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Environmental Survey
Preliminary Report

Lawrence Livermore National Laboratory
Livermore, California

December 1987

PREFACE
TO
THE DEPARTMENT OF ENERGY
LAWRENCE LIVERMORE NATIONAL LABORATORY
ENVIRONMENTAL SURVEY PRELIMINARY REPORT

This report contains the preliminary findings based on the first phase of an Environmental Survey at the Department of Energy (DOE) Lawrence Livermore National Laboratory (LLNL), located at Livermore, California. The Survey is being conducted by DOE's Office of Environment, Safety and Health.

The Survey is a portion of the larger, comprehensive DOE Environmental Survey encompassing all major operating facilities of DOE. The DOE Environmental Survey is one of a series of initiatives announced on September 18, 1985, by Secretary of Energy, John S. Herrington, to strengthen the environmental, safety, and health programs and activities within DOE. The purpose of the Environmental Survey is to identify, via a "no-fault" baseline Survey of all the Department's major operating facilities, environmental problems and areas of environmental risk. The identified problem areas will be prioritized on a Department-wide basis in order of importance in 1988.

The findings in this report are subject to modification based on the results from the Sampling and Analysis phase of the Survey. The findings are also subject to modification based on comments from the San Francisco Operations Office concerning the technical accuracy of the findings. The modified preliminary findings and any other appropriate changes will be incorporated into an interim Report. The Interim Report will serve as the site-specific source for environmental information generated by the Survey, and ultimately as the primary source of information for the DOE-wide prioritization of environmental problems in the Survey Summary Report.

November 1987
Washington, D.C.

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EXECUTIVE SUMMARY

Introduction

This report presents the preliminary findings from the first phase of the Environmental Survey of the Department of Energy (DOE) Lawrence Livermore National Laboratory (LLNL), conducted December 1 through 19, 1986.

The Survey is being conducted by an interdisciplinary team of environmental specialists, led and managed by the Office of Environment, Safety and Health's Office of Environmental Audit. Individual team components are being supplied by a private contractor. The objective of the Survey is to identify environmental problems and areas of environmental risk associated with LLNL. The Survey covers all environmental media and all areas of environmental regulation. It is being performed in accordance with the DOE Environmental Survey Manual. This phase of the Survey involves the review of existing site environmental data, observations of the operations performed at LLNL, and interviews with site personnel.

A Sampling and Analysis Plan was developed to assist in further assessing certain of the environmental problems identified during performance of on-site activities. The Sampling and Analysis Plan will be executed by a DOE National Laboratory. When completed, the results will be incorporated into the LLNL Environmental Survey Interim Report. The Interim Report will reflect the final determinations of the LLNL Survey.

Site Description

LLNL is located about 64 kilometers (km) (39 miles) east of San Francisco, California, approximately 5 km (3 miles) east of the city of Livermore. The Livermore Site, or the Main Site, occupies an area of approximately 3.3 square kilometers (km^2) (1.3 square miles). Sandia National Laboratories Livermore occupies a portion of the adjoining property to the south. LLNL is operated by the University of California and was established in 1952 to conduct nuclear weapon and controlled thermonuclear research. The laboratory performs research, development, and testing associated with the nuclear design aspects of all phases of the nuclear-weapon life cycle. More recently, research has included the areas of Laser Research, Magnetic Fusion Energy, Beam Research, Biomedical and Environmental Research, and Energy Resources. Much of the laboratory's materials testing and high-explosives diagnostic work is conducted at Site 300, 30 km (18 miles) southeast of

the Main Site. Located in the sparsely populated hills of the Diabalo Range, Site 300 covers an area of 27 km^2 (11 square miles).

The Survey team met with representatives of local and state regulatory agencies on October 22, 1986. Although no major issues were raised during this meeting, an outstanding concern of the state is contamination of groundwater at the Main Site. LLNL is currently the subject of Waste Discharge Order Number 85-134, issued by the San Francisco Bay Regional Water Quality Control Board, which has established compliance schedules for remedial assessment and cleanup of the groundwater contamination of the Main Site.

Summary of Findings

The major preliminary findings of the Environmental Survey of LLNL are as follows:

- There are at least four general areas of groundwater contamination at the Main Site. The primary contaminants are organic solvents. The most serious of the four areas is the southwest area and the resulting off-site plume. Residential wells have been contaminated with organic solvents. Alternate water supplies have been provided. Remedial investigations of all four areas are under way and/or nearing completion.

- There are at least three general areas of groundwater contamination at Site 300. The primary contaminant is trichloroethylene (TCE), although tritium has been detected in one area. No off-site contamination has been detected. Remedial investigations are planned or under way.

- A number of areas at both the Main Site and Site 300 are or may be contaminated with hazardous substances. These areas, the most serious of which are being addressed by LLNL, constitute actual or potential sources of groundwater contamination. The identification of all potential areas of contamination, as well as the characterization of those areas, is not complete.

- The accumulation of mixed waste on-site, because of the lack of treatment, disposal, and transportation alternatives, increases the potential for a release of mixed waste constituents to the environment.

- The integrity of the sanitary sewer is suspect as a result of the effects of age, corrosion, and earthquakes. There is a potential for contamination of groundwater by untreated sewage.

Overall Conclusions

The Survey found no environmental problems at LLNL that represent an immediate threat to human life. The preliminary findings identified at LLNL by the Survey team do indicate that the site is affected by several environmental problems, which are predominantly the result of past practices. The most pressing problem facing the site, at present, is the contamination of groundwater on-site and off-site. LLNL has several groundwater remedial investigations under way or nearing completion. Remedial action for the off-site contamination is expected to begin in 1988.

The environmental problems described in this report vary in terms of their magnitude and risk. Although the Survey-related sampling and analysis to be performed at LLNL will assist in further identifying environmental problems at the site, a complete understanding of the significance of some of the environmental problems identified requires a level of study and characterization that is beyond the scope of the Survey. Actions currently under way or planned at the site, particularly the groundwater investigation and site remediation activities, will contribute toward meeting this requirement.

Transmittal of Results

The findings of the Environmental Survey of LLNL were shared with the DOE San Francisco Operations Office and the site contractor at the Survey closeout briefing held December 19, 1986. By letter of December 31, 1986, the Operations Office directed the site contractor to develop a response plan to address the Survey findings. LLNL prepared a response plan on March 23, 1987. This plan was given to the EPA Region 9 (San Francisco) Office on May 1, 1987, by the Operations Office. Those findings that involve extended studies and multi-year budget commitments will be the subject of the Environmental Survey Summary Report and DOE-wide prioritization.

Within the Office of Environment, Safety and Health, the Office of Environmental Guidance and Compliance has immediate responsibility for monitoring environmental compliance and the status of LLNL findings. The Office of Environmental Audit will continue to assess the environmental problems through the program of systematic environmental audits that will be initiated toward the conclusion of the DOE Environmental Survey in 1988.

1.0 INTRODUCTION

The purpose of this report is to present the preliminary findings made during the Environmental Survey, December 1 through 19, 1986, at the Department of Energy's (DOE) Lawrence Livermore National Laboratory (LLNL) in Livermore, California. LLNL is operated for DOE by the University of California. As a Preliminary Report, the contents are subject to revision. Revisions based on San Francisco Operations Office review and comments concerning the technical accuracy, the results of the Sampling and Analysis Phase of the Survey, and other information that may come to the Survey team's attention will be incorporated into the Interim Report.

The LLNL Survey is part of the larger, comprehensive DOE Environmental Survey effort announced by Secretary John S. Herrington on September 18, 1985. The purpose of the Environmental Survey is to identify, via a "no fault" baseline Survey of all the Department's major operating facilities, existing environmental problems and areas of environmental risk. The identified problem areas will be prioritized in 1988 on a Department-wide basis in order of importance. The prioritization will enable DOE to more effectively address environmental problems and allocate the resources necessary to correct these problems. Because the Survey is "no fault" and is not an "audit," it is not designed to identify specific, isolated incidents of noncompliance or to analyze environmental management practices. Such incidents and/or management practices are, however, used in the Survey as a means of identifying existing and potential environmental problems and risk.

The LLNL Environmental Survey is being conducted by an interdisciplinary team of environmental specialists headed and managed by the Office of Environment, Safety and Health's Office of Environmental Audit. A complete list of Survey participants and their affiliations is included in Appendix A.

The Survey team focused on all environmental media, using Federal, state, and local environmental statutes and regulations; accepted industry practices; and professional judgment to make the preliminary findings included in this report. The team carried out its activities in accordance with the guidance and protocols in the DOE Environmental Survey Manual. Substantial use of existing information and of interviews with knowledgeable field office and site-contractor personnel accounted for a large part of the on-site effort. A summary of the site-specific Survey activities is presented in Appendix B, and the Survey Plan is presented in Appendix C.

The preliminary Survey findings, in the form of existing or potential environmental problems and risks, are presented in Sections 3.0 and 4.0. Section 3.0 includes those findings that pertain to a specific environmental medium (e.g., air or soil), whereas Section 4.0 includes those that are non-media specific (e.g., waste management, direct radiation, and quality assurance). Because the findings are highly varied in terms of magnitude, risk, and characterization, and consequently require different levels of management attention and response, they are further subdivided into four categories within Sections 3.0 and 4.0.

The criteria for placing a finding into one of the four categories are as follows:

Category I includes only those findings that, based upon the information available to the Team Leader, involve an immediate threat to human life. Findings of this type shall be immediately conveyed to the responsible Environmental Safety and Health personnel at the scene or in control of the facility or location in question for action. Category I findings are those environmental problems wherein the potential risk is highest; the confidence in the finding, based on the information available, is the strongest; and the appropriate response to the finding is the most restrictive in terms of alternatives.

Category II findings encompass one or more of the following situations:

- Multiple or continuing exceedances, past or present, of a health-based environmental standard where there is immediate potential for human population exposure, or a one-time exceedance wherein residual impacts pose an immediate potential for human population exposure.

- Evidence that a health-based environmental standard may be exceeded, as discussed in the preceding situation, within the time frame of the DOE-wide Survey.

- Evidence that the likelihood is high for an unplanned release due to, for example, the condition or design of pollution abatement or monitoring equipment or other management practices.

- Noncompliance with significant regulatory procedures (i.e., those substantive technical regulatory procedures designed to directly or indirectly minimize or prevent risks, such as inadequate monitoring or failure to obtain required permits).

Category II findings include these environmental problems wherein the risk is high but the definition of risk is broader than in Category I. The information available to the Team Leader is adequate to identify the problem but may be insufficient to fully characterize it. Finally, in this category, more discretion is available to the Operations Offices and Program Offices as to the appropriate response; however, the need for that response is such that management should not wait for completion of the entire DOE-wide Survey to respond. Unlike Category I findings, a sufficient, near-term response by the Operations Office may include further characterization prior to any action taken to rectify the situation.

Category III findings encompass one or both of the following criteria:

- The existence of pollutants or hazardous materials in the air, water, groundwater, or soil resulting from DOE operations that pose or may pose a hazard to human health or the environment.

- The existence of conditions at a DOE facility that pose or may pose a hazard to human health or the environment.

Category III findings are those environmental problems for which the broadest definition of risk is used. As in Category II, the information available to the Team Leader may not be sufficient to fully characterize the problem. Under this category, the range of alternatives available for response, and the corresponding time frames for response, are the greatest. Environmental problems included within this category will typically require lengthy investigation and remediation phases, and multi-year budget commitments. These problems will be included in the DOE-wide prioritization effort to ensure that DOE's limited resources are used effectively.

In general, the levels of pollutants or materials that constitute a hazard or potential for hazard are those that exceed some Federal, state, or local regulation for release of, contamination by, or exposure to such pollutants or materials. However, in some cases, the Survey may determine that the presence of some nonregulated material is in a concentration that presents a concern for local populations or the environment and, hence, warrants inclusion as an environmental problem. Likewise, the presence of regulated materials in concentrations below those established by regulatory authorities that present a potential for hazard or concern may be classified as an environmental problem. In general, however, conditions that meet regulatory or other requirements, where such exist, should not present a potential hazard and will not be identified as an environmental problem.

Conditions that pose or may pose a hazard are generally those which are violations of regulations or requirements (e.g., improper storage of hazardous chemicals in unsafe tanks). Such conditions present a potential hazardous threat to human health and the environment and should be identified as an environmental problem. Additionally, potentially hazardous conditions are those in which the likelihood of the occurrence of release is high.

