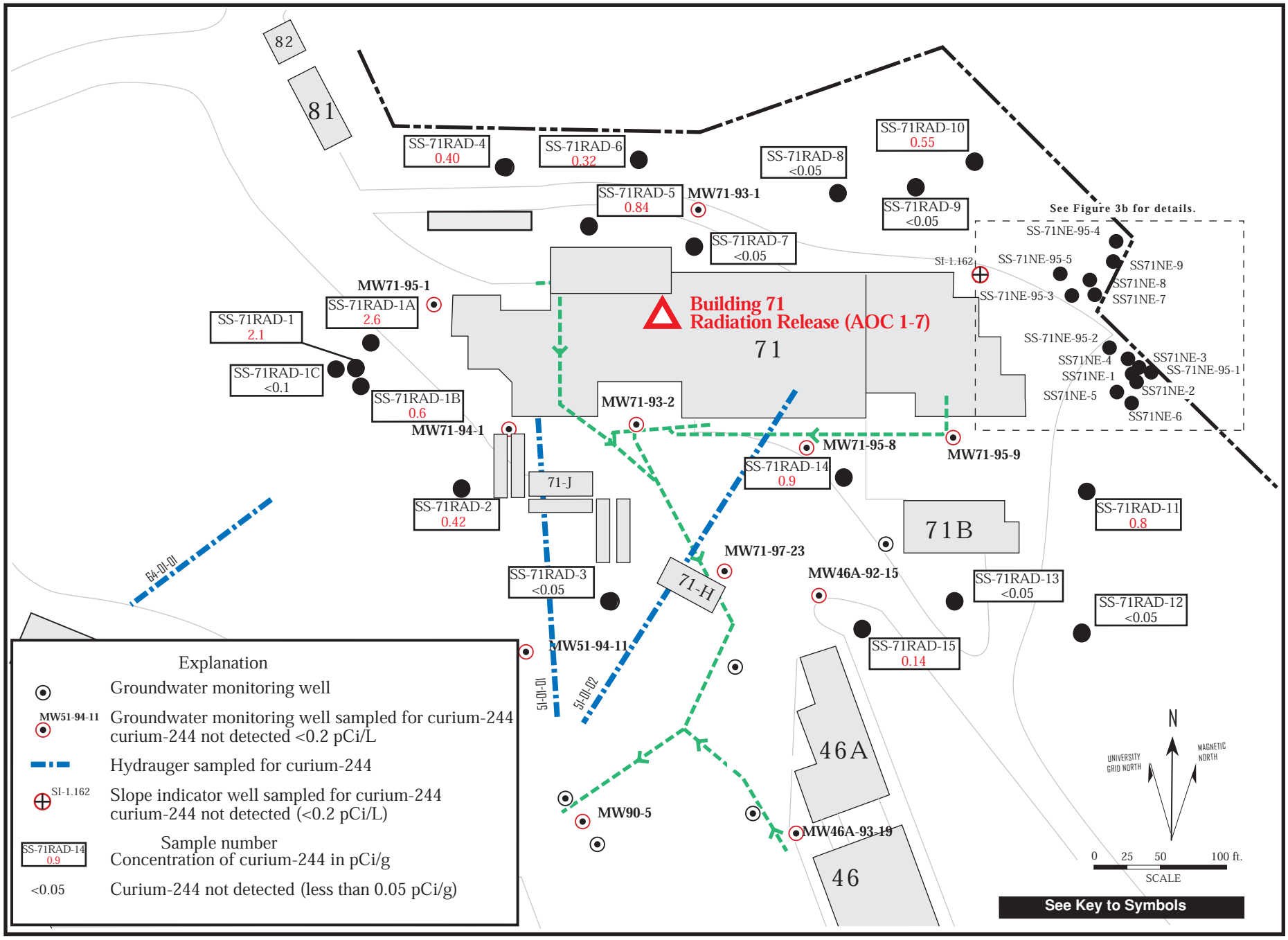
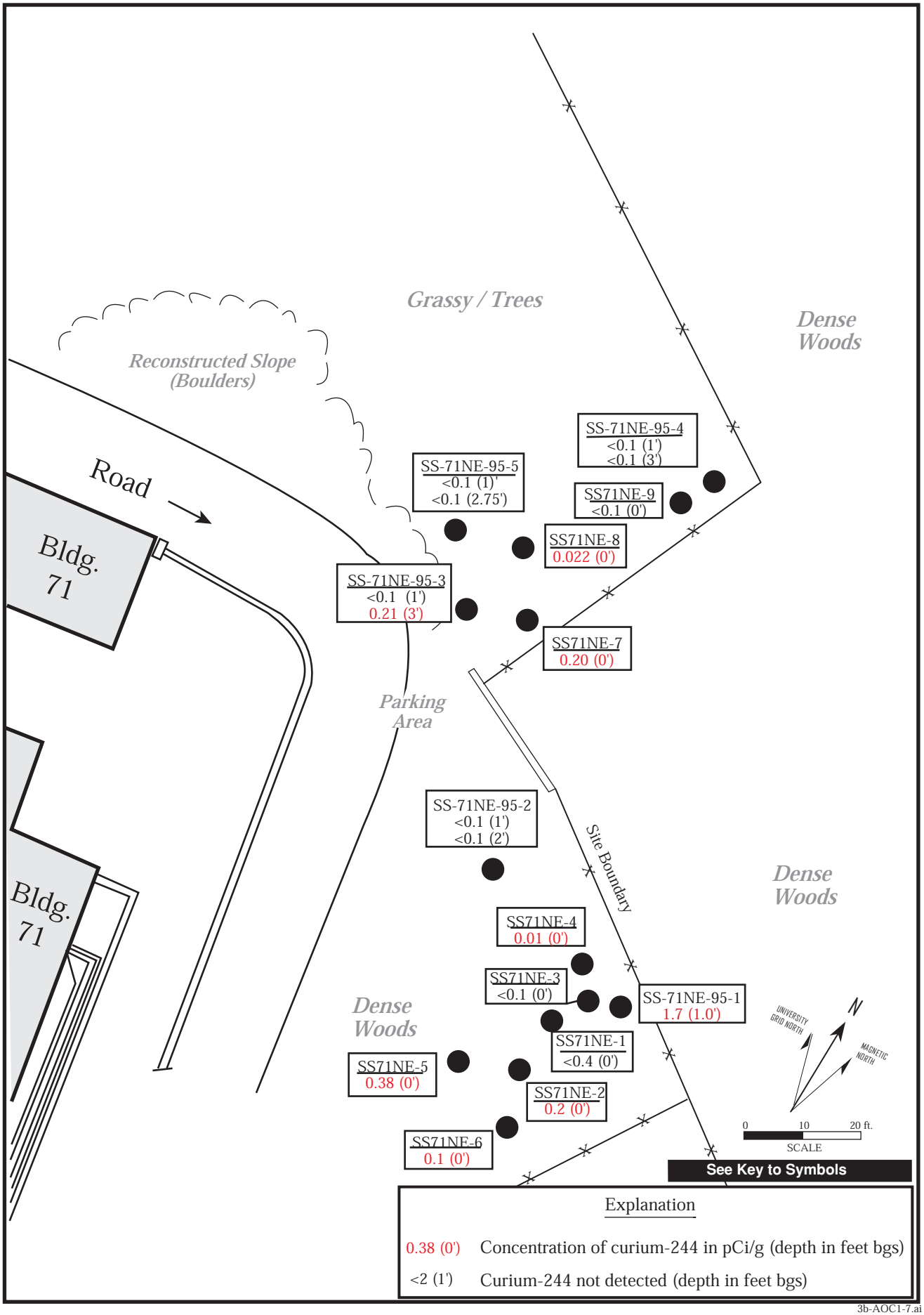


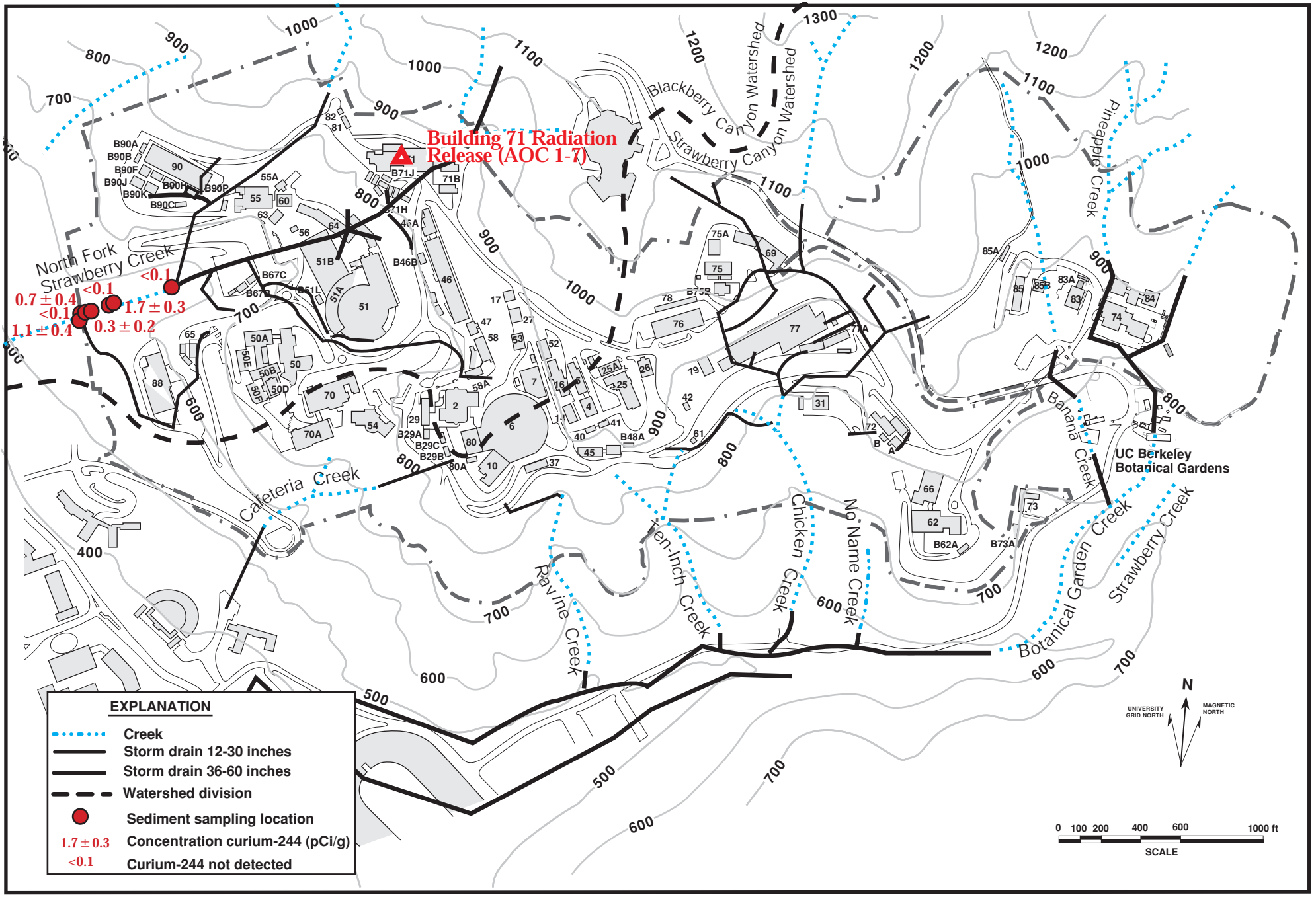
Figure 3a. Sampling Locations and Activity of Curium-244 Measured in Soil (pCi/g) Building 71 Radiation Release (AOC 1-7)

3a-AOC1-7.ai
11/98



3b-AOC1-7.ai
11/98

Figure 3b. Locations of Shallow Soil Samples and Curium-244 Detected (pCi/g) East of Building 71, Building 71 Radiation Release (AOC 1-7)



