4 ENVIRONMENTAL IMPACTS

This section summarizes the results of the Phase I and Phase II characterization activities required by the Joint Stipulation and Order (see Section 1.3) and evaluates potential impacts to LLNL workers and to the public from construction and operation of the NIF because of the possible presence of buried hazardous, toxic, or radioactive materials in the northeastern quadrant of the LLNL site as stipulated in Paragraph 2 of the Joint Stipulation and Order. The possible contamination of soil and water by buried wastes is described, and potential human exposures and health impacts are evaluated.

The results of the Phase I and II investigations, as well as data collected to support the closure of the capacitor landfill discovered at the NIF site in 1997 and the removal of residual contamination at the ETC in 1998-1999, form the basis of evaluations of potential impacts from the excavation and closure of the capacitor landfill in the NIF Construction Area and excavation and cleanup of the ETC Area. Such possible impacts include exposure to PCB-contaminated dusts generated during excavation of newly discovered but formerly contaminated soils and the excavation of residual soil contamination from previous cleanup actions. Groundwater impacts from residual PCBs in soil were also assessed.

4.1 PHASE I AND PHASE II CHARACTERIZATION ACTIVITIES

The Phase I and Phase II activities were conducted pursuant to the Joint Stipulation and Order for the purposes of establishing the presence or absence of any additional buried, hazardous, toxic, or radioactive materials, and they form the basis for impacts assessment. Phase I was a review of records, aerial photographs, and interviews; Phase II was the field program. Levels of contaminants found in Phase I and Phase II investigations were included in the description of the affected environment in Section 3. Section 4.1 evaluates whether there are any additional suspected sources in the stipulated areas that should be assessed.

4.1.1 Summary of Phase I Results

To locate any additional hazardous, toxic, or radioactive wastes buried in the stipulated areas, a series of increasingly detailed reviews and investigations were conducted (DOE 1997, 1998a-c). Phase I activities consisted of (1) review of existing documents and other available records, (2) review of aerial photographs (from 1949-1985), and (3) interviews with long-time employees and retirees (DOE 1997, 1998a-c). The documents reviewed included the historical record of waste management and sampling and characterization activities in the stipulated areas. These sampling and characterization documents date from 1982 to 1996 and include documents prepared for state and federal agencies to satisfy environmental regulations. The first comprehensive environmental document assembled is known as the Dreicer Report (Dreicer

1985), which reviewed uses, storage, and disposal of hazardous materials at LLNL up until 1985. While the Dreicer Report was primarily a review of historical information and a survey of waste management practices, many other reports covered specific sampling and characterization activities, including key monthly reports from the Environmental Restoration Division. The reviewed reports are listed in Attachment 2 of the February 1998 quarterly report on stipulated activities (DOE 1998a).

The reviewed documents indicate that, prior to 1964, storage and disposal of potentially hazardous materials was limited to the East Traffic Circle Landfill (ETCL) and an area that is now the current NIF construction site and where buried PCB capacitors were unearthed in 1997. A review of aerial photographs suggests the latter landfill was closed by 1965 and has since been remediated. The ETCL continued to operate until about 1974. It was excavated and closed in the mid-1980s (McConachie et al. 1986). As discussed in Section 1.1, soil containing residual PCBs was excavated from the East Traffic Circle during routine drainage maintenance operations in 1998 and was disposed of at an EPA-approved facility for CERCLA waste (Clive, Utah, incinerator).

There is no record of any recent disposal of any hazardous materials on the Livermore Site. Reports indicate that nonhazardous materials, including construction debris and soil, were managed in the northeastern quadrant of the Livermore Site (Northern Boundary Area and along the eastern boundary). Materials were stored in piles and later used as fill material to raise the grade of the area.

Reviewed documents indicate that soil characterization studies conducted in 1983 in the Building 571 Area before that building was constructed involved surface soil sampling of a 210- × 270-m (700- × 900-ft) area on a 60-m (200-ft) grid. The drilling of 20 borings as deep as 15 m (50 ft) was summarized in a 1983 LLNL internal memo (Dreicer 1983). Samples were analyzed for halogenated VOCs, metals, PCBs, gross radioactivity, and tritium. This information is not included in the GEMINI database, which is summarized in Section 3.5.2. The analyses indicated concentrations below detection limits for all analytes except tritium, which was present at trace levels in soil pore water. The tritium, which was present at levels below drinking water standards, was attributed at the time to slightly contaminated soil brought to the area as fill material. Tritium has not been detected at levels of concern in groundwater samples from the area.

Aerial photographs of the Livermore Site taken by LLNL and covering the period from 1949 to 1985 were examined (DOE 1998a). Photographs showing the entire site were available for most years, with several focused on the northeastern quadrant or portions thereof. The aerial photographs commonly show soil disturbances throughout the Livermore Site. The nature of soil disturbances was generally not identifiable on the photographs, although areas that were suspected of containing buried material were further investigated. The photographs showed the appearance and operation of the ETCL from about 1954 to 1974, which was thoroughly investigated in 1989 (Thorpe et al. 1990). A May 1964 photograph showed soil disturbance in the area where the capacitor landfill was discovered in the NIF Construction Area in 1997. That landfill appears to be covered over in 1965. This area has been investigated since 1989, although no buried debris or PCB soil contamination was found until 1997. After the capacitor landfill was discovered in the NIF Construction Area, it was determined that this was the same location as the disturbed area earlier identified on the 1964 photograph. The capacitor landfill was not discovered during the earlier source investigations because of lack of sufficient information to pinpoint the location accurately. Numerous photographs from about 1960 to 1980 show soil piles and surface changes consistent with the reported soil and debris storage and fill operations in the northeastern quadrant, which affected most of the stipulated areas in the main block (DOE 1998a).

The employee interview process began with the distribution of a letter to all 3,844 LLNL employees who had worked at the site before 1984. That year was selected as a cutoff for possible undocumented waste disposal activities at the site on the basis of document and photo reviews. In addition, the letter was sent to 3,325 retirees. The letter sought a response from anyone with knowledge of waste disposal or burial practices in the northeastern quadrant of the site, including all of the stipulated areas. Of the 107 direct responses received, 18 reflected personal knowledge of waste disposal practices, while 31 more claimed observational or second-hand knowledge. Follow-up of the responses led to 16 in-depth interviews of responders and other identified persons. Interviews were conducted with the aid of site maps and photographs from the period, allowing the interviewees to respond to direct questions about specific features appearing in such records.

