Module A

Bevalac Area

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MODULE A

BEVALAC AREA

This module is an attachment to Volume 1 of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for Ernest O. Lawrence Berkeley National Laboratory (LBNL). Volume 1 presents an overview of the RFI as it pertains to LBNL as a whole, and contains detailed information on the overall characteristics of the site (i.e. physical layout, geology, hydrogeology, potential contaminants, contaminant migration pathways, and potential receptors). Volume 1 is accompanied by four modules that correspond to specific areas of LBNL (Figure A-2).

A. Bevalac Area (this module)
B. Old Town Area
C. Support Services Area
D. Outlying Areas.

Each of the modules contains the following area-specific information for RCRA Facility Investigation (RFI) activities conducted since the Phase II Progress Report (LBNL, 1995k):

- the physical characteristics of the module area including geology and hydrogeology
- a description of Solid Waste Management Units (SWMUs), Areas of Concern (AOCs), and other areas that were investigated
- results of contaminant characterization activities that were completed
- Interim Corrective Measures (ICMs) that were implemented
- potential and identified sources of contamination
- contaminant migration pathways.

For reporting purposes, the RCRA Facility Assessment (RFA) subdivided LBNL into 15 study areas (LBNL, 1992d). The Bevalac Area (Figure A-3) is composed of RFA study areas 1, 9 and 15. Table A1-1 lists the SWMUs and AOCs that have been identified in the Bevalac Area and indicates which of those are discussed in this module. The table also lists two other areas (construction sites) that were investigated during the RFI, but are not discussed in this module. The SWMUs and AOCs discussed in this module include those where characterization or ICM activities have been conducted since July 1, 1995, when the Draft Final RCRA Facility

Investigation Phase II Progress Report (LBNL, 1995k) was prepared. RFI activities conducted at SWMUs and AOCs, and other areas where investigations were completed prior to July 1, 1995 are documented in the Draft Final RFI Phase I or Phase II Progress Reports (LBNL, 1994l and LBNL, 1995k).

The SWMUs and AOCs discussed in this module are primarily associated with either former operations of the Bevatron in the Building 51/64 complex or former operations of the HILAC in the Building 71 complex. Also included is a former motor pool gasoline tank (AOC 1-1) that was located at the present location of Building 46A. Groundwater monitoring wells were installed to monitor SWMUs and AOCs within the Bevalac Area. In addition, groundwater has been periodically sampled from several wells previously installed for slope stability purposes. The locations of these SWMUs, AOCs, and wells are shown on Figure A-3.

A1 BEVALAC AREA DESCRIPTION

The Bevalac Area primarily includes the Building 51/64 complex (the decommissioned Bevatron particle accelerator and support facilities) and the Building 71 complex (the decommissioned Super Heavy Ion Linear Accelerator [Super HILAC]). Several other buildings (46A, 55, 55A, 56, 60, 63, 67, 81 82, and the Building 90 complex) are also present. Major development of the area began in the early 1950s, when construction started on the Bevatron and associated support facilities. The Bevatron started operation in 1954. The HILAC started operation in 1957 and was subsequently upgraded and renamed the Super HILAC. A beam line linking the Bevatron with the Super HILAC was constructed in 1974 to create the Bevalac. The Super HILAC was shut down in December 1992. The Bevatron ceased operations in February 1993.

A2 PHYSIOGRAPHY, GEOLOGY AND HYDROGEOLOGY

A2.1 Summary of LBNL Physical Characteristics

A detailed discussion of the physiography, geology and hydrogeology of LBNL is given in Volume 1 of this report and summarized below.

LBNL is located on the moderate to steep west- and south-facing slopes of the Oakland-Berkeley Hills, with surface elevations ranging from approximately 500 to 1000 feet above mean sea level (msl). The physiography is dominated by a steep southwest-facing slope that has been modified by erosion of several steep stream canyons, by mass movement resulting from landslides and soil creep, and by cut and fill operations associated with construction of LBNL facilities.

Bedrock at LBNL consists primarily of Cretaceous and Miocene sedimentary and volcanic units, as shown on the summary stratigraphic column (Figure A2.1-1). These units form a northeast-dipping, faulted homocline, as shown on the bedrock geologic map (Figure A2.1-2). The homocline is composed of the following three rock units:

- Cretaceous marine mudstones, shales, and sandstones of the Great Valley Group
- Miocene nonmarine sandstones, siltstones, mudstones, and conglomerates of the Orinda Formation
- Miocene andesitic and volcaniclastic rocks of the Moraga Formation.

Strata of the Cretaceous Great Valley Group form the structurally lowest portion of the homocline and underlie the southern and western slopes of LBNL. The Orinda Formation lies structurally above the Great Valley Group along a fault contact that dips at a shallow angle to the northeast. The Moraga Formation overlies the Orinda Formation along a conformable contact.

Numerous isolated masses composed of Moraga Formation volcanic rock underlie the developed portions of LBNL at lower elevations than the main Moraga Formation outcrop belt. The rock at the contact between these masses and the Orinda Formation is often composed of slickensided, volcaniclastic/sedimentaclastic rocks that have been informally denoted as the "Mixed Unit". These masses are interpreted to be paleolandslide deposits that are younger than the Moraga Formation but older than historically active landslides at LBNL.

In the easternmost portion of LBNL, the homocline is truncated by the north striking Wildcat and East Canyon faults. Marine sedimentary rocks of the Miocene Claremont Formation and the Miocene San Pablo Group (?) underlie the area east of these faults at LBNL. At the western LBNL property boundary, the homocline is truncated by the north to northwest

striking Hayward Fault, a regionally extensive, active, right-lateral strike-slip fault. Rocks west of the Hayward fault consist of the Jurassic to Cretaceous Franciscan Complex.

A surficial geologic map of LBNL is shown on Figure A2.1-3. The soil is typically a silty clay less than 2-feet thick. Alluvium is present in some of the creeks and streambeds. Colluvial deposits, generally less than 20-feet thick, have developed along the bases of slopes and in hillside concavities as a result of mass wasting processes. At least one major and numerous minor landslide deposits are present on the steeper slopes at LBNL, some of which have moved since construction of LBNL facilities. These landslide deposits differ from the paleolandslide deposits described above in that they have evidence of historic movement.

Groundwater flow directions generally follow the slope of the surface topography. However, at some locations flow directions deviate due to contrasts in subsurface hydraulic conductivity or artificial drainage features such as building subdrains, subhorizontal hillside drains (hydraugers), and slope stability wells. Hydraulic conductivity testing and groundwater well yields show that the Moraga Formation is relatively permeable, and constitutes the main water-bearing unit at LBNL. In contrast, the underlying Orinda Formation is relatively impermeable. Measured hydraulic conductivities in the other units at LBNL are generally intermediate between these two formations.

A2.2 Bevalac Area Physiography and Surface Water Hydrology

Prior to development of the site, North Fork Strawberry Creek flowed through Blackberry Canyon, a major east-west-trending drainage course bisecting the current Building 51/Building 64 area (Figure A2.2-1). The south facing slopes north of the canyon were relatively steep, except for a bench formed by outcrops of Moraga Formation volcanic rocks at the present location of the Building 71 complex. South of Blackberry Canyon, a broader canyon defined by an unnamed northwest-trending drainage existed at the present location of Building 51. A third narrow, southwest-trending canyon joined Blackberry Canyon from the north in the vicinity of the present-day Blackberry Canyon parking lot.

Artificial fill, in places greater than 100 feet thick, was placed in the drainages in the Bevalac area, and the ridges were cut by up to 40 feet to provide graded areas on which to

construct buildings and parking lots. These cut and fill activities significantly transformed the topography and surface runoff patterns (Figure A2.2-2). The principal physiographic modification comprised construction of a broad flat bench upon which to site the Building 51/64 complex. This was accomplished by cutting into the hillside along the southern edge of Building 51, as well as the eastern edge of Buildings 55, 64, and 51, and filling Blackberry Canyon and its tributaries. Blackberry Canyon was also filled in the vicinity of Building 71 to form a portion of the bench for this building complex. A significant volume of fill was also placed on the slopes above and below Building 46 during landslide repairs. The principal undeveloped area in the Bevalac Area is the steep grass and tree covered slope above Building 64, northwest of the former location of Blackberry Canyon.

Surface runoff in the Bevalac Area is derived from several sources, including creeks which originate upslope of Building 71, paved and unpaved areas, a spring southwest of Building 71, and the system of subhorizontal hillside drains (hydraugers) that extends beneath Buildings 71, 46, and 46A (Figure A2.2-3). Essentially all surface water runoff from paved/developed areas is directed into storm sewers (Figure A2.2-4). The primary storm sewer is a 48-inch concrete pipe that was placed in the bottom of Blackberry Canyon prior to filling of the canyon. This pipe discharges into North Fork Strawberry Creek near the western property boundary, and then ultimately to San Francisco Bay.

A2.3 Bevalac Area Geology

Three main bedrock units (the Moraga Formation, the Orinda Formation, and the Great Valley Group) underlie the Bevalac Area (Figure A2.3-1). The subsurface relationships among these units and their relationship to the surficial units are shown on Cross Sections A-A' through G-G' (Figures A2.3-2 through A2.3-9). Mudstones, sandstones, and shales of the Great Valley Group underlie the southwestern portion of the area, including the western part of Building 51. The strata of the Great Valley Group dip north to north-northeast between 20° to 30° in this area, as indicated by attitudes measured to the west.

The Orinda Formation overlies the Great Valley Group in the central portion of the Bevalac Area along a fault contact. Excavation records and bore logs indicate that the contact dips 20° to the northeast. In this area, the Orinda Formation consists primarily of siltstones and

fine-grained sandstones that dip northeast from 25° to 60° (Figure A2.3-1). The dips appear to increase upsection.

The eastern half of the Bevalac Area is predominantly underlain by brecciated andesite and volcanic breccia of the Moraga Formation. The deposit underlying the Building 71 complex and the slope between the Building 71 trailers and Building 64 includes thin sandy silt layers and intercalated volcaniclastic gravelly sandstone and minor basaltic flows, to a total depth of 70 feet. This deposit partially fills a basin upslope of a ridge in the Orinda Formation and extends downslope over the ridge (Figures A2.3-3, A2.3-5, A2.3-8, and A2.3-9). The northwestern margin of this deposit contains a section of Mixed Unit more than 20-feet thick (Figure A2.3-8).

The second Moraga Formation deposit underlying Building 46 and the surrounding area was originally up to 40 feet thick west of Building 46. This deposit occupies a trough in the surface of the Orinda Formation (Figure A2.3-8). A section of the Mixed Unit greater than 10-feet thick was encountered at the base of the section west of Building 46 (Figure A2.3-2). Recent sliding of this mass has required excavations both upslope and downslope of Building 46 to stabilize the slope.

Several sections of the Bevalac Area are underlain by colluvium greater than 10 feet thick, and exceeding 40 feet near the parking lot adjacent to the Building 71 trailers. Most of the colluvial deposits are present in former drainages that have been covered with artificial fill. The most extensive colluvial deposits lie along the former location of Blackberry Canyon. Colluvial deposits are also present within a former drainage course under the northern portion of Building 51, under the southwest edge of Building 64 and the area to the southwest, and on the slopes above and below Building 46.

A2.4 Bevalac Area Hydrogeology

The main water-bearing units in the Bevalac Area are surficial units (i.e., alluvium, colluvium and artificial fill), and in-place bedrock and/or landslide deposits composed of Moraga Formation volcanic rocks. These are the structurally highest geologic units in the Bevalac Area.

The Orinda Formation lies structurally beneath the main water-bearing units described above throughout all but the southwestern corner of the Bevalac Area. It overlies the Great Valley Group along a fault contact that dips northwestward from west of Building 51B to a projected depth of several hundred feet beneath most of the Bevalac Area (Figures A2.3-3 through A2.3-5). The Great Valley Group underlies surficial water-bearing units in the southwest corner of the Bevalac Area. The clastic sedimentary rocks of the Orinda Formation generally have substantially lower permeabilities than the main water-bearing units described in the preceding paragraph, as shown by lower hydraulic conductivities calculated from slug tests conducted within the Bevalac Area (Figure A2.3-10). Few wells screened in the Orinda Formation can produce a sustainable yield that is sufficient for conducting interference pumping tests. Since the main water-bearing units in the Bevalac Area generally crop out at the surface, or are themselves overlain by relatively high permeability units, groundwater encountered in these units is interpreted to be unconfined. Deeper horizons within the Orinda Formation may contain groundwater under confined conditions.

The relative abundance of major cations and anions in groundwater within the Bevalac Area are shown as Stiff diagrams on Figure A2.3-11. The diagrams show distinct geochemical differences between groundwater derived from the Orinda Formation, the Moraga Formation, and surficial units (colluvium and artificial fill). Diagrams for the two main bedrock units (Orinda Formation and Moraga Formation) show generally low cation and anion concentrations compared to the surficial units. This relationship may occur because the bedrock units have been available for dissolution and migration of available cations and anions for geologic time periods, so that groundwater is closer to equilibrium with these units. In contrast, the surficial fill units have only been in contact with groundwater for a relatively short period, so equilibrium with groundwater has not been reached, resulting in higher rates of cation and anion dissolution.

Groundwater flow in the Bevalac Area generally follows the topographic slope, as indicated by groundwater elevation contours that are parallel to the surface topographic contours (Figure A2.3-12). This flow pattern results in a northwesterly inclined trough in the water table beneath the topographically flat area underlying Buildings 51, 51A and 51B. The trough may be accentuated by the interception of groundwater by subdrains around the upslope perimeter of the Building 51 complex and the presence of paving and buildings that limit infiltration. In addition,

the presence beneath Building 51 of a fault contact juxtaposing the low permeability Orinda Formation over the relatively more permeable Great Valley Group (Figures A2.3-1 and A2.3-2) may have some influence on the groundwater elevation contours at this location. Groundwater in the Bevalac Area is shallowest along the upslope perimeter of the Building 51 complex, where cuts made into the hillside during construction apparently intercepted the water table. Subdrains were installed to intercept groundwater in this area.

The water level elevation contour map indicates that the horizontal component of the hydraulic gradient (dh/dl) is approximately 0.17 north of Building 51. Assuming a hydraulic conductivity (K) of 1 x 10^{-8} meters per second, which appears to be typical for the Orinda Formation in this area, and an effective porosity (n_e) of approximately 0.2, Darcy's law ($v_x = K/n_e \times dh/dl$) indicates that the average linear groundwater velocity (v_x) would be less than 1 foot per year. It should be noted that due to the variability in gradients and bedrock physical characteristics, these calculations give only rough, order-of-magnitude estimates of likely groundwater flow velocities.

Groundwater elevation hydrographs from clustered shallow and deep wells (Figures A2.4-1 through A2.4-6) were examined to evaluate the vertical component of the groundwater potentiometric gradient. Data were available from the following well pairs, which are relatively close to one another, near Building 75.

Well Pair	Unit(s) Screened	Elevation of Midpoint of Screen (feet)	Vertical Gradient Direction
MW51-96-16 MW51-96-17	Artificial fill Orinda Formation	690 716	Up
MW51-96-19 MW51B-93-18A	Fill/Orinda Orinda Formation	699 677	Down
MW51-97-3 MW51-97-12	Artificial Fill Artificial Fill	646 670	None

These data indicate that the vertical component of the hydraulic gradient varies in direction near Buildings 51 and 64.

A2.5 Bevalac Area Conceptual Hydrogeologic Model

The hydrogeologic information discussed above suggests the following conceptual model for groundwater flow in the Bevalac Area. Over most of the area, groundwater flow occurs primarily within the surficial units and in the volcanic rocks of the Moraga Formation. In the southwestern part of the area, the Great Valley Group is the primary water-bearing unit. Groundwater flow generally parallels the slope of the overlying topography. Apparent vertical gradients observed in well clusters suggest that some degree of flow may occur both into and out of the Orinda Formation. However, groundwater flow within the Orinda Formation is of minor importance, as is indicated by the relatively low values of hydraulic conductivity.

The groundwater flow tends to converge towards North Fork Strawberry Creek. The groundwater trough beneath the Building 51 complex locally modifies the groundwater flow direction. Groundwater flowing into the trough is deflected to the northwest towards the former Blackberry Canyon drainage.

Subdrains and hydraugers capture some groundwater flow. Where the water is contaminated, it is treated and then discharged to the sanitary sewer system. Otherwise, the water discharges to the storm drain system, which flows to North Fork Strawberry Creek.

A3 SOIL CONTAMINATION - CHARACTERIZATION ACTIVITIES AND INTERIM CORRECTIVE MEASURES

The following subsections describe the results of the RFI investigations and ICM activities at SWMUs and AOCs in the Bevalac Area where soil characterization or ICM activities were conducted subsequent to those included in the Draft Final RFI Phase II Progress Report (LBNL, 1995k) (Table A1-1). As described in Section 1 of this report, the results of these characterization activities were used to help assess whether further action was required at a site (i.e., whether the unit will be included in the site-wide risk assessment). The assessment was made by comparing analytical results to both LBNL background levels and Preliminary Remediation Goals (PRGs) for residential soil (USEPA, 1999). PRGs for residential soil for metals and organic site contaminants and LBNL background levels for metals are listed in Section 1, Table 1.6-3.

For organic constituents, Chemicals of Potential Concern (COPCs) and analytical results are presented in unit-specific tables in each subsection. For metals, soil analytical results are presented for all units in Table A3-1 (soil) and Table A3-2 (sludge and sediment), for all units. Metals results are generally discussed in this module only when concentrations exceed both PRGs for residential soil and background levels, since metals concentrations that are within background levels are not considered to represent contamination and metals concentrations that are below PRGs for residential soil are not considered to represent a risk to human health.

Surface runoff and storm drain-flow from the Bevalac Area drain toward North Fork Strawberry Creek. The potential for contaminants detected in soil to migrate to surface water and sediment has been addressed by collecting surface water and sediment samples from North Fork Strawberry Creek and analyzing them for chemicals of potential concern from upgradient sources. This sampling is discussed in Section A4.6. Potential migration of soil contaminants to groundwater has been addressed by installing and sampling groundwater monitoring wells, as discussed in Sections A4.1 to A4.5.