4-Creekdrainage
11/98

Figure 4. Concentrations of Curium-244 Detected in Sediment Samples

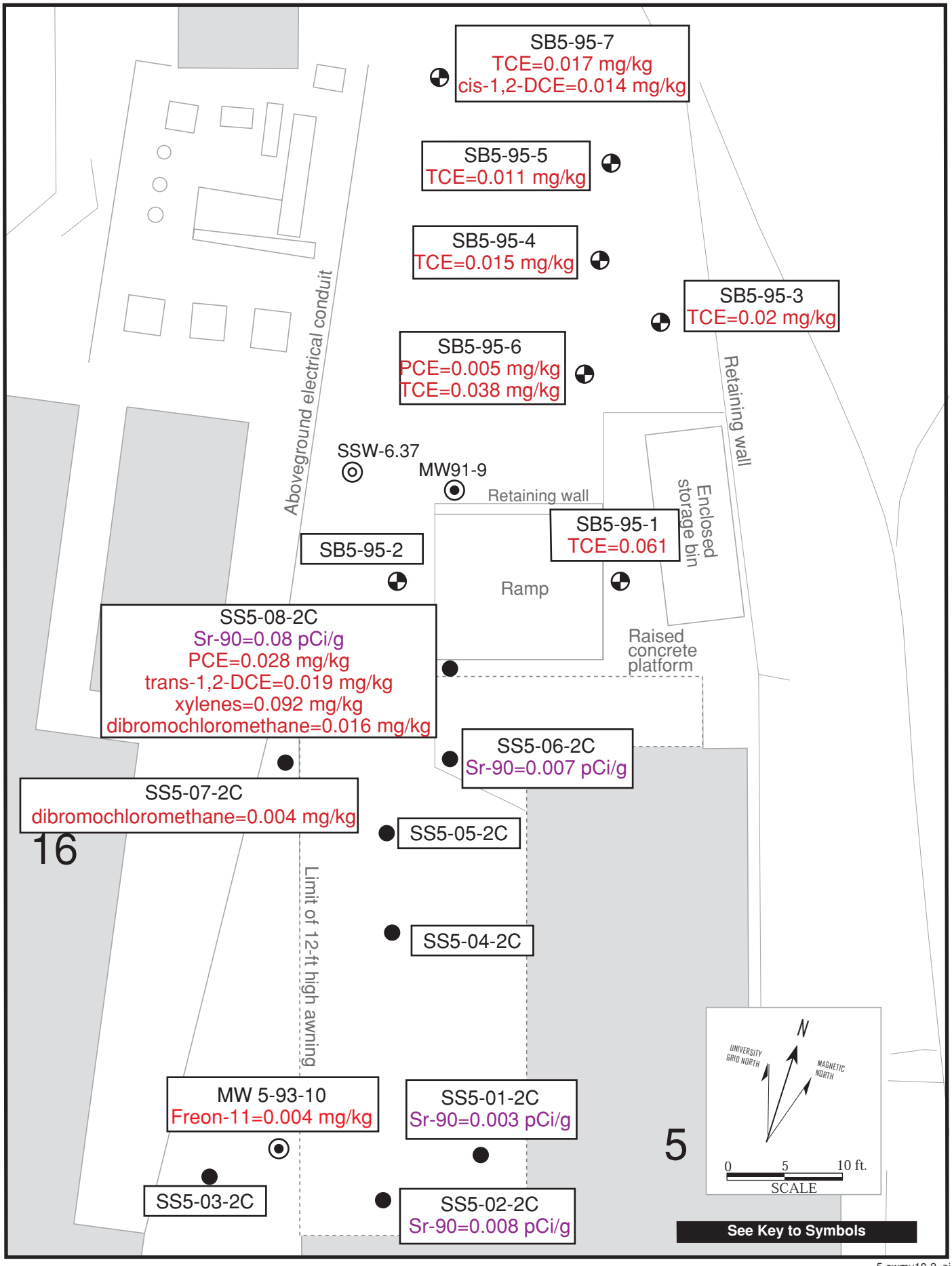


Figure 5. Locations of Soil Samples and Concentrations of Contaminants Detected Building 5 Former Decontamination Area (SWMU 10-2) and Former Outdoor Radioactive Waste Storage Area (SWMU 10-3).

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LIST OF TABLES

Table 1
Soil Sampling Results AOC 1-7
Radiological Elements

Unit/Area	Location	Sample ID	Depth	Date	Lab	Gross Alpha (pCi/g)	Gross Beta (pCi/g) (1)	Gamma (pCi/g) (2)	Curium 244 (pCi/g)
AOC 1-7 Building 71 Radiation Release	Building 71 Geologic Borings	SS71NE-1-0	0	Feb-93	LBNL				<0.4
		SS71NE-2-0	0						0.2 ± 0.1
		SS71NE-3-0	0						<0.1
		SS71NE-4-0	0						0.010 ± 0.001
		SS71NE-5-0	0						0.38 ± 0.09
		SS71NE-6-0	0						0.1 ± 0.01
		SS71NE-7-0	0						0.20 ± 0.07
		SS71NE-8-0	0						0.022 ± 0.007
		SS71NE-9-0	0						<0.1
	MW71-93-1	BS71-93-1-4	4.0	Sep-93	LBNL	<14	24 ± 5	<10	
		BS71-93-1-10.5	10.5			<22	13 ± 4	<10	
		BS71-93-1-14	14			<13	12 ± 4	<10	
	MW71-93-2	BS71-93-2-5.0	5.0	Sep-93	LBNL	<10	9 ± 3	<10	
		BS71-93-2-10.0	10			<15	13 ± 3	<10	
		BS71-93-2-15.0	15			<11	12 ± 3	<10	
	Building 71	SS-71NE-95-1-1.0	1.0	Aug-95	LBNL	<17	10 ± 1	Cs-137=0.04 ± 0.02 U-238=<0.4 Th-232=<0.2	1.7 ± 0.01
		SS-71NE-95-2-1.0	1.0			<17	12 ± 2	Cs-137=0.09 ± 0.02 U-238=<0.4 Th-232=<0.2	<0.1
		SS-71NE-95-2-2.0	2.0			<17	12 ± 2	Cs-137=<0.02 U-238=<0.4 Th-232=<0.2	<0.1
		SS-71NE-95-3-1.0	1.0			<17	9 ± 2	Cs-137=<0.02 U-238=<0.4 Th-232=<0.2	<0.1
		SS-71NE-95-3-3.0	3.0			<17	<7	Cs-137=<0.02 U-238=<0.4 Th-232=<0.2	0.21 ± 0.02
		SS-71NE-95-4-1.0	1.0			<21	<12	Cs-137=<0.02 U-238=<0.4 Th-232=<0.2	<0.1
		SS-71NE-95-4-3.0	3.0			<17	<7	Cs-137=<0.02 U-238=<0.4 Th-232=<0.2	<0.1
		SS-71NE-95-5-1.0	1.0			<17	8 ± 2	Cs-137=<0.02 U-238=<0.4 Th-232=<0.2	<0.1
		SS-71NE-95-5-2.75	2.75			<17	<6	Cs-137=<0.02 U-238=<0.4 Th-232=<0.2	<0.1
		SS-71Rad-1-0.5	0.5	Jun-96	LBNL				2.1 ± 0.46
		SS-71Rad-2-0.5	0.5						0.42 ± 0.08
		SS-71Rad-3-0.5	0.5						<0.05
		SS-71Rad-4-0.5	0.5						0.4 ± 0.1
		SS-71Rad-5-0.5	0.5						0.84 ± 0.04

Table 1 (Cont'd)
Soil Sampling Results AOC 1-7
Radiological Elements

Unit/Area	Location	Sample ID	Depth	Date	Lab	Gross Alpha (pCi/g)	Gross Beta (pCi/g) (1)	Gamma (pCi/g)	Curium 244 (pCi/g)
AOC 1-7 Building 71 Radiation Release	Building 71	SS-71Rad-6-0.5	0.5	Jun-96	LBNL				0.32 ± 0.09
		SS-71Rad-7-0.5	0.5						<0.05
		SS-71Rad-8-0.5	0.5						<0.05
		SS-71Rad-9-0.5	0.5						<0.05
		SS-71Rad-10-0.5	0.5						0.55 ± 0.03
		SS-71Rad-11-0.5	0.5						0.8 ± 0.2
		SS-71Rad-12-0.5	0.5						<0.05
		SS-71Rad-13-0.5	0.5						<0.05
		SS-71Rad-14-0.5	0.5						0.9 ± 0.2
		SS-71Rad-15-0.5	0.5						0.14 ± 0.06
		SS-71Rad-1A-0.5	0.5	Sep-96	LBNL				2.6 ± 0.6
		SS-71Rad-1B-0.5	0.5						0.6 ± 0.4
		SS-71Rad-1C-0.5	0.5						<0.1

< = concentration less than minimum detectable activity (MDA)
= Not sampled

(1) - Gross Beta values are consistent with naturally occurring Potassium 40
(2) - Cesium-137 is consistent with fallout

Table 2
Soil Sampling Results SWMUs 10-2 and 10-3
Radiological Elements

Unit/Area	Location	Sample ID	Depth	Date	Lab	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gamma (pCi/g)	Americium 241 (pCi/g)	Europium 152 (pCi/g)	Europium 154 (pCi/g)	Strontium 90 (pCi/g)	Cesium 137 (pCi/g)
SWMU 10-2 SWMU 10-3 Building 5 Former Decontamination and Waste Storage Areas	Building 5	SS5-01-2C	2.0	Mar-93	LBNL				0 ±0.3	0 ±4	0 ±2	0.003 ±0.001	0 ± 0.2
		SS5-02-2C	2.0						0 ±0.3	0 ±4	0 ±2	0.008 ±0.002	0 ± 0.2
		SS5-03-2C	2.0						0 ±0.3	0 ±4	0 ±2	0 ±0.01	0 ± 0.2
		SS5-04-2C	2.0						0 ±0.3	0 ±4	0 ±2	0 ±0.04	0 ± 0.2
		SS5-05-2C	2.0						0 ±0.3	0 ±4	0 ±2	0 ±0.02	0 ± 0.2
		SS5-06-2C	2.0						0 ±0.3	0 ±4	0 ±2	0.007 ±0.002	0 ± 0.2
		SS5-07-2C	2.0						0 ±0.3	0 ±4	0 ±2	0 ±0.1	0 ± 0.2
		SS5-08-2C	2.0						0 ±0.3	0 ±4	0 ±2	0.08 ±0.01	0 ± 0.2
	MW5-93-10	BS5-93-10-5.5	5.5	Sep-93	LBNL	<20	14 ±3	<10					
		BS5-93-10-10.6	10.6			<11	24 ±5	<10					
		BS5-93-10-15	15			<13	15 ±4	<10					
	Building 5	BS-SB-5-95-2-0.8	0.8	Apr-95	LBNL	<13	3 ± 1	4 ± 1					
		BS-SB-5-95-3-0.8	0.8			<14	<7	3 ± 1					
		BS-SB-5-95-4-2.5	2.5	May-95		<11	6 ± 1	5 ± 1					
		BS-SB-5-95-5-1.2	1.2			<11	5 ± 1	3 ± 1					
		BS-SB-5-95-6-1.2	1.2			<12	<4	3 ± 1					
		BS-SB-5-95-7-0.8	0.8			<12	<5	5 ± 1					
		BS-SB-5-95-1-0.7	0.7	Jun-95		<10	<6	3 ± 1					
		BS-SB-5-95-1-5.3	5.3			<11	<6	4 ± 1					
		BS-SB-5-95-1-10	10			<11	9 ± 2	9 ± 1					
		BS-SB-5-95-1-15	15			<11	9 ± 2	3 ± 1					
	SSW6.37	BS-SSW6.37-96-25	25	Apr-96	LBNL	<9	11 ± 3	14 ± 2		<0.1	<0.1	<0.1	<0.02
		BS-SSW6.37-96-31	31			<9	6 ± 2	3 ± 1		<0.1	<0.1	<0.1	<0.02
		BS-SSW6.37-96-37.5	37.5			<9	19 ± 5	15 ± 1		<0.1	<0.1	<0.1	<0.02

< = concentration less than minimum detectable activity (MDA)

= Not sampled

LBNL = Analysis by LBNL Radiological Measurement Laboratory

Table 3
Soil Sampling Results SWMUs 10-2 and 10-3
Organics, Fuels, and pH

Unit/Area	Location	Sample ID	Depth	Date	Lab	8010 mg/kg	8020 mg/kg	8260 mg/kg	TPH-Diesel mg/kg	TPH-Gas mg/kg	Oil & Grease mg/kg	pH S.U.
SWMU 10-2	MW91-9	91-9-S1	4.5	Dec-91	Q	ND	ND					
SWMU 10-3		91-9-S2	14.5			ND	ND					
Building 5		91-9-S3	25			ND	ND					
Former		91-9-S4	34.5			ND	ND					
Decontamination	MW5-93-10	BS5-93-10-6	6.0	Sep-93	C				<1	<1	<50	
and Waste		BS5-93-10-10.1	10.1								<50	
Storage Areas		BS5-93-10-10.6	10.6		LBNL			Freon-11=0.004				
		BS5-93-10-15.3	15.3		C				<1	<1		
		BS5-93-10-21	21		LBNL			LT				
		BS5-93-10-30.3	30.3					LT				
		BS5-93-10-35.2	35.2		C				<1	<1		
	Building 5	BS-SB-5-95-1-1.2	1.2	Jun-95	BC			TCE=0.061				7.45
		BS-SB-5-95-1-5.8	5.8					ND				
		BS-SB-5-95-1-10.2	10.2					ND				
		BS-SB-5-95-1-15.3	15.3					ND				
		BS-SB-5-95-2-1.3	1.3	Apr-95	BC			ND				8.26
		BS-SB-5-95-3-1.3	1.3					TCE=0.020				7.68
		BS-SB-5-95-4-3	3.0					TCE=0.015				
		BS-SB-5-95-4-6	6.0					TCE=0.0053				
		BS-SB-5-95-5-1.7	1.7					TCE=0.011				
		BS-SB-5-95-5-6	6.0					ND				
		BS-SB-5-95-6-1.7	1.7					PCE=0.0051, TCE=0.038				
		BS-SB-5-95-6-6	6.0					ND				
		BS-SB-5-95-7-1.3	1.3					ND				
		BS-SB-5-95-7-5.9	5.9					cis-1,2-DCE=0.014 TCE=0.017				
	SSW6-37	BS-SSW6-37-96-25.5	25.5	Apr-96	CLS			ND				
		BS-SSW6-37-96-31.5	31.5					ND				
		BS-SSW6-37-96-33.5	33.5					ND				