The first-hand accounts provided by the interviewees mostly confirmed the operation of the ETCL and possible recollection of the capacitor landfill discovered in the NIF Construction Area in 1997. There were no accounts of any other burial sites that might have involved hazardous materials. The likelihood that the soil piles and surface disturbances observed in the aerial photographs were soil storage and fill operations was also affirmed in the interviews. The previously reported disposal of nonhazardous wastes and debris in ditches in the Northern Boundary Area was also substantiated; there were no reports of disposal of any hazardous materials in this area. All persons with direct knowledge of waste disposal reported that all such activities were conducted within applicable regulations existing at the time.

On the basis of the findings of the document review, aerial photograph review, and personal interviews, areas identified for further study by geophysical surveys according to Paragraph 3 of the Joint Stipulation and Order were narrowed to the Helipad Area, the Northern Boundary Area, and the NIF Construction Area (areas identified as a, c, and g in Paragraph 2 of the Joint Stipulation and Order [see Section 1.3.2]).

4.1.2 Summary of Phase II Results

Phase II activities encompassed fieldwork performed in the three areas identified in Phase I for further investigation in conformance with Paragraphs 3-5 of the Joint Stipulation and Order. Fieldwork consisted of conducting geophysical surveys in the areas; placing test excavations and borings at suspicious or other appropriate locations; analyzing sediment samples and soil borings; and drilling, developing, and sampling several groundwater monitoring wells in key areas. This increasingly detailed approach was designed to provide wide coverage while focusing resources appropriately. The findings of the Phase II activities for the three areas identified for further investigation under Phase I and for the ETC Area are summarized in the following subsections. The ETC Area was included for Phase II activities after the discovery of residual PCB-contaminated soil there.[3]

4.1.2.1 NIF Construction Area

Several geophysical surveys have been conducted over the past year in the area of the capacitor landfill discovery and around the perimeter of the NIF Construction Area. An electromagnetic induction (EMI) survey was performed on September 9, 1997, near the excavated capacitor pit to identify areas of increased electrical conductivity that might indicate buried metal objects. Readings were taken around the pit and to about 30 m (100 ft) to the southwest of the pit to depths of about 4.6 m (15 ft) and 15 m (50 ft) in separate runs. EMI surveys made it possible to facilitate mapping subsurface conductivity changes and delineate spatial variables resulting from changes in the natural background conditions or from the presence of buried objects. The survey revealed no significant anomalies, thus indicating, in the operators' assessment, that there is a low probability that additional buried metal objects on the scale of the discovered capacitors exist in the area.

A mapped magnetometer survey was conducted along a proposed trench route surrounding the NIF construction site over the period of December 4-9, 1997, by the U.S. Navy, SSPORTS Environmental Detachment. A magnetometer measures the magnetic field strength and responds to the presence of buried ferrous metals that cause local variations in the earth's magnetic field. The instrument used in the survey collected data from both an upper and a more sensitive lower detector to uncover any anomalies from buried metal objects. Over 70 magnetic anomalies were recorded by the lower detector; the number was reduced to 13 with confirmation by the upper detector (SSPORTS 1997). Anomaly number L-41, a fairly distinct and intense signal, was perhaps the most interesting.

A ground-penetrating radar (GPR) instrument used for locating underground utilities was used on December 29, 1997, to confirm the L-41 magnetic anomaly. The transmitted energy in a GPR unit is reflected back to the radar antenna when inhomogeneities in the electrical properties, such as differences in water content, dissolved minerals, clay content, or zones of heavy mineral content, are encountered. Operated in the point-data collection mode, the instrument did not confirm an anomaly to a maximum detectable depth of approximately 3.7 m (12 ft). A further

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[3] As discussed in the *East Traffic Circle Landfill Closure Report* (LLNL 1986), PCB-contaminated capacitors and soil and other hazardous and nonhazardous material were excavated and removed in 1984. The discovery of PCB-contaminated soil in 1998 from the closed ETC Landfill is considered residual contamination and does not indicate the presence of any previously unknown or undiscovered buried hazardous, toxic, or radioactive material.

attempt to confirm the L-41 magnetic anomaly was conducted on February 9, 1998, with an electromagnetic terrain conductivity meter. It was concluded from surveys run along the sides and through the center of the suspect area that no conductivity anomaly was present.

Finally, on March 13, 1998, a second magnetic survey was conducted by the Navy in the area of the original L-41 magnetic anomaly. Again, this survey did not confirm the L-41 magnetic anomaly. On the basis of this and the other unsuccessful attempts to verify the original reading, the L-41 magnetic anomaly was concluded to have been an error (SSPORTS 1998a). It was attributed to one or more of the following factors: edge effects, operator or instrument error, rainy conditions, or near-surface construction debris that were later removed. This conclusion was confirmed when a 0.9-m (3-ft) wide by 4.6-m (15-ft) deep test pit dug at the location of the L-41 magnetic anomaly on April 15, 1998, found no buried objects.

Other intrusive sampling in the NIF Construction Area included the digging (on December 29, 1997) of two holes to a depth of 3.7 m (12 ft) at the location on the southern side of the site where construction debris had previously been unearthed. Material from the westernmost hole confirmed the presence of debris (concrete, asphalt, wood, and cuttings), while the easternmost hole contained fill material and native soil. This result confirms evidence of use of nonhazardous materials as fill in this area noted in Phase I investigations.

In addition to the described investigation of the L-41 magnetic anomaly found in the original December 1997 magnetic survey, 11 of the other 12 detected anomalies were investigated in January 1998 by drilling boreholes to depths of 6 m (20 ft) near the locations of the anomalies. Four other boreholes were drilled at random locations along the southern and western sides of the NIF Construction Area along the path of a planned utility trench. Soil or sediment samples were collected from each of the boreholes at depths of 3, 4.6, and 6 m (10, 15, and 20 ft). No buried objects, except for some nails and wire, were encountered in the drilling of any boreholes. Sediment samples were screened for organic vapors, and selected samples were sent to a state-certified laboratory for analysis of halogenated volatile organic compounds (VOCs), PCBs, and dioxins/furans; none were found in any of the samples.

4.1.2.2 Helipad and East Traffic Circle Areas

An EMI survey measuring electrical conductivity was conducted in the Helipad Area on October 1, 1997, in a manner similar to the survey conducted around the capacitor pit in the NIF Construction Area on September 9, 1997. The Helipad survey showed no anomalies that would indicate the presence of large buried metal objects, such as capacitors or drums.