The definition of the term "environmental problem" is broad and flexible to allow for the wide differences among the DOE sites and operations. Therefore, a good deal of professional judgment must be applied to the identification of environmental problems.

Category IV findings include instances of administrative noncompliance and management practices that are indirectly related to environmental risk, but are not appropriate for inclusion in Categories I-III. Such findings can be based upon any level of information available to the Team Leader, including direct observations by the team members. Findings in this category are generally expected to lend themselves to relatively simple, straightforward resolution without further evaluation or analysis. These findings, although not part of the DOE-wide prioritization effort, will be passed along to the Operations Office and Program Office for appropriate action.

Based on the professional judgment of the Team Leader, the findings within categories are arranged in order of relative significance. Comparing the relative significance of one finding to another, either between categories within a section or within categories between sections, is neither appropriate nor valid. The categorization and listing of findings in order of significance within this report is only the first step in a multi-step, iterative process to prioritize DOE's problems.

The next phase of the LLNL Survey is Sampling and Analysis (S&A). Oak Ridge National Laboratory (ORNL), the S&A team for LLNL, will begin taking samples in August 1987. Prior to sampling, an S&A Plan is prepared by DOE and ORNL in accordance with the protocols in the DOE Environmental Survey Manual. The S&A Plan is designed to fill existing data gaps or weaknesses. The results generated by the S&A effort are used to assist the Survey team in further defining the existence and extent of environmental problems and risk identified during the Survey.

An Interim Report is prepared three months after the S&A results are available. The Interim Report incorporates the results of the S&A effort as well as any changes or comments resulting from the review of the Preliminary Report. Based on the S&A results, the preliminary findings and observations made during the on-site Survey may be modified, deleted, or moved within or

between categories. The Interim Report will serve as the site-specific source for information generated by the Survey, and ultimately as the site-specific source of information for the DOE-wide prioritization of environmental problems in the Environmental Survey Summary Report.

It is clear that certain of the findings and observations contained in this report, especially those in Category II, can and should be addressed in the near-term (i.e., prior to the DOE-wide prioritization effort). It is also clear that the findings and observations in this report are highly varied in terms of magnitude, risk, and characterization. Consequently, the priority, magnitude, and timeliness of near-term responses require careful planning to ensure appropriate and effective application. The information in this Preliminary Report, albeit preliminary, will assist the San Francisco Operations Office in the planning of these near-term responses.

2.0 GENERAL SITE INFORMATION

2.1 Site Setting

Lawrence Livermore National Laboratory (LLNL) conducts its activities at two separate sites. The Livermore or Main Site is located 64 km (39 miles) east of San Francisco and 5 km (3 miles) east of the city of Livermore, California, in southern Alameda County. Site 300 is located 30 km (18 miles) southeast of the Main Site in the Diablo Range and straddles San Joaquin and Alameda Counties. These locations are shown in Figure 2-1. Figures 2-2 and 2-3 depict the Main Site and Site 300 layouts respectively.

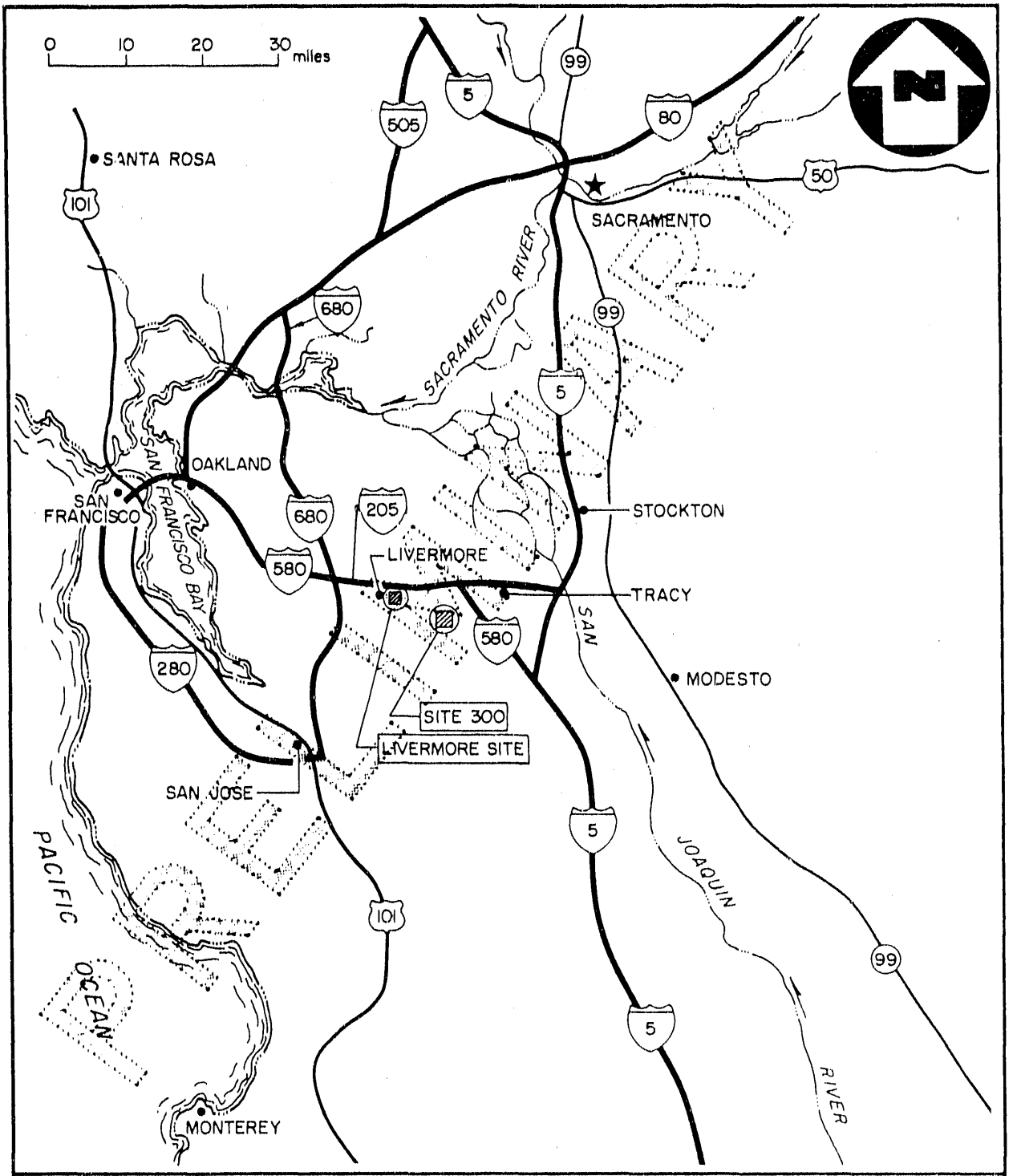
The Main Site comprises an area of approximately 3.3 square kilometers (km^2) (1.3 square miles), whereas Site 300 is about 27 km^2 (11 square miles). Land to the north of the Main Site is zoned industrial and, to the west, land is a high-density urban setting. Sandia National Laboratories Livermore (SNLL) is located to the south. Land to the east is mainly agricultural and pasture. Areas around Site 300 are sparsely populated, and the majority of the land is used for sheep and cattle ranching.

The Main Site overlies a land surface of low relief that slopes gently to the northwest. Two groups of low hills are situated about 1.0 km (0.6 miles) southeast and 3.2 km (2 miles) northwest of the site. Elevations at the site range from 250 meters (675 feet) at the southeast corner to 205 meters (570 feet) at the northwest corner. This region has experienced earthquakes in recent times, which were centered on nearby faults. In general, the soils near the Main Site vary in texture from clayey to sandy loams or mixed gravels.

The surface waters generally drain from the Main Site area to the west by means of arroyos and intermittent streams. Also nearby are the South Bay Aqueduct and the Del Valle Reservoir.

The major water-bearing formations in this area are multilayered systems of an upper, unconfined aquifer overlying a series of semiconfined aquifers. The two most important formations containing aquifers are the surface valley-fill materials and the Livermore Formation. Groundwater flow tends to be to the west or west-northwest.

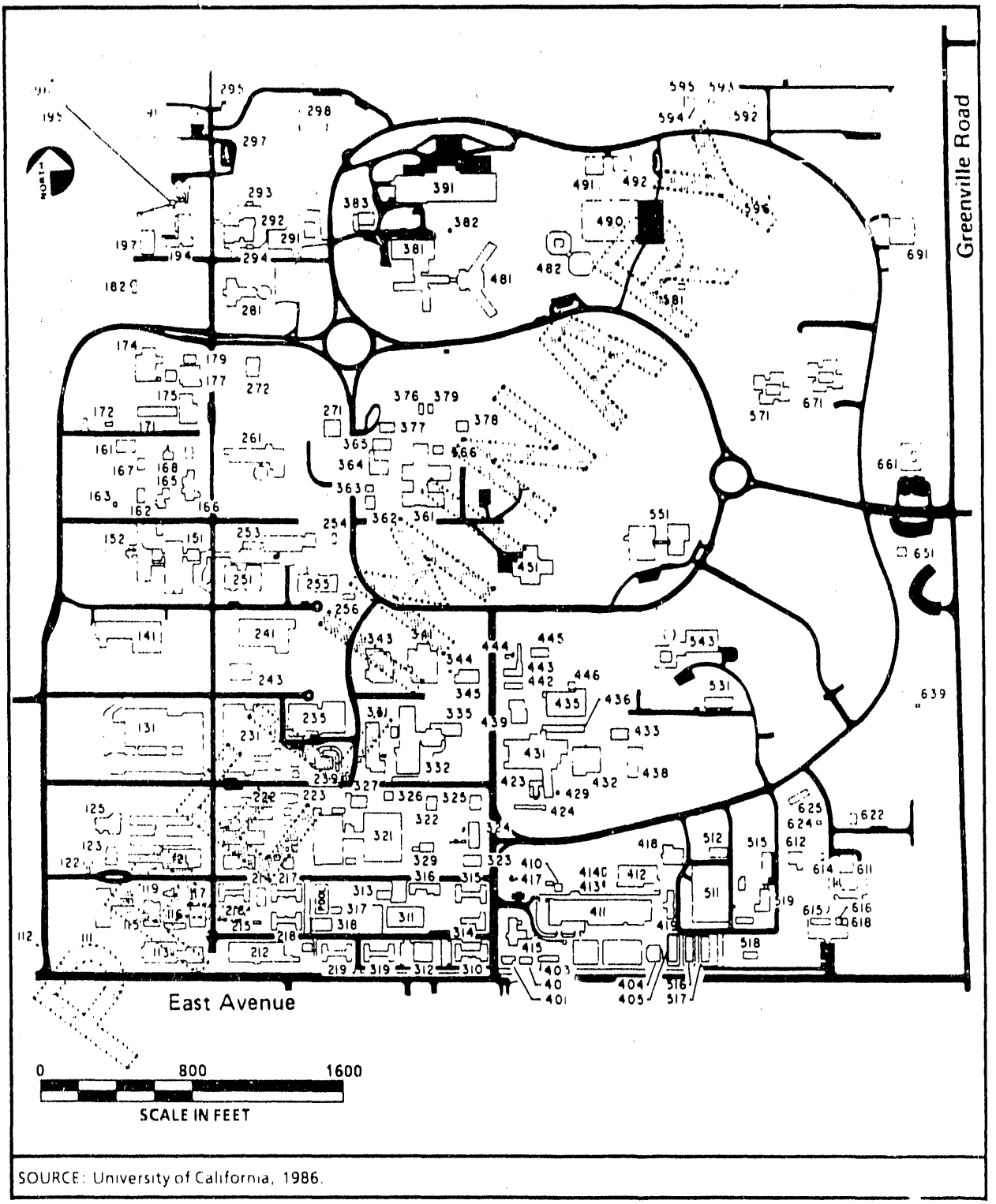
The climate is generally characterized as a Mediterranean type. Summers are typically warm and dry and winters are mild and moderately wet. Rainfall occurs mostly from October to April and averages about 35.6 centimeters (14 inches).