LT	= Less than Quantitation Limit
ND	= Not detected
	= Not analyzed

BC = Analysis by BC Laboratories
C = Analysis by Chromalab
CLS = Analysis by California Laboratory Services
LBNL = Analysis by LBNL
Q = Analysis by Quanteq Laboratories

Table 4
Soil Sampling Results SWMUs 10-2 and 10-3
Metals
(Concentrations in mg/kg)

					Sb	As	Ba	Be	Cd	Cr	CrIV	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	Tl	Vn	Zn
			DETECTION LIMIT (BC)		10	1	1	1	1	1	0.1	5	1	5	0.2	5	5	1	2	10	1	5
			Maximum Background Concentrations**		5.5	19.1	324	1.0	2.7	99.6		22.2	69.4	16.1	0.4	7.4	119.8	5.6	1.8	7.6	74.3	106.1
			USEPA Region 9 PRGs		30	0.38	5200	150	37	210	30	3300	2800	400	22	370	1500	370	370	6	520	22000
			California Modified PRGs						9		0.2*			130			150					
Unit/Area	Location	Sample ID	Date	LAB																		
SWMU 10-2	MW91-9	91-9-S1	Dec-91	Q		11	120	0.6	0.3	86	NA	19	17	12			86				66	34
SWMU 10-3		91-9-S2				8	120	0.7	0.2	57	NA	16	21	10			54				64	58
Building 5		91-9-S3				8	130	0.6	0.4	47	NA	13	27	10			73			4	39	58
Former		91-9-S4				5	82	0.3	0.4	81	NA	12	20	8			77				41	39
Decontamination	MW5-93-10	BS5-93-10-6	Sep-93	C		0.94	85	0.22	0.65	26	NA	10	11	1.2		1.2	35				38	30
and Waste		BS5-93-10-15.3					67	0.19	0.23	18	NA	9.4	19			1.6	60				42	31
Storage Areas		BS5-93-10-25.8				3.0	57	0.38	0.21	12	NA	7.9	15			1.2	36				14	24
		BS5-93-10-35.2				1.3	84	0.14		17	NA	7.5	21	3.3	0.05	1.1	44				14	33
	Building 5	BS-SB-5-95-1-1.2	Jun-95	BC		1.7	122	0.52		80	NA	18	17	4.8			78				55	33
		BS-SB-5-95-2-1.3				1.1	151			72	NA	18	26	3.6			72	0.6			60	39
		BS-SB-5-95-3-1.3				1.4	110			88	NA	14	23				103				46	36
	SSW6-37	BS-SSW6-37-96-27	Apr-96	CLS			100			73	NA	14	63				100				62	77
		BS-SSW6-37-96-33					130			67	NA	13	45		0.063		110				45	64
		BS-SSW6-37-96-37					160			44	NA	12	65				78				39	63

*This PRG value assumes that detected Cr is 100% CrVI for screening purposes.

**Berkeley Lab, 1995.

NA	= Not analyzed
	= Not detected

BC = Analysis by BC Laboratories

C = Analysis by Chromalab

CLS = Analysis by California Laboratory Services

Q = Analysis by Quanteq Laboratories

Table 5
Sediment Sampling Results AOC 1-7, SWMUs 10-2 and 10-3
Radionuclides

						AOC 1-7	SWMUs 10-2 & 10-3	
Location	Sample ID	Date	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gamma (pCi/g) (1)	Curium 244 pCi/g	Cesium 137 pCi/g	Strontium 90 pCi/g
North Fork Strawberry Creek	SSBC-1B/2B-0.4	Apr-93				<0.1	<5	<1
	SSBC-3B/4B-0.8					<0.1	<5	<1
	SS-NFStraw-96-1B-0	Aug-96	<12	9 ± 2	16 ± 4	1.1 ± 0.4		
	SS-NFStraw-96-2B-0		<17	7 ± 2	17 ± 3	0.7 ± 0.4		
	SS-NFStraw-96-3B-0		<10	11 ± 1	16 ± 4	0.3 ± 0.2		
	SS-NFStraw-96-4B-0		<12	5 ± 2	15 ± 2	<0.1		
	SS-NFStraw-96-5B-0		<10	11 ± 2	17 ± 2	1.7 ± 0.3		

< = concentration less than minimum detectable activity (MDA)

= not analyzed

All samples analyzed by LBNL Radiological Laboratory

(1) - Gamma values are naturally occurring Potassium 40

Table 6
Groundwater Sampling Results
Radiological Elements

				AOC 1-7	SWMUs 10-2 and 10-3							
Area	Well No.	Date	Lab	Curium 244 (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gamma (pCi/L)	Americium 241 (pCi/L)	Europium 152 (pCi/L)	Europium 154 (pCi/L)	Strontium 90 (pCi/L)	Cesium 137 (pCi/L)
			MCL:								8	
Groundwater Monitoring Wells												
1	46A-92-15	May-93	LBNL	<0.1								
		Nov-98	LBNL	<0.2								
	71-93-1	Oct-93	LBNL	<0.6								
		Nov-98	LBNL	<0.2								
	71-93-2	Nov-98	LBNL	<0.2								
	46A-93-19	Nov-98	LBNL	<0.2								
	71-94-1	Nov-98	LBNL	<0.2								
	71-95-1	Nov-98	LBNL	<0.2								
	71-95-8	Nov-98	LBNL	<0.2								
	71-95-9	Nov-98	LBNL	<0.2								
	71-97-23	Nov-98	LBNL	<0.2								
	MW90-3	Dec-98	LBNL	<0.2								
9	51-94-11	Nov-98	LBNL	<0.2								
10	MW91-9	Aug-93	LBNL		5 ± 4	22 ± 4	<3				1.7 ± 0.4	
		Mar-97	LBNL								<4	
		Mar-97	LAS								<0.74	
10	5-93-10	Oct-93	LBNL		15 ± 10	23 ± 4	<200	<0.6	<10	<10	<1	<10
		Aug-99	LBNL		3.4 ± 0.9		<17					
Slope Stability Facilities												
1	SI1-162	Jun-93	LBNL	<0.1								
Hydraugers												
9	51-01-01	Aug-98	LBNL	<0.2								
	51-01-02			<0.2								
	64-01-01			<0.2								
Soil Borings/Temporary Wells												
10	SB5-97-6	Mar-97	LBNL		6 ± 2	<2	<10				<4	<6
	SB5-97-7				9 ± 4	3 ± 1	<10				<4	<6
	SB5-97-8				5 ± 2	3 ± 1	<10				<4	<6
Quality Assurance Samples												
	Field Blank	Nov-98	LBNL	<0.2								

< = Less than minimum detectable activity (MDA)

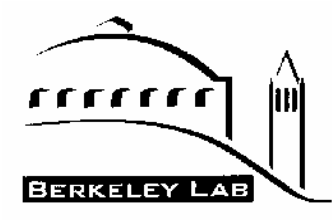
= not analyzed

LAS = Analysis by Lockheed Environmental Systems

LBNL = Analysis by LBNL Radiological Laboratory

APPENDIX B

Soil Investigation at the Building 4 Former Radioactive Waste Storage and Staging Area (Solid Waste Management Unit 10-1), July 2003.



E.O. Lawrence Berkeley National Laboratory
University of California
Environmental Restoration Program

United States Department of Energy

SOIL INVESTIGATION AT THE BUILDING 4 FORMER RADIOACTIVE WASTE STORAGE AND STAGING AREA (Solid Waste Management Unit 10-1)

for the

Lawrence Berkeley National Laboratory

ENVIRONMENTAL RESTORATION PROGRAM

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A Joint Effort of

Lawrence Berkeley National Laboratory
Environment, Health and Safety Division and
Earth Sciences Division
University of California
Berkeley, CA 94720

July 2003

This work was done at the Lawrence Berkeley National Laboratory operated by the University of California for the U. S. Department of Energy under contract DE-AC03-76SF00098.

CONTENTS

LIST OF ABBREVIATIONS

AOC	Area of Concern
Bgs	below ground surface
Cal/EPA	California Environmental Protection Agency
CAP	Corrective Action Program
CMS	Corrective Measure Study
DOE	U. S. Department of Energy
DTSC	Cal/EPA Department of Toxic Substances Control
ERP	Environmental Restoration Program
HSPP	Health and Safety Program Plan
LBF	LBNL Low Background Facility
LBNL	Lawrence Berkeley National Laboratory
NFA	No Further Action
NFI	No Further Investigation
PRG	Preliminary Remediation Goal
QAPP	Quality Assurance Program Plan
RAML	LBNL Radiation Analytical Measurement Laboratory
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RPG	Radiological Protection Group
SOP	Standard Operating Procedure
SWMU	Solid Waste Management Unit

SECTION 1

INTRODUCTION

1.1 BACKGROUND

The Lawrence Berkeley National Laboratory's (LBNL) Environmental Restoration Program (ERP) is part of a nationwide effort by the U. S. Department of Energy (DOE) to investigate and clean up hazardous and radioactive waste releases at its facilities due to past operations. Additionally, LBNL operates under a Resource Conservation and Recovery Act (RCRA) Part B Permit, which was issued by the State of California Environmental Protection Agency (Cal/EPA) Department of Toxic Substances Control (DTSC) on May 4, 1993. LBNL is required by its RCRA Part B Permit to investigate and address all historical releases of hazardous waste that may have occurred at the site. These activities are conducted under the LBNL ERP as part of the RCRA Corrective Action Program (CAP). The DTSC is the lead regulatory agency for the CAP. The ERP has been investigating and addressing potential releases of radionuclides concurrently with its RCRA required investigations. The DOE is the lead regulatory agency for issues related to radionuclides at LBNL.

LBNL received regulatory approval of the Draft Final RCRA Facility Investigation Report (LBNL, 2000) on July 27, 2001. A primary objective of the RCRA Facility Investigation (RFI) was to collect the necessary information to support corrective action decisions. To meet this objective, the RFI, conducted between October 1992 and September 2000, included identification of the sources and nature of site contamination and characterization of its magnitude and extent. In accordance with the procedure approved by the DTSC and described below, Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) included in the RFI were screened to identify those SWMUs and AOCs where No Further Action (NFA) was required and those that would be carried forward to the Corrective Measures Studies (CMS) phase of the CAP and evaluated in the Human Health Risk Assessment.

- SWMUs and AOCs were approved for No Further Action (NFA) status if: 1) the extent of contamination, if any, was sufficiently characterized; and 2) concentrations of contaminants in soil were within LBNL background levels or below USEPA Region IX and California Modified Preliminary Remediation Goals (PRGs) for residential soil. No further site investigation is required at these units, and they will not be included in the Human Health Risk Assessment.

- SWMUs and AOCs were approved for No Further Investigation (NFI) status if: 1) the extent of contamination was sufficiently characterized, and; 2) concentrations of contaminants in soil were above both LBNL background levels and PRGs for residential soil. No further site investigation is required at these units, but they will be included in the Human Health Risk Assessment, which constitutes the initial phase of the CMS.

Where the DTSC determined that insufficient site characterization had been conducted at a SWMU or AOC, the agency requested that additional investigation be conducted prior to NFA or NFI status approval. In addition, since the PRG screening process only addresses potential risks to human health, SWMUs and AOCs were also evaluated for inclusion in the Ecological Risk Assessment. SWMUs and AOCs that are not located in areas of potential resources to ecological receptors (e.g., food, water, shelter) will not be included in the Ecological Risk Assessment.

A similar process has been followed at LBNL for SWMUs and AOCs identified as having had a potential for past release of radiological contaminants. LBNL has requested that DOE provide a determination of whether the extent of radiological contamination (if any) at each SWMU or AOC has been sufficiently characterized and which of those SWMUs or AOCs should be evaluated in the risk assessments.

1.2 PURPOSE AND SCOPE

From the 1940's to the 1950's, part of Building 4 was used by LBNL's Nuclear Chemistry Division to conduct experiments involving radionuclides. Wastes from Building 4 were temporarily stored outdoors on the north side of the building. This area (Figure 1) was designated as the Building 4 Former Radioactive Waste Storage and Staging Area (SWMU 10-1) during the RFA (LBNL, 1992). The RCRA Facility Assessment (RFA) Report (LBNL,

1992) recommended that no additional work be performed at the site. Since radioactive waste was handled at this SWMU, the DOE is the regulatory oversight agency for this unit.

DOE reported that during a one-time site-wide sampling effort in 1986, 11 soil and 7 vegetation samples were collected and analyzed for radiological constituents, including one soil sample collected near the northwest corner of Building 4 (the Magnetic Fusion Energy Building) (DOE, 1988). Three of the soil samples were collected at background locations. The samples were analyzed for radiological constituents (gross alpha, gross beta, gamma emitters, and tritium. The sample collected near Building 4 contained gross alpha radiation at an activity of 11 ±5 pCi/g. The alpha activity in the three background samples ranged from 0 ±3 to 0 ±5 pCi/g, indicating that the sample collected at Building 4 was above background.

Although the RFA Report (LBNL, 1992) recommended that no additional work be performed at SWMU 10-1, DOE determined in January 2001 that additional investigation was warranted based on the previously reported results (DOE, 1988). In January 2001, LBNL therefore submitted a workplan to DOE for review and approval describing the scope of proposed investigations needed to reassess the status of SWMU 10-1 (LBNL, 2001). This report presents the results of those investigations and provides documentation to support the previous finding that No Further Action (NFA) is required for SWMU 10-1.