In March 1998, the Navy conducted a magnetometer survey in the Helipad Area (SSPORTS 1998a). Four magnetic anomalies were detected in the vertical gradient survey. Two of the anomalies were attributed to buried utilities, leaving two to be further investigated. On April 6, 1998, boreholes were drilled to a depth of 6 m (20 ft) at the latter two anomalies, and samples were collected at depths of 3, 4.6, and 6 m (10, 15, and 20 ft). Sediment (soil) samples were analyzed for halogenated VOCs and PCBs in a state-certified laboratory. All samples were negative. During the drilling, construction debris, including sheetrock and wiring, were encountered near the surface, again confirming the placement of such material as fill in the northeastern quadrant.

Groundwater sampling and analysis was carried out on March 4, April 22, July 20, and July 27, 1998, in six monitor wells installed after September 1997. Three wells in, and near, the Helipad Area (W-1311, W-1401, and W-1416) and three wells in the adjacent East Traffic Circle Area (W-1402, W-1403, and W-1405) screened at three different depths (representing the major hydrostratigraphic units underlying the site) were sampled. The wells are generally west and south, i.e., downgradient, of the NIF Construction Area and the previously excavated PCB capacitor landfill. Samples were analyzed for PCBs, VOCs, tritium, gross alpha and beta activity, and inorganic constituents. Results were negative for PCBs. VOCs, primarily chlorinated ethanes/ethenes, were detected at levels up to 1,900 ppb in the Helipad Area and up to 1,000 ppb in the East Traffic Circle Area. Those levels are consistent with the historical analysis of groundwater impacted by the East Traffic Circle Landfill. Tritium levels were below drinking water standards, and gross alpha and beta levels were near the natural background level. These data will be used in monitoring impacts on water quality from NIF construction and operation. These results, along with sediment and soil data, are presented in the various quarterly reports on stipulated activities. In general, analytes have decreased in concentration since November 1997 in response to nearby cleanup activities (Section 3.6).

While drainage maintenance work was being performed under the East Traffic Circle Drainage Improvement Project, debris was found in the ETC Area in October 1998. Routine analysis of soil samples associated with the uncovered debris detected PCB (Aroclor 1254) contamination in two samples at 98 ppm and 120 ppm. A cleanup level of 18 ppm for Aroclor 1254 was agreed to by the CERCLA RPMs (Bainer and Littlejohn 1999). This level is equivalent to the Region 9 Preliminary Remediation Goal (PRG) for Aroclor 1254 in soils at an industrial area. About 230 m^3 (300 yd^3) of affected soil was removed and sent to an off-site EPA-approved CERCLA waste disposal facility in Grandview, Idaho. The storage area where the soil was temporarily stored was scraped and sampled to verify complete removal. An investigation of the area of the PCB (Aroclor 1254) find in the ETC Area was performed in early 1999 to delineate the extent and remove any further contamination above regulatory levels.

After the original removal of contaminated soil, sediment samples from seven boreholes in the ETC Area and two more in the Helipad Area were collected at depths to 6 m (20 ft). These samples revealed additional PCB contamination in the near surface in an area defined by three of the boreholes in the ETC Area. This contamination was reported as Aroclor 1254. The area was scraped and sampled a total of three times, involving removal of a total of 85 m^3 (106 yd^3) of soil, until the 18-ppm cleanup level agreed upon by the CERCLA RPMs was ultimately achieved in July 1999. Verbal approval was given on July 15 and 16, 1999, by the regulatory agencies to end the excavation and regrade the area (Bainer 1999).

A magnetometer survey was also performed in and around the ETC Area to locate possible buried waste (SSPORTS 1999). Twenty-three anomalies were identified, and seven of those were determined to warrant subsurface investigation. The latter investigations failed to identify any additional contamination (June 1999 Quarterly Report [DOE 1999c]). DOE has concluded that no buried contaminated objects remain in the ETC.

4.1.2.3 Northern Boundary Area

The Northern Boundary Area is the site of a former garbage trench that was used for disposal of general waste from dumpsters. The trench is oriented east-west and is about 210 m (700 ft) long, 8.5 m (28 ft) wide, and 2.7 m (9 ft) deep. Garbage was placed in the trench to a depth of about 1.8 m (6 ft) and covered with about 1.8 m (6 ft) of mounded backfill. The trench was surrounded by a security fence during its operating life (Lindeken 1988).

The Navy conducted a magnetometer survey in this area over the period April 8-14, 1998, to develop a magnetic profile of the area and detect any significant subsurface magnetic anomalies (SSPORTS 1998b). All of the magnetic anomalies identified met the parameters and profiles of existing underground utilities or services in the study area and, therefore, did not warrant any further investigation.

4.2 CONSEQUENCES OF CONTINUING TO CONSTRUCT AND OPERATE THE NIF

The Phase I and II investigations, as described in Section 4.1, suggest that there is low likelihood that significant quantities of additional previously unidentified buried hazardous, toxic, or radioactive objects remain in the stipulated areas. This conclusion is based on the results of the series of increasingly detailed inquiries conducted to identify and investigate suspicious areas (summarized in Section 4.1). This approach ensured wide coverage while providing convincing evidence of the absence of any further undocumented buried hazardous, toxic, or radioactive objects in reasonably likely areas. Investigation methods relied largely on historical records, aerial photographs, personal interviews, and geophysical surveys to detect buried metal objects, such as capacitors or drums, that would be associated with waste burial. The burial of substantial quantities of wastes without such metallic containers is deemed unlikely. The absence of buried metallic waste containers or wastes was verified by borings at locations of survey anomalies. Further indication of the absence of buried wastes comes from analysis of soil samples collected from borings and groundwater samples collected in the vicinity and downgradient of potential source areas. Groundwater samples have consistently shown the absence of such sources and will continue to be monitored into the foreseeable future to detect any emerging sources.

Phase I and Phase II investigations indicated that groundwater in the northeastern quadrant is not currently being affected by buried hazardous, toxic, or radioactive material (Table 3.2). As part of Phase II activity, monitoring wells W-1311, W-1401, W-1402, W-1403, W-1405, and W-1416 were fully developed and sampled for contaminants of concern. All constituents were below their MCLs (DOE 1998b) (Section 3.6, including Table 3.2). PCBs were not detected in the sampling. Groundwater samples have consistently shown the absence of PCB contamination downgradient from soils previously contaminated with buried PCB waste and will continue to be monitored into the foreseeable future.