SOURCE: University of California, 1986

FIGURE 2-1

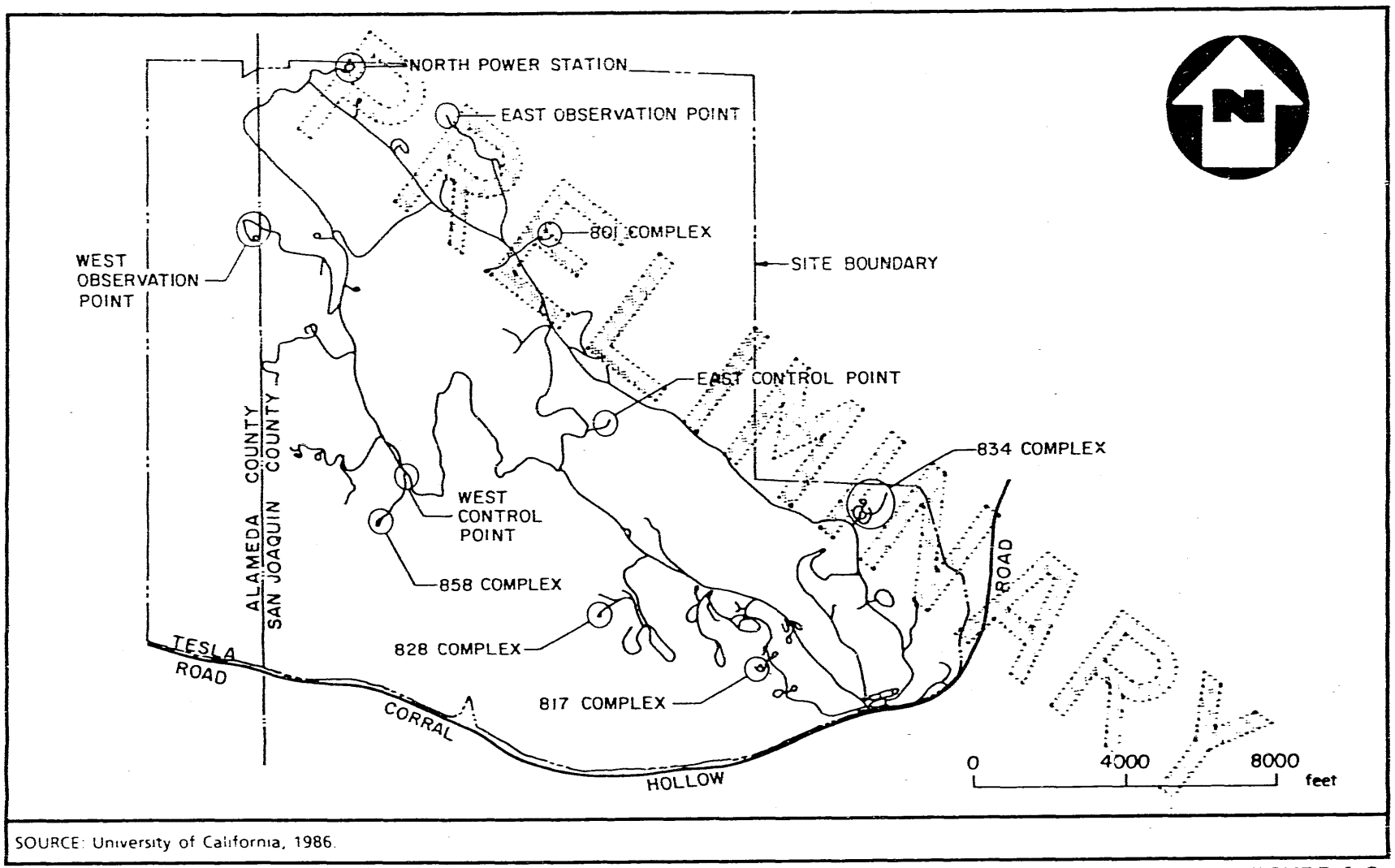
LOCATION OF MAIN SITE AND SITE 300
LLNL – LIVERMORE, CALIFORNIA



SOURCE: University of California, 1986.

FIGURE 2-2

MAIN SITE LAYOUT
LLNL – LIVERMORE, CALIFORNIA



SOURCE: University of California, 1986.

FIGURE 2-3

SITE 300 LAYOUT
LLNL – LIVERMORE, CALIFORNIA

Predominant winds in the summers are from the west and southwest, while in the winter, they are mixed, with a high percentage coming from the northeast and north. Wind speeds are most frequently in the range of 5 to 7 meters per second (11 to 16 miles per hour).

Site 300 topography consists of southeasterly-trending ridges and canyons of moderate to high relief. Elevations vary from 150 to 520 meters (500 to 1,700 feet). Three faults are present in this area but are not active: Carnegie; Elk Ravine; and a minor, unnamed fault. The soils are mostly a calcium carbonate type and contain various clay formations.

Surface-water drainage at Site 300 is mostly from intermittent streams that flow during the wet winter months. Groundwater at Site 300 is found in the two major water-bearing zones: an upper aquifer in the sandstones and conglomerates and a deeper, confined aquifer in a lower sandstone. In addition, several localized, perched aquifers have been identified.

The climate at Site 300 is also classified as a Mediterranean type. Summers are typically warm and dry, and the winters are mild and slightly wet. The average precipitation is 25 cm. (10 inches), which usually falls from October to April.

2.2 Overview of Major Site Operations

Main Site

Prior to World War II, the land now occupied by LLNL and SNLL was used for light agriculture and cattle grazing. In March of 1942, the Navy purchased the property as a site for establishing a training base, subsequently known as the Livermore Naval Air Station.

LLNL is a multiprogram laboratory that undertakes multidisciplinary fundamental and applied research and development in a broad range of scientific fields. The primary program deals with the design of nuclear weapons (Defense Systems). More recently, programs have been developing in the areas of Laser Research, Magnetic Fusion Energy, Beam Research, Biomedical and Environmental Research, and Energy and Resources.

The Defense Systems Program is divided into four areas: Nuclear Design, Military Applications, Nuclear Testing, and Weaponization. In the Nuclear Design Program, projects include developing specific nuclear explosives for proposed military purposes, and research on the x-ray laser. In the Military Applications Program, studies are under way on nuclear design alternatives and related

issues. The Nuclear Testing Program is involved in the development of new and advanced diagnostic techniques for nuclear explosive experiments. The Weaponization Program is responsible for completion of material development, design of military weapons, setup of manufacturing processes, and retirement of obsolete weapons.

Laser research includes development of novel technologies in addition to investigations of the chemistry and physics associated with these studies. The main programs are Laser Isotope Separation (LIS) and Inertial Confinement Fusion (ICF). The LIS Program deals with enrichment of uranium fuels, purification of special nuclear materials, and separation of important isotopes. The ICF Program supports research in the areas of fusion energy and weapons physics.

In the Magnetic Fusion Energy (MFE) Program, LLNL plays the principal role in the nation in developing a magnetic mirror fusion reactor and in supporting the MFE computing effort nationwide.

The Beam Research Program is dedicated to studying the utility of intense beams of high-energy electrons for defense weapons.

The Biomedical and Environmental Research (BER) program has three divisions: Biomedical Sciences, which studies the mutagenic, carcinogenic, and biological effects of energy effluents; Environmental Sciences, which studies the ecological effects of contaminants; and Atmospheric and Geophysical Sciences, which models pollutants in the atmosphere.

Energy and Resources conducts field experiments related to surface and internal earth processes. The major efforts are in the areas of underground coal gasification, nuclear waste storage, and oil shale utilization.

Site 300

Prior land use at Site 300 was limited to sheep and cattle grazing because of the rugged terrain. Most of the area at Site 300 is characterized by steep, smooth hills and deep ravines, with elevations ranging from 150 meters (492 feet) at the southwest corner along the Corral Hollow valley floor to more than 500 meters (1,640 feet) in the northwest sector.

There are seven major activity areas at Site 300 that support the high explosives (HE) testing program of LLNL. These include general services, HE formulation and manufacture, HE processing, dynamic testing, environmental testing, non-HE testing, and outside testing groups.

The General Services Area (GSA) consists of nine buildings that house all the administrative and support functions. The HE formulation and manufacturing is carried out in six major buildings and five support buildings and associated magazines. The HE processing consists of eight major buildings, 29 support buildings, and magazines. The dynamic testing takes place at seven HE firing sites (bunkers), three explosives storage magazines, and 17 support buildings. Dynamic and static environmental testing is carried out in 10 buildings. Non-HE and special testing is carried out at Site 300 whenever an isolation or special requirement situation is met at LLNL. Occasionally, space is provided to outside groups that require special consideration.

2.3 State/Federal Concerns

Representatives of LLNL, Sandia National Laboratories Livermore (SNLL), DOE San Francisco Operations and Albuquerque Operations Offices, and the Survey team met with 10 representatives of state and local environmental agencies on October 22, 1986, at the San Francisco Operations Office to discuss agency concerns at both laboratories. Attendees are shown in Appendix B. The Environmental Protection Agency (EPA) was not able to send a representative.

The Survey Team Leader described all aspects of the DOE Survey. Messrs. Ragaini and Hoffman presented status reports on environmental matters at LLNL, and Mr. T. Devlin presented a similar status report on SNLL.

The questions from the attendees were general in nature; no major issues, environmental or otherwise, were raised. The attendees expressed interest in receiving a copy of the Environmental Survey Manual and Interim Survey Report, and there were a few questions about the prioritization system and the money available for corrective action. Although the state expressed interest in the sampling aspects of the Survey, there were no inquiries on the opportunity to participate in the Survey in any way. The meeting lasted approximately 45 minutes.

3.0 MEDIA-SPECIFIC SURVEY FINDINGS

The sections in this chapter pertain to existing or potential environmental problems in the air, soil, water, and groundwater media. Each section is media specific and includes a summary of the available background environmental information, a description of the pollution sources and controls, a review of the environmental monitoring program, and a categorization and explanation of the environmental problems found by the Survey team related to each medium.

3.1 Air

3.1.1 Background Environmental Information

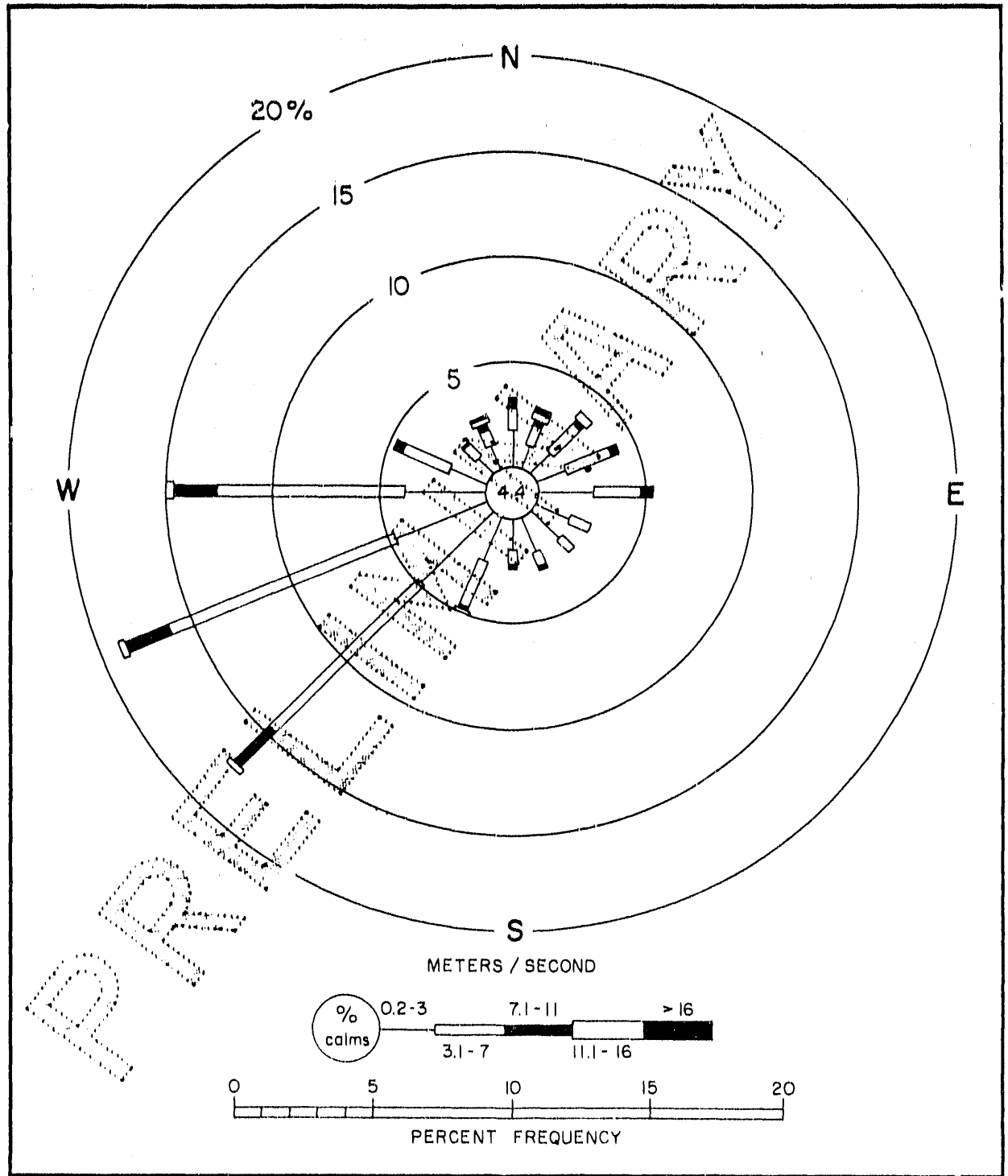
Measurements by the Bay Area Air Quality Management District (BAAQMD) at a station on Old First Street in Livermore and by the EPA at other stations, have determined that the Livermore Valley region has achieved all ambient standards except those for ozone. Attainment of the ozone (BAAQMD, 1985-1986) standard for the Livermore Valley region is dependent upon controlling releases in the San Francisco Bay region as well as the Livermore Valley region because of the regional wind pattern as presented in Figure 3-1 and Table 3-1 (University of California, 1986). The data was obtained from LLNL's meteorological tower.