1.3 PROCEDURES

The investigations were performed in accordance with procedures of the ERP Quality Assurance Program Plan (QAPP) (LBNL, 1994a), the ERP Standard Operating Procedures (SOPs) (LBNL, 1994b), and requirements of the ERP Health and Safety Program Plan (LBNL, 1993a). In addition, the LBNL Radiological Protection Group (RPG) was contacted to assess if there were any other requirements relative to potential radiological issues. In response to this request, RPG issued a radiological work permit for the video surveying of sanitary sewers of this building. A copy of the permit is given in Attachment 1. The camera and cable were wrapped for protection during use and radiological surveys after use showed no contamination.

SECTION 2

INVESTIGATION AND RESULTS

2.1 APPROACH

Investigations at the Building 4 Former Radioactive Waste Storage and Staging Area (SWMU 10-1) focused on the two areas which had the potential for release of contaminants to the environment: 1) the area where wastes were temporarily stored on the north side of the building and 2) the sanitary sewer line originating from the northwest corner of the building.

2.2 SOIL SAMPLING

In February and March 2001, soil samples were collected from 12 locations (SB4-01-1 through SB4-01-12) near the northwest corner of the Building 4 in the area where radioactive wastes were temporarily stored (Figure 2). The DOE soil sample where gross alpha activity had exceeded background levels (DOE, 1988) was apparently collected from this area. Two samples were collected from each of the 12 locations, at depths of approximately 1 and 2 feet below ground surface (bgs). The sample location plan was originally based on a modified grid sampling pattern at approximately 10-foot spacing. However, several of the planned sampling locations were relocated to avoid underground utilities detected during a utility clearance survey.

In addition to the 24 samples described above, samples were collected at four locations (SB4-01-S1 through SB4-01-S4) adjacent to the sanitary sewer line at a depth of approximately 5 feet, which is at an elevation below the bottom of the sewer.

All 28 samples collected were tested for gross alpha and gross beta emissions, and were analyzed for gamma emitters using gamma ray spectroscopy by the LBNL Radiation Analytical Measurement Laboratory (RAML). In addition, the shallowest of the two samples collected at the 12 locations near the northwest corner of the building and the four samples collected next to the sanitary sewer line were also analyzed by gamma ray spectroscopy by LBNL's Low Background Facility (LBF). This facility is a special laboratory designed specifically to

conduct ultra-sensitive gamma ray spectroscopy, therefore results from the LBF are more precise than those from RAML.

Soil analytical results are shown in Table 1. Gross alpha radiation (8 ± 3 picocuries/gram [pCi/g]) was only detected at a depth of 2.3 feet in SB4-01-12. Gross beta radiation was reported as consistent with the amount of (naturally occurring) potassium-40 in the sample. Gamma ray spectroscopy indicated the presence of the naturally occurring radionuclides potassium-40 (4.1 ± 0.4 to 13.96 pCi/g), thorium-232 (<0.09 to 0.731 pCi/g), and uranium (<0.2 to 0.645 pCi/g) in most of the samples.

The only synthesized radionuclides detected by gamma spectroscopy were cesium-137 and americium-241. These isotopes are present in the environment primarily as a result of fallout from past aboveground testing of nuclear weapons. Cesium-137 was detected in 8 of the 16 samples and americium-241 in 11 of the 16 samples analyzed at the LBF. The maximum activities detected were 0.036 and 0.044 pCi/g for cesium-137 and americium 241, respectively, which is consistent with normal background levels.

In June 2001, two additional samples were collected from soil boring SB4-01-12A, adjacent to soil boring location SB4-01-12, where gross alpha radiation had been detected in the March 2001 sample. Samples were collected from 1.2 and 2.6 feet below ground surface, immediately above and below the sample location where gross alpha radiation had been previously detected. The samples were analyzed for gross alpha and gross beta emissions, and for gamma emitters using gamma ray spectroscopy. No gross alpha radiation was detected (<5 pCi/g). Gross beta activity was consistent with the amount of naturally occurring potassium-40 in the sample. Naturally occurring potassium-40, thorium-232, and uranium were the only gamma emitters detected. These results indicate that the extent of the soil encountered in boring SB4-01-12 for which gross alpha radiation exceeds the detection level is limited.

A summary of the gamma ray spectroscopy results for both naturally occurring and synthesized radionuclides is presented in the following table. Preliminary Remediation Goals (PRGs) for residential soil, which represent estimates of the radionuclide activities that would result in one in a million lifetime cancer risks, are included in the table. Except for potassium-

40 and natural uranium, concentrations of the gamma emitters were below PRGs for residential soil. Potassium-40 is a naturally occurring radionuclide. The concentrations of potassium-40 detected were within natural activity levels for soil (1 to 30 pCi/g) reported by the Idaho State University Physics Department Radiation Information Network.

Summary of Gamma Ray Spectroscopy Results in Soil (pCi/g)*

	K-40	Th-232	U (natural)	Cs-137	Am-241
Preliminary Remediation Goal for Residential Soil	0.11	3.1	.20**	3.88	1.9
Maximum Activity	14	1.1	0.6	0.04	0.06
Average Activity	8.92	0.48	0.35	0.02	0.04
Median Activity	8.85	0.45	0.35	0.02	0.04
Standard Deviation	2.15	0.20	0.13	0.00	0.00
Number of Samples	30	30	30	30	30

* Non-detects set at the detection limit for statistical calculations.
**PRG for U-235. This is the most conservative of the PRGs for natural uranium.

2.3 SANITARY SEWER EVALUATION

Based on interviews with former LBNL employees who worked in Building 4, the laboratories that handled radionuclides were located on the second floor of the building. The two sanitary sewer lines from the second floor were routed along the first floor ceiling, down both the north wall and northwest wall of the building and then underground. From these two locations, the lines were connected to the exterior 4-inch cast iron sanitary sewer line. The location of the sanitary sewer line is shown on Figure 2.

To supplement the soil sampling conducted along the sanitary sewer line, the integrity of the sewer line between Building 4 and the main sewer line branch was evaluated by conducting a video survey (Figure 3). No dislocations, breaks or perforations were identified. Details and results of the video surveys are included in the attached memorandum (Attachment 3). The main sanitary sewer line downflow from Building 4 was inspected in 1991. According to the video survey report, no defects were observed in this line either. Further soil sampling

was planned contingent on identification of any dislocations, breaks, or perforations. However, no such features were identified, so no further sampling was conducted.

SECTION 3

SUMMARY AND CONCLUSION

The results of the 2001 investigations reported in this document support the previous decision of NFA status for the Building 4 Former Radioactive Waste Storage and Staging Area (SWMU 10-1). Thirty soil samples were collected in 2001 to assess the reported detection of gross alpha activity at approximately two times the background level in a sample collected by DOE near the northwest corner of Building 4 in 1986. The sampling results indicate that:

- Gross alpha radiation was detected in one of the thirty samples (SB4-01-12). The extent of detectable gross alpha radiation in the soil is limited, since it was not detected in soil samples collected from adjacent borings, or in the same depth interval from a second sample collected at a later date from the same boring.

- Gross beta activities were consistent with the amount of potassium-40, a naturally occurring radionuclide, present in the sample.

- The detected gamma emitters were potassium-40, thorium-232, uranium, cesium-137, and americium-241. Potassium-40, thorium 232, and uranium are naturally occurring radionuclides. Cesium-137 and americium-241 are present in the environment primarily as a result of fallout from past aboveground testing of nuclear weapons. Except for potassium-40, concentrations of these radionuclides were below PRGs for residential soil. The concentrations of potassium-40 detected were within natural activity levels reported for soil.
- No defect, root intrusion, or displacement was observed in a video survey of the sanitary sewer line emanating from Building 4.

In addition, the Building 4 Former Radioactive Waste Storage and Staging Area is in the developed area of the site and not in an area of potential resources to ecological receptors (i.e., food, water, shelter). The unit will therefore not be included in the Ecological Risk Assessment.

SECTION 4

REFERENCES

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LIST OF FIGURES

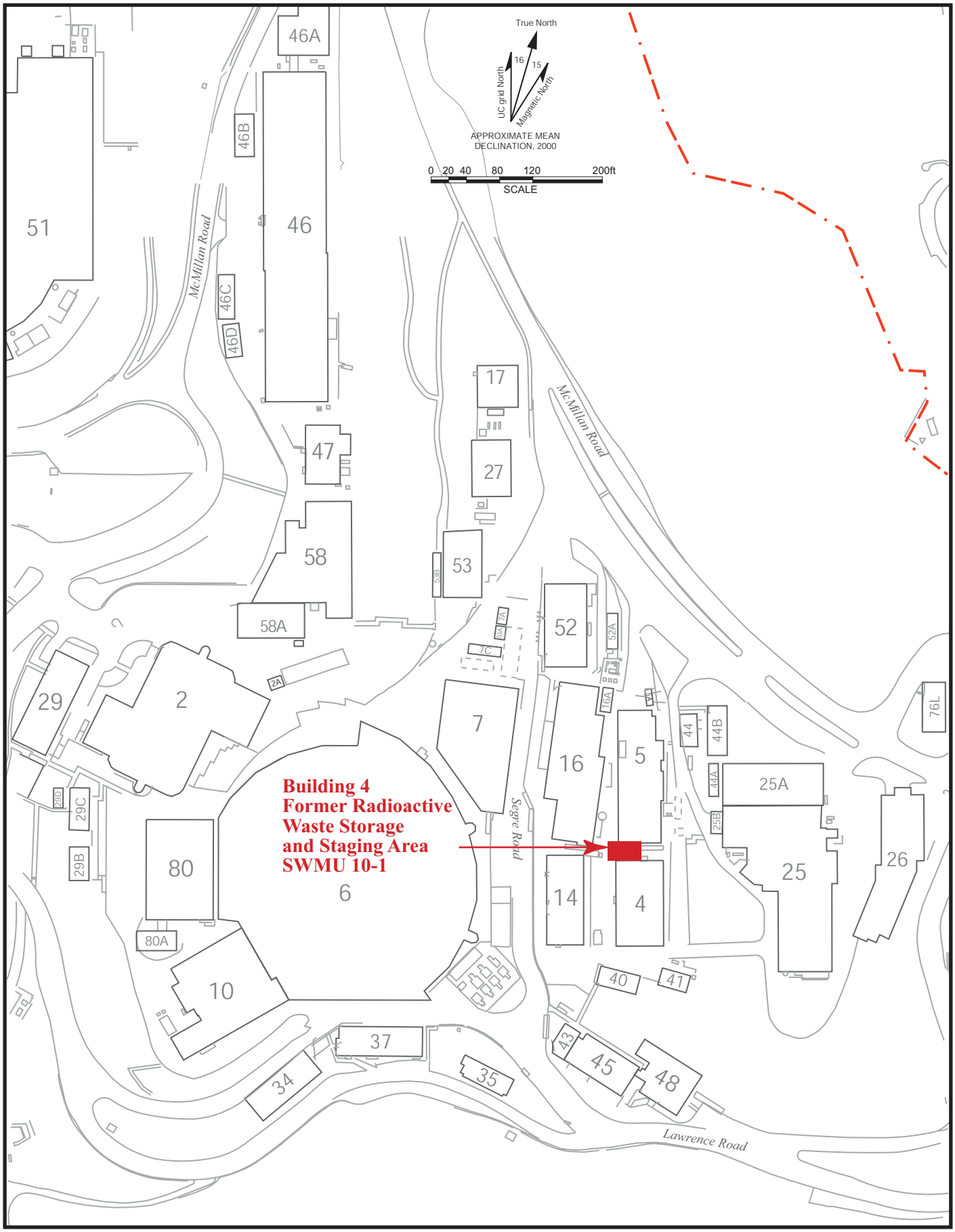

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Figure 1. Location of Building 4 Former Radioactive Waste Storage and Staging Area (SWMU 10-1)