A3.1 SWMU 9-1: Building 51 Vacuum Pump Room Waste Oil Tank

Description and History

The Building 51 Vacuum Pump Room (Figures A3.1-1 and A3.1-2) contained pumps that were used to develop vacuum in the particle beam line of the Bevatron particle accelerator. The vacuum pumps were located on a concrete pad on the east side of the room. There were also two hydraulic oil pumps at the south end of the room that were supplied by oil tank GP-116-51. The oil was used to remove moisture in the vacuum pumps. Used oil was routed into waste oil tank GP-117-51 (SWMU-9-1). The two oil tanks were located on a metal platform within an alcove at the north end of the pump room. The vacuum room floor was sloped so that spills would flow into the Vacuum Pump Room Sump and Collection Basins (SWMU-9-4). The waste oil was periodically pumped into a truck for disposal. Beginning in 1990, the waste oil was pumped directly from the waste oil tanks to a 55-gallon drum for offsite disposal.

Sampling

One soil boring (SB51-96-1) was drilled through the concrete floor next to the two oil tanks (SWMU 9-1) (Figure A3.1-2). No COPCs were detected (Table A3.1-1, Table A3-1).

Potential Migration of Contaminants

No contaminants were detected in soil at SWMU 9-1

Status of Unit

SWMU 9-1 was approved for No Further Action (NFA) status by the California Environmental Protection Agency (CAL-EPA) Department of Toxic Substances Control (DTSC) in August 1997 (DTSC, 1997).

A3.2 SWMU 9-4: Building 51 Vacuum Pump Room Sump and Collection Basin

Description and History

The vacuum pump room operations and layout is described in the preceding section. The floor of the room slopes towards a trench (collection basin) that runs the length of the room and empties into an approximately 1-foot-deep sump that was used to catch potential spills (Figure A3.1-2). The collection basin is covered with a series of removable metal lids. A vertical drainpipe approximately 6-inches in diameter drained liquid from the bottom of the sump into the Building 51 drainage system (AOC 9-9) in the basement. The sump was reportedly sealed off from the Building 51 drainage system in about December 1990, when it was no longer used. The floor of the vacuum pump room was periodically mopped with an organic solvent (Freon) to clean the grease and oils from the vacuum pump equipment and the floor. Other solvents (trichloroethene [TCE], 1,1,1-trichloroethane [TCA], and acetone) were also used when equipment was periodically rebuilt. Hydraulic oils (standard mechanical pump oils) were stored in the room and were used in the pump equipment.

Both the pumps and the pump room floor were stained with oil. There have been no known releases from the vacuum pump room sump and collection basin to areas outside the drainage system. However, oil was discovered within sections of the Building 51 subdrain system in 1990, as discussed in Section A3.3 below.

Sampling

In April and May 1996, shallow soil samples (5 feet maximum depth) were collected from three borings at the unit (Figure A3.1-2). Boring SB51-96-2A was drilled through the bottom of the collection trench next to the sump and boring SB51-96-3 was drilled through the bottom of the collection trench approximately 20 feet south of the sump. Boring SB51-96-4 was drilled at the southern end of the vacuum pump room within the wooden enclosure that housed the two oil pumps.

The only organic chemical detected was benzene, which was detected in all three samples collected at SB51-96-3 (Table A3.2-1). The detected concentrations were well below the PRG for residential soil. Nickel was detected at a concentration above both the background level and the PRG for residential soil at a depth of 1 foot in SB51-96-4. The concentration of nickel at a depth of 3 feet in this boring was well below the maximum LBNL background level (Table A3-1).

Potential Migration of Contaminants

Potential migration of contaminants to surface water and sediment is discussed in Section A4.6. Effluent from the Building 51 drainage system has in the past (primarily prior to 1962) been routed through the storm drain system to the erosion control basins on North Fork Strawberry Creek. Surface water and sediment samples have been collected from North Fork Strawberry Creek and analyzed for chemicals of potential concern from upgradient sources, including SWMU 9-4.

Surface Water and Sediment

Benzene has not been detected in surface water or sediment samples collected from North Fork Strawberry Creek. Nickel has been within LBNL background levels in 10 of the 11 sediment samples collected from North Fork Strawberry Creek (Table A4.6-8), and was only detected in one surface water sample. The concentration detected in the surface water was less than 2% of the Maximum Contaminant Level for drinking water (MCL) (Table A4.6-3). The potential impact to the environment from contaminants detected in surface water and sediment will be evaluated in the ecological risk assessment.

Groundwater

Groundwater has not been sampled since concentrations of benzene detected in soil are relatively low (an order of magnitude lower than the PRG for residential soil) (Table A3.2-1) and the contamination is present in fine-grained Orinda Formation sediments, which have the lowest hydraulic conductivity of geologic units at LBNL.

Status of Unit

SWMU 9-4 was approved for No Further Investigation (NFI) status by DTSC in September 1998 (DTSC, 1998). The unit will be included in the human health risk assessment since nickel was detected at one location at a concentration above both the LBNL background level and the PRG for residential soil.

A3.3 SWMU 9-6: Building 51 Motor Generator Room Filter Sump

Description and History

The NFI request report for the Building 51 Motor Generator Room Sump, which was submitted to DTSC on September 8, 1999 (LBNL, 1999o), is included in Appendix C. Following is a summary of the information contained in the NFI request.

A network of subdrains and relief wells located around the perimeter of Building 51 collects subsurface water from the adjacent hillside. Water collected by this network discharges

to the Building 51 internal floor drain system. The Motor Generator Room Filter Sump (SWMU 9-6) is part of the internal floor drain system, and is the confluence point for drainlines J and K (Figure A3.3-1), both of which convey effluent from part of the exterior relief well/subdrain system. Water in the filter sump is routed by gravity flow via the E, B, and A drainlines to the discharge sump at the northern end of the building. These drainlines and the discharge sump constitute AOC 9-9, which is discussed in Section A3.11 below. The filter sump has 2½-foot square concrete walls and a concrete base 5.3 feet below the basement floor surface. Initially, when the discharge sump was connected to the storm drain system, effluent from the filter sump would flow to the discharge sump, and then through the storm drain system to North Fork Strawberry Creek. Since 1962, water from the discharge sump has been routed to the sanitary sewer, except for a period between 1994 and 1996 when contaminants were not detected in discharge samples. Currently, the effluent from the discharge sump is treated and discharged to the sanitary sewer under LBNL's East Bay Municipal Utility District (EBMUD) Wastewater Discharge Permit.

The Building 51 Motor Generator Room (Figure A3.1-1) houses two large motor generators and associated equipment that was used to supply power to the Bevatron particle accelerator. In November 1990, oil (apparently originating from capacitors stored in the basement) was found in the filter sump. Due to the potential for contamination of the Building 51 drainage system with oil and polychlorinated biphenyls (PCBs), several concurrent investigations and ICMs were conducted between November 1990 and February 2000 to reduce potential impacts to groundwater and surface water. Activities related to SWMU 9-6, which are discussed below, involved:

- sampling and cleaning of sludge and sediment from the filter sump
- installation and sampling of soil borings to assess the magnitude and extent of contamination around the filter sump.

Additional investigations and ICMs were conducted for the drainage system (AOC 9-11). These are discussed in Section A3.11.

Sampling and Cleaning of Drains, Pipes and Sumps

The initial phase of investigation and ICM activities occurred in November 1990, when oil (apparently originating from capacitors stored in the basement) was found in the filter sump. Water, oil, and sediment samples collected from the sump all contained PCBs. A subsequent survey of the drainage system showed that lines draining into the filter sump (lines J and K) and lines downstream from the filter sump (Lines A, B, and parts of C, D, and F) contained an oil product. The system was flushed, and more than 1,300 gallons of contaminated water were removed and properly disposed offsite.

Additional sediment (sludge) samples were collected from the filter sump in May 1996 and May 1999. PCBs, total petroleum hydrocarbons (TPH) in the range of hydraulic/motor oil (TPH-H/MO), oil & grease, and semi-volatile organic compounds (SVOCs) were detected (Table A3.11-1). Mercury and chromium were also detected at concentrations greater than background levels and PRGs for residential soil (Table A3-2).

In 1999, sediment and sludge were removed from both the filter and discharge sumps, the sumps were cleaned with high-pressure water and steam, and the cast iron drain line connecting them was cleaned with a high-pressure water jet. A subsequent video survey indicated no remaining oil contamination.

Soil Sampling

In April 1996, borings SB51-96-5 and SB51-96-6 were drilled adjacent to the Filter Sump. Motor oil and oil & grease were detected in soil samples collected from both borings. In addition, PCBs were detected in one sample, at a concentration above the PRG for residential soil (Tables A3.3-1).

In June 1999, nine soil borings (SB51-99-1 through SB51-99-9) were drilled in a 3-foot grid adjacent to and within the filter sump to assess the extent of contamination (Figure A3.3-2). PCBs were detected in 6 of the 43 in-situ soil samples, at concentrations below the PRG for residential soil; however, PCBs were detected above the PRG in a sample of slough material from the boring beneath the Filter Sump (Table A3.3-1, Figure A3.3-3, and Figure A3.3-4). Low

concentrations of halogenated volatile organic compounds (VOCs) (below PRGs for residential soil) were also detected in 8 samples (Table A3.3-1, Figure A3.3-5, and Figure A3.3-6). In addition, TPH in the range of crude/waste oil (TPH-C/WO) was detected in 2 of the samples (Tables A3.3-1, Figure A3.3-7, and Figure A3.3-8).

Chromium (1 of 46 samples) and nickel (4 of 46 samples) were the only metals detected at concentrations above both PRGs for residential soil and LBNL background levels (Table A3-1). The higher nickel concentrations were detected in the Orinda Formation and Orinda Formation derived fill. The Orinda Formation has a higher background nickel level than the other geologic formations at LBNL (LBNL, 1995i). In addition, based on the random distribution of nickel concentrations around the sump, there is no indication that the elevated nickel concentrations are the result of contamination from a source such as the sump.

Potential Migration of Contaminants

Potential migration of contaminants to surface water and sediment is discussed in Section A4.6. Effluent from the Building 51 drainage system has in the past (primarily prior to 1962) been routed through the storm drain system to the erosion control basins on North Fork Strawberry Creek. Surface water and sediment samples have been collected from North Fork Strawberry Creek and analyzed for chemicals of potential concern from upgradient sources, including SWMU 9-6.

Surface Water and Sediment

Water from the filter sump discharges through the Building 51 Drainage System (AOC 9-9) discharge sump, which is discussed in Section A.3.11.

Groundwater

Soil borings SB51-96-6 adjacent to the filter sump was converted to a temporary groundwater sampling point. Grab water samples were collected from SB51-96-6 and analyzed for VOCs, PCBs, or oil & grease. No PCBs or oil & grease were detected. VOCs were detected at a total concentration of 113 μg/L in April 1996. Relatively low concentrations of VOCs (below MCLs) were detected in a groundwater sample collected from SB51-96-6 in December

1997 (Table A4.3-2). As shown on Figure A3.3-6, this temporary groundwater sampling point is completed in a zone of fill around the filter sump. The fill is surrounded by low permeability Orinda Formation siltstone.

Status of Unit

SWMU 9-6 was approved for NFI status by DTSC in September 1999 (DTSC, 1999a). The unit will be included in the site-wide risk assessment because PCBs, chromium, and nickel were detected at concentrations above both LBNL background levels and PRGs for residential soil

A3.4 AOC 1-1: Building 46A Former Motor Pool Gasoline UST

Description and History

An abandoned underground storage tank of single-walled construction (unknown capacity) is located beneath Building 46A. The tank was installed in the 1940s and stored gasoline for the motor pool that had been located where Building 46A currently stands. The motor pool closed in about 1964 and moved to its present location at Building 76. The tank was decommissioned and filled with concrete sometime between 1970 and 1976. In 1977, Building 46A was built over the tank location. The approximate locations of the tank, former pump island, and soil sampling locations are shown on Figure A3.4-1.

Sampling

In April 1996, a 45° angled boring was drilled under the tank to assess whether releases had occurred. Soil samples were collected at 5-foot intervals from distances of 35 to 60 feet along the borehole (Figure A3.4-1). Sample depths were approximately 25 to 40 feet below ground surface (bgs), which corresponds to depths of 15 to 30 feet below the tank (assuming that the base of the tank is at approximately 10 feet bgs). No COPCs were detected (Table A3.4-1).

Potential Migration of Contaminants

No contaminants were detected in soil at AOC 1-1. No aromatic hydrocarbons have been detected in the effluent from the hydraugers that drain groundwater from the area of Building 46A (hydraugers 51-01-03, 51-01-03A, 51-01-04, and 51-01-09).

Status of Unit

AOC 1-1 was approved for NFA status by the City of Berkeley (COB) in May 1997 (COB, 1997a).

A3.5 AOC 1-3: Building 71 Linear Accelerator Cooling Unit

Description and History

The linear accelerator cooling unit (Figure A3.5-1) was installed in 1975 and dismantled in 1993, at which time the system was drained and purged. The unit cooled magnets by pumping Freon-113 through heat exchangers within the linear accelerator system. The Freon-113 was then circulated through additional heat exchangers where it was cooled with water. While the linear accelerator was in operation, there were numerous small Freon leaks in the injector area, beam-line area, and other areas of the system. Reportedly, the volume of leakage was typically less than 1 gallon. In 1988 or 1989, one of the magnets malfunctioned and there was a large spill of Freon-113 into a spill containment tank. Most of the Freon was recovered but about 110 gallons evaporated and may have exited the building as vapor through the vacuum pumps.

Sampling

Soil samples have been collected from two exploratory geological borings and four monitoring well borings in the vicinity of the cooling unit. Borings BS71-93-B1 and BS71-93-B2 were drilled in the area south of the unit to provide information on subsurface geology (Figure A3.5-1). Subsequently, monitoring wells MW71-93-1, MW71-93-2, MW71-94-1, and MW71-95-1 were installed north, south, southwest and west, respectively, of Building 71,

primarily to provide information on the Building 71 Groundwater Solvent and Freon plume (AOC 1-9).

VOCs were only detected sporadically in soil samples, at concentrations significantly lower than PRGs for residential soil (Table A3.5-1). Notably, Freon 113, the COPC for the unit, was only detected in two deep samples in the boring for monitoring well MW71-93-2. Both samples were collected from below the water table in an area of known Freon-113 contamination in the groundwater (AOC 1-9) and are therefore are not representative of soil contamination derived directly from a release from the linear accelerator cooling unit. Although antimony is not a COPC for this unit, it was detected at a concentration exceeding both background and the PRG for residential soil in a single sample collected at a depth of 70 feet in boring SB71-93-B2 (Table A3-1).

Potential Migration of Contaminants

Potential migration of contaminants detected in soil in the Bevalac area to surface water and sediment is discussed in Section A4.6. Groundwater contamination is discussed in Section A4.3. Surface runoff in the Building 71 area is directed through the storm drain system to North Fork Strawberry Creek. Surface water and sediment samples have been collected from North Fork Strawberry Creek and analyzed for chemicals of potential concern from upgradient sources, including AOC 1-3.

Surface Water and Sediment

Freon has been detected in the effluent from hydraugers (51-01-01 and 51-01-02) that drain the slope southwest of Building 71. The concentration of Freon-113 detected has decreased from a maximum of 970 μg/L in 51-01-01 in June 1995 to 20 μg/L in 2000 (Table A4.6-4). Effluent from these hydraugers is treated and discharged to the sanitary sewer. Freon-113 has also been detected in the spring southwest of Building 51. The concentration of Freon-113 detected in the spring has decreased from 31 μg/L in December 1995 to 1.7 μg/L in March 2000 (Table A4.6-1). Freon has not been detected in surface water or sediment samples collected from North Fork Strawberry Creek.

Groundwater

Groundwater south of building 71 is contaminated with Freon-113. The Building 71 Freon Plume (AOC 1-9) is discussed in Section A4.3.

Status of Unit

AOC 1-3 was approved for NFI status by DTSC in July 1996 (DTSC, 1996b). The unit will be included in the site-wide risk assessment because a single deep sample at 70 feet bgs contained antimony at a concentration above both the LBNL background level and the PRG for residential soil.

A3.6 AOC 1-6: Building 71 Transformers

Description and History

Four transformers are located on a fenced and bermed concrete pad on the northwest side of Building 71 (Figure A3.6-1). Runoff from the pad flowed through a drainpipe that emptied into a shallow (18-inch), gravel-filled catchment. Prior to 1988, the transformers used oil containing PCBs. In 1988, PCB-containing oil was discovered in the catchment. The contaminated soil and gravel were removed and the catchment refilled with gravel. The drain was sealed with a locking cap (LBNL, 1992d). The drainpipe was later extended to the north to empty onto the paved road that runs north of the transformers.

Sampling

Two soil samples (SS-71NW-1 and SS-71NW-2) were initially collected at the unit from 2 feet bgs near a drain for the western end of the transformer berm. Subsequently, a 5.5-foot deep test pit was excavated at the west end of the transformer pad, at the location where water from the pad formerly drained (Figure A3.6-2). No gravel or evidence of the former catchment was observed during excavation of the test pit. Four soil samples were collected from the sidewall (SS-71NP-96-W and one from the floor (SS-71NP-F) of the test pit, and two 3-point

composite samples (SS-71NP-StockA and SS-71NP-StockB) were collected from the excavated soil.

The only PCBs detected were found in one of the two composite samples from the excavated soil (Table A3.6-1). Oil & Grease was detected in two composite samples from the excavated soil and in three of the *in situ* wall samples.

Potential Migration of Contaminants

Potential migration of contaminants detected in soil in the Bevalac area to surface water and sediment is discussed in Section A4.6. Groundwater contamination is discussed in Section A4. Surface runoff in the Building 71 area is directed through the storm drain system to North Fork Strawberry Creek. Surface water and sediment samples have been collected from North Fork Strawberry Creek and analyzed for chemicals of potential concern from upgradient sources, including AOC 1-6.

Surface Water and Sediment

PCBs have not been detected in surface water or sediment samples collected from North Fork Strawberry Creek.

Groundwater

Monitoring well MW71-95-1 is downgradient from the transformers. A groundwater sample collected from the well in June 2000 was analyzed for PCBs. No PCBs were detected.

Status of Unit

Approximately 2 cubic yards of contaminated soil was excavated for offsite disposal. AOC 1-6 was approved for NFA status by DTSC in August 1997 (DTSC, 1997).

A3.7 AOC 1-10: Building 71 Room 003 Mercury Release

Description and History

On January 6, 1995, while repairing a drain connection in Room 003 in the basement of Building 71, some mercury was released from the pipe to the soil when a section of pipe was removed(Figure A3.6-1). The mercury remaining in the pipe was collected by flushing the pipe with water and the contaminated soil was removed, as described below.