At the LLNL Main Site, the predominant winds during the summer dry season are from the southwest and average between 3-7 meters per second (m/s). During the wet season, northeast and north-northeast winds, which are associated with post-frontal anti-cyclonic flow, are also common and average between 2 and 10 m/s.

Strong, persistent winds are characteristic of the Site 300 area. Marine air flows through the canyons of the site into Corral Hollow and the San Joaquin Valley beyond, producing strong afternoon and evening winds with gusts up to 49 m/s. Directional distribution of winds at Site 300 is approximately the same as that of the LLNL Main Site.

Ambient air quality at Site 300 is somewhat better than that described for the LLNL Main Site. The region is sparsely populated, so man-made pollutants are not generated in significant quantities. Furthermore, the winds are stronger and more persistent than in the Livermore Valley.

The Livermore Valley rarely experiences severe weather. The greatest recorded daily rainfall is about 90 millimeters (mm). Thunderstorms occur less than 5 days per year and are not intense. Hail occurs



SOURCE: University of California, 1986

FIGURE 3-1

ANNUAL WIND ROSE
LLNL – LIVERMORE, CALIFORNIA

TABLE 3-1

SUMMARY OF TYPICAL WIND FREQUENCY TABLES BY STABILITY CATEGORIES[a] LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

DRY SEASON

	Stability Category[b]					
	A	B	C	D	E	F
Most Frequent Direction	WSW, W	WSW, W	WSW, W	SW, WSW	SW, WSW	SW
Frequency (%)	~34	~48	~55	~62	~57	29
Speed (m/s)	3	3	4	5	5	5
Least Frequent Direction	ESE, SE, SSE	SE, SSE	ESE, SE	SE, NW	SE	SSE
Frequency (%)	5	~3	~2	~2	<1	0
Speed (m/s)	2	1-2	2	3-4	4	3
Highest Ave. Speed (m/s)	3	4	5	8	10	8
Direction	WNW, NW	WNW	N	NNW	NNW	NNW
Frequency	7-9	7	4	2	3	10
Lowest Ave. Speed (m/s)	2	2	2	2	2	0
Direction	S	SSE	SE	S	E	SSE
Frequency	7	2	1	1	1	0

WET SEASON

Most Frequent Direction	N	E	WSW, W	WSW, W	WSW, W	E
Frequency (%)	9	11	~25	~28	~32	15
Speed (m/s)	2	3	4	5	5-6	6
Least Frequent Direction	ESE	SSW	N	NNW	NNW	NW
Frequency (%)	3	4	2	2	1	<1
Speed (m/s)	2	3	4	3	4	2
Highest Ave. Speed (m/s)	3	~3	4	5	7	12
Direction	NW	WSW, W, WNW	WSW	WSW	NNE	NNE
Frequency	5	~28	12	14	4	9
Lowest Ave. Speed (m/s)	2	2	3	3	3	2
Direction	ESE	SE, SSE	SSW, NNW	SSE	ESE, SE	NNW
Frequency (%)	3	~9	3-4	2	8	1

Source: DOE, 1982.

a Values rounded to nearest whole number

b A = Extremely unstable conditions; B = Moderately stable conditions; C = Slightly unstable conditions; D = Neutral conditions (applicable to heavy overcast, day or night); E = Slightly stable conditions; F = Moderately stable conditions.

even less frequently. Strong winds with gusts to about 30 m/s occur a few times each fall and winter, usually following the passage of a low-pressure system.

In one study, the tornado recurrence interval was estimated to be about 1 per 292,000 years, or 3×10^{-6} per year. In a more recent study, it was indicated that extreme winds pose a more significant threat of structural damage in the central California area than do tornados.

Another consideration is the formation of smog in the Livermore Valley. Because of its location, surrounded by hills, it has more days of high photochemical smog (high ozone concentrations) than most bay area locations with air pollution sampling stations. During 1986, the Federal ozone standard (hourly average) of 0.12 parts per million was exceeded on 3 days (BAAQMD, 1987). It has been estimated that about one-third of the Valley smog is imported from upwind metropolitan bay areas (University of California, 1986).

The LLNL Main Site also maintains a meteorological program to provide meteorological parameters that may be used to estimate potential doses to individuals in the event of an accidental release of hazardous or radioactive materials into the atmosphere. This is known as the Atmospheric Release Advisory Capability (ARAC) service. It has three main functions: (1) to provide support to designated DOE facilities during an accidental release of radionuclides; (2) to support the DOE Emergency Response Team in the event of potential or actual releases of radionuclides; and (3) to provide the Federal Aviation Administration (FAA) with dose assessments whenever aircraft could possibly intercept nuclear debris clouds from foreign atmospheric nuclear tests.

The ARAC central facility receives meteorological data from the Air Force Global Weather Central (AFGWC). In an accident, the meteorological data collected nearest the accident site are used to predict cloud trajectories, concentrations, and population doses. At present, ARAC has two-way communications with AFGWC, the LLNL computer center, four DOE installations, the DOE Emergency Response Team, and the FAA.

3.1.2 General Description of Pollution Sources and Controls

During 1986, LLNL was issued 166 permits to operate equipment at the Main Site and Site 300. The permits allow the operation of 99 boilers for space heat, 26 degreasers, two gasoline pump islands, one gasoline storage facility, five paint-spray booths, 11 machine shop operations, 7 diesel-fuel storage tanks, and 15 miscellaneous items. The Main Site air-pollution sources are regulated by the BAAQMD, and Site 300 sources are regulated by the San Joaquin County Air Pollution Control

District. Primary pollution sources, associated contaminants, and controls in place are discussed below.

LLNL Main Site

Radionuclide airborne emission sources contributing the most to public dose during the period 1981-1986 and controls used to limit public exposure are summarized in Tables 3-2 and 3-3. (A more complete discussion of dose assessment is provided in Section 4.3.2.) Generally, at both the Main Site and at Site 300, High Efficiency Particulate Air (HEPA) filters are used to remove particulate radionuclide materials. Catalytic oxidation-molecular sieve collection units are employed for removal of tritium, the major gaseous radionuclide. Other gaseous contaminants with very short half-lives (2-10 minutes), including Oxygen-15 (^{15}O) and Nitrogen-13 (^{13}N), are released essentially without control, but with continuous monitoring.

At the Main Site, HEPA filters are used in exhaust air systems to assure that radioactive or hazardous particulate matter is not released to the environment. All facilities handling plutonium, uranium, and beryllium are equipped with these filters. In buildings such as Nuclear Chemistry Operations and the Plutonium Facility, exhaust air from the glove boxes is passed through double HEPA filters (two stages of filters in series). Following this filtration, the air enters a manifold system and is HEPA-filtered a third time before being exhausted to the outside atmosphere.

LLNL's inventory indicates that 957 HEPA filters are in use (some intermittently). LLNL conducts extensive research into use, durability, and testing of HEPA filters. Before being installed, every HEPA filter is tested for efficiency. After installation, the HEPA filters are tested in-place to assure that filter damage has not occurred during installation and that the filters are properly gasketed. Filters are re-tested annually. Spent filters are disposed of as solid radioactive waste.

Building 331, Tritium Research, is the largest airborne radionuclide emissions source at LLNL, emitting 90 percent of all tritium releases to the atmosphere and 83 percent of the total curies contributing to the public dose in 1986. Primary control technology employed includes catalytic oxidation followed by molecular sieve trapping. Building ventilation is designed to maintain airflow toward zones of high hazard. A major upgrade of the building ventilation system is under way and will provide for capturing and retaining small quantities of tritium that are released during routine operations.

TABLE 3-2

RADIOACTIVE AIRBORNE EFFLUENT RELEASES FROM LAWRENCE LIVERMORE NATIONAL LABORATORY, LIVERMORE, CALIFORNIA, FROM 1981 THROUGH 1986 (Curies)

Year	^{3}H	$^{13}N + ^{15}O$
1981	2,620	344
1982	2,014	584
1983	3,245	855
1984	7,354	51
1985	2,204	520
1986	1,254	113

Source: Holland et al., 1987

TABLE 3-3

RADIONUCLIDE EMISSION SOURCES CONTRIBUTING TO PUBLIC DOSE
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Nuclide	Bldg. No.	Facility	Curies	Primary Controls
^{3}H	331	Tritium Facility	1,128	Partial catalytic oxidations and molecular sieve trapping
	212	Insulating Core Accelerator	15	Administrative procedures
	292	Rotating Target Neutron Source	106	Administrative procedures
	292	Incinerator	5.1	Administrative procedures
^{13}N, ^{15}O	194	Linear Accelerator	90	None for gaseous emissions
	865	ATA[a] (Site 300)	23	None for gaseous emissions

Source: Holland et al., 1987.

[a] Advanced Test Accelerator

Buildings 292 and 212 also release tritium and together account for about 10 percent of all LLNL tritium releases to the atmosphere and 9 percent of the total curies contributing to the public dose in 1986. Primary control technology is the same as Building 331, but on a smaller scale except for ventilation design and upgrades.

The remaining airborne radionuclide emissions contributing to public dose include ^{13}N and ^{15}O from the Linear Accelerator operated in Building 194 on the Main Site and the Advanced Test Accelerator (ATA) operated in Building 865 at Site 300. Both operations produce ^{13}N and ^{15}O by gamma-neutron (γ, n) reactions on these elements in air. These two operations account for all of the measurable ^{13}N and ^{15}O and approximately 8 percent of the total airborne curies contributing to public dose in 1986. Because both of these radionuclides have very short half-lives (^{15}O = 2 minutes and ^{13}N = 10 minutes), and because of the low curie releases, rapid radioactive decay, and intermittent operation of the sources, no emissions control equipment is needed. Activated dust particles are removed by HEPA filtration units in both operations.

Other radionuclide emissions, not considered to be significant public dose contributors, are summarized on Table 3-4. Criteria for the decision that these sources should not be included in dose assessment calculations centered on detectability of emissions. Most radionuclide air emission sources are continuously monitored or sampled. Because of control technology employed, nondetectable results are frequently obtained; thus the need for dose assessment calculations is infrequent. Brief descriptions of two of the representative facilities are discussed below.

Airborne emissions generated in Building 251 by work performed in the various glove boxes and hot cells consist of alpha-contaminated particulates. Air from the glove boxes passes through double HEPA filters at the glove box and then is exhausted through manifolds to stacks on the rooftop, where the air is again filtered through HEPA filters. Continuous particulate sampling is done on all Building 251 exhausts. Gaseous waste from the several hot cells is treated similarly, except that continuous monitoring is provided at the discharge point to provide gross release detection capability. Detection is provided by on-line proportional detectors for alpha contaminants and sodium iodide detectors for gamma emitters. Room air is continuously sampled for particulate contamination and is discharged through exhaust ducts to the roof, where it is filtered through double HEPA filters.