On the basis of the above findings, it is concluded that the only sources of previously unknown or undiscovered buried hazardous, toxic, or radioactive waste existing in the northeastern quadrant at the time NIF construction began were the capacitor landfill discovered in September 1997 and the elevated concentrations of residual PCBs discovered in soil in the ETC Area in 1998. These sites were cleaned up to action levels agreed upon by the CERCLA RPMs, thereby reducing heretofore unsuspected contamination in soils at the NIF Construction Area and the ETC Area.

4.2.1 Impacts from Soil Suspended in Ambient Air from Capacitor Removal during NIF Construction

The findings under the Phase I and II investigations indicate that the capacitor landfill discovered in September 1997 was the only source of previously unknown or undiscovered buried hazardous, toxic, or radioactive waste in any of the areas identified under the Joint Stipulation and Order since the NIF construction groundbreaking. Because the discovery and excavation of the PCB capacitor landfill in 1997 was a direct result of the NIF construction activities and occurred in what was later designated as a stipulated area (NIF Construction Area), and because the discovery and cleanup of PCB-contaminated soil in the ETC Area (unrelated to NIF construction) in 1998 and 1999 was also in a stipulated area, possible impacts associated with the contamination and cleanup in these areas were analyzed.[4] For both areas, potential health impacts from dust generated during excavation of contaminated soil were analyzed in some detail. The assessed impacts are associated with the CERCLA cleanup of contaminated soil during a period of NIF construction. The impacts resulting from disturbance and suspension of PCB-contaminated soil from cleanup activities during this period were evaluated, and resulting health risk was then assessed in terms of latent cancer risk from inhalation of the PCB-contaminated fugitive dust.

Dust emission rates from heavy equipment operation were estimated from EPA standards (EPA 1995a) and from a description of the excavation activity. Dispersion of the emitted dust, which was assumed to contain PCB residuals at the highest concentration detected in the excavated soils, was modeled with a conservative screening approach, employing the SCREEN3 model consistent with EPA guidance (1995b). Conservative meteorological conditions were assumed with a dispersion model (SCREEN3) designed to produce conservative results

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[4] The buried waste and associated contaminated soil discovered in the NIF Construction Area and the ETC Area are nonroutine legacy waste not connected with the NIF project.

(e.g., estimates of maximum potential exposure levels).[5] Exposure to PCBs on the respirable (PM_{10}) fraction of dust via inhalation by a hypothetical member of the public standing at the nearest point of public access was then estimated. The exposure scenario assumed that an adult stood at the fence line for the entire duration of excavation for each action. Calculated cancer risks (chance per year), estimated for this highly conservative PCB exposure scenario by using a cancer slope factor from EPA's IRIS database for inhalation, were 1×10^{-9} (1 in 1,000,000,000) and 4×10^{-9} (1 in 250,000,000) for the NIF Construction Area and ETC Area cleanup actions, respectively. These calculated cancer risks from dust are, respectively, 1,000 times and 250 times smaller than the EPA point of departure for determining remediation goals — 1×10^{-6} (1 in 1,000,000) as established in 40 CFR Part 300. Noncancer impacts were estimated as hazard quotients of 0.08 and 0.6 for the NIF Construction Area and ETC Area, respectively. Both are below a threshold value of 1.0 for the reference dose for chronic exposure (EPA IRIS, Aroclor 1254). The reference dose applies to long-term exposure, while the PCB hazard quantities calculated for the NIF Construction Area and ETC Area are short term, adding an additional level of conservatism to the estimates. The details of the dispersion modeling and risk estimates are presented in Appendix A.

Workers involved in the two cleanup actions were protected from dust-borne PCB exposures through the use of appropriate personal protective equipment and safe work practices. Excavation equipment used in the actions was carefully decontaminated and verified clean. Areas where PCB soils were stored or stockpiled were scraped and sampled to verify complete removal of contamination.

Given the results of the analyses discussed here and the good work practices used by cleanup workers, health impacts to the public and involved workers from the execution of the two PCB remedial actions are estimated to be very low, well below applicable levels of concern.

4.2.2 Impacts to Soil from Operation of the NIF

Impacts on soil resources from the operation of the NIF in the current context would relate to any increased release of any existing buried hazardous, toxic, or radioactive wastes resulting from facility operations, or any releases of such wastes to soils from facility operations. Potential impacts of either type are highly unlikely for two reasons. First, the results of Phase I and Phase II investigations under the Joint Stipulation and Order indicate that there is low probability that undiscovered buried hazardous, toxic, or radioactive wastes exist in the vicinity of the facility. Second, evaluations of environmental, safety, and health considerations conducted during the design of the facility (LLNL 1994b) and during subsequent environmental analysis (DOE 1996a) indicate that emissions of material effluents or radiation that could contaminate soils in the NIF site area will be extremely small or nonexistent during NIF operations. Neither liquids nor solids would be discharged to or disposed of in the NIF site area. Thus, facility

[5] Thus, use of the model results in estimating that PCB exposure levels would be substantially higher than what would actually be expected to occur.

operations will neither increase any presently existing impacts to soil nor result in additional contamination of soil.

4.2.3 Impacts from Soil Contaminant Migration to Groundwater during Construction and Operation of the NIF

None of the activities for construction of NIF would normally affect groundwater under the stipulated areas at the Livermore Site. Construction and operation of the NIF would not require use of groundwater, and there would be no contaminant discharges from the surface to groundwater. With the ongoing remediation activities taking place in these study areas, groundwater quality would, therefore, be expected to improve with time (DOE 1996). The potential future impacts to groundwater from any potential remaining PCB residues in soil are evaluated below.

Figure 4.1 shows the approximate locations of 112 capacitors containing PCBs that were unearthed at the NIF Construction Area in the northeastern portion of the Livermore Site (Bainer and Berg 1998). The capacitors and about 694 metric tons (766 short tons) of PCB-contaminated soil were removed and managed in full consultation with the CERCLA RPMs. The highest PCB concentration in the excavated soil was 66 ppm. After excavation, 12 evenly spaced soil samples along the perimeter of the pit floor, 6 samples along the centerline of the pit floor, and 5 surface soil samples around the outside of the pit showed residual PCB levels in soil less than 1 ppm. Because construction activities at the NIF resulted in the unearthing and discovery of the PCB-containing capacitors, a groundwater analysis of potential impacts is included below. However, detailed analyses for the other contaminants of concern in the groundwater discussed in detail in Section 3.4.3 (TCE, PCE, carbon tetrachloride, Freon 11, chromium VI, and tritium) were not performed because none of the NIF construction activities had a direct disturbance that involved a discovery of these constituents, and none of the sediment samples taken under Phase II activities found any of these constituents.