Sampling and Interim Corrective Measures

On January 20m, 1995, soil samples SS71-003-1 through SS71-003-4 (Figure A3.7-1) were collected from two locations: 1) near the center of the excavation where the floor drain was located, and 2) near the end of the removed drain line where mercury had been released during pipe removal. Mercury was detected at both locations, and additional soil was excavated until no mercury was detected (<0.2 mg/kg) in confirmatory soil samples (SS71-003-5 and SS71-003-6) (Table A3-1). On February 24, 1995, three soil samples (SS71S-1, SS71S-2 and SS71S-3) were collected from the bottom of a trench south of Building 71. The trench was excavated to inspect the downslope section of the cast iron pipe from which the mercury had been released in the Building 71 basement (Table A3-1). No mercury was detected in the soil. Selected samples collected both inside and outside the building were also analyzed for VOCs. No VOCs were detected (Table A3.7-1).

Potential Migration of Contaminants

Potential migration of contaminants detected in soil in the Bevalac area to surface water and sediment is discussed in Section A4.6. Concentrations of metals detected in groundwater is discussed in Section A4.5.4 (metals). Surface runoff in the Building 71 area is directed through the storm drain system to North Fork Strawberry Creek. Surface water and sediment samples have been collected from North Fork Strawberry Creek and analyzed for chemicals of potential concern from upgradient sources, including AOC 1-10.

Surface Water and Sediment

To assess whether mercury had been released through the storm drain to North Fork Strawberry Creek while repairing the drain connection, four sediment samples were collected from the erosion control basins at the head of North Fork Strawberry Creek in January 1995 and analyzed for mercury. No mercury was detected (Table A4.6-8). Mercury was detected in one of four samples collected from the North Fork Strawberry Creek erosion control basins in July 1995. The detected concentration was within LBNL background levels for soil. Mercury was not detected in the five sediment samples collected from the creek in August 1996 (Table A4.6-8). Mercury has not been detected in surface water samples collected from North Fork Strawberry Creek. The potential impact to the environment from contaminants detected in sediment will be evaluated in the ecological risk assessment.

Groundwater

Groundwater monitoring wells MW71-93-2 and MW51-94-11 are downgradient from AOC 1-10. Mercury has not been detected in either well (Table A4.5-4).

Status of Unit

Approximately 4 cubic yards of mercury contaminated soil was excavated for offsite disposal. AOC 1-10 was approved for NFA status by DTSC in July 1996 (DTSC, 1996b).

A3.8 AOC 9-2: Building 51 Former Diesel UST

Description and History

The former diesel underground storage tank (UST) (TK-35-51) was installed in 1968 below the fire trail east of Building 51 (the Bevatron) (Figure A3.8-1). The tank was of single-walled, steel construction with a 550-gallon capacity. The UST was partially buried with the upslope end within five feet of the ground surface and the downslope end exposed. The tank sat on a bed of sand and fine gravel, and was surrounded and covered with sand. Diesel fuel was supplied from the UST through a gravity feed hose to an aboveground day-tank mounted on the east wall of Building 51. The diesel fuel was used for an emergency generator within Building

51. In April 1993, the day tank and aboveground piping were disconnected and removed. The UST was drained in August 1993 and removed on April 20, 1994.

Sampling and Interim Corrective Measures

In 1992, prior to UST removal, three soil samples (BS51-92-11A-3.5', BS51-92-11A-6', BS51-92-11B-6') were collected at the UST site at depths between 3.5 and 6 feet bgs (LBNL, 1992d). TPH in the range of diesel (TPH-D) was detected in all three samples (Table A3.8-1).

An ICM consisting of removal of the UST, excavation of approximately 120 cubic yards of contaminated soil, and backfill of the excavation with clean material was conducted in 1994. The ICM was documented in a tank removal report (Environmental Solutions, 1994), which is summarized as follows:

- During the ICM, the City of Berkeley Office of Emergency and Toxics Management specified all soil-sampling locations in the field.
- Several stages of soil excavation and confirmation sampling was conducted until TPH-D was not detected in confirmatory samples 51Tank03 and 51Tank04 taken from the sidewalls of the excavation on June 8, 1994 (Table A3.8-1). However, TPH-D concentrations up to 5900 ppm were present in the final confirmatory excavation floor samples (51Tank01 and 51Tank02) taken immediately downslope of the UST on June 8, 1994.
- Additional soil excavation was not performed due to the inability of the construction equipment to extend the excavation on the steep slope. The base of the excavation was then covered with plastic, and the entire excavation was backfilled with imported clean fill and compacted.

Several additional samples were collected downgradient from the former UST excavation subsequent to completion of the ICM. In August 1995, three shallow soil samples (SS51E-95-1, -2, and -3) were collected along the alignment of the former gravity feed supply pipe that joined the former UST to the above ground day-tank. In February 1996, monitoring well MW51-95-17 was installed immediately downslope from the former tank location, near the location where high residual soil contamination had been detected at the base of the tank excavation. Soil samples were collected at approximately 5-foot intervals to a depth of 37 feet bgs. In September 1996, eight shallow soil samples (SS-51Slope-96-1 through SS-51Slope-96-8) were collected at approximately 1 foot bgs from native soil below the deepest excavation limit downslope of the

former UST location (Figures A3.8-2 and Figure A3.8-3, Table A3.8-1). TPH-D was detected at a maximum concentration of 620 mg/kg. No VOCs were detected. Two polynuclear aromatic hydrocarbons (PAHs) were detected, but at concentrations below PRGs for residential soil.

The post-ICM sampling showed that contamination was probably limited to the upper few feet of soil and was present only in areas near the former tank location.

Potential Migration of Contaminants

Potential migration of contaminants detected in soil in the Bevalac area to surface water and sediment is discussed in Section A4.6. Groundwater contamination is discussed in Section A4.5.1 (petroleum hydrocarbons). Surface runoff in the Building 51 area is directed through the storm drain system to North Fork Strawberry Creek. Surface water and sediment samples have been collected from North Fork Strawberry Creek and analyzed for chemicals of potential concern from upgradient sources, including AOC 9-2.

Surface Water and Sediment

No aromatic hydrocarbons have been detected in surface water samples from North Fork Strawberry Creek. Toluene and oil have been detected in sediment samples (Table A4.6-7). The source of these contaminants was probably runoff from the streets. The potential impact to the environment from contaminants detected in surface water and sediment will be evaluated in the ecological risk assessment.

Groundwater

Monitoring wells MW46-94-16 and MW51-95-17 are upgradient and downgradient from AOC 9-2, respectively. TPH-D (56 μg/L) has only been detected one of the eight times MW51-95-17 has been sampled (Table A4.5-1).

Status of Unit

Approximately 135 cubic yards of diesel contaminated soil was excavated and recycled offsite. AOC 9-2 was approved for NFA status by City of Berkeley in July 1997 (COB, 1997b).

A3.9 AOC 9-7: Building 51 Former Hazardous Materials Storage Area

Description and History

Based on interviews with former Building 51 personnel, a storage area for hazardous materials was located between Building 51 and Building 64 (Figure A3.9-1). The area was operational from about 1977 until approximately 1989. Two racks capable of holding three rows of drums stored 55-gallon drums of solvents and coolants (e.g., TCE, 1,1,1-TCA, and Freon-113) and various oils on concrete pads. A collection trough approximately 5 feet long, 2 feet high, and 3 feet wide was located on wooden planks above the asphalt-paved ground surface in front of the drum racks. The collection trough was used for dumping spent solvents and oils, which were periodically drained and transported off-site

Sampling

In April 1996, soil samples were collected from three borings (SB51-96-13, SB51-96-14, and SB51-96-15) at the suspected hazardous materials storage area (Figure A3.9-1). VOCs were detected in most of the samples, but at concentrations well below PRGs for residential soil (Table A3.9-1). Motor oil was detected in two shallow samples. PCBs were not detected. Metals were detected at concentrations below LBNL background levels or PRGs for residential soil (Table A3-1). Concentrations of VOCs generally increased downward, with the maximum concentration near the water table.

Potential Migration of Contaminants

Potential migration of contaminants detected in soil in the Bevalac area to surface water and sediment is discussed in Section A4.6. Groundwater contamination is discussed in Section A4. Surface runoff in the Building 51 area is directed through the storm drain system to North Fork Strawberry Creek. Surface water and sediment samples have been collected from North Fork Strawberry Creek and analyzed for chemicals of potential concern from upgradient sources, including AOC 9-7.

Surface Water and Sediment

The VOCs detected in soil samples collected at AOC 9-7 have not been detected in surface water or sediment samples collected from North Fork Strawberry Creek.

Groundwater

AOC 9-7 is located over the Building 51/64 Groundwater Solvent Plume (AOC 9-13). As discussed in Section A3.13, the Building 51/64 Former Temporary Equipment Storage Area (AOC 9-12) is the source area for the groundwater contamination.

Status of Unit

AOC 9-7 was approved for NFA status by DTSC in September 1998 (DTSC, 1998).

A3.10 AOC 9-8: Sanitary Sewer Lines North and West of Buildings 51 and 51B

Description and History

The NFA request for the Sanitary Sewer Lines North and West of Buildings 51 and 51B that was submitted to the DTSC in January 2000 (LBNL, 2000a) is included in Appendix C. Following is a summary of the information included in the NFA request.

The sanitary sewer lines north and west of Buildings 51 (the Bevatron) and 51B (Figure A3.10-1) carry effluent from a number of different locations, including the sanitary sewer effluent lines from Building 51, Building 64, Building 51B, and Building 71. The sanitary sewer lines also receive effluent from the Building 51 internal floor drainage system discharge sump (AOC 9-9). During most of its operational history, water in the discharge sump has been pumped to the sanitary sewer inlet at manhole SMH-11N21E.

Sampling and Sewer Line Surveys

In 1992, five soil samples (SS51W-03, SS51W-07, SS51N-02, SS51N-03, and BS51-92-13A on Figure A3.10-1) were collected along the sanitary sewer lines north and west of Building

51 to evaluate whether PCBs originating from the Building 51 Motor Generator Room Sump (SWMU 9-6) could have been released to soil from the sanitary sewers outside Building 51. In 1996 and 1997 soil samples were collected from groundwater monitoring well borings (MW51-96-15, MW51-96-16, MW51-96-17, MW51-96-18, MW51-96-19, MW51-97-3, MW51-97-4, MW51-97-12, and MW51-97-14 on Figure A3.10-1) installed along the sewer lines east and west of Buildings 51B. The purpose of these wells was to investigate the source and extent of groundwater contamination that had been detected in MW51B-93-18A. In May 1998, three soil samples (SS-51Sew-98-1 and SS51Sew-98-3, SS-51Sew-98-2) were collected from a trench excavated during relocation of the sanitary sewer north of Building 51.

Halogenated VOCs were detected in several soil samples collected along the sanitary sewer lines at concentrations below PRGs for residential soil (Table A3.10-1). However, with the exception of the three sewer line samples collected adjacent to manhole SMH 11N-21E, these samples were all collected below the water table in an area of known solvent contamination of groundwater. The samples collected below the water table are therefore probably not representative of soil contamination derived directly from a release from this AOC.

Nickel was detected at a concentration above both the LBNL background level and the PRG for residential soil in one sample (Table A3-1). This sample was collected approximately 45 feet below the elevation of the sanitary sewer line. Shallower samples had significantly lower nickel concentrations, indicating that the elevated nickel concentrations were unlikely to have been derived from the sanitary sewer lines.

In addition to sampling studies, a pipeline video survey (Figure A3.10-2) was conducted on October 26, 1999 to determine whether any dislocations, breaks, or perforations were present within the sanitary sewer system that could be a source of release. No defects, root intrusion, or displacement was observed within any of the lines surveyed.

Potential Migration of Contaminants

Potential migration of contaminants detected in soil in the Bevalac area to surface water and sediment is discussed in Section A4.6. Groundwater contamination is discussed in Section A4. Surface runoff in the Building 51 area is directed through the storm drain system to North

Fork Strawberry Creek. Surface water and sediment samples have been collected from North Fork Strawberry Creek and analyzed for chemicals of potential concern from upgradient sources, including AOC 9-8.

Surface Water and Sediment

The VOCs detected in soil samples collected at AOC 9-8 have not been detected in surface water or sediment samples collected from North Fork Strawberry Creek.

Groundwater

Several groundwater monitoring wells (MW51-96-15, MW51-96-16, MW51-96-17, MW51-96-18, MW51-96-19, MW51-97-3, MW51-97-4, MW51-97-12, and MW51-97-14) are located along the sanitary sewer lines. These wells were installed to help locate the source and characterize the magnitude and extent of the Building 51/64 Groundwater Plume (AOC 9-13)

Status of Unit

AOC 9-8 was approved for NFA status by DTSC in February 2000 (DTSC, 2000a).

A3.11 AOC 9-9: Building 51 Sanitary Sewer and Drainage System

Description and History

The NFI request report for the Building 51 Sanitary Sewer and Drainage System, which was submitted to DTSC on April 24, 2000 (LBNL, 2000f), is included in Appendix C. Following is a summary of the information contained in the NFI request.

As discussed in Section A3.3, a variety of oil-containing equipment was operated and/or stored in the Motor Generator Room of Building 51 (the Bevatron) and its basement, including oil pumps, capacitors, and transformers. There were also two oil pumps in the basement that delivered oil to the motor generators on the main floor.

The configuration of the subfloor drainage system for the Building 51 Motor Generator Room basement is shown on Figure A.3.11-1. The system consists of a terra cotta subdrain approximately 1.5 feet below the basement floor and a parallel cast iron pipe at a depth of 4 to 5 feet. The cast iron pipe is part of a larger drainage system that collects water from the Building 51 complex and empties into a discharge sump located at the north end of the Motor Generator Room basement. Several wells and subdrains are used to dewater the hillside immediately east of Building 51. This dewatering system discharges to the filter sump at the south end of the Motor Generator Room basement. Water from the filter sump is conveyed through the cast iron pipe to the discharge sump. The underground utility drawings for Building 51 indicate that the terra cotta drain and the cast iron pipe are not connected. However, a connection was discovered at the north end of the basement in 1999, when the two drain lines were exposed.

During most of its history, the effluent from the discharge sump was discharged to the sanitary sewer. However, prior to 1962, and for a period between 1994 and 1996, when contaminants were not detected in the effluent, the sump contents emptied to the storm drain system that discharges to North Fork Strawberry Creek. Currently, the effluent from the discharge sump is treated by a granular activated carbon (GAC) system and discharged to the sanitary sewer under LBNL's EBMUD Wastewater Discharge Permit.

On November 12, 1990 during a routine inspection, LBNL personnel observed that water in the filter sump was covered with black oil that was found to contain PCBs. Based on this occurrence, the DTSC RCRA Facility Assessment (RFA) (DTSC, 1991) identified the Building 51 PCB Spill Sumps and Drainage system as AOC #1. The LBNL RFA (LBNL, 1992d) identified the filter sump as SWMU 9-6, which was discussed in Section A3.3. LBNL later designated the impacted section of the drainage line and the discharge sump as AOC 9-9.

Sump and Drainline Sampling and Water Treatment

Investigations at AOC 9-9 were initiated in November 1990, when PCB-containing oil was found in the filter sump. Samples of water, oil, and sludge collected from the filter sump at that time contained PCBs (Kaldveer Associates, 1991). The oil apparently originated from blown capacitors stored in the basement. A subsequent survey (Kaldveer Associates, 1991)

indicated that lines draining into the filter sump (Lines J and K) and lines downstream from the filter sump (lines A, B, and parts of C, D, and F) contained an oil product. The system was flushed, and more than 1,300 gallons of contaminated water were removed, containerized and disposed of.

Beginning in November 1990, effluent from the discharge sump was pumped to a GAC system for treatment. Treated effluent from this system was used as makeup water for the Building 51 cooling towers. Eight water samples were collected from the treatment system influent line between March and November 1993. Neither VOCs nor PCBs were detected; therefore, water treatment was discontinued. The floor drains in the building were sealed and the effluent from the discharge sump rerouted to the storm drain.

In May 1996, PCBs and oil & grease were detected in sediment samples collected from the filter and discharge sumps (Table A3.11-1). Based on these results, water treatment was resumed, and treatment system effluent was routed to the sanitary sewer.

Initial Evaluation of Contamination and Potential Release Routes

A workplan was submitted to the regulatory agencies in March 1996 for investigation of the Building 51 (Bevatron) complex (LBNL, 1996e). The workplan proposed sampling to evaluate whether potential releases from the building's interior drain lines had impacted surrounding soils. In accordance with the addendum, eight soil borings (SB51-96-5 to SB51-96-12) were installed adjacent to the drain lines and sumps (Figure A3.11-2). Samples collected from most of these borings contained oil & grease and TPH in the range of motor oil (TPH-MO). PCBs were detected in SB51-96-12 and SB51-96-8 adjacent to the northern section of the drain line, at concentrations above the PRG for residential soil (Table A3.11-2). No VOCs were detected.

SB51-96-6, SB51-96-8, and SB51-96-12 were converted to temporary groundwater sampling points. Analytes detected in groundwater samples collected from SB51-96-8 and SB51-96-12 in April 1996 included PCBs and oil & grease. These data are discussed further in Section A4 (Groundwater).

Also in accordance with the March 1996 addendum, Test Pit 1 was excavated at a location where a video survey had indicated blockage of the cast iron drain line (Figure A3.11-2). The purpose of the test pit was to verify the locations and depths of the terra cotta and cast iron drain lines, and investigate whether the area of blockage was a source of releases of contaminants to the environment. No contaminants were detected in soil samples collected from the bedrock, including samples collected adjacent to the cast iron pipe (Figure A3.11-3 and Table A3.11-2). The sample (SS-51MRPit-96-6) collected from soil immediately beneath the terra cotta drain contained PCBs at a concentration above the PRG for residential soil and TPH-MO. Samples of black chips from the underside of the concrete (SS-51-MRPit-96-3) contained PCBs (Aroclor-1260). The Aroclor-1260 contamination was probably the result of a thin layer of oil that had been applied as a moisture barrier on top of the base rock.

Source Investigations

Test Pit 2 - November 1996

In November 1996, Test Pit 2 was excavated along the drain lines between the two former oil pumps (Figure A3.11-2). The purpose of the test pit was to evaluate whether the former oil pumps or drain lines in this area could be the source of the PCBs and oil & grease detected in groundwater samples from boring SB51-96-12. Four soil samples (SS-51MRP2-1 through SS-51MRP2-4) and one sample of product seeping into the east side of the pit (SS-51MRP2-PROD) were collected.