TABLE 3-4

RADIONUCLIDE EMISSIONS NOT CONTRIBUTING TO PUBLIC DOSE*
LAWRENCE LIVERMORE NATIONAL LABORATORY-LIVERMORE, CALIFORNIA

Building No.	Facility	Nuclides
175	Mass Uranium Enrichment Facility	Uranium
231	Controlled Material Vault	Uranium Plutonium
251	Heavy Element Facility	Uranium Plutonium Curium and other transuranics
332	Plutonium Research	Plutonium Uranium
419	Decontamination	Tritium Uranium Americium Plutonium
490	Special Isotope Facility	Uranium
514	Waste Management Facility	Low-level Wastes
612	Waste Management Facility	Various nuclides and Tritium and TRU
624[a]	Waste Management Facility	Various nuclides and Tritium and TRU

*Source: DOE Survey team.

[a] Impact of radionuclides emitted on pubic dose under investigation.

In Building 332, alpha-contaminated particulate emissions are generated by operations in the glove boxes used for continuing processes and experimental work. The glove box exhaust is passed through double HEPA filters (in series). After passing into a manifold, the air is again passed through a HEPA filter before being discharged to the atmosphere. All exhaust air is continuously monitored for particulate radioactivity. Room air exhaust is filtered through double HEPA filters, and temperature-activated water spray nozzles are installed (to prevent heat damage to the filters) in room exhaust ducts.

Various operations at the LLNL Main Site are sources for nonradioactive air emission. These sources are also regulated by the BAAQMD. Estimates made by the BAAQMD of emissions from LLNL Main Site (University of California, 1986) are as follows:

Particulate Matter	9 lb/day
Volatile Organic Compounds	114 lb/day
Oxides of Nitrogen	163 lb/day
Sulfur Dioxide	1 lb/day
Carbon Monoxide	24 lb/day

The BAAQMD considers the LLNL Main Site to be a major stationary source because its total emissions of volatile organic compounds (VOCs) and oxides of nitrogen exceed 274 pounds per day (50 tons per year, a BAAQMD administrative criterion). The above total for VOCs includes exempt solvents (those not involved in smog formation), such as perchloroethylene, methylene chloride, trichloroethane, and freons. These total about 45 pounds per day so that the remainder of the so-called reactive organics total about 69 pounds per day. Thus, LLNL is only marginally a major stationary source. The BAAQMD also estimated that permitted sources emit 146 gallons of fully halogenated hydrocarbons per year.

The Federal ozone standard (hourly average) was exceeded on 3 days in 1986 (BAAQMD, 1987). However, since ozone is produced principally from reactions involving the constituents of automobile exhaust, it can safely be stated that present emission levels of air pollutants from the Main Site do not cause any violations of state or Federal ambient-air-quality standards.

Site 300

The sources of routine releases at Site 300 are depleted uranium from firing table experiments and measurable quantities of ^{13}N and ^{15}O from Advanced Test Accelerator (ATA) operations. Substantial

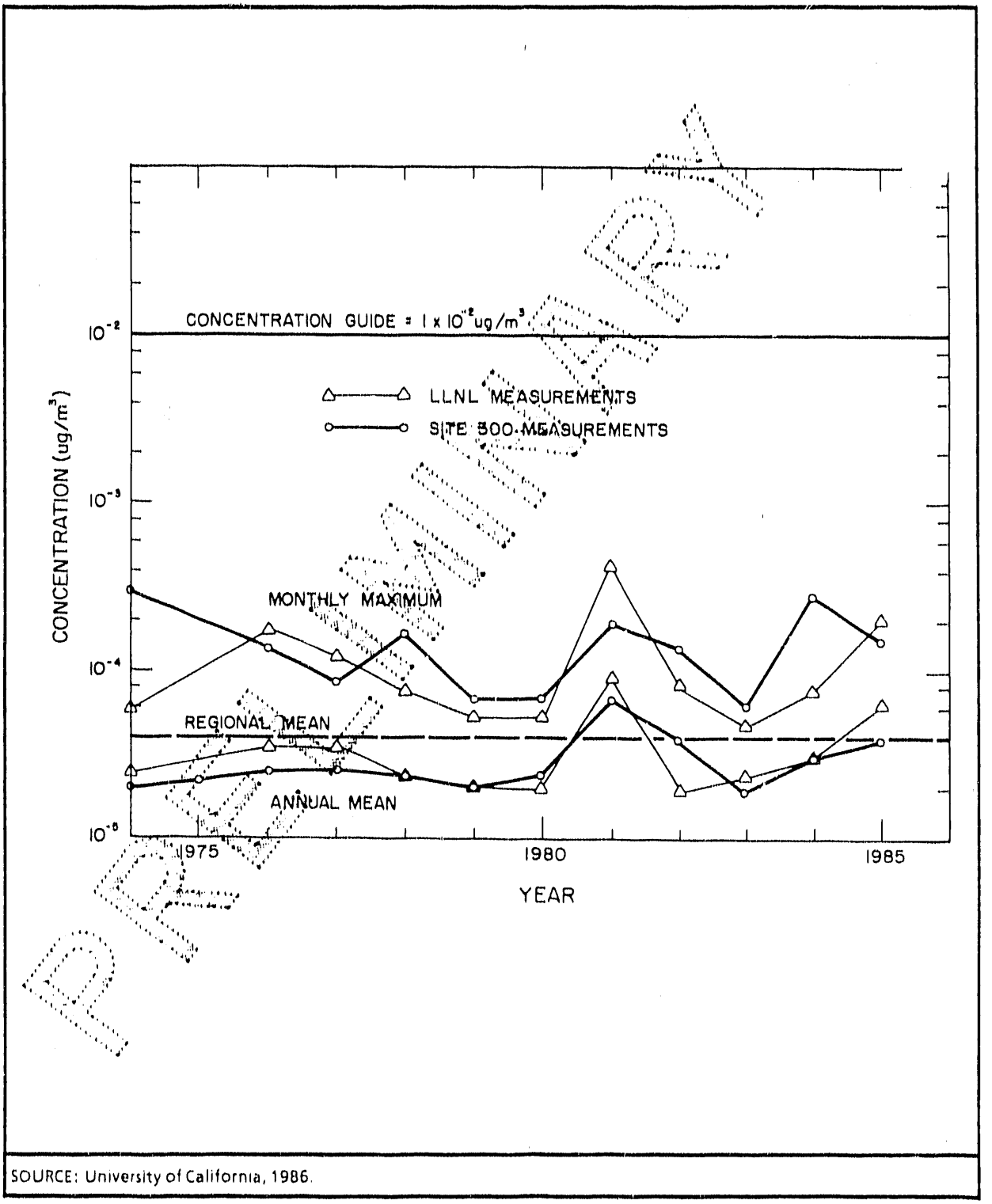
amounts of depleted uranium (U) are used at Site 300. The amount expended in 1985 was estimated to be 350 kg (770 pounds) (University of California, 1986). Air samples collected at the Site 300 perimeter in 1986 showed ratios of ^{235}U to ^{238}U, slightly below the natural ratio of 0.0071. Monthly averages during 1986 ranged from 0.0047 to 0.0069, with an annual average of 0.0064 (which indicates a mixture containing about 13% depleted uranium). However, values of both ^{238}U and ^{235}U are less than 1 percent of derived concentration guidelines.

The principal source of routine releases of nonradioactive hazardous contaminants from Site 300 is the detonation and burning of explosives. The 1985 annual expenditure of beryllium from high explosives (HE) testing activities at Site 300 was approximately 2.4 pounds (1.1 kg) (University of California, 1986). Yearly analyses of soil indicate that beryllium contamination is limited to areas immediately adjacent to the firing table bunkers. HE testing is not believed to contribute significantly to the levels of beryllium in the soil or the air outside of the areas adjacent to the firing table bunkers.

Figure 3-2 shows the annual mean and monthly maximum for beryllium levels measured at the Main Site and at Site 300. The annual airborne beryllium concentrations at Site 300 average less than 1 percent of the ambient air concentration limit established by BAAQMD and the San Joaquin County Air Pollution Control District, and can be accounted for by resuspension of surface soil containing naturally occurring beryllium (Holland, et al., 1987).

Because of the high temperatures and pressures generated during detonations, only simple gas molecules are formed. These molecules are nitrogen, water, carbon dioxide, hydrogen, ammonia, solid carbon, and less than one volume percent of other simple gases. With the exception of carbon, these products are gases that would not be found in the firing-table gravel.

In addition to the atmospheric releases from combustion and detonation activities discussed above, small quantities of solvents and other volatile organics, including degreasing agents, are released to the atmosphere from routine operations at the site. These materials are utilized in general cleaning and equipment maintenance, primarily in the General Services Area (GSA).



SOURCE: University of California, 1986.

FIGURE 3-2

BERYLLIUM IN AIR LEVELS AT MAIN SITE AND SITE 300
LLNL – LIVERMORE, CALIFORNIA

Similar to LLNL Main Site, Site 300 makes extensive use of HEPA filters. Of the total of 957 filters listed in LLNL's inventory, 102 are used at Site 300 for control of particulates (mostly depleted uranium).

Miscellaneous Areas

Toxic gases are used in limited amounts in some Main Site shops and laboratories. Gases, such as fluorine and others identified in Table 3-5, are typically contained in small canisters or in diluted concentrations (less than 1 percent by volume) in larger canisters. These gases are used in microchip processing (Building 131), and chemistry, physics, and laser research.

3.1.3 Environmental Monitoring Program

The LLNL ambient air monitoring program uses analytical techniques capable of detecting the activity of numerous radionuclides in the environment at natural background levels. At present, the radionuclides of concern include the transuranic elements, products of neutron activation, fission products, uranium, plutonium, and tritium.

Particulate air sampling is conducted with 26 continuously operating air sampling stations strategically located around the Main Site and Site 300. The six samplers on the LLNL perimeter (Figure 3-3), the nine samplers at Site 300 (Figure 3-4) and seven of the eleven off-site samplers (Figure 3-5) use 5.2×10^{-2} m^2 Whatman 41 cellulose filters. These samplers are operated at average flow rates of 400 to 700 liters/minute. The filters are cut in half; one half of each filter is retained for beryllium analysis and one-half is used for analyses discussed below. An easily dissolved filter and a low trace-metal background are required for these analyses. Whatman 41 represents a balance between such requirements and particulate-collection efficiency (Lindeken et al., 1963). The remaining particulate samplers in the Livermore Valley use 8.11×10^{-3} m^2 glass-fiber filters (Flanders F-700) and are operated at a flow rate of 85 liters/minute. All air filters are changed weekly.

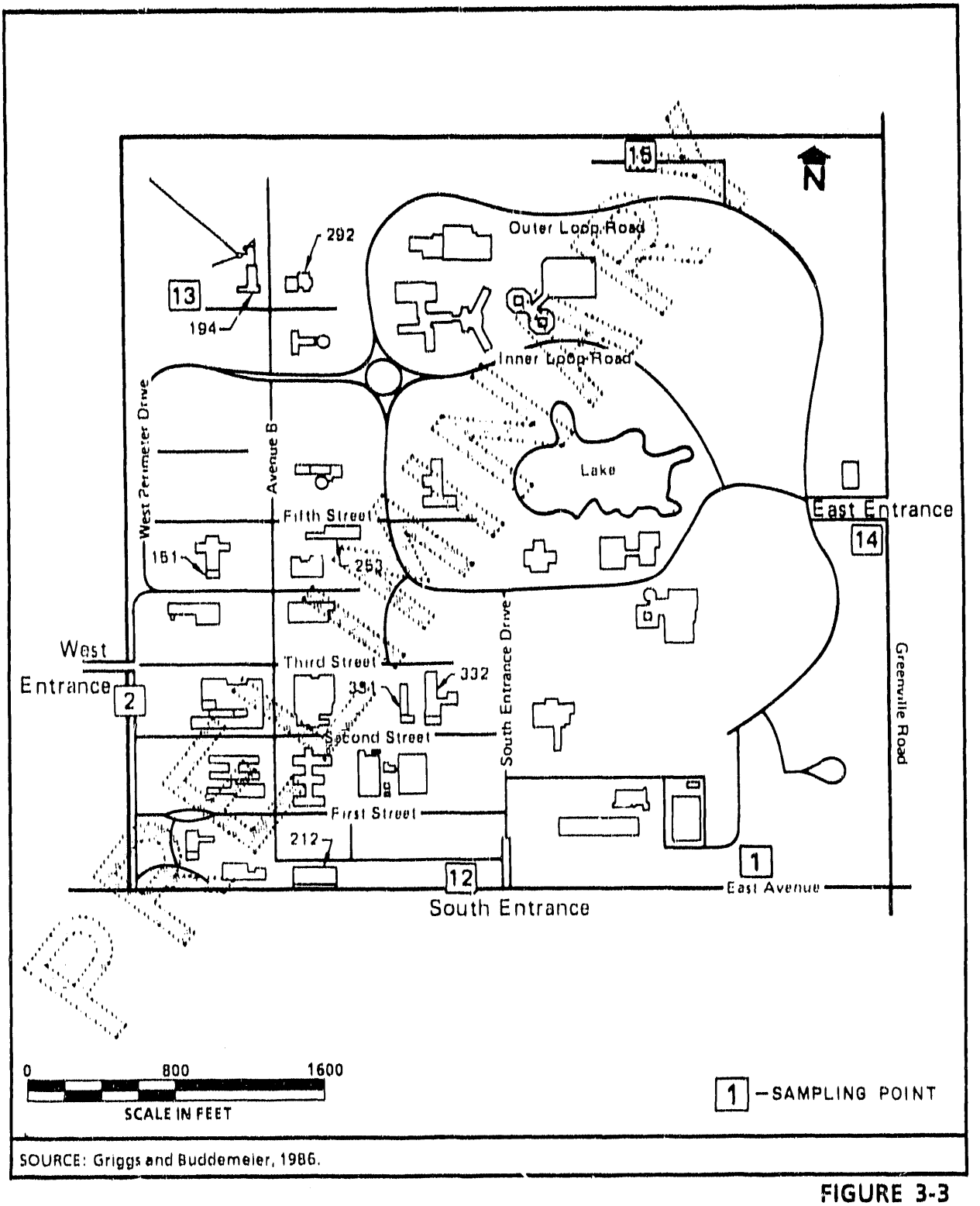
After a 4-day delay for decay of the radon-thoron daughters, gross alpha and beta activities on the filters are determined with an automatic gas-flow proportional counter. Monthly composites of LLNL perimeter and Site 300 filters are also counted for gamma-emitting radionuclides using low-background germanium-lithium detectors. Following gamma counting, the LLNL perimeter filters from individual locations and the Site 300 composites are analyzed for the presence of