As discussed in Section 4.1.2.2, about 230 m^3 (300 yd^3) of PCB-contaminated soils was removed from the ETC Area. A cleanup level of 18 ppm was approved by the CERCLA RPMs. Because of similarities in the hydrogeology between the NIF Construction Area and the ETC Area, rates of movement to groundwater of residual PCB contamination in the ETC soil are expected to be similar to the rates of movement to groundwater of PCBs in the NIF Construction Area and should scale directly with the soil concentration. However, since residual PCB concentrations are below 18 ppm in the ETC Area and below 1 ppm in the NIF Construction Area, potential groundwater concentrations derived from PCB soil contamination in the ETC Area would be about 18 times greater than potential groundwater concentrations derived from PCB contamination in the NIF Construction Area.

To calculate the potential impacts of the residual PCBs in the soil on groundwater, a mathematical model for porous media transport and groundwater mixing was employed (see

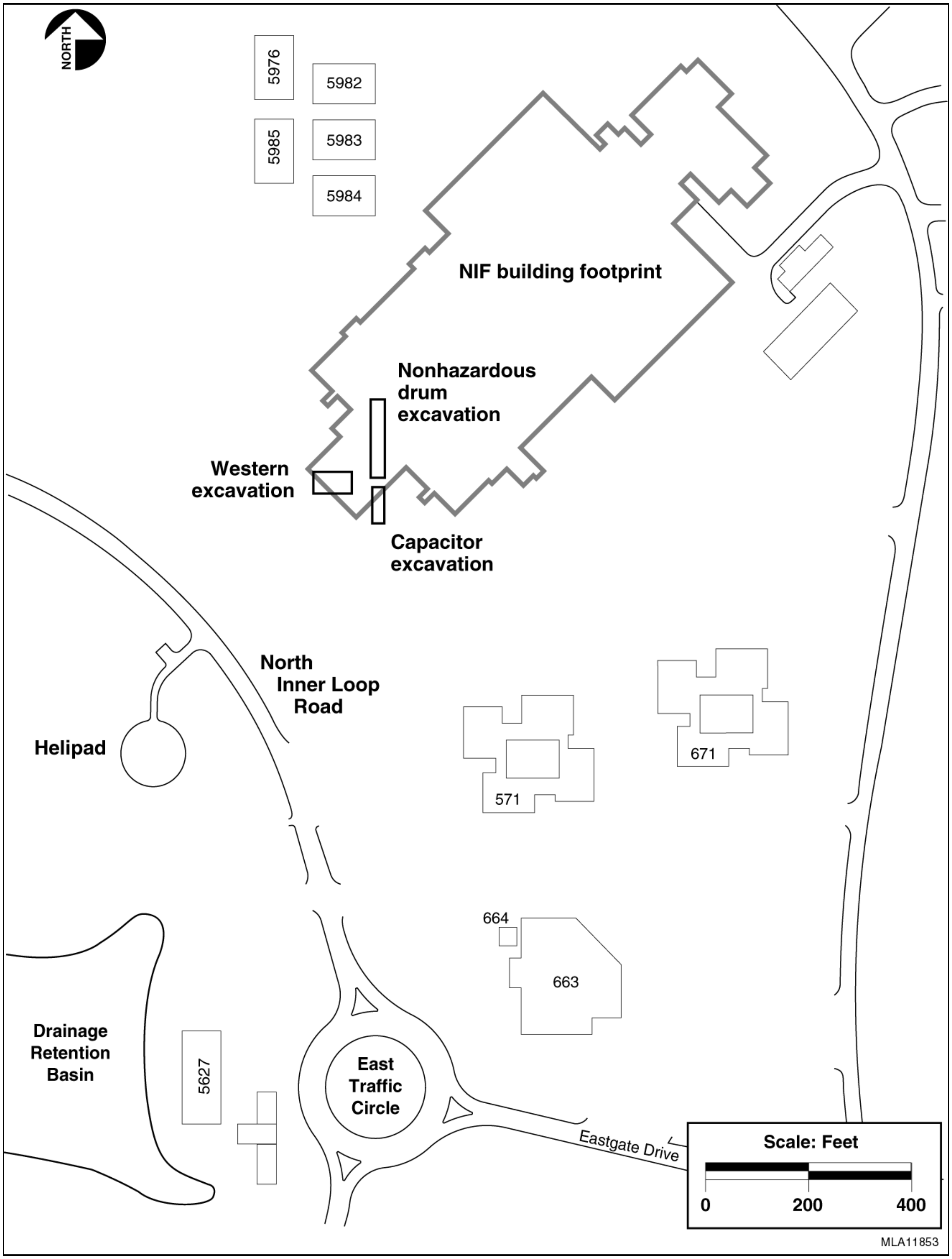

FIGURE 4.1 Locations of the Capacitor, Drum, and Western Excavations at the NIF Construction Site and Location of the East Traffic Circle

Appendix B). For this analysis, it was assumed that the remaining PCB material in the soil dissolves under the influence of infiltrating precipitation and is transported with soil water vertically downward to the underlying water table. Because of the length of the path that must be traveled (about 13 m [43 ft]) and sorption, the concentration of dissolved PCB is a complex function of both time and space. At the water table, the contaminated soil water mixes with initially clean groundwater in the saturated zone. Impacts of the soil PCB concentrations were evaluated by comparing the maximum estimated groundwater PCB values with the MCL of 0.0005 ppm.

A number of simplifying, conservative assumptions (i.e., assumptions that lead to predictions that have greater impacts than those that would actually be expected to occur) were made for performing the calculations for the above referenced model. These assumptions included the following:

- PCB soil concentrations are at a level of 1 ppm over a depth of 0.3 m (1 ft);
- The PCB is nondecaying and does not degrade along its flow path to the water table;
- The PCB in the soil was composed entirely of Aroclor 1242, the PCB that has the highest solubility and undergoes the least sorption;
- The concentration of Aroclor 1242 in the soil water in the contaminated zone is equal to the solubility limit of the PCB;
- Transport of Aroclor 1242 occurs only vertically; and
- The infiltration velocity of the dissolved Aroclor is equal to the average annual groundwater recharge at the site. (Maximum annual discharge is not known and would be inappropriate for modeling concentrations over a 200,000-year period.)