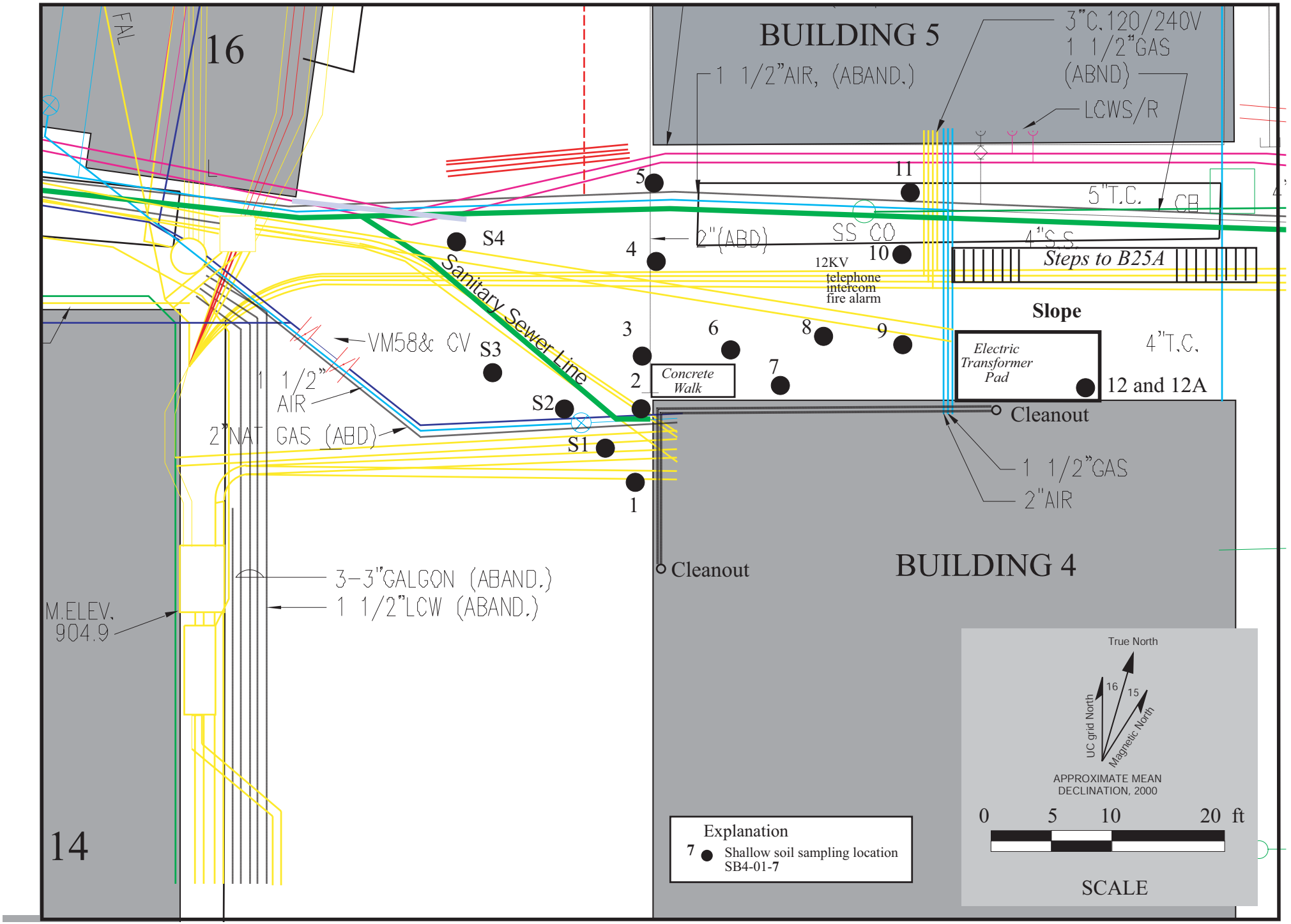

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Figure 2. Soil Sampling Locations Building 4 Former Radioactive Waste Storage and Staging Area (SWMU 10-1)

Figure 3. The condition of Building 4 sanitary sewer is being checked using a video camera.

LIST OF TABLE

Table 1
Soil Sampling Results for Radionuclides at Building 4
Gross Alpha, Gross Beta, and Gamma Spectroscopy
(Concentrations in pCi/g)

					Gamma Spectroscopy									
			Gross Alpha	Gross Beta*	Potassium 40		Thorium 232		Uranium natural		Cesium 137		Americium 241	
		PRG			0.068		24		0.69**		0.020		1.9	
Location	Depth	Sample Date	RAML	RAML	RAML	LBF	RAML	LBF	RAML	LBF	RAML	LBF	RAML	LBF
SB4-01-1	1.0	2/15/2001	<5	18 ± 2	14 ± 1	13.96	0.67 ± 0.09	0.731	0.5 ± 0.2	0.588	<0.02	<0.0006	<0.04	0.002
	2.2		<5	9 ± 2	5.8 ± 0.6		0.41 ± 0.08		0.3 ± 0.2		<0.02		<0.04	
SB4-01-2	0.8	2/15/2001	<5	13 ± 2	9.8 ± 0.8	10.22	0.54 ± 0.09	0.570	0.6 ± 0.2	0.645	0.04 ± 0.02	0.036	0.06 ± 0.02	0.044
	1.8		<5	8 ± 2	8.3 ± 0.8		0.40 ± 0.08		0.4 ± 0.2		<0.02		<0.04	
SB4-01-3	1.4	2/16/2001	<5	11 ± 2	7.6 ± 0.7	8.10	0.45 ± 0.07	0.486	0.3 ± 0.2	0.472	<0.02	0.0028	<0.04	0.001
	2.5		<5	8 ± 2	5.8 ± 0.6		0.37 ± 0.06		0.3 ± 0.2		<0.02		<0.04	
SB4-01-4	1.0	2/15/2001	<5	7 ± 1	8.5 ± 0.8	9.09	0.42 ± 0.08	0.514	0.3 ± 0.2	0.471	<0.02	<0.0003	<0.04	0.002
	2.0		<5	8 ± 2	6.1 ± 0.6		0.39 ± 0.06		0.2 ± 0.1		<0.02		<0.04	
SB4-01-5	0.8	2/15/2001	<5	6 ± 1	6.4 ± 0.6	6.24	0.12 ± 0.04	0.166	0.2 ± 0.2	0.189	<0.02	0.002	<0.04	0.008
	1.5		<5	8 ± 2	4.1 ± 0.4		<0.09		<0.2		<0.02		<0.04	
SB4-01-6	0.8	2/15/2001	<5	11 ± 2	7.7 ± 0.7	9.14	0.44 ± 0.07	0.582	0.4 ± 0.2	0.537	0.02 ± 0.01	0.024	<0.04	0.005
	2.0		<5	8 ± 2	7.3 ± 0.7		0.42 ± 0.07		0.3 ± 0.2		<0.02		<0.04	
SB4-01-7	0.9	2/15/2001	<5	8 ± 2	9.2 ± 0.8	9.43	0.31 ± 0.06	0.370	0.4 ± 0.2	0.385	<0.02	0.0028	<0.04	0.004
	2.0		<5	11 ± 2	8.2 ± 0.7		0.42 ± 0.06		0.2 ± 0.1		<0.02		<0.04	
SB4-01-8	0.8	2/15/2001	<5	9 ± 2	8.3 ± 0.8	8.50	0.47 ± 0.07	0.486	0.4 ± 0.2	0.438	<0.02	<0.0003	<0.04	<0.001
	1.8		<5	14 ± 2	11 ± 1		0.62 ± 0.09		0.2 ± 0.1		<0.02		<0.04	
SB4-01-9	0.8	2/16/2001	<5	8 ± 2	10.2 ± 0.9	10.16	0.41 ± 0.08	0.517	0.5 ± 0.2	0.478	<0.02	0.0023	<0.04	0.003
	2.0		<5	7 ± 2	8.6 ± 0.8		0.32 ± 0.06		0.3 ± 0.2		<0.02		<0.04	
SB4-01-10	1.0	2/16/2001	<5	11 ± 2	9.3 ± 0.9	10.67	0.47 ± 0.08	0.605	0.3 ± 0.2	0.514	<0.02	<0.0003	<0.04	0.008
	2.0		<5	12 ± 2	8.9 ± 0.8		0.52 ± 0.08		<0.2		<0.02		<0.04	
SB4-01-11	1.0	2/16/2001	<5	11 ± 2	11 ± 1	11.86	0.48 ± 0.08	0.579	0.4 ± 0.2	0.498	<0.02	<0.0003	<0.04	<0.001
	2.0		<5	14 ± 2	12 ± 1		0.51 ± 0.08		0.2 ± 0.1		<0.02		<0.04	
SB4-01-12	1.6	3/12/2001	<5	11 ± 2	11 ± 1	12.37	0.65 ± 0.09	0.714	0.5 ± 0.2	0.569	<0.02	0.0016	<0.04	0.006
	2.3		8 ± 3	17 ± 2	10.8 ± 0.9		0.55 ± 0.08		0.4 ± 0.2		<0.02		<0.04	
SB4-01-12A	1.2	6/7/2001	<5	11 ± 1	12 ± 1		1.1 ± 0.1		0.5 ± 0.1		<0.02		<0.04	
	2.6		<5	9 ± 1	10 ± 1		1.0 ± 0.1		0.3 ± 0.1		<0.02		<0.04	
SB4-01-S1	5.0	2/26/2001	<5	14 ± 2	9.7 ± 0.9	10.42	0.4 ± 0.1	0.352	0.4 ± 0.2	0.442	<0.02	<0.0003	<0.04	<0.001
SB4-01-S2	5.0	2/26/2001	<5	13 ± 2	10 ± 1	10.57	0.5 ± 0.1	0.610	0.5 ± 0.2	0.534	<0.02	<0.0003	<0.04	<0.001
SB4-01-S3	5.0	2/26/2001	<5	11 ± 2	8.8 ± 0.8	9.44	0.5 ± 0.1	0.568	0.5 ± 0.2	0.481	<0.02	<0.0003	<0.04	0.002
SB4-01-S4	4.7	2/26/2001	<5	10 ± 2	7.3 ± 0.7	7.62	0.4 ± 0.1	0.480	0.4 ± 0.2	0.449	<0.02	0.0026	<0.04	<0.001

< = Less than minimum detectable activity

= Not analyzed

RAML = LBNL Radiation Analytical Measurement Laboratory

LBF = LBNL Low Background Facility

*Gross beta results are consistent with the amount of potassium 40 in the sample

**PRG for U-235 with decay products included in risk calculation. This is the most conservative of the PRGs for natural uranium.

ATTACHMENT 1

Sanitary Sewer Investigation

Sanitary Sewer Investigation

A video survey was conducted to investigate the condition of the sanitary sewer under Building 4 and its vicinity. Prior to conducting this activity, the LBNL Radiological Protection Group was contacted to advise on the safety issues related to this job. A radiation control technician collected a few mg of rust from inside of a standpipe shown in Figure 3, inside Building 4. This sample was tested for radionuclides and its result is presented in the attached radiological work permit. Attempt was made to collect another rust sample from the original standpipe or other available sanitary sewer standpipes, but it was not possible.

To investigate the impact of this finding on the surrounding environment, the following action was taken:

We requested all archived data from analyses of water samples collected from the Hearst Sewer Outfall. This is the location where effluent from Building 4 Sanitary Sewer would have left the Lab. More than 30 years data was recovered and thoroughly reviewed by a radiochemist. The result of this study is documented in ATTACHMENT 2. According to this study, no significant release of gross alpha radiation has been recorded during the last 30 years.

Some summary data were also available for the period between 1963 and 1969. These documents contained number of water samples collected from the Hearst Outfall, the average and maximum concentration of alpha and beta activities of these samples. Both concentrations and total annual activities (whenever they are available) discharged at the Hearst Outfall were below permissible levels.

[See attached Radiological Work Permit]

RADIOLOGICAL WORK PERMIT
RWP 01-122
Class I

Date: 1/31/01

This form **must** be completed and approved prior to beginning work on the project.

Locations	4-102 & 4-102 B	**Issued**	2/1/01	**Expires**	2/28/01

Project Manager	Iraj Javandel	**Phone**	x6106
Work Leader	Bette Muhammad	**Phone**	x7602

Description

Camera Inspection of Building 4 Sewer

The purpose of this project is to insert a camera in the Building 4 sanitary sewer to observe the condition of the cast iron pipe. Evidence of dislocation or serious damage to the pipe will guide subsequent soil sampling and sewer repair (not covered under this authorization).

Radiological Conditions

Radioactive contamination was identified in the rust inside the sewer: ^{40}K (67 pCi/g), ^{137}Cs (6 pCi/g), ^{214}Pb (7 pCi/g), ^{238}Pu (19 pCi/g), ^{239}Pu (421 pCi/g), and ^{238}U (35 pCi/g). These radionuclides could contaminate the camera and the attached cable. Based on the above results, we do not expect any release from this project that exceeds regulatory permissible limits for sanitary sewer discharges.

Other Conditions

This radiation work permit (RWP) addresses radiation protection issues only. Other hazards noted include chemical contaminants and sewer gases. The project manager must consult with the appropriate EH&S expert on these issues. Each worker is responsible for reporting hazardous conditions to the project manager.

Personnel Protective Equipment

Standard safety items, including lab coats or coveralls, safety glasses, and gloves (as appropriate), must be worn while handling radioactively contaminated equipment.

EH&S Coverage

The RWP Program radiation control technician (RCT) inspects and surveys the work area at least once. A Materials and Facilities Disposition Group RCT-qualified person must be present at all times during this project. The project manager coordinates evaluations by other EH&S disciplines as necessary.

Posting / Barriers

No radiological posting is required because the work area will be continuously attended by an RCT-qualified person.

Instruments

The following detectors must be used on this project.

- Ludlum Model 3 with a 44-9 (pancake) detector
- air proportional alpha detector

Additional detectors may be obtained if needed.

Surveys

A Materials and Facilities Disposition Group RCT-qualified person conducts meter and smear (contamination) surveys of the work area after the camera is removed from the sewer. Surveys must be documented in accordance with EHS Procedure 710 and submitted to the Radiation Work Permit RCT for the close-out report.

Air Sampling

Air sampling is not required.

Equipment Release / Material Transfer

All material found to be radioactive must be transferred and stored in accordance with EHS Procedures 708, 709, and 750. Waste must be managed in accordance with EHS Procedure 868.

Stay Time Restrictions / Hold Points

Work must stop if

- unexpected radiological conditions are encountered
- the potential for contaminants to become airborne is identified (for example, if fine dust is encountered)

Any work stoppage must be reported immediately to the RWP Program Manager. Before work resumes, the RWP Program Manager must review the project.

External Dosimetry

Thermoluminescent dosimeters (TLDs) are not required.