TABLE 3-5

TYPICAL TOXIC GASES IN USE
LAWRENCE LIVERMORE NATIONAL LABORATORY
LIVERMORE, CALIFORNIA

Gas	Usual Maximum Amount in One Location (Cubic Feet)
Ammonia	200
Arsine	2
Boron trifluoride	10
Carbon monoxide	200
Chlorine	200
Diborane	10
Dimethylamine	1
Fluorine	100
Hydrogen chloride	25
Hydrogen fluoride	100
Hydrogen sulfide	25
Nitrogen dioxide	200
Phosgene	10
Phosphine	10
Silane	200
Sulfur dioxide	200

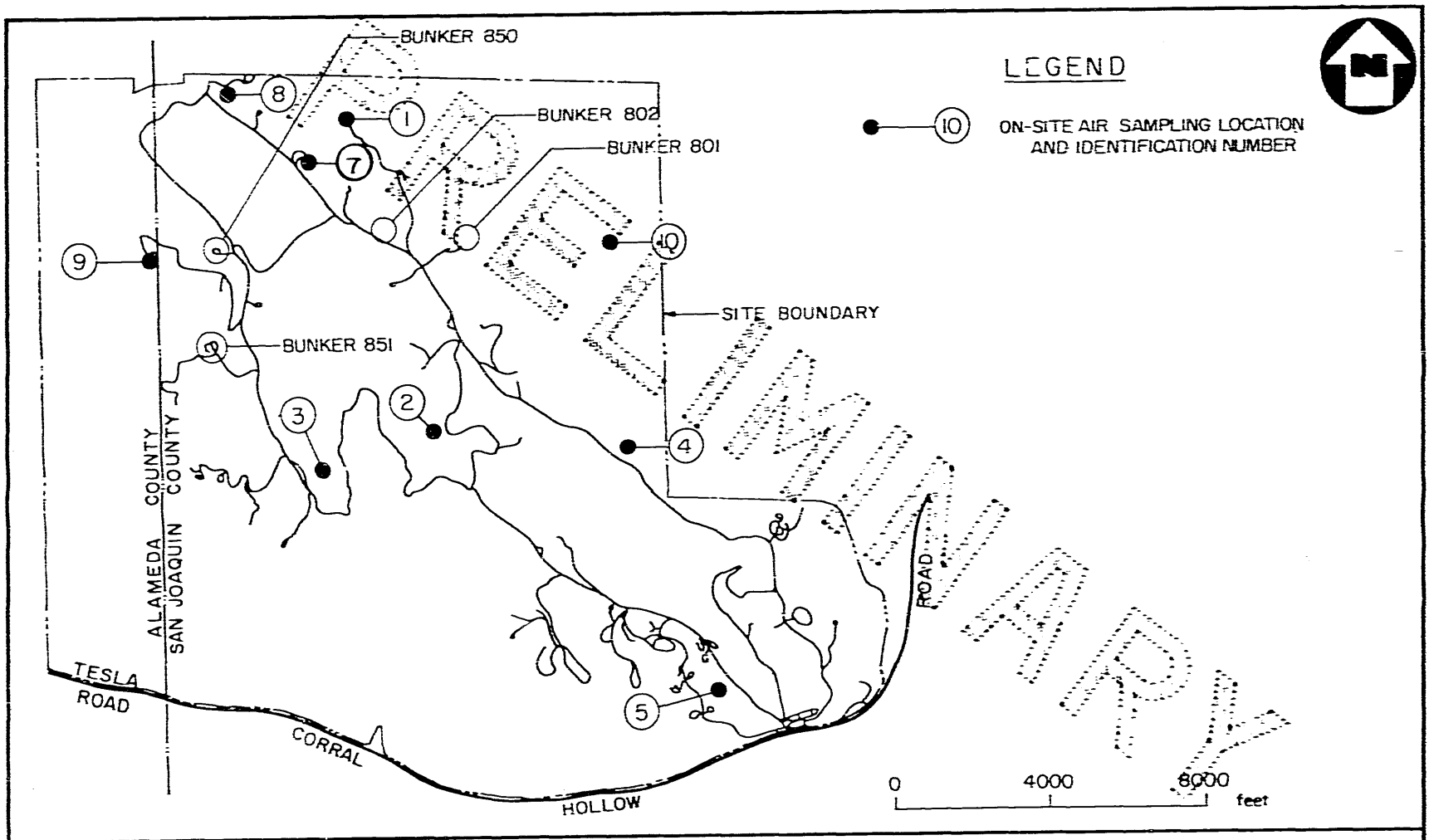
Source: University of California, 1986.



SOURCE: Griggs and Buddemeier, 1986.

FIGURE 3-3

MAIN SITE PERIMETER AIR-SAMPLING LOCATIONS
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Griggs and Buddemeier, 1986

FIGURE 3-4

SITE 300 ON-SITE AIR SAMPLING LOCATIONS
LLNL – LIVERMORE, CALIFORNIA

SOURCE: Griggs and Buddemeier, 1986

FIGURE 3-5

LIVERMORE VALLEY AIR-SAMPLING LOCATIONS
LLNL – LIVERMORE, CALIFORNIA*

Plutonium-239 (^{239}Pu), ^{235}U, and ^{238}U. Selected off-site samples from the Livermore Valley and the City of Tracy are analyzed for ^{239}Pu.

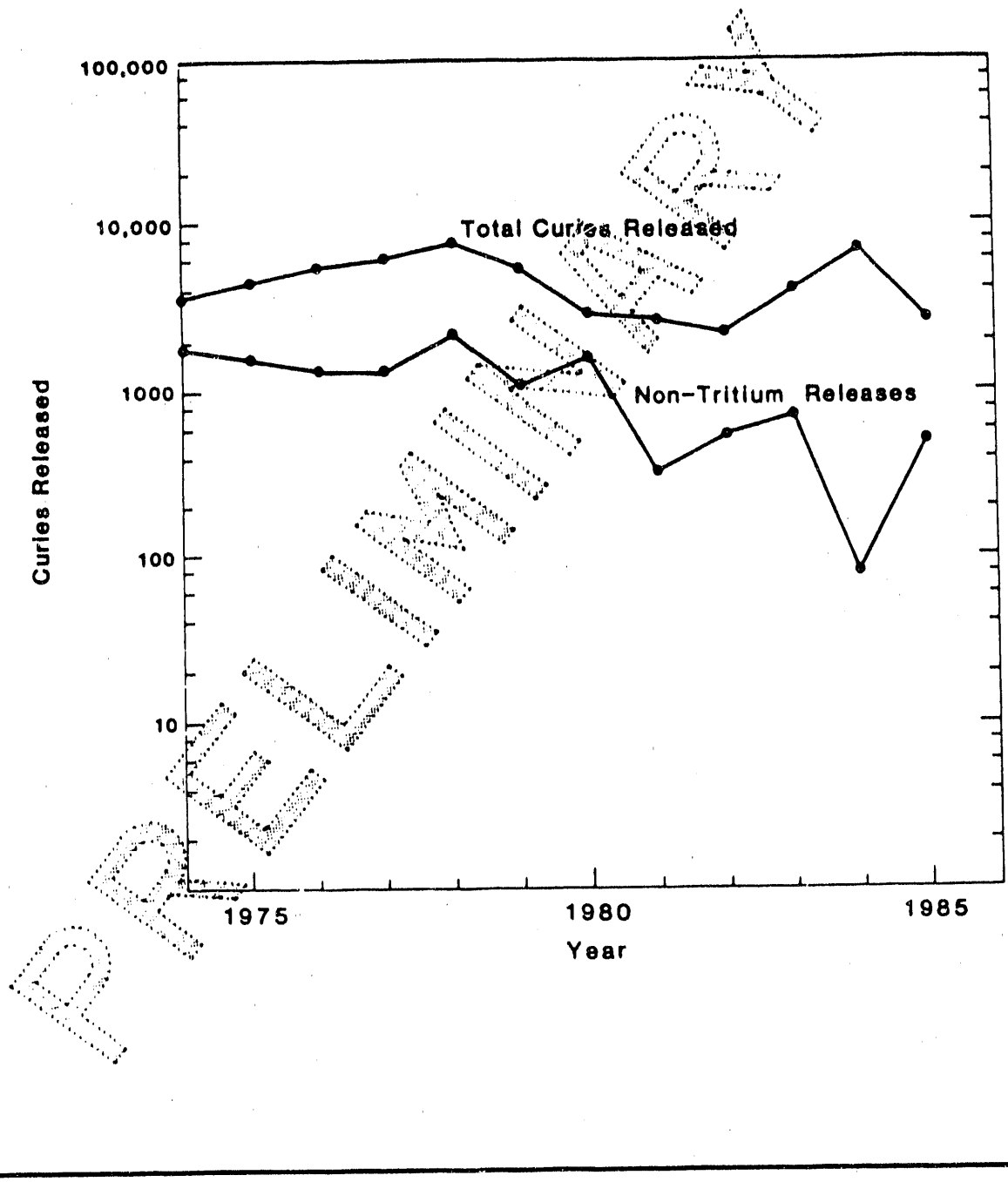
Concentrations of airborne tritiated water (HTO) are determined for each of the LLNL perimeter air-sampling locations, off-site locations S-1 and S-2, and four additional Livermore Valley locations (4, 7, 9, and 17). Water vapor is collected on silica-gel samplers operated at a flow rate of about 0.7 liters/minute for a 2-week period. The collected water is distilled at 100-125°C, and the HTO is measured by liquid scintillation counting.

Atmospheric releases of radioactivity over the period of 1974 to 1985 are summarized in Figure 3-6. Noting that the scale for curies released is logarithmic, a sizable proportion of these emissions have been tritium releases. Figure 3-7 shows tritium concentrations over the same period of time compared with the DOE concentration guide and the U.S. mean. As can be seen, emissions are well below concentration guides and have also, as an annual mean, been below the U.S. (nationwide) mean since 1978.

The annual trends for the atmospheric concentrations of radiocontaminants measured at or near the Main Site between 1974 and 1985 are shown in Figures 3-7 through 3-11. Spikes in the concentrations shown are typical of statistical variations in measurements of such small quantities. To provide perspective, the results shown in these figures include both background levels (U.S. Mean) and the DOE concentration guide levels that were applicable during those years (University of California, 1986). The concentration guide levels are based on keeping below 100 mrem, the annual dose to the maximally exposed individual. In all cases, the measured annual mean concentration was significantly lower than the limits specified by the DOE concentration guide, and was comparable to the expected background level.