Site-specific parameters required to solve the transport equation used for this analysis are given in Appendix B. In addition, that appendix also describes the one-dimensional solution to the advection/dispersion equation used for the analysis.

Figure 4.2 shows the concentration of PCB (Aroclor 1242) at the water table divided by its concentration at the point of dissolution (conservatively assumed to be equal to the Aroclor solubility) as a function of time. This breakthrough curve indicates that a maximum normalized concentration of about 0.001 would occur in about 140,000 years, a period of time much longer than the time estimated for the PCB (Aroclor 1242) to dissolve completely from the soil

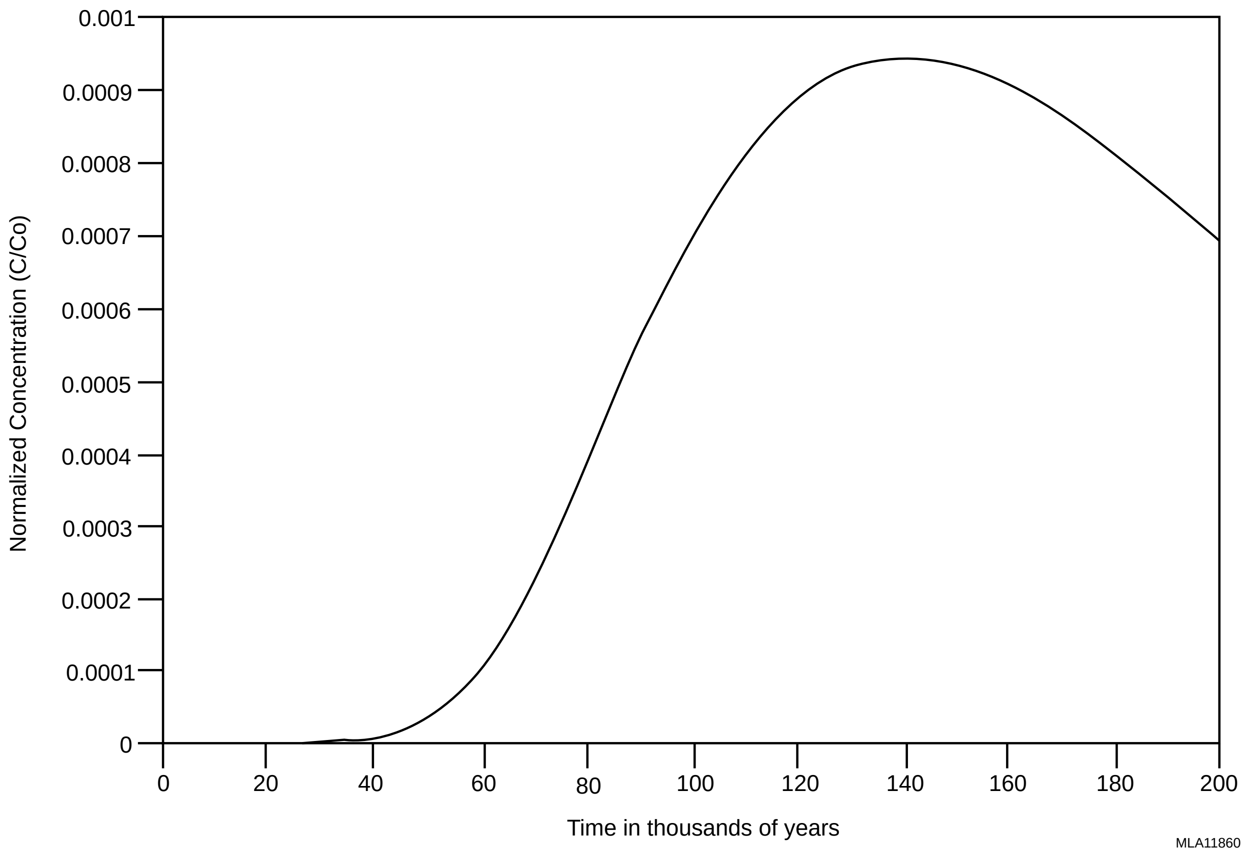

FIGURE 4.2 Water Table Breakthrough Curve for PCB (Aroclor 1242) at the NIF Construction Site

(160 years) (Appendix B). This long period of time is primarily caused by the length of the path from the residual PCB soil zone to the water table and the high degree of sorption expected for the PCB (retardation coefficient[6] approximately equal to 500) (see Appendix B).

To obtain an actual concentration in the groundwater recharge from the above normalized value, the 0.001 value must be multiplied by the Aroclor solubility (1.0×10^{-7} g/cm^3) (Appendix B). The resulting maximum concentration of PCB at the water table in about 140,000 years would, therefore, be about 0.0001 ppm (1.0×10^{-10} g/cm^3). This value is about five times less than the EPA maximum contaminant level (MCL) of 0.0005 ppm (5.0×10^{-10} g/cm^3) (EPA 1994). The conservative assumptions listed above make it likely that this number is an overestimate.

After reaching the groundwater, the dissolved PCB will be diluted by mixing with initially clean groundwater. A simple mixing model (Appendix B) for site-specific conditions

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[6] The retardation coefficient is the ratio of the rate of groundwater movement divided by the rate of movement of a chemical dissolved in the groundwater. A large retardation coefficient indicates that the chemical moves much more slowly than the groundwater.

indicates that a dilution factor of about 40 would occur over the thickness of the saturated zone (about 10 m [30 ft]). The resulting maximum PCB concentration at 140,000 years would thus be about 2.5×10^{-12} g/cm^3 (0.0000025 ppm). This value is conservatively estimated to be a factor of 200 smaller than, or about 0.5% of, the current EPA drinking water MCL.

As mentioned previously, groundwater concentrations of PCB derived from contaminated soils in the ETC Area would be about 18 times larger than the values for the NIF Construction Area. The concentration would thus be about 0.000045 ppm (4.5×10^{-11} g/cm^3), which is less than 1% of the drinking water MCL.