PCBs were detected in a sample collected from the base of the concrete and the moisture barrier immediately beneath the concrete floor. Soil samples collected at the elevation of the terra cotta drain contained only low concentrations of oil & grease. PCBs, oil & grease, and TPH-MO were detected in the soil sample collected below the terra cotta drain (Figure A3.11-4 and Table A3.11-2). The product seeping into the pit contained PCBs and TPH-H/MO (Table A3.11-3). Since contaminant concentrations appear to increase with depth and inspection of the cast iron pipe indicated no potential locations of leakage, the source of the contamination did not appear to be in the area of Test Pit 2.

Test Pit 3 – 1996 to 2000

A workplan was submitted to the regulatory agencies in January 1997 that included requirements for additional investigation of the drain lines (LBNL, 1997a). This workplan specified that a third test pit be excavated along the drain lines north of Test Pit 2, near temporary groundwater sampling point SB51-96-8, in the area of maximum detected soil and groundwater PCB concentrations (Figure A3.11-2). The purpose of this test pit was to help evaluate the source and assess the extent of the contamination previously detected in the soil and groundwater.

Test Pit 3 was excavated in stages starting in April 1997. During the initial excavation of the pit only composite samples were collected from excavated soil for disposal purposes. The pit was deepened in July 1998 in order to expose the terra cotta and cast iron drain lines for inspection and allow the collection of soil samples beneath drainlines. Water and product (oil or sludge) were observed seeping into the test pit at several locations. A sample of the product contained PCBs, TPH-MO, and several PAHs (Table A3.11-3).

Soil samples (SS-51MRPit3-98-1 through SS-51MRPit3-98-10) were collected from the walls and floor of the excavation (Figure A3.11-5). TPH-MO was detected in all the samples. Seven of the samples also contained PCBs at concentrations above the PRG for residential soil (Table A3.11-2).

Several rounds of confirmation sampling and enlargement of Test Pit 3 were conducted between June 1999 and February 2000. Sumps were installed for dewatering the excavation. Methylene chloride and PCBs were detected in soil sample (SS-51MRP3-99-1-7.3) collected at one of the sump locations in June 1999 (Figure A3.11-7, Table A3.11-2). The concentration of PCBs was above the PRG for residential soil.

Borings SB51-98-1 to SB51-98-9 February and June 1998

In February and June 1998, soil samples were collected from soil borings (SB51-98-1 through SB51-98-9) in the Motor Generator Room basement (Figure A3.11-2). The purpose of these borings was to characterize soil contamination both adjacent to and away from the drain lines, and provide additional information on the source of the contamination. TPH-H/MO oil

and TPH-C/WO were detected (Table A3.11-2). Two PCB compounds were detected: Aroclor-1242 was detected in several samples, with the maximum concentration found adjacent to the drain line at the north end of the basement; Aroclor-1260 was only detected in the oil layer forming a moisture barrier immediately beneath the concrete floor. Concentrations of PCBs generally decreased with distance from the drain line, indicating that the drain line was the source of the contamination.

Former Oil Pumps - April 1999

The locations of the former oil pumps are shown on Figure A3.11-1. In April 1999, samples of oil from each pump were analyzed for PCBs. PCBs were not detected (Table A3.11-3). When the abandoned east oil pump was removed, the concrete pad under the pump was observed to be heavily stained with oil. The concrete pad was therefore removed and soil samples were collected from ten borings (51MRP4-SB1 through 51MRP4-SB10) under the former pad location (Figure A3.11-6) to investigate whether the oil pump could have been a source of the PCB contamination detected in soil and groundwater beneath the basement. TPH-D and high concentrations of TPH-H/MO (28,000 mg/kg maximum) were detected, primarily in the shallow samples. PCBs were detected in only four of the samples, with one detection above the PRG for residential soil (Table A3.11-2, Figure A3.11-6).

Area of Wall Stains - April 1999

On April 28, 1999, two wipe samples (51MR-99WALLWIPE-1 and -2) were collected from the oil-stained concrete basement wall in the room east of Test Pit 3. The staining was observed below holes in the wall that had previously held electrical conduits. The sampling was conducted to assess if this oil could have been the source of the PCB contamination detected in the soil and groundwater. PCBs were not detected, indicating that this was not the source. TPH-C/WO was detected (Table A3.11-3).

Source Identification

The absence of PCBs where the highest concentrations of TPH were detected and the limited detections of PCBs in the samples collected at the eastern oil pump indicated that leaking from this oil pump was not the source of the PCB contamination.

Test Pit 3 was extended 10 feet toward the north in July 1999 to further investigate the source of the contamination. After the pit was extended, oil was observed seeping into the pit around the backfill of the cast iron pipe on the north wall of the excavation. In August 1999, the excavation was further extended to the north wall of the basement to attempt to locate the source of the seep. Near the north wall, the shallow terra cotta tile drain was observed to extend downward and connect to the cast iron pipe (Figure A3.11-7). This configuration, which was not indicated on utility drawings, may explain the mechanism for the release of the PCBs. In the past, when the pump in the discharge sump was not operating or was being repaired, the water level could rise in the sump. Contaminated water could then back up in the cast iron pipe and, from there, into the terra cotta drain. Since the terra cotta drain is not a solid pipe, any PCB-contaminated water that backed up into the terra cotta drain could be released to the surrounding coarse-grained backfill material around the drain lines.

Magnitude and Extent of Contamination

In December 1999 a workplan was submitted to the regulatory agencies that included provisions for both the evaluation of the magnitude and extent of contamination in the walls and beneath the floor of Test Pit 3 and for the excavation of Test Pit 5 to assess contamination in the soil around the discharge sump (LBNL, 1999v).

Test Pit 3 Floor and Wall Samples - 1999

Soil samples were collected at 21 locations in the walls (SS-51MRP3-99-W1 through SS-51MRP3-99-W21 and SS-51MRP3-99-FW9) and 5 locations beneath the floor (SS-51MRP3-99-F1 through SS-51MRP3-99-F5) of Test Pit 3 (Figure A3.11-7 and Figure A3.11-8). One PCB compound (Aroclor-1242), TPH (primarily TPH-H/MO), and thirteen PAHs were detected (Table A3.11-2). The detected PAHs included benzo(a)pyrene, which was detected slightly above the PRG for residential soil in two samples. PCBs were also detected above the PRG for residential soil in a number of samples.

Concentrations of PCBs detected in the east and west walls of the pit decreased with depth into the walls (distance from the drain lines), except for one location to the west of the drain line (SS-51MRP3-99-W20). SS-51MRP3-99-W20 is near the connection of the cast iron

pipe and terra cotta drain, the apparent source area for the contamination. This area of soil contamination was excavated when Test Pit 3 was subsequently extended to the west wall of the basement. The results were further evidence that the drain lines were the source of the release.

Test Pit 5 Floor and Wall Sampling - 1999

Removal of the concrete floor adjacent to the discharge sump and excavation of Test Pit 5 (Figure A3.11-2) started in August 1999. A 2-inch diameter hole was observed on the underside of the cast iron drain line when it was exposed in the excavation; however, no visual evidence of oil seepage was observed on the pit walls or floor. The hole in the pipe was repaired.

Soil samples were collected at eight locations in the walls (SS-51MRP5-99-W1 through SS-51MRP5-99-W8) and three locations beneath the floor (SS-51MRP5-99-F1 through SS-51MRP5-99-F3) of Test Pit 5. A number of the soil samples contained PCBs (Aroclor-1242), TPH-H/MO, PAHs, and VOCs (Table A3.11-2). Detected VOC concentrations were all less than PRGs for residential soil, while PCBs and one PAH (benzo(a)pyrene) was detected at a concentration above the PRG (Figure A3.11-9 and Figure A3.11-10).

Test Pit 2 Area - 2000

No confirmation samples were collected from the walls of Test Pit 2 prior to backfilling of the excavation, therefore additional sampling was conducted in February 2000 to ascertain whether contaminants were present adjacent to the backfilled pit. Soil samples were collected from soil borings SB51-MRP2-WW-1A, -2, -2A, -3, and -4 (Figure A3.11-2). PCBs (Aroclor-1242) were detected in one sample at a concentration below the PRG for residential soil (Table A3.11-2). No PAHs were detected. No additional samples were needed along the east wall of test Pit 2 because it was coincident with the west wall of Test Pit 4.

Interim Corrective Measures

Interim Measures were conducted in the Motor Generator Room basement to reduce the potential impact of contaminants to groundwater and to protect human health and the environment.

Cleaning the Drain Lines and Sumps

In June and August 1999, the sediment and sludge were removed from the filter and discharge sumps. The interior of each sump was then cleaned with a high-pressure water jet and steam and the cast iron drain line connecting them was cleaned with high-pressure water. A subsequent video survey of the pipe indicated no remaining oil contamination. More than 2000 gallons of contaminated wastewater were generated during these operations and recovered for offsite disposal using a vacuum truck.

The connection of the cast iron pipe to the terra cotta drain line was sealed and the elbow section of the cast iron pipe was replaced with a new section that provides a cleanout access. The effluent from the discharge sump is treated by a GAC system and discharged to the sanitary sewer under LBNL's EBMUD Wastewater Discharge Permit.

Excavating Contaminated Soil and Backfill

ICM cleanup levels for soil excavation were included in LBNL's December 1999 workplan (LBNL, 1999v). The objective of the ICMs was to remove contaminated soil with concentrations of PCBs above the USEPA self-implementing cleanup level (i.e., the "walk away" level) of 1 mg/kg for soil in high occupancy (residential) areas (USEPA, 1998) and soil with concentrations of other COPCs above PRGs for residential soil. This objective was accomplished except for one location where detected concentrations of PCBs remaining in place are slightly above 1 mg/kg and three locations where benzo(a)pyrene was detected at concentrations just above the PRG for residential soil. The ICM cleanup levels were conservative, since the remediated contaminants were only present in soil and backfill below an 8-inch-thick concrete floor in the basement of a laboratory building. Following is a description of the ICMs.

Accessible soil in Test Pit 3 with concentrations of PCBs above 1 mg/kg was removed. The initial excavation was extended to the east, based on analytical results from wall samples and to the west to the Motor Generator Room Basement wall (Figure A3.11-7). In February 2000, additional soil was excavated at a depth of approximately 4 feet under the west wall of Test Pit 3, at the location of the October 1999 wall samples SS-51MRP3-99-W11A and B. This was the location where a product seep was observed when the pit was opened in 1998. After

removing this additional soil, PCBs were detected at a concentration of 2.2 mg/kg in a sample collected from the back of the excavated area. The area of this sample was also excavated. In order to evaluate the final extent of the contamination, soil samples were collected at 2 and 4 feet below the floor surface from boring SB51-MRP3-WW-11D, approximately 2 feet west of SS-51MRP3-00-W11C (Figure A3.11-7). No PCBs were detected.

Soil in the northwest corner Test Pit 5 with concentrations of PCBs above 1 mg/kg (SS-51MRP5-99-W3A) was removed (Figure A3.11-9).

TPH-H/MO had been detected at a maximum concentration of 28,000 mg/kg (soil boring 51MRP4-SB1-1.2) in soil borings drilled at the planned location of Test Pit 4. Therefore, in January and February 2000, Test Pit 4 was excavated to a depth of approximately 4 feet below the basement floor. Confirmation samples were collected beneath the floor (SS-51-MRP4-00-F1 through SS-51-MRP4-00-F3) and along the walls (SS-51-MRP4-00-W1 through SS-51-MRP4-00-W3) of the excavation. PCBs were detected in only one wall sample, at a concentration below the PRG for residential soil. TPH-H/MO was detected at maximum concentration of 310 mg/kg. No VOCs were detected.

Potential Migration of Contaminants

Potential migration of contaminants detected in soil in the Bevalac area to surface water and sediment is discussed in Section A4.6. Groundwater contamination is discussed in Section A4.4.2 (VOCs) and A4.5-3 (PCBs). As discussed previously, the discharge sump has in the past (primarily prior to 1962) been connected to the LBNL storm drain system. Effluent from the storm drain system near Building 51 is routed to the erosion control basins on North Fork Strawberry Creek, located approximately 700 feet northwest of Building 51. Surface water and sediment samples have been collected from North Fork Strawberry Creek and analyzed for chemicals of potential concern from upgradient sources, including AOC 9-9.

Surface Water and Sediment

In November 1993, a sediment sample was collected from a catch basin located between Buildings 51 and 64 (Figure A4.6-2). The catch basin is a former collection basin for materials

discharging from the Building 51 drainage system (AOC 9-9). No VOCs were detected. PCBs (Aroclor-1260), TPH-D, and four phthalate compounds (SVOCs) were detected (Table A3.11-1).

Neither PCBs nor PAHs have been detected in surface water or sediment samples collected from North Fork Strawberry Creek. Mercury, which was detected in one sediment sample, was within the LBNL soil background level. The potential impact to the environment from contaminants detected in surface water and sediment will be evaluated in the ecological risk assessment.

Groundwater

Both PCBs and oil & grease were detected in groundwater samples collected from temporary groundwater sampling points SB51-96-8 and SB51-96-12 along the northern section of drain line. These sampling points were located within fill material. Contaminated materials near the sampling points have been excavated, and both temporary groundwater sampling points have been removed.

Status of Unit

Approximately 70 cubic yards of contaminated soil was excavated for offsite disposal. - AOC 9-9 was approved for NFI status by DTSC in April 2000 (DTSC, 2000d). The unit will be included in the site-wide risk assessment because of the detection of COPCs at concentrations greater than PRGs for residential soil and LBNL background levels.

A3.12 AOC 9-11: Former Cooling Towers Southeast of Building 51

Description and History

The NFA request report for the Former Cooling Towers Southeast of Building 51 (AOC 9-11), which was submitted to DTSC on March 29, 2000 (LBNL, 2000e), is included in Appendix C. Following is a summary of the information contained in the NFA request.

The Bevatron particle accelerator located inside Building 51 was operational from 1954 to 1993. During operations, water used to cool the Bevatron magnet ring was circulated through

three cooling towers (CT-4, CT-5, and CT-6) located southeast of the building (Figure A3.12-1). Two of the towers have been removed and one inactive tower is still in place. About 1962, discharge water from the cooling towers was redirected from the storm drain system to the sanitary sewers. Prior to 1983, the cooling tower cleaning activities may have released rinse water. The system was designed to catch any released water in drainholes of a subsurface drainage system that routed the water to a sump located next to the CT-4 containment basin, which in turn discharged to the sanitary sewer.

In addition, a subsurface tile drain parallels the southern perimeter of Building 51 (the "Building 51 Drain" on Figure A3.12-1 and A3.12-2) and collects groundwater from a wide area, including the cooling tower area. A second subsurface drain (the "Building 51 Spring Drain" on Figure A3.12-1) intercepts a natural spring that was present prior to construction of Building 51 at the southwest edge of the building, and is located approximately 4 feet from the Building 51 Drain in the vicinity of the spring. Both drains empty into a stormwater catch basin located inside Building 51A; the catch basin ultimately discharges to the storm drain outfall on North Fork Strawberry Creek (Figure A3.12-3).

Sampling

During the RFA in 1991 and 1992 , one soil sample (SS51S-07) was collected from a depth of 9 feet bgs to assess possible leakage from the cooling tower or sanitary sewer and soil samples were collected from two borings (51-92-2 and 51-92-3) drilled along the southeast side of the former cooling tower basins (LBNL, 1992d). Boring 51-92-2 was completed as a monitoring well (MW51-92-2) and boring 51-92-3 was completed as a series of five nested piezometers (PZ51-92-3) (Figure A3.12-2). In April 1996, soil samples were collected from two borings (SB51-96-19 and SB51-96-20) located next to surface drainholes adjacent to the former cooling tower basins CT-5 and CT-6, and from one boring (SB51-96-22) next to the sump adjacent to former cooling tower basin CT-4.

Total hydrocarbons (THC) and trace concentrations (<0.2 mg/kg) of 1,1,1-TCA, benzene, and other aromatic hydrocarbons were detected in the 1992 samples. Arsenic, chromium, and thallium were detected at concentrations above both LBNL background levels and PRGs for

residential soil in one sample each. Chromium was also detected above both LBNL background levels and PRGs for residential soil at a depth of 1 foot in SB51-96-20 (Tables A3.12-1 and A3-1).

In September 1996, two soil samples collected at 1.1 and 2.1 feet bgs from SB51-96-20A (adjacent to SB51-96-20) at 1.1 and 2.1 feet bgs were analyzed for hexavalent chromium (chromium VI). No hexavalent chromium was detected.

A work plan was submitted to regulatory agencies in January 2000 to assess the contamination detected in 1991 and 1992 (LBNL, 2000b). Four soil borings (SS51-00-1, SS51-00-2, SS51-00-3, SB51-00-4), one monitoring well (MW51-00-1), and one replacement temporary groundwater sampling point were drilled in the vicinity of previously drilled borings (Figure A3.12-2). Soil samples were collected adjacent to the locations where contaminants were previously detected. Based on the results of this sampling, there was no evidence of soil contamination at AOC 9-11. Concentrations of arsenic, chromium, and thallium detected in soil were all within LBNL background levels. No VOCs were detected (Tables A3.12-1 and A3-1). The locations and concentrations of the previously detected contaminants and those of the 2000 samples are shown in cross section on Figures A3.12-4 and A3.12-5.

Potential Migration of Contaminants

Potential migration of contaminants detected in soil in the Bevalac area to surface water and sediment is discussed in Section A4.6. Groundwater contamination is discussed in Section A4. The storm drain system near AOC 9-11 discharges to North Fork Strawberry Creek. Surface water and sediment samples were collected from North Fork Strawberry Creek and analyzed for chemicals of potential concern from upgradient sources, including AOC 9-11.

Surface Water and Sediment

The storm drain system near AOC 9-11 discharges to North Fork Strawberry Creek. Surface water and sediment samples have been collected from North Fork Strawberry Creek and analyzed for chemicals of potential concern from upgradient sources, including AOC 9-11. Hexavalent chromium was detected (4.2 μg/L) in the surface water sample collected from North

Fork Strawberry Creek at the boundary fence in July 1999, but was not detected in water collected upstream at the erosion control basin. The detected concentration is below the MCL for drinking water (50 μg/L) and the DHS Water Quality Criteria of 11 μg/L for protection of freshwater aquatic life. Hexavalent chromium was not detected in either of the sediment samples collected at the same surface water sampling locations. Furthermore, hexavalent chromium was not detected (<2 μg/L) in the surface water sample collected from North Fork Strawberry Creek in January 2000. The potential impact to the environment from contaminants detected in surface water will be evaluated in the ecological risk assessment.