Annual variations of alpha, beta, and gamma activities in the Site 300 vicinity are depicted in Figures 3-12, 3-13, and 3-14 and that of ^{239}Pu in Figure 3-15. DOE concentration guide levels and background levels are indicated on these figures for reference. In all cases the measured activity levels are well below DOE concentration guides and are comparable to background levels.

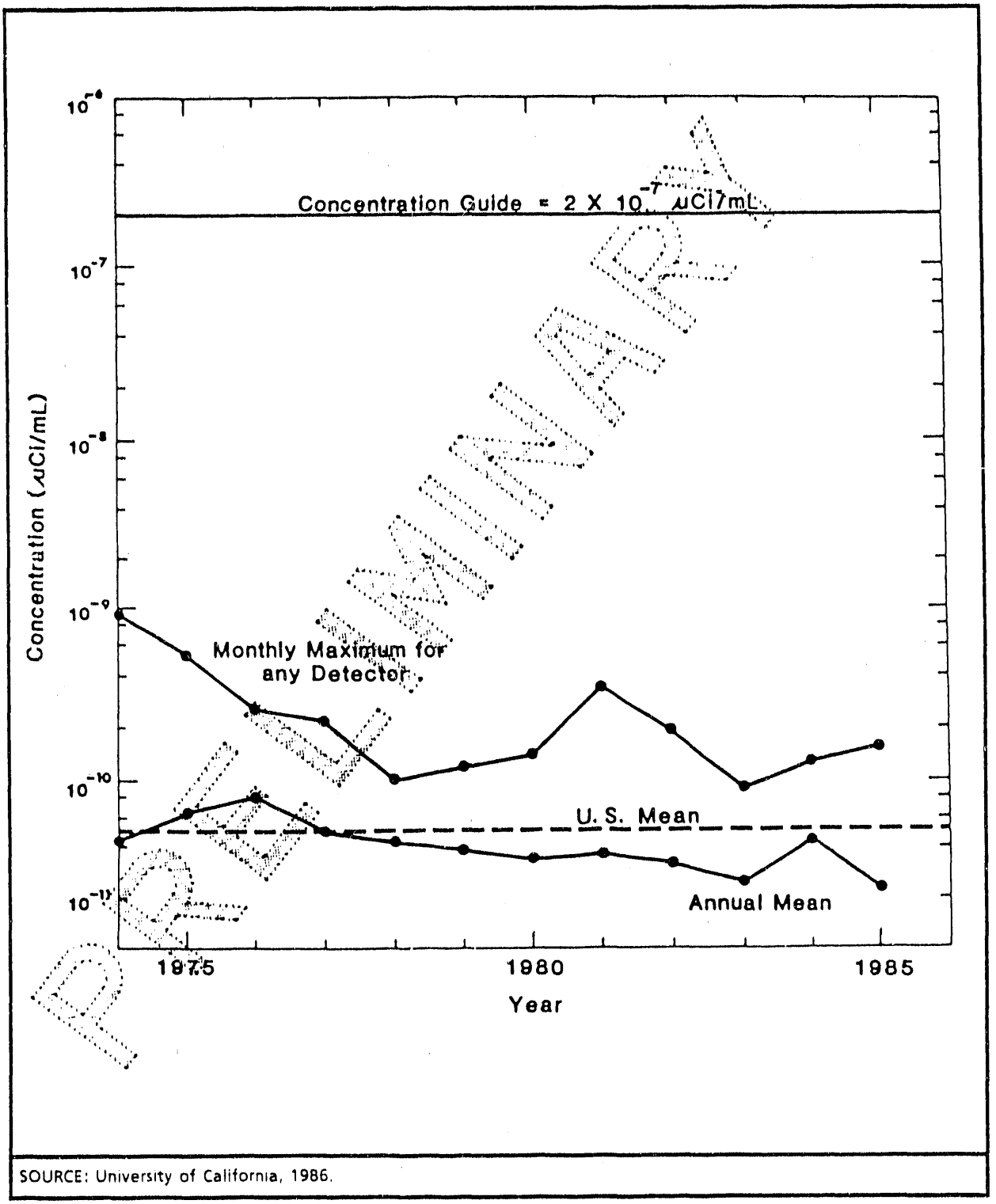
The annual trends in atmospheric concentrations of uranium at the Site 300 boundary and near vicinity locations are shown in Figures 3-16 and 3-17 for ^{235}U and ^{238}U, respectively. A curve of the monthly maximum for the year and of the yearly mean is shown on each plot. Year-to-year fluctuations are typical of statistical variation in small-quantity measurements of this type. Overall



SOURCE: University of California, 1986.

FIGURE 3-6

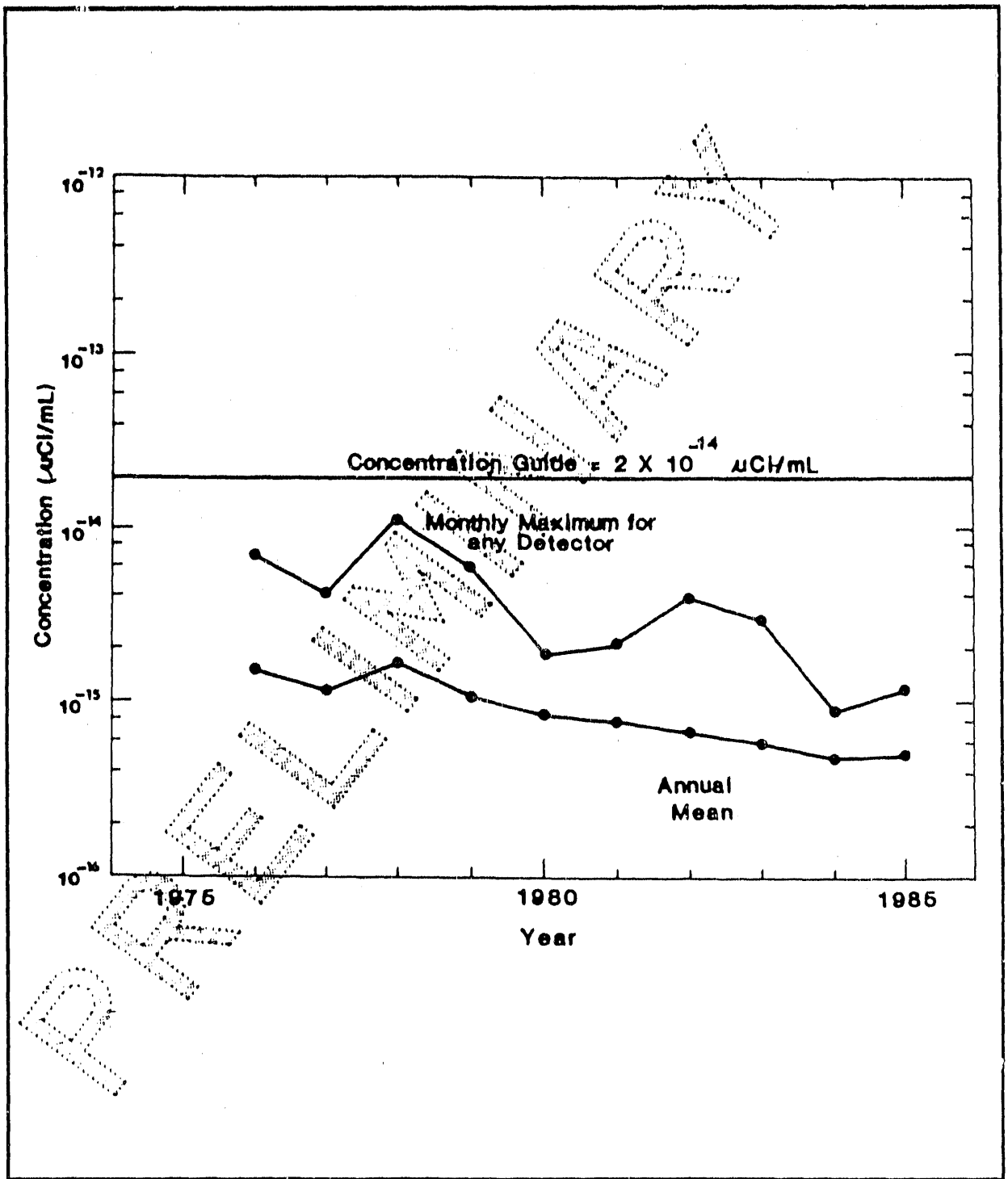
THE ANNUAL ATMOSPHERIC RELEASES OF RADIOACTIVITY IN THE VICINITY OF THE LIVERMORE SITE SHOWN FOR THE YEARS 1975 - 1985
LLNL – LIVERMORE, CALIFORNIA



SOURCE: University of California, 1986.

FIGURE 3-7

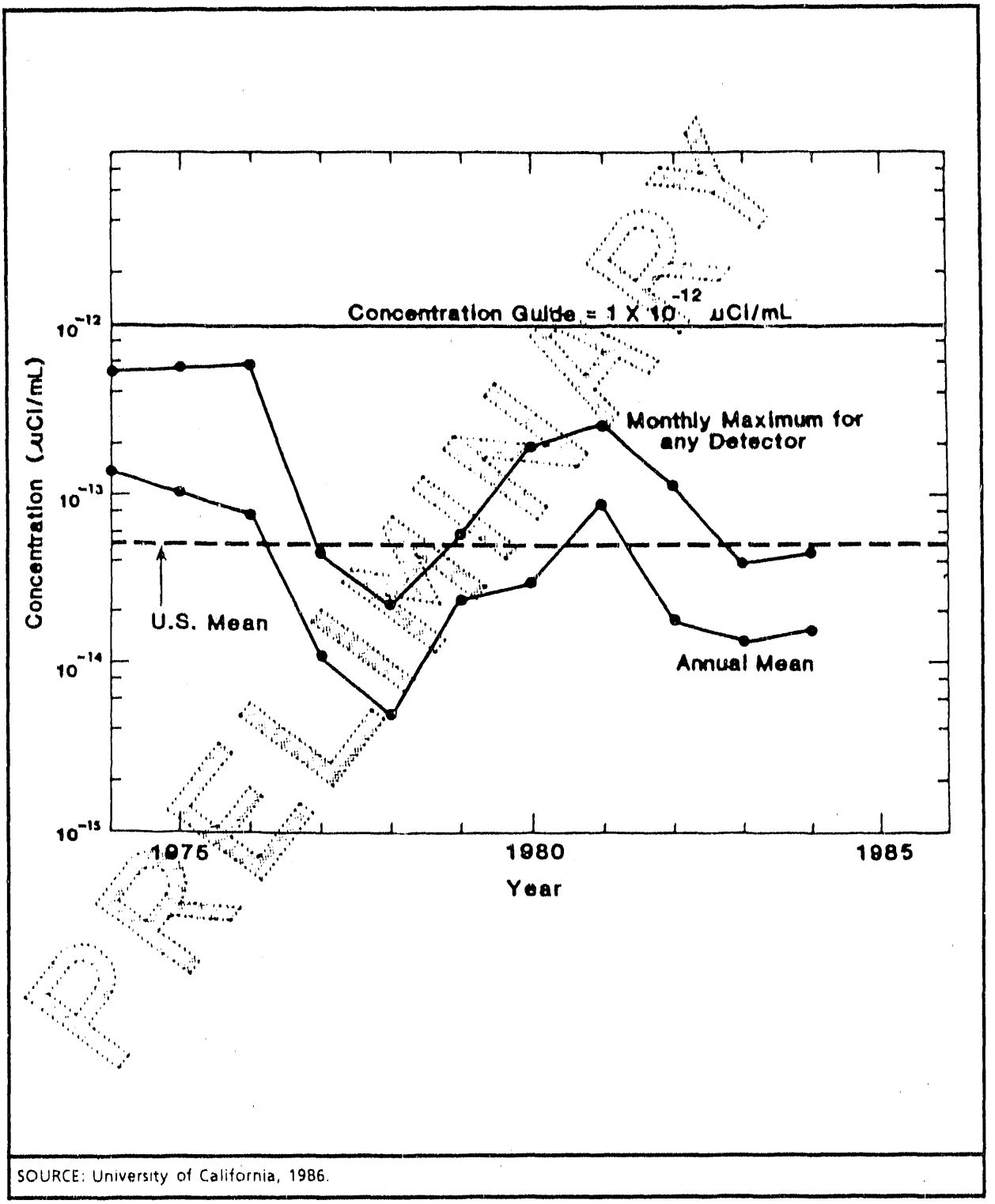
ANNUAL VARIATION OF MEASURED AIRBORNE TRITIUM FOR THE LIVERMORE SITE AND VICINITY
LLNL – LIVERMORE, CALIFORNIA



SOURCE: University of California, 1986.