Bioassay

Bioassay is not required unless an intake is suspected.

Training

There must be an RCT-qualified person present at all times during this project. All other workers must have completed general employee radiation training (GERT) and attended a prejob briefing before beginning work on this project.

Emergency Procedures

Report emergencies to 7-911. In the event of a radiological spill, follow the S.W.I.M.S. protocol: stop work, warn others, isolate the area, monitor carefully, and stay near by.

Addendum

Plastic or paper must be spread on the floor at the access to the sewer. To minimize contamination, the flexible section behind the camera head should be wrapped with tape. The cable of the camera must be wiped as it is removed from the sewer to remove any contaminants. The head of the camera must be wiped and decontaminated when it is removed from the sewer. The entire camera system must be surveyed and found to be free of contamination before it is released.

Authorized Personnel

All work must be performed in accordance with the terms and conditions of this RWP. Personnel listed below must attend a prejob briefing and sign below before they are authorized to work under this RWP. A signature indicates that the terms and conditions of this RWP have been read and understood.

Name	Emp #	Training	Expires	Signature
Javandel, Iraj	437388	GERT[b]	9/02	
Muhammad, Bette	631506	RCT-QP[a]	12/02	
Torres, Robert	898894	GERT	9/02	
Walling, Joseph	933688	GERT	9/02	

[a]RCT-QP = radiation control technician qualified person
[b]GERT = general employee radiation training (EHS405)

BERKELEY LAB	RADIOLOGICAL WORK PERMIT **RWP 01-122** Class I	Date: 1/31/01 Page 3 of 3

Approved

Iraj Javandel, Project Manager	Date 1/31/01
Ron Pauer, Environmental Services Group	Date 1/31/01
Gary Zeman, Radiological Control Manager	Date 1/31/01
Christine Donahue, Operational Health Physics Group Leader	Date 1/31/01
Linnea Wahl, Radiation Work Permit Program Manager	Date

ATTACHMENT 2

Evaluation of Historical Gross Alpha Results of Hearst Sewer Samples

Evaluation of Historical Gross Alpha Results of Hearst Sewer Samples

Jim Floyd

Group Leader
Technical Services Group
Environment, Health & Safety Division

May 2003

EVALUATION OF HISTORICAL GROSS ALPHA RESULTS OF HEARST SEWER SAMPLES

Purpose and Introduction

A review of the Hearst sewer samples was conducted for the years 1970 to 2001. The purpose of this review was to evaluate the potential low-level releases of actinides at or near the detection limits of the analysis. The standard analysis performed to measure this has been a gross alpha analysis where an aliquot of the sample is evaporated onto a 2" planchet and counted on a gas flow proportional counter. This is a screening method and does not give isotopic information.

Because this review spanned more than 30 years, there was a wide range of data completeness and documentation for that analysis. Broadly, the data was grouped into three sets for purposes of evaluation. From 1995 to present, comprehensive information existed on the raw data, reported results, and sensitivities of each analysis. Evaluation of these data consisted merely of tabulating the data.

From 1990 to 1994, the raw data and calculated results were in archives and available for review. However, the sensitivity reported at the time was a constant, predetermined value based on an annualized calculation rather than a per analysis value. To correctly determine whether or not each reported result was positive required calculation of the corresponding minimum detectable activity (MDA) and comparison to that analytical result.

Prior to 1990, there were gaps in the raw data and in the published results in addition to the MDA methodology issue. These gaps were significant enough that only an evaluation of the available raw counting data could be performed. The review consisted of a determination of whether the sample count was above or below the sensitivity of the detector for that count. Though there was not enough data to recalculate reported specific activity, it did give a reliable indication of whether or not the gross alpha concentration was detectable or not.

Methodology for the post 1994 data

All of these data have been generated and archived in a current Environmental Services Group data system. A simple query was performed to generate a listing of all positive Hearst Sewer samples in this time frame. Current, accepted methodologies for calculating sensitivities and comparing to the net result apply to this entire data set. This set is summarized in Attachment A.

Methodology for 1990-1994 data

For this set, individual, sample-specific MDAs needed to be calculated. This required retrieval of the raw data from archives. The raw data was then entered into a spreadsheet (Attachment B) for calculation using current methodology. This process was straightforward for all parameters except the instrument efficiency.

The efficiency calculation used in the original "AQUASSY" formula for these samples was a two-component function, derived from both a detector-specific constant and a sample-specific self-absorption function. Archival records had the self-absorption values, but the detector-specific constants were poorly documented, and had to be regenerated. This was done by using the original published result, inputting all other variables and back-calculating the efficiency. Where available, the documented efficiencies agreed with these recalculated efficiencies.

With the raw data and the generated efficiencies, the sample specific MDAs could then be calculated and compared to the original results. As another check on this process, the overall calculated efficiency was checked against the current calibration for that analysis. Generally very good agreement was obtained with acceptance limits set from 0.5 to 2.0. Any values outside of this range were reviewed for key entry or calculation errors. These checks on both the key entry and the formula give high confidence in the validity of the calculated MDAs.

Methodology for pre-1990 data

The archival records for the data before 1990 were missing a significant amount of information. In order to maintain comprehensiveness and ensure accuracy, the evaluation was therefore done with just the raw detector output, which was generally available. With this information, the net counts per minute and the minimum detectable counts per minute for each sample could still be calculated and then evaluated to determine if that result was positive. Though the calculation could not be done at the pCi/L level, it was still possible to unambiguously determine if the result was above the detection limit. These data and calculations are summarized in Attachment C.

Results

For the 1995 to current data set, 12 samples out of a total of 260 validated samples were above the MDA. These are summarized in Attachment A.

For the 1990 to 1994 data set, the calculated MDAs generally range from 2 to 5 pCi/L and are consistent with currently accepted MDAs. Comparison of original results to these new MDAs

reveals many fewer positive results than was reported at the time. Table 1 below summarizes for each year the number of true positives against the number originally reported for this period.

Table 1. Summary of Original Positives *vs.* True Positives for 1990-1994

Calendar Year	Total Number of Results Evaluated	Number of Positives (Original)	Number of Positives (True)
1994	39	32	2
1993	44	18	1
1992	21	8	0
1991	37	7	1
1990	47	15	0
Total	188	80	4

For the pre-1990 data set, 424 analyses had enough raw counting information to perform the evaluation. This comparison demonstrated that only 5 samples had net counting levels above the detection limit of the detector for that count.

Evaluation

The original MDA of 0.2 pCi/L for the data from 1990 to 1994 was calculated using different assumptions and methodology than is consistent with current practice. The true MDAs typically range from 2 to 5 pCi/L. Therefore, use of the original MDA value to determine whether or not individual results were positive vastly overestimated the number of positive results. Comparing the analytical results to the true MDA values demonstrates that few were actually above the detection limit. Overall, of the 188 values evaluated in this period, only 4 positives were actually recorded.

After the MDA was recalculated, the data set from 1990 to 1994 was summarized and compared with the data from 1995 to 2001. All of the samples with positive results for this overall period 1990 to 2001 are summarized in Table 2. There are 15 of these samples out of a total 448 reviewed. With the single exception of the 3/16/94 sample, all of the positive results are very close to the MDA value and could be false positives. From the definition of the MDA (with Type II error set at 0.05), it is expected that 5% of the results would be positive. The actual distribution from this set is 4% of the total, which is consistent with that expected of a normally distributed background population.

Table 2. Summary of Positive Gross Alpha Results for Hearst Sewer 1990-2001

Sample Date	Result (pCi/L)	MDA (pCi/L)
10/10/2001	5.1	3
8/16/2001	2.1	2
6/21/2001	2.1	2
12/22/1999	4.1	3
9/14/1999	4.2	3
8/30/1999	3.7	3
4/27/1999	3.3	3
9/14/1998	7.6	6
8/15/1995	2.8	2
6/8/1995	1.7	1.7
3/10/1995	1.1	1
11/10/1994	5.0	3
3/16/1994	13.9	5
5/12/1993	2.0	2
9/4/1991	5.8	3

A similar pattern holds true for the older data from the period 1970. Table 3 lists the five samples with net count rates above the detection limit. Note that these are in units of count/minute (cpm) and could not be converted to specific activity (pCi/L).

Table 3. Summary of Positive Gross Alpha Results for Hearst Sewer 1970-1990

Sample Date	Net Sample Count Rate (cpm)	MDA (cpm)
5/24/1989	0.21	0.20
4/22/87	0.06	0.06
11/27/1979	0.30	0.30
12/29/1976	0.38	0.38
8/14/1974	0.29	0.23

These 5 values represent only 1% of the total data set evaluated. This is significantly less than the expected 5% from the MDA calculation methodology. The values, while positive, are very close to the MDA and could also be expected to be false positives.

Conclusion

A review of the gross alpha analyses of the Hearst Sewer samples was performed for the period 1970 to current. The raw data was evaluated and compared to the sample-specific MDA to determine which samples were actually positive. Data was available to perform this analysis on a total of 872 samples. Of these, 20 had results above the detection limit.

The percentage of positives to total was equal to or less than that expected from a normally distributed background population. Further, those positives were, with one exception, very close to the MDA values. These can reasonably be interpreted as false positives.

No pattern of positive results exists in the data set from 1970 to current to indicate any release of actinides through the Hearst Sewer.

Attachment A

Summary of Positive Gross Alpha Results for 1995 to Present

Sample Date	Result	MDA	Units
3/10/95	1.1	1	pCi/L
6/8/95	1.8	1.7	pCi/L
8/15/95	2.8	2.5	pCi/L
9/14/1998	7.6	6	pCi/L
4/27/1999	3.3	3	pCi/L
8/30/1999	3.7	3	pCi/L
9/14/1999	4.2	3	pCi/L
11/9/1999	2.7	3	pCi/L
12/22/1999	4.1	3	pCi/L
6/21/2001	2.1	2	pCi/L
8/16/2001	2.1	2	pCi/L
10/10/2001	5.1	3	pCi/L

Attachment B

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1990 to 1994

Sample Date	Original Published MDA (pCi/L)	Original Published Result (pCi/L)	True Calculated MDA (pCi/L)	True Positive
8/17/1994	0.20	0.22	2.30	
6/29/1994	0.20	-1.03	3.47	
11/30/1994	0.20	0.14	2.94	
11/16/1994	0.20	0.45	3.12	
11/10/1994	0.20	5.05	3.21	x
11/2/1994	0.20	-1.42	4.27	
10/26/1994	0.20	0.99	4.14	
10/19/1994	0.20	0.92	2.71	
9/26/1994	0.20	1.89	2.72	
9/20/1994	0.20	0.14	2.96	
9/14/1994	0.20	0.82	1.37	
9/7/1994	0.20	1.06	1.30	
8/31/1994	0.20	0.89	3.50	
8/24/1994	0.20	0.60	2.44	
8/17/1994	0.20	0.59	2.39	
8/10/1994	0.20	1.57	3.94	
8/3/1994	0.20	0.85	4.59	
7/27/1994	0.20	3.39	4.87	
7/13/1994	0.20	1.61	2.98	
7/6/1994	0.20	0.50	3.03	
6/29/1994	0.20	0.25	3.58	
6/22/1994	0.20	-1.58	6.83	
6/8/1994	0.20	1.67	4.78	
5/25/1994	0.20	2.53	3.89	
5/11/1994	0.20	1.72	4.62	
5/4/1994	0.20	1.99	3.80	
4/13/1994	0.20	2.09	4.14	
4/6/1994	0.20	-0.62	4.77	
3/23/1994	0.20	5.57	6.00	x
3/16/1994	0.20	13.89	5.47	
3/9/1994	0.20	2.15	4.95	
3/2/1994	0.20	-0.18	6.47	
2/22/1994	0.20	1.19	5.03	
2/18/1994	0.20	1.11	6.29	
2/9/1994	0.20	0.32	5.36	
2/2/1994	0.20	0.33	5.54	
1/26/1994	0.20	1.05	5.37	
1/19/1994	0.20	0.88	5.18	
12/14/1993	0.20	0.75	4.75	
12/9/1993	0.20	0.75	4.75	
11/30/1993	0.20	0.15	5.59	
11/24/1993	0.20	-1.13	6.04	
11/16/1993	0.20	-2.09	6.04	
11/10/1993	0.20	0.62	5.03	
10/27/1993	0.20	2.53	4.84	
10/20/1993	0.20	-1.36	5.18	