Groundwater

Two groundwater monitoring wells, two temporary groundwater sampling points, and one piezometer in the area of AOC 9-11 were concurrently sampled for VOCs, metals, and hexavalent chromium in February 2000. No VOCs were detected. Concentrations of metals detected were below MCLs. Hexavalent chromium, which was only detected in SB51-96-20R, was the only contaminant identified in the groundwater. The detection only in SB51-96-20R indicates that the horizontal extent of the contamination is limited. SB51-96-20R is screened from approximately 5 to 15 feet bgs in the fill. Hexavalent chromium was not detected in adjacent (within 5 feet) monitoring well MW51-00-01, which is screened from 20 to 25 feet bgs in the Orinda Formation, indicating that the vertical extent of the contamination is limited.

Status of Unit

AOC 9-11 was approved for NFA status by DTSC in April 2000 (DTSC, 2000c).

A3.13 AOC 9-12: Building 51/64 Former Temporary Equipment Storage Area

Description and History

A temporary equipment storage area was formerly located between Buildings 51 and 64. The period of operation for the area is unknown. The area was used for storage of used iglatron tubes (electrical equipment containing mercury) that were used in Building 51 high-voltage

electrical equipment. Some of the tubes were refurbished in the mercury storage room (AOC 9-1) prior to reuse, and some tubes were shipped offsite.

Sampling

Several samples were collected from the general area of AOC 9-12 in 1994. Soil samples were collected from monitoring well boring MW51B-93-18A and shallow soil samples (SS64ETrench-01 to -04) were collected during excavation of a utility trench (Figure A3.13-1).

In 1996, soil samples were collected from six borings (SB51-96-23 through SB51-96-28) drilled in the open area between Buildings 51 and 64 and from two nearby groundwater monitoring wells (MW51-96-18 and MW51-96-19) (Figure A3.13-2). Based on relatively high concentrations of contaminants detected in the groundwater in this area, an extensive soil-sampling program was conducted in 1998 to locate the source of the contamination. Sixteen soil borings (SB64-98-1 to SB64-98-16) were drilled near the southern end of Building 64. SB64-98-1 was converted to groundwater monitoring well MW64-98-4. The remaining fifteen borings were converted to temporary groundwater sampling points.

Halogenated VOCs were detected in most of the 1998 soil samples (Figure A3.13-2, Table A3.13-1), with the highest concentrations being detected in the vicinity of soil boring 64-98-7. Several borings also contained aromatic hydrocarbons, generally at lower concentrations than halogenated VOCs. With the exception of several samples collected in the vicinity of boring 64-98-7, constituent concentrations were less than PRGs for residential soil. Except for lead in SB51-96-25 and SB51-96-28, concentrations of metals were below both LBNL background levels and PRGs for residential soil (Table A3-1).

Potential Migration of Contaminants

Potential migration of contaminants detected in soil in the Bevalac area to surface water and sediment is discussed in Section A4.6. Groundwater contamination is discussed in Section A4.4.2. The storm drain system near AOC 9-12 discharges to North Fork Strawberry Creek. Surface water and sediment samples were collected from North Fork Strawberry Creek and analyzed for chemicals of potential concern from upgradient sources, including AOC 9-12. The

potential impact to the environment from contaminants detected in surface water and sediment will be evaluated in the ecological risk assessment.

Surface Water and Sediment

The only halogenated VOC detected in surface water or sediment samples collected from North Fork Strawberry Creek was a trace concentration (<1 μg/L) of 1,1,1-TCA in the surface water in May 1995. 1,1,1-TCA has not been detected in the ten samples collected since that time. The MCL for 1,1,1-TCA is 200 μg/L.

Groundwater

This is a source area for the Building 51/64 Groundwater Solvent Plume (AOC 9-13). The plume is discussed in Section A4.4.2.

Status of Unit

AOC 9-12 was approved for NFI status by DTSC in September 1998 (DTSC, 1998). The unit will be included in the site-wide risk assessment since several halogenated hydrocarbons were detected at concentrations greater than the PRG for residential soil. An ICM is in progress to remove soil from the area of maximum soil contamination, in order to eliminate the source of groundwater contamination in this area.

A3.14 Potential Source Area for the Building 71 Groundwater Solvent Plumes (AOC 1-9)

Description and History

The area around Building 71B was investigated as a potential area for the Building 71 Groundwater Solvent Plume (AOC 1-9) because it houses a machine shop and is upgradient from the area where the groundwater contamination had been detected.

Sampling

Two temporary groundwater sampling points (SB71B-99-1 and SB71B-99-2) were installed along the sanitary sewer line west of Building 71B in May 1999 Figure A3.14-1), a potential source for the groundwater contamination. Soil samples were collected from the borings for the sampling points at approximately 5-foot intervals. A trace concentration (0.008 mg/kg) of tetrachloroethene (PCE) was the only VOC detected. In July 1999, soil gas samples were collected from probes installed along the sanitary sewer line west of the building and in the open area on the south side of the building, a location where solvents could have been released or spilled. Monitoring well MW71B-99-3 was installed in July 1999 on the south side of the building adjacent to the soil gas monitoring point that showed the highest concentrations of total ionizable vapors (Figure A3.14-1). Soil samples collected from the monitoring well contained PCE at a maximum concentration of 2.7 mg/kg (Table A3.14-1).

Potential Migration to Surface Water and Groundwater

The south side of Building 71B is a source of AOC 1-9 (Building 71 Groundwater Solvent Plume). AOC 1-9 is discussed in detail in Section A4.4.1. Migration of contaminants to surface water and sediment from potential Bevalac Area sources is discussed in Section A4.6.

Status of Area

The Building 71B area has not been specifically designated as a SWMU or AOC. This area has been identified as a source of the Building 71 Groundwater Solvent Plume (AOC 1-9), which is discussed in Section A4.

A.3.15 Other Soil Sampling

Soil samples have been collected at locations in the Bevalac Area other than at the SWMUs and AOCs discussed above. These samples were collected primarily from the borings for groundwater monitoring wells and temporary groundwater sampling points that were installed to characterize the extent of groundwater contamination or help identify the source of

the groundwater AOCs discussed in Section A4. The locations of these samples are shown on Figure A3.15-1.

Low concentrations of halogenated VOCs (well below PRGs for residential soil) were detected in soil samples collected from several of the monitoring well and temporary groundwater sampling point borings. The contaminants consisted primarily of TCE, PCE, cis-1,2-dichloroethene (DCE), and 1,1,1-TCA. For the most part, these samples were collected in areas of known halogenated VOC contamination in the groundwater. Soil analytical results are listed in Tables A3.14-1 and A3-1. Groundwater results are discussed in Section A4.

A4 NATURE AND EXTENT OF CONTAMINATION IN GROUNDWATER AND SURFACE WATER

A4.1 Introduction

Groundwater in the Bevalac Area is contaminated with halogenated VOCs including chlorofluorocarbons (CFCs); referred to in the following sections by the tradename Freon™), PCBs, and fuel hydrocarbons. The areas of groundwater contaminated with halogenated VOCs are shown on Figure A4.1-1 and include:

- the Building 71 Groundwater Solvent and Freon Plumes (AOC 1-9) is composed of two chemically distinct plumes, a Freon plume and a solvent plume. The solvent plume consists of at least two geographically distinct subplumes (the Building 71 lobe and the Building 71B lobe), although the margins of these two subplumes may merge. The solvent plume contains common industrial solvents (primarily PCE and TCE) and their degradation products (i.e., DCE and vinyl chloride). In addition, 1,1,1-TCA and dichloroethane [DCA] have been detected north of Building 71B. The Freon Plume is composed of Freon-113 (1,1,2-trichloro-1,2,2-trifluoroethane), and is commingled with the Building 71 lobe of the solvent plume.
- the Building 51/64 Groundwater Solvent Plume (AOC 9-13) contains common industrial solvents (primarily 1,1,1-TCA, PCE, TCE, and methylene chloride) and their degradation products (i.e., DCE, DCA, and vinyl chloride).
- an area of halogenated VOCs in groundwater has been identified south of Building 51L that appears to be separate from AOC 9-13.

Other chemicals were detected in the plume areas in addition to the primary contaminants described above. TPH (primarily TPH-C/WO), aromatic hydrocarbons, PCBs, and oil & grease

were detected in several wells in the area of the Building 51/64 Groundwater Solvent Plume. Also, arsenic and selenium were detected at concentrations above MCLs. Non-solvent related VOCs (primarily chloroform and bromodichloromethane) were detected in the area of the Building 71 Groundwater Solvent Plume.

The magnitude and extent of groundwater contamination in the Bevalac Area are documented in the analytical results tables, and illustrated on the isoconcentration contour maps and cross sections referenced in the following sections. The contamination was characterized primarily based on groundwater samples collected from monitoring wells and temporary sampling points, and water samples collected from the spring southwest of Building 71.

For comparison purposes, Maximum Contaminant Levels for drinking water (MCLs) are referenced on the groundwater sampling result tables. The MCL values given are the more conservative of either the Federal (Safe Drinking Water Act [40 CFR 141]) or State (Cal-EPA CCR Title 22) standards.

The isoconcentration contour maps (plume maps) display the arithmetic mean of contaminant concentrations detected during Fiscal Year 1999 (FY99) (October 1, 1998 to September 30, 1999). To present a consistent and representative depiction of conditions at the water table, the plume maps were drawn using data from wells screened in the upper portion of the saturated zone (generally within approximately 10 feet of the water table). For wells in which specific chemicals were detected during some, but not all, sampling events, mean concentrations were calculated by using one-half of the laboratory reporting limit as the non-detect concentrations. For wells that were not sampled during FY99, the results from the most recent (pre FY99) sampling event were utilized for contouring unless the results appeared to represent an outlier, in which case results from a prior sampling event were substituted.

The vertical distribution of contaminants in groundwater is depicted on the attached hydrogeologic cross sections, which include data collected from wells screened in the deeper portion of the saturated zone. The cross sections show geology, groundwater levels, total halogenated VOC concentrations (excluding Freon compounds), and isoconcentration contour lines. These data were based on the isoconcentration contour maps, geological and hydrogeological information collected from monitoring wells and temporary groundwater

sampling points, and the conceptual model described in the following section. Significantly lower concentrations of contaminants have been detected in the deeper wells, which is consistent with the conceptual model.

A4.2 Conceptual Model for Contaminant Transport in Groundwater

According to the conceptual hydrogeologic model discussed in Section A2.5, contaminant transport in groundwater in the Bevalac Area is primarily within the relatively high permeability surficial units and Moraga Formation volcanic rocks. Groundwater flow within the underlying Orinda Formation is of minor importance, as is indicated by its relatively low hydraulic conductivity. Groundwater flows generally westward parallel to the surface slope, except beneath Building 51, where flow converges and forms a trough in the groundwater surface (Figure A2.3-12).

The following conceptual model was developed for contaminant transport, based primarily on the type, concentration, and distribution of contaminants detected in the groundwater:

- Groundwater plumes 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 and moderate permeabilities of the upper portion of the saturated zone at LBNL.
- Contaminant concentrations and hydraulic conductivity values decrease with depth, as indicated by analytical data from two multi-well clusters. These observations indicate that advective transport downward into, and laterally within, the deeper horizons is of relatively small magnitude. They are also consistent with the conceptual groundwater flow model, in which the shallower surficial units and rocks of the Moraga Formation represent preferential flow pathways, whereas the low permeability rocks of the Orinda Formation impede groundwater flow.
- Organic contaminants are often transformed into other compounds by microbial or chemical processes in the subsurface. Halogenated VOCs usually degrade by sequences of reactions that occur under different environmental conditions. As a result of these reactions, intermediate daughter products are often produced. Depending on site conditions, these intermediate products may further degrade into different end products. Common degradation pathways for halogenated VOCs are shown on Figure A.4.2-1.

A4.3 Freon Compounds (CFCs) and Chloroform in Groundwater

A4.3.1 Building 71 Groundwater Freon-113 Plume (AOC 1-9)

Description of Contaminants

The Building 71 Groundwater Freon Plume is defined by the presence of 1,1,2-trichloro-1,2,2-trifluoroethane (Freon-113) (Figure A4.3-1). Concentrations of Freon-113 detected in the Bevalac Area are included in Tables A4.3-1a to A4.3-1c (monitoring wells), Table A4.3-2 (temporary groundwater sampling points), Table A.4.6.1 (surface water), and Table A.4.6.4 (hydraugers).

Lateral Extent of Freon-113 in Groundwater

The plume is limited to the area immediately southwest of Building 71(Figure A4.3-1). In FY99, Freon-113 was detected in only two wells (MW71-93-2 and MW71-94-1), in the effluent from two hydraugers (51-01-01 and 51-01-02), and at the spring southwest of Building 71. The downgradient (southern) extent, transgradient (eastern), extent, and upgradient (northern) extent of the plume are limited, as indicated by the absence of Freon-113 in monitoring wells in these areas. The transgradient (western) extent of the plume is indicated by the low concentration of Freon-113 (1.7 μg/L) measured at the spring southwest of Building 71 in 1999.

Vertical Extent of Freon-113 in Groundwater

The vertical extent of Freon-113 in the groundwater has not been evaluated because of the low concentrations detected (two orders of magnitude below the MCL in 1999) and its limited lateral extent. Based on the contaminant transport model described above and the low concentrations detected, the vertical extent of the plume is limited.

Trends in Contaminant Concentrations

The magnitude and extent of the Building 71 Groundwater Freon-113 Plume have decreased over time. Concentrations of Freon-113 detected in monitoring wells MW71-93-2 and MW71-94-1 decreased from more than 1,000 μg/L in both wells in 1994 to less than 30 μg/L in 1999 (Figure A4.3-2). Concentrations also decreased in the spring southwest of Building 71 and hydraugers 51-01-01 and 51-01-02. Freon-113 has not been detected in downgradient monitoring wells MW51-94-11 or MW90-5 since 1995, indicating that the downgradient extent of the plume has decreased. Concentrations of Freon-113 detected in MW71-93-2 and MW71-94-1 began to decrease at the same time that bromodichloromethane and chloroform first appeared in both wells in December 1994 (Figure A4.3-3). The source of these compounds, which are byproducts of drinking water disinfection, was water leaking from an EBMUD water supply pipeline. The leak was discovered and repaired in early 1996. Apparently, water leaking from the pipe accelerated the dilution and dispersion of the Freon-113 in the groundwater. Since the pipe was repaired, concentrations of bromodichloromethane and chloroform in groundwater have decreased to non-detectable levels (Figure A4.3-3).

Potential Source(s) of Contamination

The Linear Accelerator Cooling Unit (AOC 1-3) and the associated Freon-113 Storage Tank (AOC 1-2) are the only SWMUs or AOCs in the area of the Freon plume where Freon compounds are known to have been stored or used (Figure A4.3-4). The source of Freon-113 is most likely past spills at AOC 1-3, which is described in Section A3.5 of this report.

Plume Management (Interim Corrective Measures)

The effluent from the 51-01-series hydraugers, two of which contain Freon-113, has been collected and treated by a GAC treatment system located east of Building 51 (Figure A4.3-4). The treated water is discharged to the sanitary sewer under a permit issued by the East Bay Municipal Utility District. Concentrations of Freon-113 in the groundwater are currently well below MCLs. Groundwater monitoring will continue in accordance with requirements of the regional Water Quality Control Board (RWQCB).

A4.3.2 Other Freon Compounds

Low concentrations (3.9 μg/L maximum concentration) of other chlorofluorocarbons (CFCs) have been sporadically detected in groundwater in the Bevalac Area including: trichlorofluoromethane (Freon-11), dichlorodifluoromethane (Freon-12), and 1,2-dichloro-1,1,2-trifluoroethane (Freon-123A). Detected concentrations of Freon-11 have been two orders of magnitude below the MCL. There are no MCLs for Freon-12 or Freon-123A.

A4.4 VOC Solvent Plumes in Groundwater

The solvent plumes in the Bevalac Area contain primarily PCE, TCE and 1,1,1-TCA and their degradation products (DCE, DCA, vinyl chloride, etc.). Concentrations of VOCs detected are presented in Tables A4.3-1a to A4.3-1c (monitoring wells), Table A4.3-2 (temporary groundwater sampling points), Table A.4.6.1 (surface water), and Table A.4.6.4 (hydraugers). Isoconcentration maps of total halogenated VOCs (excluding Freon), PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, 1,1,1-TCA, 1,1-DCA, 1,2-DCA, vinyl chloride, chloroform, and methylene chloride are presented on Figure A4.4-1 through Figure A4.4-12, respectively. The mean concentration of total halogenated VOCs detected in groundwater monitoring wells and temporary groundwater sampling points in FY99 is shown on cross sections C-B', C-C', G-F', and E-E' (Figure A4.4-14 through Figure A4.4-17). An index map for the cross sections is shown on Figure A4.4-13.

A4.4.1 The Building 71 Groundwater Solvent Plumes (AOC 1-9)

Description of Contaminants

Lobes of the Building 71 Groundwater Solvent Plumes (AOC 1-9) extend southward from both the Building 71B and Building 71 areas (Figure A4.1-1). Each lobe contains a different suite of chemicals. The Building 71B lobe contains primarily PCE, TCE and cis-1,2-DCE, while the Building 71 lobe consists primarily of TCE and 1,1,1-TCA. The difference in the suites of chemicals and the configuration of each lobe implies that the two lobes have distinct sources. The maximum concentrations of total halogenated VOCs detected in FY99 were 337 μg/L and 20 μg/L for the Building 71B and Building 71 plume lobes, respectively. The

maximum concentration for the Building 71B lobe was detected in monitoring well MW71B-99-3, which was installed in the source area of the plume in July 1999, and sampled only once in FY99. Higher concentrations were detected in this well in FY00 (640 μg/L maximum).

Several VOCs have been detected at concentrations above MCLs in wells monitoring AOC 1-9. Maximum concentrations of VOCs detected above MCLs in FY99 are shown in the following table.