The maximum PCB concentrations predicted in the previous section on the basis of conservative assumptions would be very low and less than the MCL. The time to reach this maximum concentration would be very long (maximum PCB concentrations of 0.0000025 ppm and 0.0001 ppm would not be reached for about 140,000 years) and below the MCL of 0.0005 ppm for drinking water. The soil cleanup level of 1 ppm at the capacitor landfill in the NIF Construction Area and 18 ppm at the ETC Area will provide an environmentally safe level. This conclusion is consistent with cleanup guidelines followed at the landfill and discussed in the Action Memorandum (Bainer and Berg 1998). Because of the very low levels of PCBs predicted to reach groundwater and the fact that they are much less than the drinking water MCL guideline, no risk-based assessment of health effects were performed. The existing information is sufficient to conclude that following remediation, the PCB contamination discovered during NIF construction would not adversely affect human health.

4.2.4 Impacts to Groundwater from Operation of the NIF

Operation of the NIF would not result in any direct release of hazardous, toxic, or radioactive materials to groundwater at LLNL (DOE 1996). Because Phase II investigations did not identify any new sources of hazardous, toxic, or radioactive materials at the NIF site area, operation of the NIF would not result in releases of buried hazardous, toxic, or radioactive wastes to groundwater. By the same analysis used for soils, such potential impacts to groundwater from operation of the NIF are not expected. First, recent investigations have shown that there is low probability of residual buried hazardous, toxic, or radioactive waste in the vicinity of the facility. Second, evaluations performed during scoping the NIF PSA, based on facility design, concluded that little or no material effluents or radiation will be emitted from NIF during operation that could impact groundwater.

4.3 CONSEQUENCES OF CEASING NIF CONSTRUCTION

Although DOE does not consider the no action alternative of ceasing NIF construction to be reasonable (Section 2.1.2), the impacts that are expected from such an action are discussed here. Upon ceasing NIF construction, DOE could take one of the following two actions: (1) complete construction of the buildings for other use, which would require redesign of the building interiors, or (2) demolish the NIF structures and return the site to a brownfield condition. In either case, the impacts of any remaining residual PCB contamination in Stipulated Areas would remain the same as for the preferred alternative (to continue construction and operation of NIF) for soils, groundwater, and health and safety. The recently discovered PCBs in the NIF Construction Area and the residual PCB contamination in the ETC Area have been identified and removed, and the surveys conducted pursuant to the Joint Stipulation and Order indicate that is highly unlikely that further contamination would be found in the future.

In order to use the NIF structures for another purpose, construction of the buildings would be completed. Conventional NIF construction is about 80% complete, and site preparation and excavation are complete. The NIF facility has specialized features, including (1) massive vibration-free structures for lasers; (2) a clean room for lasers; (3) specialized shielding and ventilation; (4) a target chamber 9 m (30-ft) in diameter; and (5) seismic resistant design. These features make the facility most suitable for another research effort requiring laser and/or radiological capabilities. The NIF is being constructed as a nonhazardous, radiological facility; it would not be a nuclear facility. Modifications to support a new research effort would be added work. The use of the NIF for an office building, light laboratories, or manufacturing use would require major redesign and significant modifications beyond those required for use by another research program. Such a use is not considered likely.

Impacts of existing and planned programs, including laser research and radiological activities have been analyzed in a Supplement Analysis (SA) (DOE 1999a) for continued operation of LLNL. The SA assesses the impacts on human health and the environment of recent changes in existing programs and planned programs. The SA compares the impacts of new and planned programs and facilities at LLNL to the impacts assessed in the LLNL sitewide EIS (DOE 1992).

If DOE ceased construction of NIF and all constructed features were demolished, the site could be returned to a brownfield condition. The specialized nature of the building includes (1) reinforced shielding walls that are 1.8 to 3.6 m (6-12 ft) thick and (2) laser foundations that are 9 m (30 ft) thick and approximately 30 m (100 ft) wide by 120 m (400 ft) long. A large workforce with heavy equipment would be required to demolish existing structures and return the site to its original condition. About 4,400 m^3 (about 5,800 yd^3) of nonhazardous waste would be produced and disposed of off-site. Fill for the excavations would be obtained from an off-site source. The impacts of demolishing NIF would be due to additional site excavation needed to remove building foundations, transportation of nonhazardous wastes to an off-site disposal facility, and transportation of fill material from off-site sources to the NIF Construction Area. The type of activities required for demolition would be similar to the activities required to decontaminate and decommission NIF, as discussed in the SSM PEIS, Appendix I (DOE 1996a). However, no radiological contamination would be present.

Briefly, the impacts of the NIF no action alternative as ceasing construction are:

- The construction workforce would continue until the buildings were either made suitable for a new use or the buildings were demolished and excavations filled. Construction workers would be employed for a longer period for demolition of NIF than if NIF were reused or completed for operations. Preparation of NIF buildings for reuse would continue construction employment for a longer period than completion of NIF for operations, but for a shorter period than demolition. NIF operations would support a large workforce, which would keep LLNL workforce numbers stable in the foreseeable future. However, LLNL workforce and payroll would decline for both the reuse and demolition alternatives, because NIF workers would not be employed. Reduced employment and payroll would have an adverse socioeconomic effect in the Tri-Valley area.

- Remodeling the building for another use would increase the time construction and transportation workers were at risk of occupational injuries. However, demolishing NIF and transporting wastes and fill would require the longest time and greatest effort. More workers would be injured during demolition of NIF than for the other alternatives.

- Demolition would generate up to 4,400 m^3 (about 5,800 yd^3) of nonhazardous solid wastes that would be disposed of at an off-site facility. Fill for NIF excavations would come from off-site sources. Alternative use of NIF would produce wastes from remodeling, in addition to wastes generated by completion of the NIF buildings. For both alternatives, some materials may be sold as scrap.

- Alternative use of NIF for another scientific program would use hazardous materials for equipment cleaning and other research activities similar to how hazardous materials would be used for NIF operations. Risks to workers and the public from hazardous materials would be small and within applicable regulations and guidelines. Use of hazardous materials would be regulated by the Occupational Safety and Health Administration and by LLNL management activities and would be similar for both alternatives. Risks from hazardous materials at the NIF facility are addressed in the SSM PEIS (DOE 1996a). If the NIF structures were demolished, risks to human health and safety from hazardous mateials would be absent.

- Alternative use of NIF for another scientific program could include radiological doses to workers and the public that are likely to be small and, less than, or greater than applicable regulations and guidelines. This impact could be similar to the impact of operating NIF as described in the SSM PEIS

(DOE 1996a). If the NIF structures were demolished, there would be no radiological doses to workers and the public.