Sample Date	Original Published MDA (pCi/L)	Original Published Result (pCi/L)	True Calculated MDA (pCi/L)	True Positive
10/13/1993	0.20	1.03	5.27	
10/6/1993	0.20	0.31	4.76	
9/29/1993	0.20	-0.98	3.51	
9/15/1993	0.20	0.70	4.70	
9/8/1993	0.20	-1.29	4.31	
9/1/1993	0.20	-0.68	4.54	
8/25/1993	0.20	-0.42	5.63	
8/20/1993	0.20	0.32	4.23	
8/11/1993	0.20	-0.30	3.71	
8/3/1993	0.20	0.60	3.71	
7/28/1993	0.20	-0.14	2.90	
7/21/1993	0.20	-0.30	4.05	
7/14/1993	0.20	-0.59	3.92	
7/6/1993	0.20	-1.54	2.92	
6/30/1993	0.20	-6.30	5.11	
6/23/1993	0.20	0.28	2.68	
6/16/1993	0.20	0.91	2.89	
6/2/1993	0.20	0.37	3.55	
5/26/1993	0.20	-0.16	3.84	
5/19/1993	0.20	0.79	3.70	
5/12/1993	0.20	2.06	1.99	x
5/5/1993	0.20	0.78	1.96	
4/20/1993	0.20	0.52	3.01	
4/14/1993	0.20	-0.18	3.12	
4/7/1993	0.20	-2.16	3.78	
3/31/1993	0.20	-0.93	3.35	
2/23/1993	0.20	-1.79	5.51	
2/16/1993	0.20	-0.47	5.64	
2/3/1993	0.20	-0.39	5.22	
1/27/1993	0.20	1.28	6.56	
1/20/1993	0.20	-0.12	7.64	
1/13/1993	0.20	-0.41	5.27	
8/20/1992	0.20	-0.06	3.74	
6/26/1992	0.20	0.25	9.03	
6/3/1992	0.20	-0.79	4.37	
5/28/1992	0.20	1.33	3.26	
5/20/1992	0.20	0.76	4.32	
5/6/1992	0.20	-0.26	2.87	
4/29/1992	0.20	-0.13	2.26	
4/22/1992	0.20	-0.17	3.01	
4/8/1992	0.20	0.68	2.77	
4/1/1992	0.20	0.47	2.87	
3/25/1992	0.20	1.59	4.01	
3/18/1992	0.20	-0.34	3.13	
3/11/1992	0.20	0.12	3.37	
3/4/1992	0.20	0.63	3.56	
2/25/1992	0.20	-0.59	4.11	
2/19/1992	0.20	1.55	3.13	
2/12/1992	0.20	-1.45	4.11	
2/5/1992	0.20	-0.27	3.57	
1/15/1992	0.20	-0.71	4.20	
1/2/1992	0.20	-0.66	3.89	

Sample Date	Original Published MDA (pCi/L)	Original Published Result (pCi/L)	True Calculated MDA (pCi/L)	True Positive
12/16/1991	0.20	-1.89	4.57	
11/26/1991	0.20	1.58	3.45	
11/20/1991	0.20	0.63	3.23	
10/23/1991	0.20	-1.56	5.31	
10/16/1991	0.20	-0.07	4.03	
10/10/1991	0.20	0.36	4.01	
10/3/1991	0.20	-1.25	3.83	
9/4/1991	0.20	5.76	3.19	x
8/14/1991	0.20	-0.63	3.23	
7/31/1991	0.20	-0.60	3.52	
7/24/1991	0.20	-0.92	3.70	
7/2/1991	0.20	-0.19	2.13	
6/11/1991	0.20	-0.05	1.71	
6/5/1991	0.20	0.56	1.68	
5/29/1991	0.20	0.11	3.03	
5/22/1991	0.20	-0.10	2.89	
5/15/1991	0.20	-0.05	2.79	
5/1/1991	0.20	-0.40	2.70	
4/24/1991	0.20	-0.33	1.82	
4/17/1991	0.20	-0.19	1.42	
4/10/1991	0.20	-0.76	2.34	
4/3/1991	0.20	-0.12	1.42	
3/27/1991	0.20	0.05	2.14	
3/20/1991	0.20	-0.10	2.75	
3/13/1991	0.20	-0.71	2.80	
2/27/1991	0.20	-0.09	1.58	
2/20/1991	0.20	-0.29	2.00	
2/13/1991	0.20	-0.10	1.69	
2/6/1991	0.20	-0.28	1.63	
1/30/1991	0.20	0.86	3.10	
1/23/1991	0.20	0.14	1.82	
1/16/1991	0.20	-0.19	1.77	
1/9/1991	0.20	0.10	1.76	
1/2/1991	0.20	0.10	1.72	
12/18/1990	0.20	0.14	1.56	
12/12/1990	0.20	-0.55	2.26	
12/4/1990	0.20	-0.28	3.44	
11/27/1990	0.20	-0.28	1.63	
11/20/1990	0.20	-0.36	2.10	
11/14/1990	0.20	-0.42	2.58	
10/31/1990	0.20	0.34	1.96	
10/24/1990	0.20	0.33	1.90	
10/17/1990	0.20	0.72	1.78	
10/10/1990	0.20	0.45	1.85	
10/3/1990	0.20	0.33	2.39	
9/26/1990	0.20	0.06	2.40	
9/12/1990	0.20	-0.29	2.60	
9/5/1990	0.20	0.26	2.19	
8/29/1990	0.20	-0.16	1.90	
8/22/1990	0.20	-0.22	2.09	
8/15/1990	0.20	-0.26	2.66	

Sample Date	Original Published MDA (pCi/L)	Original Published Result (pCi/L)	True Calculated MDA (pCi/L)	True Positive
8/1/1990	0.20	-0.12	2.46	
7/24/1990	0.20	-0.41	2.86	
7/18/1990	0.20	-0.53	2.19	
7/11/1990	0.20	0.29	2.25	
7/3/1990	0.20	0.27	2.07	
6/27/1990	0.20	0.28	2.03	
6/20/1990	0.20	0.43	1.64	
6/6/1990	0.20	-0.11	1.93	
5/30/1990	0.20	-0.11	1.40	
5/23/1990	0.20	-0.28	1.74	
5/16/1990	0.20	-0.10	1.81	
5/9/1990	0.20	-0.32	2.19	
4/25/1990	0.20	-0.37	2.55	
4/18/1990	0.20	0.06	2.48	
4/11/1990	0.20	0.05	2.23	
4/4/1990	0.20	-0.13	2.59	
3/28/1990	0.20	0.79	2.33	
3/21/1990	0.20	0.80	2.14	
3/14/1990	0.20	-0.36	2.46	
3/7/1990	0.20	-0.12	2.38	
2/28/1990	0.20	0.47	2.27	
2/21/1990	0.20	-0.44	2.68	
2/14/1990	0.20	-0.62	2.41	
2/7/1990	0.20	1.09	2.09	
1/31/1990	0.20	0.45	1.72	
1/24/1990	0.20	-0.18	2.17	
1/17/1990	0.20	-0.38	1.96	
1/10/1990	0.20	-0.28	2.79	
1/3/1990	0.20	-0.66	2.54	

Attachment C

Calculation of Sample Specific MDAs for
Hearst Sewer Samples 1970 to 1989

(cpm calculations attached)

ATTACHMENT C

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1970 to 1971

Sample Date	Net CPM	MDA (cpm)	Positive
10/26/1971	-0.012	0.218	
9/29/1971	0.012	0.211	
9/22/1971	-0.007	0.213	
12/2/1970	-0.015	0.203	
11/11/1970	0.127	0.193	
10/7/1970	-0.043	0.197	
9/16/1970	-0.012	0.218	
9/9/1970	-0.073	0.230	
9/1/1970	-0.060	0.233	
8/26/1970	-0.055	0.228	
8/19/1970	-0.055	0.228	
7/15/1970	-0.037	0.227	
7/8/1970	0.015	0.225	
7/1/1970	0.008	0.232	
6/17/1970	-0.012	0.235	
6/3/1970	-0.060	0.233	
5/20/1970	0.007	0.216	
4/29/1970	-0.060	0.216	
4/15/1970	-0.025	0.214	
4/8/1970	0.120	0.540	
4/1/1970	-0.080	0.220	

ATTACHMENT C (cont'd.)

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1973

Sample Date	Net CPM	MDA (cpm)	Positive
7/25/1973	0.083	0.184	
7/18/1973	0.015	0.186	
7/11/1973	0.342	0.490	
6/27/1973	0.078	0.191	
6/13/1973	0.043	0.193	
5/30/1973	0.082	0.186	
5/23/1973	0.032	0.186	
5/16/1973	0.055	0.177	
5/9/1973	-0.013	0.180	
4/11/1973	-0.040	0.193	
2/21/1973	-0.012	0.218	
2/14/1973	-0.053	0.209	
2/7/1973	-0.075	0.061	
1/31/1973	-0.085	0.061	
1/24/1973	-0.052	0.053	

ATTACHMENT C (cont'd.)

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1974

Sample Date	Net CPM	MDA (cpm)	Positive
10/30/1974	0.133	0.373	
10/23/1974	-0.047	0.344	
10/16/1974	0.047	0.364	
10/2/1974	0.000	0.339	
9/25/1974	-0.013	0.180	
9/4/1974	0.007	0.136	
8/28/1974	-0.100	0.268	
8/21/1974	0.020	0.268	
8/14/1974	0.293	0.230	x
8/7/1974	-0.020	0.192	
7/31/1974	-0.020	0.192	
7/10/1974	-0.020	0.221	
6/12/1974	0.027	0.180	
6/5/1974	-0.013	0.212	
5/29/1974	0.000	0.153	
5/8/1974	-1.400	0.844	
5/1/1974	0.047	0.180	

ATTACHMENT C (cont'd.)

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1975

Sample Date	Net CPM	MDA (cpm)	Positive
12/2/1975	0.227	0.281	
10/29/1975	-0.060	0.323	
9/24/1975	0.053	0.275	
9/17/1975	-0.053	0.281	
9/3/1975	-0.007	0.294	
8/20/1975	0.030	0.361	
7/9/1975	-0.033	0.300	
4/23/1975	0.007	0.281	
3/18/1975	-0.153	0.318	
3/12/1975	0.020	0.306	
3/4/1975	0.040	0.306	
2/26/1975	0.007	0.318	

ATTACHMENT C (cont'd.)

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1976

Sample Date	Net CPM	MDA (cpm)	Positive
12/29/1976	0.385	0.379	x
12/15/1976	0.068	0.299	
11/24/1976	-0.075	0.240	
11/17/1976	0.025	0.240	
11/3/1976	-0.075	0.240	
10/26/1976	-0.010	0.234	
10/13/1976	-0.060	0.268	
10/5/1976	-0.050	0.234	
9/1/1976	0.030	0.207	
8/18/1976	-0.013	0.261	
8/4/1976	-0.025	0.200	
7/27/1976	0.055	0.200	
6/30/1976	-0.005	0.252	
6/23/1976	-0.005	0.252	
6/16/1976	0.135	0.252	
5/26/1976	0.135	0.343	
4/14/1976	-0.045	0.358	
4/7/1976	0.045	0.392	
1/28/1976	0.020	0.323	
1/20/1976	-0.060	0.323	
1/14/1976	0.060	0.323	

ATTACHMENT C (cont'd.)
Calculation of Sample Specific MDAs for Hearst Sewer Samples 1977

Sample Date	Net CPM	MDA (cpm)	Positive
11/16/1977	-0.025	0.293	
10/18/1977	0.033	0.254	
10/12/1977	-0.025	0.358	
10/5/1977	0.010	0.297	
9/27/1977	0.085	0.350	
9/21/1977	0.085	0.350	
9/7/1977	-0.065	0.310	
8/31/1977	0.030	0.315	
8/23/1977	-0.200	0.382	
7/26/1977	-0.025	0.343	
7/20/1977	-0.080	0.339	
7/13/1977	0.155	0.310	
6/8/1977	0.135	0.327	
5/24/1977	0.225	0.350	
4/13/1977	0.100	0.382	
3/30/1977	-0.240	0.496	
3/22/1977	-0.065	0.343	
3/16/1977	-0.060	0.382	
3/9/1977	-0.230	0.438	
2/9/1977	0.040	0.306	
2/2/1977	0.010	0.297	
1/19/1977	-0.100	0.382	
1/12/1977	-0.060	0.339	

ATTACHMENT C (cont'd.)
Calculation of Sample Specific MDAs for Hearst Sewer Samples 1978

Sample Date	Net CPM	MDA (cpm)	Positive
12/13/1978	0.035	0.386	
12/6/1978	0.140	0.339	
11/28/1978	-0.140	0.395	
11/8/1978	-0.140	0.354	
11/1/1978	0.085	0.302	
10/25/1978	0.025	0.335	
10/18/1978	-0.095	0.335	
10/11/1978	-0.025	0.273	
10/4/1978	-0.030	0.331	
9/27/1978	0.140	0.288	
9/20/1978	0.000	0.323	
9/13/1978	0.000	0.339	
9/6/1978	-0.075	0.350	
8/30/1978	0.000	0.323	
8/23/1978	-0.100	0.382	
8/17/1978	0.030	0.297	
8/9/1978	0.110	0.278	
8/2/1978	0.015	0.310	
7/26/1978	-0.030	0.331	
7/12/1978	-0.020	0.288	
7/5/1978	-0.035	0.283	
6/21/1978	-0.065	0.343	
6/14/1978	-0.020	0.268	
5/31/1978	0.040	0.323	
5/24/1978	-0.015	0.335	
5/17/1978	0.070	0.315	
5/10/1978	0.075	0.228	
4/12/1978	-0.150	0.389	
3/29/1978	-0.070	0.331	
3/15/1978	0.015	0.358	
2/22/1978	0.040	0.268	
2/1/1978	0.170	0.278	

ATTACHMENT C (cont'd.)