Maximum Concentrations (μg/L) of VOCs Detected Above MCLs in FY99

Well Number	PCE	TCE	cis-1,2-DCE	vinyl chloride
MCL	5	5	6	0.5
Building 71B Lobe				
MW90-3	33	31	24	
MW46A-92-15				21
MW71B-98-13	180	91	58	4.0
SB71B-99-3	330	6.7		
Building 71 Lobe				
MW71-93-2		25		
MW71-97-23		10		

Other non-solvent related VOCs (primarily chloroform and bromodichloromethane in MW90-3, MW71-93-2, and MW71-94-1) have been detected in the AOC 1-9 area. The sources of these contaminants, which are described in a following subsection (chloroform and bromodichloromethane), are different than those of the plume lobes discussed above.

Lateral Extent of Contamination

The lateral extent of the Building 71B plume lobe is shown on Figure A4.4-1. The isoconcentration maps (Figures A4.4-2 through A4.4-4) indicate a similar lateral extent for the primary plume contaminants (PCE, TCE, and cis 1,2-DCE). The downgradient extent of this lobe is indicated by the low concentrations, or absence of contaminants, in downgradient monitoring wells MW90-4, MW90-5, or MW90-6. The transgradient (southeastern) extent of the plume is indicated by the absence of contaminants in monitoring wells to the south of the plume area (primarily MW46-93-19 and the steep slope toward the east). The transgradient (northern) edge of the plume may merge with the Building 71 lobe.

The lateral extent of the Building 71 plume lobe is shown on Figure A.4.4-1 and is defined by the extent of TCE Figure A4.4-3. Neither TCE nor TCE degradation products have been detected in the spring southwest of Building 71 or in MW71-95-1, west of Building 71, indicating the transgradient (northwestern) extent of the plume. The downgradient extent of this lobe is indicated by the low concentrations, or absence of contaminants, in downgradient monitoring wells MW51-94-11, MW90-4, MW90-5, and MW90-6.

Vertical Extent of Contamination

The vertical distribution of total halogenated VOCs (excluding Freon compounds) in the Building 71 Groundwater Solvent Plumes (AOC 1-9) is depicted on cross sections C-B', C-C', and G-G' (Figure A.4.4-14 through Figure A.4.4-16). Groundwater contaminants in the Building 71 lobe were detected in monitoring wells MW71-93-2 and MW71-94-1, which are screened entirely within volcanic rocks of the Moraga Formation (cross sections C-B' and G-G'). Only relatively low concentrations of halogenated VOCs have been detected (19 μg/L mean total concentration in FY99). Based on the relatively low concentrations of contaminants detected and the conceptual model for contaminant transport, the vertical migration of contaminants into the underlying Orinda Formation should be minimal.

Groundwater contaminants in the Building 71B lobe were detected in wells primarily screened within the artificial fill and colluvium deposits (cross sections C-C' and G-G'). In order to address RWQCB concerns regarding the vertical extent of contamination and to verify the conceptual model, monitoring well MW71B-00-2 was installed in the area where the highest concentrations of contaminants had been detected in the groundwater. MW71B-00-2 was screened at a greater depth than the previously installed wells, entirely within the Orinda Formation. Groundwater sampling results from this well indicate that the concentrations of halogenated VOCs are two orders of magnitude higher near the water table in the artificial fill than near the top of the underlying Orinda Formation, which is consistent with the conceptual model. Halogenated VOCs, which have been detected at a maximum total concentration of 640 μg/L in the fill in the source area, were detected at concentrations below MCLs in MW71B-00-2 (PCE = 1.7 and 4.9 μg/L; TCE = 0.83 and 4.7 μg/L and cis-1,2-DCE = 0.5 and 1.7 μg/L).

Trends in Contaminant Concentrations

Historical variations in concentrations of total halogenated VOCs (excluding Freon compounds, chloroform and bromodichloromethane) detected in selected wells monitoring the Building 71 lobe are plotted on Figure A4.4-18. There is a decreasing trend in the concentrations of halogenated VOCs detected in MW71-93-1. Concentrations of halogenated VOCs declined in MW71-93-2 during the period of the water supply pipe leak, but returned to prior levels after the leak was repaired.

The historical variation of total halogenated VOCs (excluding Freon compounds) detected in selected wells monitoring the Building 71B lobe is shown on Figure A4.4-19. Concentrations detected in MW90-4 at the downgradient end of the plume have decreased to non-detectable levels. Concentrations detected in MW90-3, downgradient of the main source area at Building 71B, have remained fairly constant. Concentrations detected in MW46A-92-15 were relatively constant until May 1998, when they began to decline significantly. The reason for this decrease is unknown.

Both lobes of the plume appear to be stable, in that contaminant concentrations detected in wells monitoring the plume have remained relatively constant over several years of monitoring, and contaminants have either not been detected, or detected at only low concentrations, in downgradient monitoring wells.

Potential Sources of Contamination

The only identified SWMUs or AOCs in the vicinity of Building 71 and Building 71B that stored or used organic solvents are the Former Building 71H Hazardous Materials Storage Area (AOC 1-4) and the Former Building 71 Hazardous Materials Storage Area (AOC 1-5) (Figure A4.4-20). The location of these units away from the plume core areas indicates that they are not the source of the groundwater contamination. Based on results of the RFA, no soil sampling was required at these units during the RFI.

Building 71B Lobe Source

Building 71B houses a machine shop and was therefore investigated during the RFI as a potential source area for the Building 71 Solvent Plume. Based on the relatively high concentrations of PCE detected in soil and soil gas samples collected immediately south of the building, monitoring well MW71B-99-3 was installed to assess whether Building 71B was the source area for the contamination (Section A3.14). The maximum concentrations of halogenated VOCs detected in wells monitoring the plume have been in MW71B-99-3. Based on the geometry of the Building 71B plume lobe and concentrations of contaminants detected in groundwater, soil, and soil gas; the area immediately south of Building 71B appears to be the source area for Building 71B plume lobe. Solvents (PCE and possibly TCE) which provided a source for the plume, may have been spilled on the surface. The presence of other halogenated VOCs are likely the result of degradation of PCE and possibly TCE. The TCE could also be a product of PCE degradation.

Building 71 Lobe Source

The plume maps indicate that TCE (Figure A4.4-3) and 1,1,1-TCA (Figure A4.4-7) were released near the location of well MW71-93-2. Machine shops inside Building 71 may have been the original source of the solvents. Solvents may have been spilled adjacent to the building or may have been released to the environment through the sanitary sewer system (shown on Figure A4.4-20). Investigations along the sewer lines, however, have not indicated they were a source of release or migration pathway for contaminants.

Chloroform and Bromodichloromethane

The source of the bromodichloromethane and chloroform in MW71-93-2 and MW71-94-1 was water leaking from an EBMUD water supply line. The leak was repaired in 1996 concentrations of chloroform and bromodichloromethane have since decreased significantly. The source of the chloroform detected in well MW90-3 was drinking water injected into the well during a tracer test conducted during the summer of 1996.

Plume Management (Interim Corrective Measures)

Several subhorizontal drains (hydraugers) have been installed in this area to dewater and stabilize the slope. A few of these hydraugers (51-01-01, 51-01-02, 51-01-03, 51-01-03A, 51-01-04, and 51-01-09 on Figure A4.4-1) intercept contaminated groundwater. Since 1991, effluent from these hydraugers has been collected, treated to non-detectable levels, and discharged to the sanitary sewer under LBNL's EBMUD Wastewater Discharge Permit.

Monitoring of the Building 71 Freon and Solvent Plumes will continue in accordance with requirements of the RWQCB.

A4.4.2 Building 51/64 Groundwater Solvent Plume (AOC 9-13)

Description of Contaminants

The Building 51/64 groundwater solvent plume (AOC 9-13) is defined by the presence of 1,1,1-TCA, TCE, 1,1-DCE, 1,1-DCA, and PCE. Lower concentrations of other halogenated VOCs have also been detected. The maximum mean concentrations of halogenated VOCs that were detected at concentrations above MCLs in FY99 are listed in the following table. The listed contaminants have been detected at maximum concentrations that are approximately two to four times greater than the mean values listed in the table.

Maximum Mean Concentrations of Contaminants Detected Above MCLs in FY99 in Wells Monitoring AOC 9-13

Chemical	Maximum Mean Concentration Detected in FY99 (μg/L)	MCL (μg/L)	Well Number
1,1,1-TCA	158,500	200	SB64-98-7
TCE	15,880	5	SB64-98-7
1,1-DCE	15,490	6	SB64-98-7
1,1-DCA	11,290	5	MW64-98-4
PCE	10,350	5	SB64-98-7
cis-1,2-DCE	346	6	MW51-96-16
methylene chloride	350	5	SB64-98-17
1,2-DCA	113	0.5	SB64-99-4
vinyl chloride	42	0.5	MW51-96-16
trans-1,2-DCE	31	10	MW51-96-16
1,1,2-TCA	10	5	SB64-98-17

Based on the isoconcentration maps of individual constituents (Figures A4.4-2 through A4.4-12), and the common degradation pathways for halogenated hydrocarbons (Figure A4.2-1), at least two solvents (1,1,1-TCA and PCE) were released in the AOC 9-13 source area. The maximum concentrations of these two chemicals were detected in groundwater samples collected from SB64-98-7, near the southwest corner of Building 64. The majority of the other chemicals detected are probably degradation products of 1,1,1-TCA or PCE. Some of the chemicals, such as TCE, could also have been solvents released in the original spills.

Lateral Extent of Contamination

The lateral extent of total halogenated VOCs (excluding Freon compounds) in groundwater is shown on Figure A4.4-1. The upgradient extent of the plume is indicated by the low concentrations, or absence of contaminants, in wells located upgradient (upslope) of the plume source area (MW51-94-11, MW90-4, MW90-5, and MW90-6). These four wells monitor the downgradient edge of the Building 71 Groundwater Solvent Plume (AOC 1-9). The downgradient extent of the plume is defined by the absence of halogenated VOCs in wells MW51-97-15 and MWP-1. The transgradient (southwest) extent of the plume is defined by the absence of VOCs in MW51-97-14 and the northwest trending “trough” in the groundwater table beneath Building 51 (Figure A2.3-12), which appears to act as a hydraulic boundary. The transgradient (northern) extent of the plume is defined by the absence of halogenated VOCs in temporary groundwater sampling point SB64-99-7, located beneath Building 64, and the low concentrations of VOCs detected in MW63-98-18.

The maximum concentration of 1,1,1-TCA detected in the plume is at least an order of magnitude greater than that of other plume constituents; however, the lateral extent of 1,1,1-TCA is relatively small (Figure A4.4-7). In contrast, 1,1-DCA (Figure A4.4-8) and 1,1-DCE (Figure A4.4-6), which are primary degradation products of 1,1,1-TCA, extend significantly farther downgradient than 1,1,1-TCA. These results indicate that 1,1,1-TCA has completely degraded during migration away from the source area. A secondary degradation product of 1,1,1-TCA, 1,2-DCA, has a relatively limited lateral extent (Figure A4.4-9). This limited extent may be due to the absence of 1,1,1-TCA in the downgradient areas, the rapid degradation of 1,2-DCA, or the

absence of conditions conducive to its degradation. The presence of 1,1-DCE may also be the result of biodegradation of TCE.

The extent of PCE (Figure A4.4-2) is more limited than the extent of TCE (Figure A4.4-3), which is probably the result of the biodegradation of PCE into TCE. Cis-1,2-DCE, which is the most common biodegradation product of TCE, has a lateral extent that is similar to that of TCE (Figure A4.4-4). Trans-1,2-DCE, a secondary product of PCE/TCE biodegradation, is much more limited in extent than cis-1,2-DCE (Figure A4.4-5). Vinyl chloride has a downgradient lateral extent greater than that of other plume constituents (Figure A4.4-10), probably due to conditions favorable for the degradation of 1,1-DCE, cis-1,2-DCE, and trans-1,2-DCE in the downgradient area.

Chloroform (Figure A4.4-11) and methylene chloride (Figure A4.4-12) have relatively limited lateral extents that differ from each other and from other plume contaminants, indicating that they may originate from different sources.

Vertical Extent of Contamination

The vertical extent of halogenated VOCs (excluding Freon compounds) in AOC 9-13 is illustrated on cross sections C-B', C-C', and E-E' (Figures A4.4-14, A4.4-15, and A4.4-17). The highest contaminant concentrations are found within the Orinda Formation at the southeast corner of Building 64 (cross sections C-B' and E-E'). A steep vertical concentration gradient exists in the source area, as shown by the decrease in concentrations of total halogenated VOCs from 205,145 μg/L in well MW64-98-20 to 3 μg/L in well MW64-98-19, a vertical distance of approximately 7 feet (cross section C-B'). This significant decrease in contaminant concentrations with depth in the Orinda Formation is consistent with the site conceptual model.

The vertical distribution of groundwater contaminants shown on the cross sections is also defined by groundwater samples collected from two well clusters: MW51-96-16 and MW51-96-17 east of Building 51B; and MW51-97-12, MW51-97-3, and MW51-97-4 west of Building 51B (cross section C-B' and C-C'). Contaminant concentrations are highest near the water table and decrease significantly with depth.

Trends in Contaminant Concentrations

Historical variations in concentrations of total halogenated VOCs (excluding Freon compounds) detected in selected wells monitoring the AOC 9-13 plume are plotted on Figure A4.4-21. Monitoring well MW51B-93-18A shows an increasing trend. Concentrations detected in other wells appear to be relatively stable, with indications of increasing or decreasing trends in some wells. Most of these wells have not been sampled for a sufficient period to assess long-term trends.

The plume appears to be stable, in that contaminant concentrations detected in most wells monitoring the plume have remained relatively stable, and contaminants have not been detected in downgradient monitoring wells MW51-97-15 or MWP-1.

Potential Sources of Contamination

As part of the source investigations for the plume, a number of potential sources were evaluated. These included SWMUs and AOCs in the Building 51/64 area that were reported to have stored or used organic solvents (LBNL, 1992d) and other locations that were identified, based on discussions with LBNL employees.

SWMUs and AOCs in the vicinity of the Building 51/64 Groundwater Solvent Plume (AOC 9-13) that were reported to have stored or used organic solvents are shown on Figure A4.4-22 and listed in the following table.

SWMUs and AOCs in the Area of the Building 51/64 Groundwater Solvent Plume that Stored or Used Solvents

Unit Number	Unit Name
SWMU 9-4*	Building 51 Vacuum Pump Room Sump and Collection Basins
SWMU 9-5	Building 51 Waste Accumulation Area
SWMU 9-6*	Building 51 Motor Generator Room Filter Sump
SWMU 9-8	Building 64 Former Waste Accumulation Area
AOC 9-5	Building 64 Possible Solvent Spills
AOC 9-7*	Building 51 Suspected Hazardous Materials Storage Area
AOC 9-8*	Sanitary Sewer Lines North and West of Buildings 51 and 51B
AOC 9-9*	Building 51 Sanitary Sewer and Drainage System
AOC 9-12*	Building 51/64 Former Temporary Equipment Storage Area

* SWMUs and AOCs discussed in Section A3

Other potential sources in the vicinity of the plume are shown on Figure A4.4-22 and include:

- a machine shop that was formerly located outside Building 64 and later moved inside the building
- a degreasing station that was located near the southeast corner of Building 64
- a drum rack that was located on the north side of Building 64 and subsequently moved to the southeast corner of the building
- an electronics shop and a machine shop that were located in Building 63
- the cooling tower pads east of Building 64 were periodically used as an equipment cleaning area
- TCE may have been used around the HISS magnet within Building 51
- the Building 51 motor generator room basement was used as an emergency maintenance room, where equipment that needed rapid cleaning or repair was taken
- compressors used at Building 56 were periodically cleaned outside the building.

Based on concentrations of contaminants detected in soil and groundwater, the source area for the Building 51/64 Solvent Plume was located near the southeast corner of Building 64. Soil samples collected in soil boring SB64-98-7 in this area contained relatively high concentrations of halogenated hydrocarbons including 1,1,1-TCA (2,800 mg/kg), PCE (680 mg/kg), and TCE (120 mg/kg). The contamination may have resulted from solvent spills in this area. The source of the contamination has not been identified; however, the most likely sources include the Building 51/64 Former Temporary Equipment Storage Area (AOC 9-12), the former drum rack, and the former degreasing station.

The chloroform and methylene chloride detected in groundwater appear to have resulted from a different source than the PCE and 1,1,1-TCA. Chloroform and methylene chloride are degradation products of carbon tetrachloride; however, carbon tetrachloride has not been detected in the groundwater. Methylene chloride may therefore have been spilled in the same area as the PCE and 1,1,1-TCA. Since chloroform is present in drinking water, its presence may have been the result of a leaking water supply or sewer line.

Plume Management (Interim Corrective Measures)

The initial phase of an ICM to remove the primary source of the Building 51/64 Groundwater Solvent Plume (AOC 9-13) has started. A subdrain collected groundwater from the area east of Building 64 (Figure A4.4-23) and conveyed the groundwater into a 48-inch culvert that discharges to North Fork Strawberry Creek. Plume contaminants were detected in the subdrain water. To prevent the migration of contaminants to surface water, water flowing in the subdrain has been intercepted upflow from the area of groundwater contamination. The intercepted water is discharged to the storm drain. The area of maximum soil contamination near the southwest corner of Building 64, which is the source of the groundwater contamination, has been removed by overdrilling.

Potential for Natural Biodegradation of Contaminants in Groundwater

To assess whether biodegradation could have occurred in the past or might occur in the future, groundwater samples were collected from selected areas of LBNL and analyzed for specific indicator parameters (i.e., electron acceptors and metabolic byproducts). The process of natural biodegradation and ranges in values of parameters that indicate conditions favorable for biodegradation are discussed in Section 3 of Volume 1 of this report.

Samples collected from selected wells monitoring the Building 51/64 Solvent Plume were analyzed for specific indicator parameters for natural biodegradation. Concentrations of dissolved oxygen (DO) and nitrate, which are electron acceptors, are shown on Figure A4.4-24 and Figure A4.4-25, respectively. Concentrations of divalent manganese and ferrous iron, which are metabolic byproducts of the reduction of manganese and ferric iron, are shown on Figure A4.4-26) and Figure A4.4-27, respectively. Concentrations of sulfate, another electron acceptor, are shown on Figure A4.4-28.