- Demolishing the buildings would result in additional truck traffic (see bullet 3 above) because wastes would be taken off-site for disposal and fill would be delivered from off-site sources. Truck traffic from waste removal and fill delivery could adversely affect nests of the white-tailed kite, a state-protected species, as described in the impact analysis for NIF construction (DOE 1996a). This species nests near the East Gate entrance to the Livermore Site. Activities from demolition would be conducted in consultation with appropriate regulatory agencies. Fewer such impacts would result from the other alternatives, because much less bulk materials would be transported.

- Demolition activities, including removing structures and filling and grading the site, would produce dusts, including PM_{10} for a longer period than either completing NIF for operations or reuse. The Livermore region is not in attainment for this criteria pollutant (DOE 1996a). Best available technology would be used to reduce such dust emissions to the extent possible. Because of cleanup activities described in this SEIS, potential contaminant levels in dusts would be below levels of concern, and impacts to human health would be below those described for site cleanup.

- Demolition, filling, and grading might further disturb paleontological resources that were left in place during NIF construction. If such resources were found, potential impacts would be mitigated in consultation with appropriate authorities. Neither completion of NIF for operations nor reuse of NIF would involve additional excavation, filling, and grading.

In addition to the direct impacts described above, ceasing construction of NIF at LLNL could result in the indirect impacts associated with constructing and operating NIF at another DOE site (see Section 2.1.2). The NIF PSA contained in the SSM PEIS (DOE 1996a) analyzed the impacts of constructing and operating the NIF at each of the following additional sites: Los Alamos National Laboratory and Sandia National Laboratories, both in New Mexico; and the Nevada Test Site.

4.4 CUMULATIVE IMPACTS

This section evaluates the contribution of any incremental impacts from potential or confirmed buried material when evaluated in conjunction with similar impacts to the same human and ecological receptors from regional sources. The purpose of evaluating such cumulative impacts is to weigh the effect of the incremental impacts from the evaluated action in concert with other such impacts and to determine whether impacts that may be small in isolation may be of concern when considered in total with other impacts.

The sitewide EIS prepared in 1992 for LLNL (DOE 1992) identified the combined and cumulative impacts of site operations projected for the period from then until the year 2002. DOE has recently prepared a Supplement Analysis to determine whether the sitewide EIS should be supplemented (DOE 1999a). Furthermore, the SSM PEIS (DOE 1996) discusses cumulative impacts of NIF construction and operation.

This SEIS concludes that the impacts from potential buried hazardous, toxic, or radioactive materials are below applicable levels of concern as defined by EPA Region 9 Industrial Preliminary Remediation Goals (PRGs) and drinking water standards (MCLs). Investigations conducted pursuant to the Joint Stipulation and Order demonstrate that there is a low likelihood that more buried materials will be found in the area. This conclusion was based on historical records, interviews, and geophysical and monitoring studies. The effective soil cleanup levels of 1 ppm at the capacitor landfill discovered in the NIF Construction Area and 18 ppm at the ETC Area are protective of groundwater and human health. Groundwater concentrations of PCBs from remaining contamination at 1 ppm in soil would reach 0.0001 ppm at the water table (maximum concentration) and 0.0000025 ppm in the groundwater in about 140,000 years. These values are, respectively, 5 and 200 times less than the EPA MCL of 0.0005 ppm. Potential exposures of the public from cleanup of the PCB landfill in the NIF Construction Area and the residual PCB contamination in the ETC Area would have been orders of magnitude below levels of concern established by the EPA (Section 4.2 and Appendix A). No adverse effects on human health would have resulted from either cleanup action.

Because of the historical use of the Livermore Site and past practices used for the handling, storage, and disposal of hazardous materials, it is common to encounter low levels of contaminated soils during excavations throughout the site. Being a Superfund Site on the National Priorities List implies that various levels of contamination are likely to be found during normal construction activities. LLNL has in place procedures that dictate what needs to be done when contaminated soil is encountered. The disposition of contaminated soils is dependent on the concentration of the individual contaminants encountered. On the basis of source investigations and subsurface geophysical studies, it is not likely that additional buried hazardous objects will be discovered in the areas identified in the Joint Stipulation and Order. It is possible, however, that future Livermore Site grading activities or site improvements may identify soil contamination such as occurred at the ETC Area. As soil contamination is identified, it will be handled through permitted processes as determined by LLNL's Operations and Regulatory Affairs and Hazardous Waste Management Divisions. CERCLA RPMs will be notified or consulted as appropriate.

Near the NIF site, generators of material releases and wastes include the Livermore Site and Sandia National Laboratories-California (SNL-CA). Operations of these facilities have been described in the 1992 sitewide EIS (DOE 1992) and were reevaluated in the Supplement Analysis (DOE 1999a). Both of these documents discuss waste generation and hazardous and toxic materials. LLNL's *1997 Site Environmental Report* (LLNL 1998) indicates that site operations result in few, low-level, and controlled releases of pollutants. Neither LLNL nor SNL-CA operations produce routine releases of PCBs. No PCB contamination is known from SNL-CA. Locations at LLNL where past activities may have resulted in buried wastes or materials or contaminated soil or groundwater are undergoing active remediation. This remediation at LLNL is performed under CERCLA in full consultation with the RPMs. These remedial activities at LLNL may also release particulates (PM_{10}) that contain PCBs. The exposure of the public and workers from remediation of contaminated soil, such as the capacitor landfill, has been shown in this SEIS to be well below levels at which health effects could be reasonably expected.

The Livermore Site is in the San Francisco Bay watershed. Some surface waters from the Livermore Site recharge the Amador Valley groundwater basin, where some water is withdrawn by Zone 7 for domestic supply. Wastewater is discharged to the Central Bay via the East Bay Municipal Utility District outfall. Outflow from the valley basin is also withdrawn by the Alameda County Water District for domestic supplies, and some flows into the bay. Monitoring of sediments and PCBs in the bay has indicated the presence of PCBs in fish and sediment. The sources of these PCBs are various industrial activities in the watersheds of the bay. The San Francisco Estuary Regional Monitoring Program for Trace Substances gives concentrations of PCBs in fish in the South Bay (http://www.sfei.org/rmp/rmpother.htm). The California EPA Office of Environmental Health Hazard Assessment (OEHHA) reports a long-term trend of decreasing PCB levels. The agency has issued an interim consumption advisory to protect human health (http://www.oehha.org/scientific/pcb.htm). Removal of PCB-containing capacitors and contaminated soils at the Livermore Site would reduce the potential for PCBs to enter drainageways at the Livermore Site, a beneficial impact for the regional groundwater resources.

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