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1979

Sample Date	Net CPM	MDA (cpm)	Positive
12/18/1979	-0.065	0.411	
12/4/1979	0.020	0.354	
11/27/1979	0.300	0.306	x
11/20/1979	0.040	0.268	
11/13/1979	0.065	0.429	
11/6/1979	0.080	0.323	
10/17/1979	-0.025	0.343	
10/3/1979	0.080	0.268	
9/19/1979	0.120	0.288	
9/12/1979	-0.015	0.283	
8/29/1979	0.020	0.323	
8/22/1979	-0.060	0.288	
8/8/1979	-0.010	0.278	
8/1/1979	-0.060	0.323	
6/27/1979	-0.010	0.331	
6/20/1979	0.005	0.335	
6/13/1979	-0.005	0.310	
6/6/1979	-0.040	0.306	
5/16/1979	-0.035	0.335	
5/2/1979	0.055	0.358	
4/25/1979	-0.020	0.306	
4/18/1979	-0.020	0.288	
3/29/1979	0.040	0.306	
3/21/1979	0.050	0.414	
3/7/1979	0.045	0.335	
2/28/1979	-0.040	0.323	
2/21/1979	0.040	0.221	
2/14/1979	-0.025	0.372	
2/7/1979	0.005	0.379	
1/31/1979	0.060	0.323	
1/24/1979	0.035	0.327	

ATTACHMENT C (cont'd.)

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1980

Sample Date	Net CPM	MDA (cpm)	Positive
12/23/1980	-0.020	0.306	
12/9/1980	-0.160	0.339	
12/2/1980	-0.050	0.315	
11/26/1980	0.160	0.323	
11/19/1980	0.040	0.339	
11/12/1980	-0.080	0.382	
11/4/1980	-0.015	0.302	
10/21/1980	-0.025	0.327	
10/14/1980	-0.065	0.358	
10/7/1980	-0.095	0.335	
9/23/1980	0.135	0.273	
8/26/1980	-0.065	0.293	
8/19/1980	-0.020	0.354	
7/22/1980	-0.035	0.283	
7/8/1980	-0.065	0.310	
7/1/1980	0.100	0.246	
6/17/1980	0.035	0.273	
6/10/1980	0.055	0.252	
5/20/1980	0.070	0.257	
4/15/1980	-0.065	0.293	
4/1/1980	0.005	0.302	
3/25/1980	-0.055	0.319	
3/18/1980	-0.020	0.268	
3/11/1980	0.095	0.273	
3/4/1980	0.060	0.246	
2/26/1980	-0.085	0.310	
2/20/1980	0.080	0.246	
2/12/1980	-0.060	0.323	
2/5/1980	0.180	0.268	
1/22/1980	-0.020	0.323	
1/15/1980	0.020	0.323	
1/8/1980	-0.030	0.315	
1/1/1980	0.040	0.268	

ATTACHMENT C (cont'd.)

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1981

Sample Date	Net CPM	MDA (cpm)	Positive
12/1/1981	0.005	0.240	
11/25/1981	-0.080	0.306	
11/17/1981	-0.020	0.354	
11/10/1981	0.000	0.288	
11/3/1981	-0.070	0.257	
10/27/1981	-0.120	0.339	
10/13/1981	0.020	0.339	
10/6/1981	0.025	0.302	
9/29/1981	-0.150	0.361	
9/9/1981	-0.090	0.347	
9/1/1981	-0.060	0.323	
8/25/1981	0.010	0.315	
8/4/1981	-0.080	0.339	
7/28/1981	-0.005	0.273	
7/14/1981	-0.070	0.375	
7/7/1981	-0.085	0.343	
6/30/1981	0.015	0.343	
6/23/1981	0.055	0.310	
6/16/1981	0.100	0.306	
6/9/1981	-0.025	0.327	
6/2/1981	0.015	0.327	
5/27/1981	-0.065	0.343	
5/12/1981	-0.045	0.293	
4/28/1981	-0.130	0.361	
3/31/1981	-0.035	0.335	
3/24/1981	0.005	0.283	
3/17/1981	-0.020	0.268	
3/10/1981	-0.020	0.354	
2/24/1981	-0.040	0.368	
2/10/1981	-0.065	0.327	
1/27/1981	0.000	0.268	
1/20/1981	0.030	0.297	

ATTACHMENT C (cont'd.)

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1982

Sample Date	Net CPM	MDA (cpm)	Positive
6/22/1982	-0.040	0.306	
6/15/1982	0.040	0.306	
6/8/1982	0.040	0.288	
6/2/1982	-0.175	0.350	
6/2/1982	-0.130	0.315	
5/25/1982	0.045	0.283	
5/18/1982	-0.005	0.310	
5/11/1982	0.000	0.288	
5/4/1982	-0.010	0.278	
4/27/1982	-0.030	0.297	
4/20/1982	-0.005	0.343	
3/9/1982	-0.040	0.268	
2/9/1982	-0.045	0.252	
1/26/1982	0.020	0.306	
1/21/1982	0.000	0.339	
1/5/1982	-0.060	0.268	

ATTACHMENT C (cont'd.)

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1983

Sample Date	Net CPM	MDA (cpm)	Positive
12/20/1983	-0.003	0.125	
12/13/1983	-0.038	0.167	
12/6/1983	-0.015	0.141	
11/22/1983	0.000	0.060	
11/15/1983	-0.020	0.153	
11/8/1983	0.015	0.252	
11/1/1983	-0.060	0.288	
10/25/1983	-0.220	0.382	
10/18/1983	0.015	0.293	
10/11/1983	-0.055	0.240	
10/4/1983	-0.040	0.288	
9/27/1983	-0.065	0.252	
9/20/1983	-0.160	0.382	
9/13/1983	0.020	0.192	
9/6/1983	-0.030	0.257	
8/30/1983	-0.025	0.252	
8/23/1983	-0.065	0.293	
8/17/1983	-0.040	0.288	
8/9/1983	-0.010	0.257	
8/2/1983	-0.040	0.221	
7/26/1983	-0.110	0.315	
7/19/1983	-0.015	0.302	
7/12/1983	0.015	0.252	
7/5/1983	0.005	0.240	
6/28/1983	-0.075	0.350	
6/21/1983	0.085	0.240	
6/14/1983	-0.115	0.319	
5/31/1983	-0.005	0.252	
5/24/1983	0.000	0.268	
5/17/1983	0.045	0.214	
5/10/1983	0.100	0.288	
5/3/1983	0.020	0.288	

Sample Date	Net CPM	MDA (cpm)	Positive
4/26/1983	0.040	0.268	
4/19/1983	-0.020	0.288	
4/12/1983	0.020	0.306	
4/5/1983	-0.020	0.288	
3/29/1983	0.040	0.246	
3/15/1983	0.100	0.288	
3/8/1983	-0.100	0.339	
3/1/1983	-0.080	0.323	
2/23/1983	0.020	0.246	
2/16/1983	0.040	0.246	
2/8/1983	0.040	0.306	
2/1/1983	-0.080	0.323	
1/25/1983	-0.500	0.594	
1/18/1983	0.040	0.192	
1/11/1983	-0.030	0.257	
1/4/1983	0.065	0.263	

ATTACHMENT C (cont'd.)

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1984

Sample Date	Net CPM	MDA (cpm)	Positive
10/23/1984	-0.020	0.192	
10/5/1984	0.060	0.246	
9/18/1984	-0.070	0.234	
9/11/1984	0.005	0.240	
9/5/1984	0.000	0.192	
8/28/1984	-0.040	0.221	
8/21/1984	-0.035	0.240	
8/7/1984	-0.020	0.221	
7/31/1984	0.100	0.192	
7/24/1984	0.010	0.207	
7/17/1984	0.025	0.183	
7/10/1984	-0.020	0.192	
7/3/1984	-0.020	0.192	
6/26/1984	-0.045	0.228	
6/19/1984	-0.035	0.183	
6/5/1984	-0.050	0.234	
5/30/1984	-0.040	0.221	
5/22/1984	-0.040	0.192	
5/15/1984	0.015	0.200	
5/8/1984	-0.010	0.174	
4/24/1984	-0.020	0.153	
4/3/1984	0.030	0.174	

ATTACHMENT C (cont'd.)

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1986

Sample Date	Net CPM	MDA (cpm)	Positive
6/25/1986	0.010	0.174	
6/18/1986	-0.015	0.214	
6/11/1986	0.040	0.060	
6/4/1986	-0.020	0.192	
5/28/1986	0.005	0.141	
5/21/1986	-0.010	0.207	
5/14/1986	0.045	0.141	
4/23/1986	-0.030	0.174	
4/16/1986	-0.010	0.174	
4/9/1986	-0.030	0.174	
4/2/1986	0.010	0.174	
3/12/1986	0.040	0.060	
3/5/1986	-0.015	0.183	
2/19/1986	-0.035	0.183	
2/12/1986	-0.045	0.228	
1/29/1986	0.000	0.192	
1/22/1986	-0.015	0.183	
1/15/1986	-0.010	0.174	
1/8/1986	-0.030	0.174	

ATTACHMENT C (cont'd.)

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1987

Sample Date	Net CPM	MDA (cpm)	Positive
12/21/1987	-0.027	0.167	
12/16/1987	0.080	0.192	
12/2/1987	-0.050	0.234	
11/23/1987	0.005	0.183	
11/18/1987	-0.010	0.126	
11/11/1987	-0.030	0.174	
11/4/1987	0.020	0.153	
10/28/1987	-0.005	0.164	
10/21/1987	-0.005	0.164	
10/14/1987	0.000	0.192	
10/7/1987	-0.030	0.207	
9/30/1987	0.030	0.207	
9/23/1987	-0.015	0.214	
9/16/1987	-0.015	0.214	
9/9/1987	0.025	0.183	
9/2/1987	0.025	0.183	
8/26/1987	-0.035	0.183	
8/19/1987	0.010	0.126	
8/5/1987	-0.055	0.214	
7/22/1987	0.005	0.141	
7/15/1987	-0.030	0.174	
7/8/1987	0.000	0.153	
7/1/1987	-0.005	0.164	
6/24/1987	0.060	0.153	
6/16/1987	0.045	0.141	
6/10/1987	0.025	0.141	
6/3/1987	0.025	0.141	
5/27/1987	-0.010	0.174	
5/20/1987	-0.015	0.141	
5/13/1987	0.015	0.164	
5/6/1987	0.060	0.192	
4/29/1987	-0.035	0.214	
4/22/1987	0.060	0.060	x
4/15/1987	0.055	0.164	
4/8/1987	0.000	0.192	

Sample Date	Net CPM	MDA (cpm)	Positive
4/1/1987	0.020	0.153	
3/25/1987	0.005	0.141	
3/18/1987	-0.035	0.183	
3/11/1987	0.020	0.221	
2/25/1987	-0.040	0.221	
2/18/1987	-0.200	0.354	
2/4/1987	-0.015	0.141	
1/28/1987	-0.020	0.153	
1/7/1987	0.020	0.153	

ATTACHMENT C (cont'd.)

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1988

Sample Date	Net CPM	MDA (cpm)	Positive
10/19/1988	-0.025	0.200	
10/5/1988	-0.015	0.319	
9/28/1988	-0.035	0.214	
8/24/1988	0.055	0.164	
8/17/1988	0.005	0.214	
8/3/1988	0.045	0.141	
7/27/1988	-0.030	0.207	
7/13/1988	-0.010	0.174	
7/6/1988	0.025	0.141	
6/29/1988	-0.030	0.207	
6/21/1988	-0.015	0.183	
4/6/1988	-0.005	0.200	
3/23/1988	-0.020	0.153	

ATTACHMENT C (cont'd.)

Calculation of Sample Specific MDAs for Hearst Sewer Samples 1989

Sample Date	Net CPM	MDA (cpm)	Positive
12/19/1989	-0.010	0.207	
12/13/1989	-0.030	0.174	
12/6/1989	-0.010	0.174	
11/29/1989	-0.040	0.268	
11/22/1989	-0.060	0.268	
11/1/1989	-0.010	0.257	
10/25/1989	-0.045	0.252	
10/18/1989	-0.005	0.252	
10/11/1989	-0.035	0.214	
10/4/1989	-0.055	0.214	
9/27/1989	0.015	0.228	
9/18/1989	-0.025	0.228	
9/13/1989	0.005	0.214	
9/6/1989	-0.035	0.214	
8/30/1989	0.120	0.192	
8/23/1989	0.040	0.192	
8/16/1989	0.000	0.246	
8/9/1989	0.005	0.183	
7/26/1989	-0.040	0.192	
7/12/1989	-0.020	0.192	
5/24/1989	0.215	0.200	x
5/17/1989	-0.027	0.202	
4/19/1989	0.020	0.246	
4/12/1989	0.025	0.183	
3/1/1989	-0.035	0.183	

ATTACHMENT 3

Memorandum re:

Inspection of Sanitary Sewer lines Northwest of Building 4

February 14, 2001

MEMORANDUM

TO: Iraj Javandel

From: Joseph Walling and Robert Torres Robert Torres, Joseph C Walling

RE: Inspection of Sanitary Sewer lines northwest of Building 4

As per your request, on February 6, 2001, we surveyed the sanitary sewer lines, northwest of Building 4 between the building and the main sewer line branch, using a R. S. Technical Services Inc. 1200-series camera. The total length of the pipes surveyed was about 95 ft. No defects, root intrusion or displacement were observed within any section of the lines inspected. All of our observations were recorded on a video tape that has been submitted to you for your record. As you may know, the main section of sewer downstream of Building 4 was video surveyed in 1991. No defects were observed in that line either. Please contact Joseph Walling, Berkeley Lab Utility Coordinator, at 486-4842 for additional information if needed.