Based on the concentrations of these indicator parameters, especially DO, divalent manganese, and ferrous iron, chlorinated solvents are being naturally biodegraded in the downgradient area of the plume. The widespread presence of the degradation products 1,1-DCA, 1,1-DCE, cis-1,2-DCE, and vinyl chloride (Figures A4.4-4, A4.4-6, A4.4-8, and A4.4-10) in the downgradient area is additional evidence that biodegradation is occurring. The concentrations of

specific electron acceptors and metabolic byproducts (i.e. divalent manganese and sulfate) indicate there is potential for further biodegradation of halogenated hydrocarbons, particularly in the downgradient portion of the plume and the area downgradient from the plume.

A4.4.3 Halogenated VOCs in Groundwater at Building 51L

Description of Contaminants

Halogenated VOCs have also been detected near Building 51L (Figure A4.4-1). TCE and cis-1,2-DCE are the primary contaminants detected (Figures A4.4-3 and A4.4-4). The maximum concentrations of halogenated VOCs detected at concentrations above MCLs are noted in the following table.

Maximum Concentrations (μg/L) of VOCs Detected Above MCLs in Groundwater, Building 51L

Well Number	PCE	TCE	1,1-DCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCA	Carbon Tetrachloride	Vinyl chloride
MCL	**5**	**5**	**6**	**6**	**10**	**5**	**0.5**	**0.5**
MW51-97-16	ND	20	0.6	17	1.3	3.2	<1	0.85
SB51L-98-1A	3	32	1.7	84	9.2	18	<1	<1
SB51L-98-1B	52	1110	14	2,950	62	74	62	23
SB51L-99-1	33	398	1.7	242	2.6	5.1	1.8	<1

<1: Less than 1 μg/L (not detected)

Lateral Extent of Contamination

The extent of halogenated VOCs in groundwater at Building 51L is shown on Figure A4.4-1. Based on the water table elevations (Figure A2.3-12), the groundwater flow direction in this area is generally northeastwards. The relatively limited lateral extent of this plume is indicated by the absence of halogenated VOCs in upgradient sampling point SB51A-98-1, and the absence or relatively low concentrations of VOCs in downgradient wells MW51-97-14 and MW51-98-5 (Figure A4.4-1). No data have been collected to assess the vertical extent of contamination.

Trends in Contaminant Concentrations

Variations in concentrations of TCE, cis-1,2-DCE, and 1,1-DCA in MW51-97-16, which monitors the core of the plume, are plotted on Figure A4.4-29. There appears to be a decreasing trend in the concentration of TCE.

Potential Sources of Contamination

The source(s) of the groundwater contamination in the Building 51L area is not known. A machine shop and maintenance shop were formerly located in the plume area (Figure A4.4-22).

Twenty-two soil-gas probes were installed in the vicinity of Building 51L in 1999 to help locate the source of contamination. Total ionizable vapor (TIV) concentrations were measured with a photoionization detector (PID). TIV readings greater than 100 ppmv were detected in the soil gas along the south and west walls of Building 51L, at two probe locations. Soil-gas samples collected from these two probes contained the same general suite of chemicals as in groundwater samples at the site, except for carbon tetrachloride and chloroform, which were only detected in the groundwater. TCE was detected in the soil gas at a maximum concentration of 86,000 ppbv.

Water samples were collected from a weephole in the retaining wall southwest of Building 51L in February 2000 to evaluate whether groundwater upgradient from the retaining wall could be the source area for the groundwater contamination (Figure A4.6-1, Table A4.6-5). No VOCs were detected.

Plume Management (Interim Corrective Measures)

Both halogenated and aromatic (ethylbenzene and total xylenes) VOCs have been detected in water samples collected from the catch basin located at the southwest corner of Building 51L (B51L Catch Basin samples in Table A4.6-5). The aromatic hydrocarbons; however, were not detected in a subsequent sample. The source of this halogenated VOCs appears to be the contaminated groundwater. LBNL installed extraction well EW51L-99-1 in

1999 to lower the water table below the base of the catch basin, to prevent contaminated groundwater from infiltrating the catch basin and migrating to surface water. Groundwater is currently extracted from EW51L-99-1, treated with GAC, and discharged to the sanitary sewer under LBNL's EBMUD Wastewater Discharge Permit.

A4.5 Petroleum Hydrocarbons, SVOCs, PCBs and Metals in Groundwater

A4.5.1 Petroleum Hydrocarbons

Two general evaluation methods were used to assess potential releases of fuels or lubricants to groundwater:

1. Groundwater samples collected near SWMUs and AOCs that managed fuel hydrocarbon products, petroleum lubricants, or petroleum wastes were analyzed for Total Petroleum Hydrocarbons (TPH). In addition, selected groundwater samples in the Bevalac Area were analyzed for TPH and total Oil and Grease (Table A4.5-1; Figure A.4.5-1). SWMUs and AOCs in the Bevalac Area that stored or used fuel hydrocarbon products or wastes are shown on Figure A4.5-1.

2. Samples collected from all groundwater monitoring wells have been routinely analyzed for VOCs by EPA Method 8260. Samples collected from temporary groundwater sampling points and flowing hydraugers are also analyzed for VOCs by EPA Method 8260. The target analytes for this method include several classes of organic compounds, including non-aromatic halogenated hydrocarbons (e.g., PCE, TCE, etc.), monoaromatic halogenated hydrocarbons (e.g., 1,2 dichlorobenzene), monoaromatic non-halogenated hydrocarbons (e.g., benzene), and polyaromatic non-halogenated hydrocarbons (e.g., naphthalene and other PAHs). The first class of compounds (non-aromatic hydrocarbons) is commonly derived from industrial solvents, which are discussed in detail in the Section A4.4. The last three classes of compounds (all three comprise various aromatic hydrocarbons) include constituents that are commonly present in fuel products. For this reason, compounds in these three classes were evaluated separately from other VOCs. These data are presented in Tables A4.3-1a, b, and c (monitoring wells); Table A4.3-2 (temporary groundwater sapling points); and Table A4.6-4 (hydraugers).

Aromatic and non-halogenated hydrocarbons, including benzene, toluene, xylenes, 1,2,4- and 1,3,5-trimethylbenzene, p-isopropyltoluene, and methyl tert-butyl ether (MTBE) were sporadically detected in groundwater in Bevalac Area wells. Except for toluene in the source area of the Building 51/64 solvent plume (SB64-98-17) none of these chemicals was confirmed (detected more than one time in a well).

TPH-C/WO was detected in the same area as the Building 51/64 Groundwater Solvent Plume (AOC 9-13). TPH-C/WO and Total Oil & Grease were detected in groundwater beneath the Motor Generator Room basement, in wells installed along the Building 51 Sanitary Sewer and Drainage System (AOC 9-9). TPH-D was detected in MW51-95-17 downgradient from the Former Building 51 Diesel UST (AOC 9-4) and in the area of the solvent contaminated groundwater at Building 51L, in MW51-97-16. The maximum concentrations of fuel hydrocarbons detected in each of these areas are listed in the following table.

Maximum Concentrations (μg/L) of Fuel Hydrocarbons Detected in Groundwater, Bevalac Area

Fuel Hydrocarbon	Building 51/64 Groundwater Solvent Plume (AOC 9-13)	Building 51 Sanitary Sewer and Drainage System (AOC 9-9)	Former Building 51 Diesel UST (AOC 9-2)	Building 51L
TPH-(Crude/Waste Oil)	1,300 μg/L	4,900 μg/L		
TPH-Diesel			56 μg/L	57 μg/L
Total Oil & Grease		16,000 μg/L		

The source of the TPH-C/WO and aromatic/non-halogenated hydrocarbons detected in wells monitoring the Building 51/64 groundwater solvent plume is likely the same as that for the halogenated VOCs. Cleaning oily equipment with solvents would have released both solvent and aromatic/non-halogenated hydrocarbons. The source of the TPH-D in MW51-97-16 (near Building 51L) is not known; however, it may also be related to equipment cleaning activities.

The source of the TPH-C/WO and Total Oil & Grease detected in groundwater under the north end of Building 51 were releases from the Building 51 Sanitary Sewer and Drainage System (AOC 9-9). AOC 9-9 is discussed in Section A3.11. The source of the TPH-D detected in MW51-95-17 is the Former Building 51 Diesel UST (AOC 9-4). TPH-D was detected only the first time the well was sampled and has not been detected the seven times the well has been sampled since then.

A4.5.2 Semi-Volatile Organic Compounds (SVOCs) in Groundwater

Samples collected from twelve Bevalac Area monitoring wells in August or September 1994 were analyzed for SVOCs (Table A4.5-2 and Figure A4.5-2). The only SVOC detected

was bis(2-ethylhexyl)phthalate (DEHP). DEHP was also detected in 35 of the 79 wells sampled site-wide during the same sampling event, and in five of the seven field (rinse) blanks. No DEHP was detected in laboratory QC samples. DEHP is a common laboratory contaminant. The presence of DEHP in these samples is interpreted to have resulted from sample contamination and the results are therefore not representative of groundwater contamination.

A4.5.3 Polychlorinated Biphenyls (PCBs) in Groundwater

Soil beneath the Motor Generator Room basement is contaminated with PCBs. Groundwater samples were therefore collected from wells in the basement and from the downgradient area, and analyzed for PCBs. Concentrations of PCBs detected in groundwater are shown in Table A4.5-3 and on Figure A4.5-3. PCBs were detected in temporary groundwater sampling points (SB51-96-8, SB51-96-12, and SB51-98-4. And SB51-98-5) that were installed adjacent to the drain line near the northern end of the basement. PCBs were not detected in the downgradient wells, indicating that the extent of PCB contamination is limited. As discussed in section A.3.11, the source of the contamination has been identified as releases from the Building 51 Sanitary Sewer and Drainage System (AOC 9-9). To prevent further migration of contaminants to groundwater, soil contaminated with concentrations of PCBs above 1 mg/kg has been excavated from beneath the Motor Generator Room basement. In April 1999, groundwater samples were collected from the available temporary groundwater sampling points in the Motor Generator Room basement and three groundwater monitoring wells outside of Building 51. PCBs (0.37 μg/L) were only detected in SB51-98-4.

A4.5.4 Metals in Groundwater

Groundwater samples were collected from all newly installed groundwater monitoring wells and analyzed for metals. Subsequently analyses for metals were conducted in accordance with requirements of the RWQCB. In addition, samples collected from temporary groundwater sampling points in the Motor Generator Room basement (AOC 9-9) and near the Former Cooling Towers Southeast of Building 51 (AOC 9-11) were analyzed for metals. Results are listed in Table A4.5-4. Locations where metals were detected in groundwater in the Bevalac Area at concentrations above MCLs are shown on Figure A4.5-4.

Arsenic, selenium, cadmium, and hexavalent chromium were the only metals detected at concentrations above the MCL. Arsenic and selenium were detected at concentrations above the MCL in three monitoring wells (MW51B-93-18A, MW51-96-17, and MW64-97-1) and selenium in one monitoring well (MW64-97-2) near the southern end of Building 64. Although several SWMUs and AOCs in the Bevalac Area include some metals as COPCs (Figure A4.5-4), none of these units were known to have used arsenic or selenium. These metals may therefore be naturally occurring.

Samples collected near the Former Cooling Towers Southeast of Building 51 (AOC 9-11) contained elevated concentrations of several metals including hexavalent chromium. in temporary groundwater sampling point SB51-96-20 and cadmium in piezometer nest PZ51-92-3 in 1993. In addition, molybdenum, which has no MCL, was detected at elevated concentrations in MW51-92-2 and PZ51-92-3. The detection of cadmium in PZ51-92-3 in 1993 was not confirmed in a sample collected at the same piezometer level (42 feet) in January 2000 and cadmium has not been detected in the other four levels of the piezometer nest. The elevated concentrations of molybdenum and hexavalent chromium may be related to operations at the former cooling towers.

A4.6 Potential Migration of Contaminants to Surface Water

As shown on Figure A4.6-1, the storm drain system in the Bevalac Area discharges to North Fork Strawberry Creek. In addition, groundwater in the Bevalac area flows toward North Fork Strawberry Creek. Surface water samples have been routinely collected and analyzed for VOCs and metals. In addition, surface water and sediment samples have been collected from North Fork Strawberry Creek and analyzed for COPCs associated with potential contaminant sources upgradient from the creek. Surface water samples were also collected from the spring southwest of Building 71. The spring discharges directly to a surface catch basin, from which water is routed by pipelines to an inlet structure northeast of Building 60, and then to the North Fork Strawberry Creek erosion control basin (Figure A4.6-1). Surface water sampling results are included in Table A4.6-1 (VOCs), Table A4.6-2 (SVOCs, PCBs, and fuels), and Table A4.6-3 (metals). Creek sediment sampling results are included in Table A4.6-7 (VOCs, SVOCs, PCBs, and TPH) and Table A4.6-8 (metals).

Water samples were also collected from potential migration pathways that could ultimately discharge to North Fork Strawberry Creek, or could have discharged to the creek in the past. These locations include various sumps, catch basins, drain lines, weepholes, and hydraugers in the Bevalac Area. Weepholes drain the water from the upslope side of retaining walls. Where the weepholes drain contaminated groundwater, they are a potential migration pathway of contaminated water to surface waters. Free-flowing, sub-horizontal subdrains (hydraugers) have been installed at LBNL to dewater, and thereby stabilize, areas of potential slope instability. Effluent from these drains, some of which intercepted contaminated groundwater, if not collected would ultimately discharge to creeks. The effluent from hydraugers 51-01-01, 51-01-02, 51-01-03 and –03A, 51-01-04, and 51-01-09 has been treated since 1991 and the treated water discharged to the sanitary sewer. Potential migration pathways to surface water and surface water sampling locations are shown on Figure A4.6-1. Sediment sampling locations are shown on Figure A4.6-2. Results of water sampling of potential migration pathways are included in Table A4.6-4 (VOCs in hydraugers), Table A4.6-5 (VOCs in catch basins, drains, and weepholes), and Table A4.6-6 (metals in drains).

A4.6.1 Surface Water and Creek Sediment Sampling (North Fork Strawberry Creek and Spring Southwest of Building 71)

North Fork Strawberry Creek

Surface water samples have been collected from North Fork Strawberry Creek and analyzed for VOCs, SVOCs, PCBs, metals, and hexavalent chromium (CrVI). Samples were collected primarily at the site perimeter, but samples were also collected upstream at the erosion control basins and at the Women's Faculty Club on the UC campus (Figure A4.6-1).

The only VOC detected was a trace concentration of 1,1,1-TCA (0.95 μg/L) at the erosion control basins in 1995. 1,1,1-TCA has not been detected in the ten surface water samples collected since that time. The MCL for 1,1,1-TCA is 200 μg/L. Diethylphthalate (2.2 μg/L), which was detected in April 1998, has been the only SVOC detected. Diethylphthalate was not detected in a subsequent sample collected in July 1998. In addition, phthalates are common laboratory contaminants, indicating that this result may not be representative of surface

water contamination. No PCBs were detected. Metals were either not detected or detected at concentrations well below MCLs. Hexavalent chromium was detected in a surface water sample collected from the creek at the site boundary in July 1999, but was not detected in water collected upstream at the erosion control basin. Hexavalent chromium was not detected in a subsequent sample collected from the creek at the boundary in January 2000. The detected concentration of hexavalent chromium (4.2 μg/L) is below the MCL for drinking water for total chromium (50 μg/L) and the State of California Department of Health Services (DHS) Water Quality Criteria of 11 μg/L for protection of freshwater aquatic life.

Sediment samples have been collected from North Fork Strawberry Creek and analyzed for VOCs, SVOCs, PCBs, fuels, metals, and hexavalent chromium. Samples analyzed for metals and SVOCs were collected from several locations along the creek (Figure A4.6-2). The only VOC detected was a trace concentration of toluene (0.013 mg/kg) in April 1993 at the site boundary. Neither SVOCs nor PCBs were detected. TPH quantified as 'oil' (within the diesel range) was also detected at low concentrations (49 mg/kg maximum). The only metal detected at concentrations above both LBNL background levels for soil and PRGs for residential soil were lead and nickel. Lead was detected in a sediment sample collected in the erosion control basin in April 1993 at a concentration above both the LBNL soil background level and PRG for residential soil. Nickel was detected at a concentration above both the LBNL soil background level and PRG for residential soil in one of the five samples collected in August 1996. No hexavalent chromium was detected.

Building 71 Spring

Water samples collected from the spring southwest of Building 71 were analyzed for VOCs (Table A4.6-1). Only Freon-113, chloroform, and bromodichloromethane were detected. The Freon-113 is associated with the Building 71 Groundwater Freon Plume (AOC 1-9). The chloroform and bromodichloromethane were derived from an EBMUD water supply pipe leak (Section A.4.4-1), and have declined to non-detectable levels in the spring water since the pipe was repaired.

A4.6.2 Potential Migration Pathway from Building 71 Groundwater Solvent and Freon Plumes (AOC 1-9) to North Fork Strawberry Creek

Contaminated Hydrauger Discharges AOC-SW1:

Six hydraugers (hydraugers 51-01-01, 51-01-02, 51-01-03, 51-01-03A, 51-01-04, and 51-01-09 on Figure A4.6-1) located northeast of Building 51 intercept the Building 71 Groundwater Solvent and Freon Plumes (AOC 1-9)(Section A4.3 and Section A.4.4). LBNL installed a GAC system to treat effluent from these hydraugers in 1991, to prevent the migration of groundwater plume contaminants to surface water. A sample was collected from an additional hydrauger in this area in 1999 (noted as firetrail hydrauger). TCE was detected at a concentration below the MCL.

Weepholes in Retaining Wall North of Building 51

Water samples collected from the weepholes in the retaining wall north of Building 51 (B51N cooling tower weepholes) in April and May 1995 contained Freon-113, chloroform, bromodichloromethane, and/or a trace (<1μg/L) of TCE (Figure A4.6-1, Table A4.6-5). The source of the contaminants was the Building 71 Groundwater Solvent and Freon Plumes (AOC 1-9), which is discussed in Sections A4.3.1 and A4.4.1. On May 4, 1995, water samples were collected from the drainage channel that collects the weephole water and discharges to the storm drain and from the erosion control basin on North Fork Strawberry Creek where the storm drain discharges. The only VOC detected was a trace (<1 μg/L) of 1,1,1-TCA. Freon-113 and chloroform were detected in a sample collected from a second drainage channel on May 12, 1995. Water samples collected in 1994 and 1995 from monitoring well MW51-94-11 also contained chloroform, TCE, and Freon 113; however, these chemicals have not been detected in the well since that time. The results from MW51-94-11, which is upgradient from the retaining wall, indicate that these contaminants are no longer present in the groundwater in the area of the retaining wall.

A water sample was collected from a weephole in the retaining wall north of Building 51 (Firetrail Weephole W16) in February 2000 (Figure A4.6-1, Table A4.6-5). This location is downgradient from the Building 71 Solvent Plume. No VOCs were detected.

A4.6.3 Potential Migration Pathway from South of Building 51 and Building 51L Area to North Fork Strawberry Creek

Building 51 Spring Drain and Cooling Tower Drain

A subsurface tile drain collects groundwater along the southern perimeter of Building 51 (the "Building 51 Cooling Tower Drain"). A second drain (The "Building 51 Spring Drain") originates at a historical spring southwest of Building 51 that was mapped prior to construction of the building. Near the historical spring location, the two drain lines are in close proximity. The drains discharge into a storm water catch basin located inside Building 51A. The water from the catch basin flows to a second catch basin near Building 51L, and ultimately discharges to North Fork Strawberry Creek.

In 1998, water samples were collected from both drains at the catch basin inside Building 51A. Halogenated VOCs (primarily PCE, TCE, and cis-1,2-DCE) (Table A4.6-5) and hexavalent chromium (Table A4.6-6) were detected in both drains. A trace (<1 μg/L) of MTBE was also detected. The concentrations of hexavalent chromium detected were below both the MCL and the DHS Water Quality Criteria for protection of freshwater aquatic life. The similar concentrations of hexavalent chromium and halogenated VOCs detected in the effluent from both lines indicate that either both lines intercept the same area of contaminated groundwater or that there is cross-flow between the two lines. Hexavalent chromium has also been detected in groundwater at the Former Cooling Towers Southeast of Building 51 (AOC 9-11) (Section A3.12), which is a potential source area. The source of the VOCs is not known. Monitoring well MW51-99-1 was installed at the historical spring location, but no VOCs have been detected in the well, indicating that the spring is not a source or migration pathway for groundwater contamination.

Building 51L Catch Basin

Halogenated VOCs and aromatic VOCs (ethylbenzene and xylenes) were detected in a water sample collected from the catch basin at the southwest corner of Building 51L in 1999 (Figure A4.6-1, Table 4.6-5). To investigate the source of the contamination, in June 1999 water samples were collected from two drainlines (NE drain and S Drain on Figure A4.6-1) discharging into the catch basin. No VOCs were detected in the line from the northeast (NE Drain). PCE, TCE, cis-1,2-DCE, and carbon tetrachloride were detected in the water from the south drain line (S Drain) (Table A4.6-5). This line carries water from the catch basin inside Building 51L, where the Building 51 Cooling Tower Drain and the Building 51 Spring Drain discharge. Water in these two drain lines also contained PCE, TCE, and cis-1,2-DCE, as discussed in the preceding section. Water samples were also collected at the same time from a drain line originating in Building 51 (Power Tunnel Drain) (Figure A4.6-1, Table 4.6-5). No VOCs were detected.

This Building 51L catch basin is located in the core area for the solvent contaminated groundwater at Building 51L (Section A4.4.3). The bottom of the catch basin is below the water table. The contaminated water in the catch basin is therefore probably the result of both contaminated groundwater seeping into the catch basin and contaminated inflow of water originating from the Building 51 Cooling Tower and Spring Drains. As discussed in Section A4.4-3, LBNL installed extraction well EW51L-99-1 in 1999 to lower the water table below the base of the catch basin, to prevent infiltration of contaminated groundwater into the catch basin. The extracted groundwater is treated with a GAC system prior to discharge to the sanitary sewer under LBNL's EBMUD Wastewater Discharge Permit.

A4.6.4 Potential Migration Pathway from Building 51/64 Groundwater Solvent Plume

A north-south trending subdrain previously collected groundwater from the area east of Building 64 (Figure A4.6-1) and conveyed the water into the 48-inch culvert that discharges to North Fork Strawberry Creek. The subdrain crosses the source area of the Building 51/64 Groundwater Solvent Plume (AOC 9-13) at a depth of approximately 6.5 feet bgs. A trench was excavated to the bottom of the subdrain approximately 22 feet south of the plume's source area

and a boring (SD64-98-1) was drilled to a depth of 10 feet inside the trench adjacent to the subdrain. PVC casing was installed in the boring to collect water from the drain. Water samples collected from the well in 1998 contained 1,1,1-TCA, 1,1-DCA, TCE, PCE, 1,1-DCE, vinyl chloride and cis-1,2-DCE (Table A4.6-5). To prevent the migration of contaminated water to surface water, the subdrain is intercepted upstream from the area of groundwater contamination and the intercepted clean water is discharged to the storm drain.

A5 AIR SAMPLING

Outdoor and indoor air samples were collected in the Bevalac area in order to provide data that will be required for the human health risk assessment.

A5.1 Outdoor Air Sampling

Twenty-four hour outdoor air samples were collected at four locations in the Bevalac area in November 1997. Sampling locations are shown on Figure A5.1-1. Also included on the figure is a windrose that covers the period when the outdoor air samples were collected. The windrose shows the percentage of the time the wind was blowing from directions spaced at 30° intervals. For most of the sampling period the wind was blowing either directly from the east or from the west.

Concentrations of analytes detected are listed in the table below. Also included in the table are Bay Area Air Quality Management District (BAAQMD) and California Air Resources Board (ARB) data from nearby monitoring stations, for comparison.

Outdoor Air Sample Results, Bevalac Area

Sample Number	Location	Concentration (ppbv) Vinyl chloride	Freon-113	Chloroform	Carbon Tetrachloride	TCE	PCE
LBNL Bevalac Area							
Outdoor Air Sample Results							
A97-1-4.9	West of Building 88	**<0.18**	**0.190**	**0.072**	**0.099**	**0.055**	**0.090**
A97-2-5.2	Northwest of Building 71	**<0.32**	**0.140**	**0.064**	**0.096**	<0.32	**0.064**
A97-4-5.4	East of Building 64	**<0.36**	**0.140**	**0.066**	**0.096**	**0.170**	**0.300**
A97-6-4.8	Southeast of Building 71B	**<0.18**	**0.092**	**0.048**	**0.100**	**0.028**	**0.056**
A97-1-12	QC sample (blank)	<0.1	<0.1	<0.1	<0.1	**0.059**	**0.033**
BAAQMD and ARB							
Comparison Results							
Oakland (November 1997)		**NA**	**NA**	<0.02	**0.1**	<0.08	**0.06**
Fremont (median 1996)		**NA**	**NA**	**0.03**	**0.08**	**0.01**	**0.06**
Fremont (90th percentile 1996)		**NA**	**NA**	**0.05**	**0.08**	**0.01**	**0.12**
Richmond (median 1996)		**NA**	**NA**	**0.02**	**0.08**	**0.01**	**0.03**
Richmond (90th percentile 1996)		**NA**	**NA**	**0.04**	**0.08**	**0.04**	**0.06**

<0.18: Not detected (showing detection limit in ppbv)
NA: Not analyzed

A5.2 Indoor Air Sampling

Twenty-four hour indoor air samples were collected in March 1999 at three locations in the Bevalac area. In addition a background sample was collected from the second floor of Building 90. Sampling locations are shown on Figure A5.1-1.

Of the approximately 50 chemicals detected in soil gas, the following seven were selected for indoor air monitoring in the Bevalac Area.

- PCE
- TCE
- benzene
- 1,1-DCE
- carbon tetrachloride
- chloroform
- vinyl chloride.

These chemicals are among the most commonly detected in soil gas and they have the most potential to present a health risk should their vapors infiltrate into buildings.

Concentrations of analytes detected are listed in the following table. In addition samples from the Building 51/64 area were analyzed for 1,1,1-TCA and 1,1-DCA, since these two chemicals were detected at relatively high concentrations o the groundwater in this area. Also listed in the table are the California OSHA Permissible Exposure Limits (PELs). Benzene, chloroform, and carbon tetrachloride were the only analytes detected. Except for chloroform in Building 64, concentrations detected were approximately the same as those detected in the background sample from Building 90. The source of the chloroform is probably inside Building 64, since chloroform has either not been detected or detected at relatively low concentrations in groundwater in the Building 64 area. Indoor air sampling results will be assessed in the human health risk assessment.

Indoor Air Sample Results, Bevalac Area

		Concentration (ppbv)								
		1,1-DCE	**Benzene**	**1,1,1-TCA**	**1,1-DCA**	**chloroform**	**carbon tet**	**TCE**	**PCE**	**Vinyl chloride**
	PELs Action Level	1000	1000 500			2000	2000	25,000	25,000	1000
Sample No.	***Building No.***									
IA64-99-1	64	<0.04	0.46	<0.2	<0.2	0.12	0.093	<0.2	<0.1	<0.16
IA51L-99-1	51L	<0.031	0.62	NA	NA	<0.031	0.055	<0.16	<0.078	<0.12
IA71-99-1	71	<0.03	0.58	NA	NA	0.032	0.060	<0.15	<0.076	<0.12
IA90-99-1 (Building 90 background)	90	<0.03	0.52	NA	NA	0.064	0.071	<0.15	<0.076	<0.12

PEL: California OSHA Permissible Exposure Limit
<0.03: Not detected (showing detection limit in ppbv)
NA: Not analyzed

A6. SUMMARY AND CONCLUSIONS

A6.1 Status of Solid Waste Management Units and Areas of Concern

Except for groundwater AOCs, all identified SWMUs and AOCs in the Bevalac area have been approved for either No Further Action (NFA) or No Further Investigation (NFI) Status by the DTSC or the City of Berkeley. The status of SWMUs and AOCs in the Bevalac Area is listed in Table A1-1. No further site characterization is required for SWMUs and AOCs

approved for either NFA or NFI status, and units that have been approved for NFA status will not be included in the Corrective Measures Studies (CMS) phase of the RCRA Corrective Action Program (CAP). However, SWMUs and AOCs approved for NFI status will be included in the site wide risk assessment to be conducted as part of the CMS.

A6.2 Management of Groundwater AOCs

Groundwater plume AOCs were evaluated for the following criteria, which were described in Section A4 and are summarized below.

- Sources of groundwater contamination have been located and have been or will be removed
- The magnitude and extent of contamination have been characterized
- The plumes are stable

A6.2.1 AOC 1-9 Building 71 Freon-113

Source Identification and Removal

The source of Freon-113 is most likely past spills at the Building 71 Linear Accelerator Cooling Unit (AOC 1-3). The system ceased operation in 1993. Maximum concentrations of Freon-113 detected have decreased from 8,250 μg/L 1994 to less than 30 μg/L in 1999 in the source area.

Plume Characterization

The lateral extent of the plume has been characterized. The plume is limited to the area immediately southwest of Building 71 (Figure A4.3-1). The vertical extent of groundwater contamination has not been evaluated because of the low concentrations detected (currently two orders of magnitude below the MCL) and its limited lateral extent. Based on the conceptual model of contaminant transport presented in this module and the low concentrations of Freon-113 detected, the vertical extent of the plume should be limited.

Plume Stability and Potential Migration of Contaminants

Monitoring wells are located downgradient and transgradient from the plume to monitor plume stability. Freon-113 has not been detected in downgradient monitoring wells MW51-94-11 or MW90-5 since 1995, indicating that the downgradient extent of the plume has decreased. Groundwater monitoring will continue in accordance with requirements of the RWQCB.

To prevent migration of contaminants to surface water, the effluent from the 51-01-series hydraugers, two of which contained Freon-113 in FY99, is treated by GAC prior to discharge to the sanitary sewer. Freon-113 was detected at a concentration of 1.7 μg/L at the spring southwest of Building 71 in 1999, but has not been detected in surface water or sediment samples from North Fork Strawberry Creek. No indoor air sampling has been conducted for Freon-113 because of the relatively low concentrations detected in the groundwater and its relatively low toxicity.

A6.2.2 AOC 1-9 Building 71 Solvent Plume

Source Identification and Removal

The area immediately south of Building 71B has been identified as the source area for the Building 71B lobe of the Building 71 Solvent Plume. Accessible soil with the highest concentrations of contaminants will be excavated from the source area as an ICM.

The source area of the Building 71 lobe of the Building 71 Solvent Plume appears to be located near MW71-93-2; however, the source location has not been determined. Concentrations of contaminants detected in this lobe of the plume are an order of magnitude less than that of the Building 71B lobe. Only TCE was detected at a concentration above the MCL in 1999.

Plume Characterization

The downgradient extent of the Building 71 Solvent Plume is indicated by the low concentrations, or absence of contaminants, in downgradient monitoring wells MW90-4, MW90-5, MW90-6, and MW51-94-11. The transgradient (southeastern) extent of the plume is defined

by the absence of contaminants in monitoring wells south of the plume area (primarily MW46A-93-19) and the steep slope toward the east. The transgradient (northwestern) extent of the plume is defined by the absence of plume-related contaminants in the spring southwest of Building 71 and in MW71-95-1, west of Building 71

The vertical extent of groundwater contamination is limited. Based on groundwater sampling results in the Building 71B plume source area, concentrations of halogenated VOCs are approximately two orders of magnitude lower at the top of the Orinda Formation (all concentrations below MCLs) than near the water table in the overlying artificial fill, which is consistent with the conceptual model for contaminant transport. Based on the relatively low concentrations of contaminants detected in the Building 71 lobe area and the conceptual model, the vertical migration of contaminants into the underlying Orinda Formation in the Building 71 lobe area should also be minimal.

Plume Stability and Potential Migration of Contaminants

Monitoring wells are located downgradient and transgradient from the plume to monitor plume stability. Both lobes of the plume appear to be stable, in that contaminant concentrations detected in wells monitoring the plume have remained relatively constant over several years of monitoring, and contaminants have either not been detected or detected at only low concentrations in downgradient monitoring wells. Groundwater monitoring will continue in accordance with requirements of the RWQCB.

To prevent migration of contaminants to surface water, the effluent from the 51-01-series hydraugers, is treated by GAC prior to discharge to the sanitary sewer. No plume related contaminants have been detected at the spring southwest of Building 71. A trace concentration (<1 μg/L) of 1,1,1-TCA in one surface water sample collected in 1995 has been the only VOC detected in either water or sediment samples from North Fork Strawberry Creek. Based on concentrations of halogenated hydrocarbons detected in monitoring wells and potential migration pathways, the source of the 1,1,1-TCA was more likely the Building 51/64 Solvent Plume (discussed below) than the Building 71 Solvent Plume. The potential impact to the environment

from contaminants detected in surface water and sediment will be evaluated in the ecological risk assessment.

Neither PCE nor TCE, the primary plume contaminants were detected in indoor air samples collected in Building 71 in 1999.

A6.2.3 AOC 9-13 Building 51/64 Solvent Plume

Source Identification and Removal

The source area for the Building 51/64 Solvent Plume has been identified near the southeast corner of Building 64. The area of maximum soil contamination near the southwest corner of Building 64, which is the source of the groundwater contamination, has been removed by overdrilling.

Plume Characterization

The lateral extent of total halogenated VOCs in groundwater for AOC 9-13 is shown on Figure A4.4-1. The upgradient extent of the plume is indicated by the low concentrations, or absence of contaminants, in wells located upgradient (upslope) of the plume source area (MW51-94-11, MW90-4, MW90-5, and MW90-6). These wells monitor the downgradient edge of the Building 71 Groundwater Solvent Plume (AOC 1-9). The downgradient extent of the plume is defined by the absence of halogenated VOCs in wells MW51-97-15 and MWP-1. The transgradient (southwest) extent of the plume is defined by the absence of VOCs in MW51-97-14. The transgradient (northern) extent of the plume is defined by the absence of halogenated VOCs in temporary groundwater sampling point SB64-99-7, located beneath Building 64, and the low concentrations of VOCs detected in MW63-98-18.

The vertical extent of groundwater contamination is limited. A steep vertical concentration gradient exists in the source area, as shown by the decrease in concentrations of total halogenated VOCs from 205,145 μg/L in well MW64-98-20 near the water table to 3 μg/L in well MW64-98-19, a vertical distance of approximately 7 feet. The vertical distribution of groundwater contaminants is also defined by groundwater samples collected from two well

clusters: MW51-96-16 and MW51-96-17 east of Building 51B; and MW51-97-12, MW51-97-3, and MW51-97-4 west of Building 51B. Contaminant concentrations are highest near the water table and decline significantly with depth.

Plume Stability and Potential Migration of Contaminants

The plume appears to be stable, in that contaminant concentrations detected in most wells monitoring the plume have remained relatively constant, and contaminants have not been detected in downgradient monitoring wells MW51-97-15 and MWP-1. Groundwater monitoring will continue in accordance with requirements of the RWQCB.

Based on the concentrations of several indicator parameters, chlorinated solvents are being naturally biodegraded in the downgradient area of the plume. Also, the concentrations of specific electron acceptors and metabolic byproducts indicate there is potential for further biodegradation of halogenated hydrocarbons, particularly in the downgradient portion of the plume.

A trace concentration (<1 μg/L) of 1,1,1-TCA in one surface water sample collected in 1995 has been the only VOC detected in either water or sediment samples from North Fork Strawberry Creek. The subdrain east of Building 64 was a potential pathway for this contamination. The subdrain is currently intercepted upflow of the area of groundwater contamination to prevent migration of contaminants to surface water.

PCE, TCE, and 1,1,1-TCA the primary plume contaminants were not detected in indoor air samples collected in Building 64 in 1999.

A6.2.4 Halogenated VOCs in Groundwater at Building 51L

Source Identification and Removal

The source area has been located near Building 51L. Additional investigations may be conducted to further characterize the source and provide data for source removal activities.

Plume Characterization

The relatively limited lateral extent of this plume is indicated by the absence of halogenated VOCs in upgradient sampling point SB51A-98-1, and the absence or relatively low concentrations of halogenated VOCs in wells MW51-97-14 and MW51-98-5, located downgradient from Building 51L. No data have been collected to assess the vertical extent of contamination; however, based on the conceptual model the vertical extent of groundwater contamination should be limited.

Plume Stability and Potential Migration of Contaminants

Data have been collected for an insufficient period to assess plume stability. Wells MW51-74-15 and MW51-97-5, which are located downgradient from the plume, monitor plume stability. Groundwater monitoring will continue in accordance with requirements of the RWQCB. Groundwater is extracted from well EW51L-99-1 to lower the water table below the base of the adjacent catch basin, to prevent the migration of contaminated groundwater to surface water. The extracted water is treated.