FIGURE 3-8

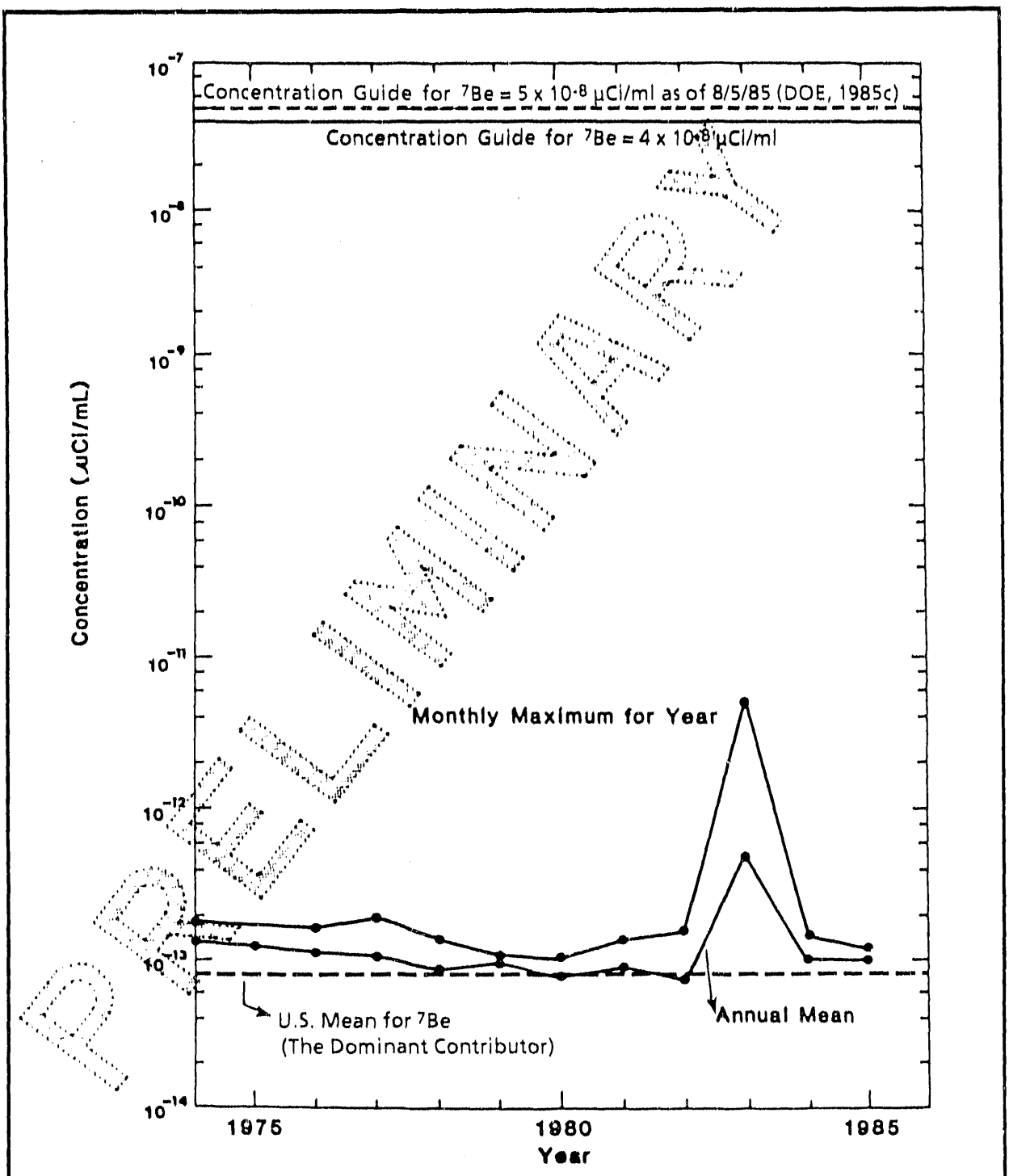
ANNUAL VARIATION IN AIRBORNE ALPHA ACTIVITY
FOR THE LIVERMORE SITE AND VICINITY
LLNL – LIVERMORE, CALIFORNIA



SOURCE: University of California, 1986.

FIGURE 3-9

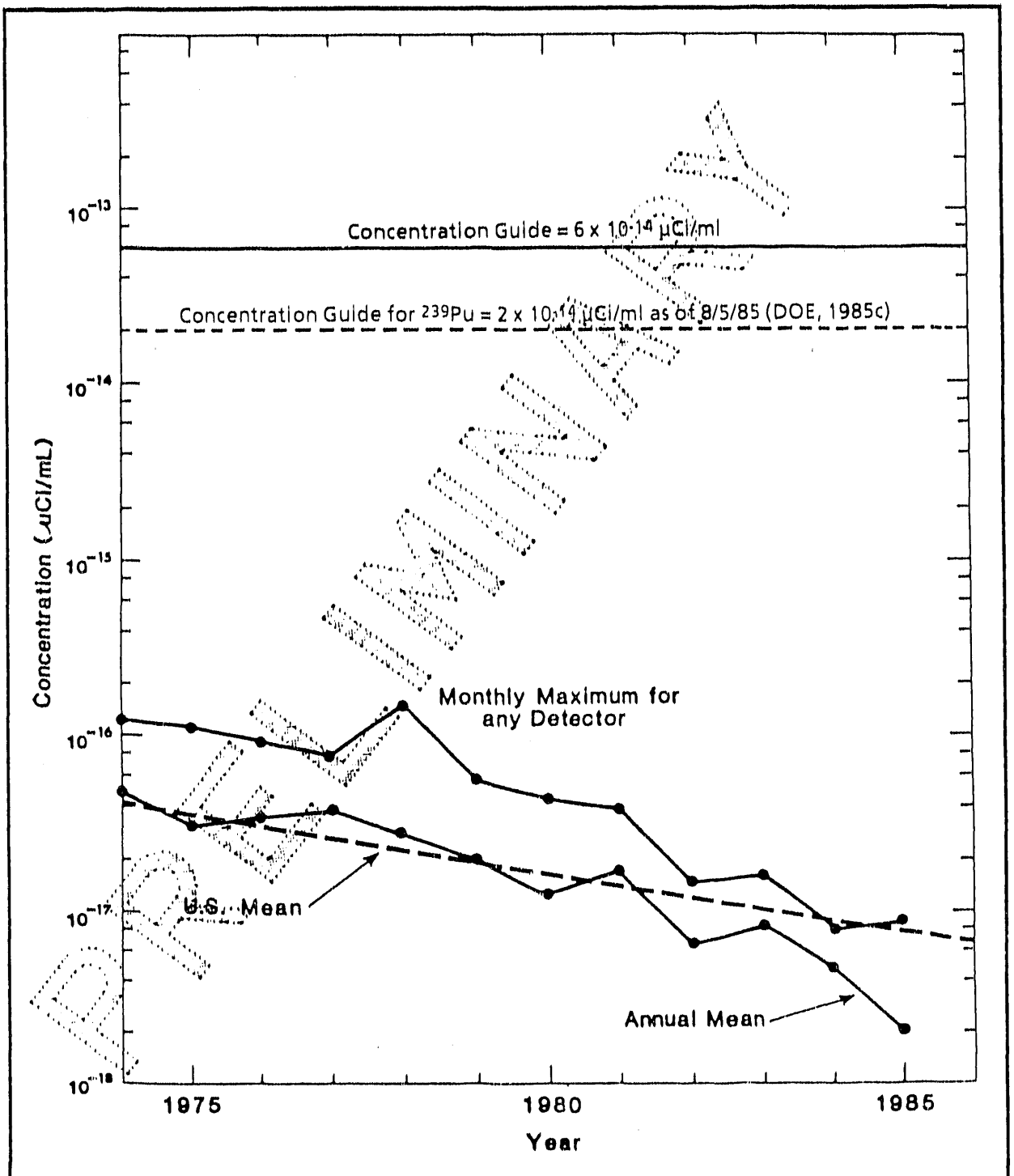
ANNUAL VARIATION IN ATMOSPHERIC BETA CONCENTRATION
FOR THE LIVERMORE SITE AND VICINITY
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Adapted from University of California, 1986.

FIGURE 3-10

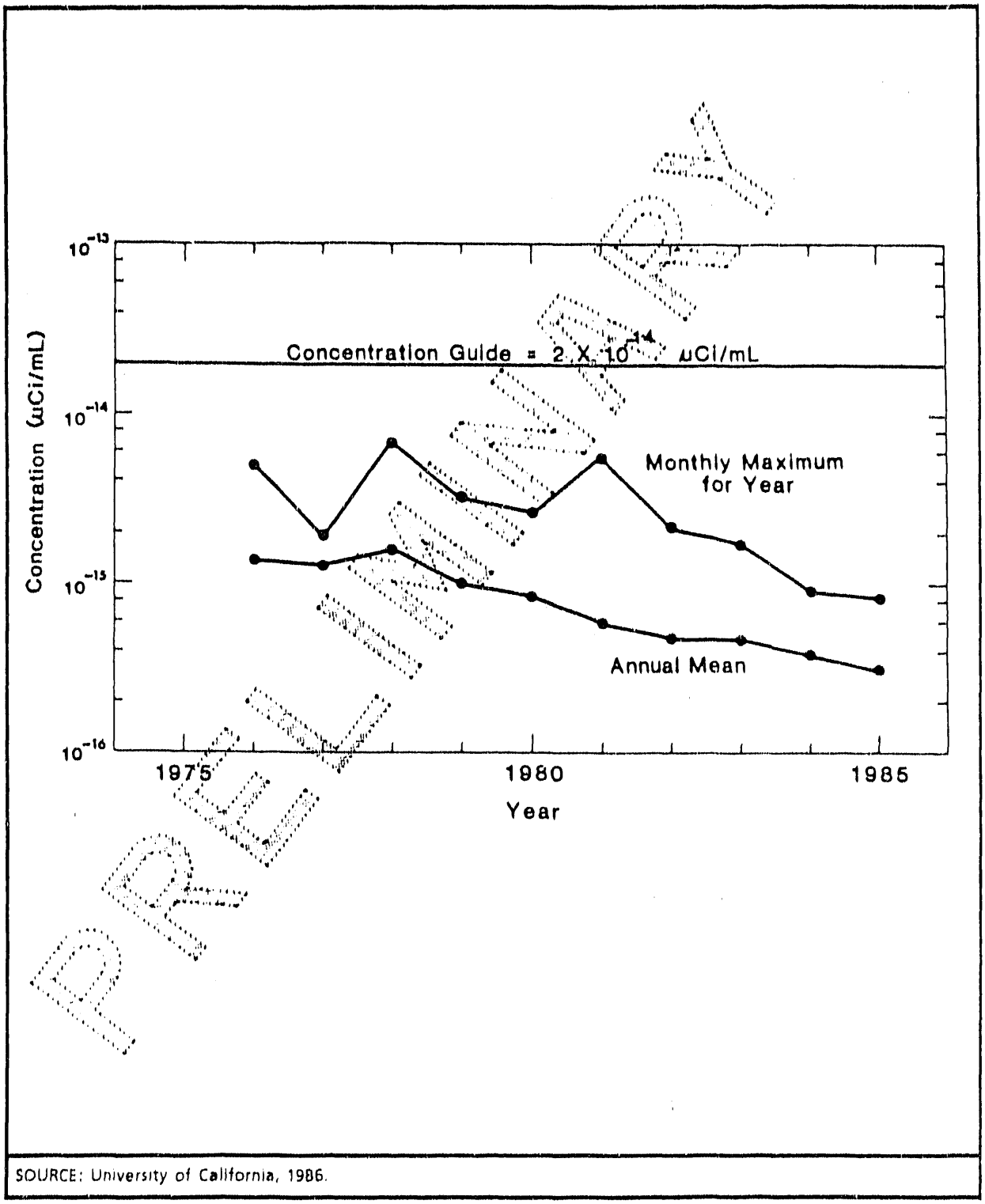
ANNUAL VARIATION IN AIRBORNE GAMMA ACTIVITY
FOR THE LIVERMORE SITE AND VICINITY
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Adapted from University of California, 1986.

FIGURE 3-11

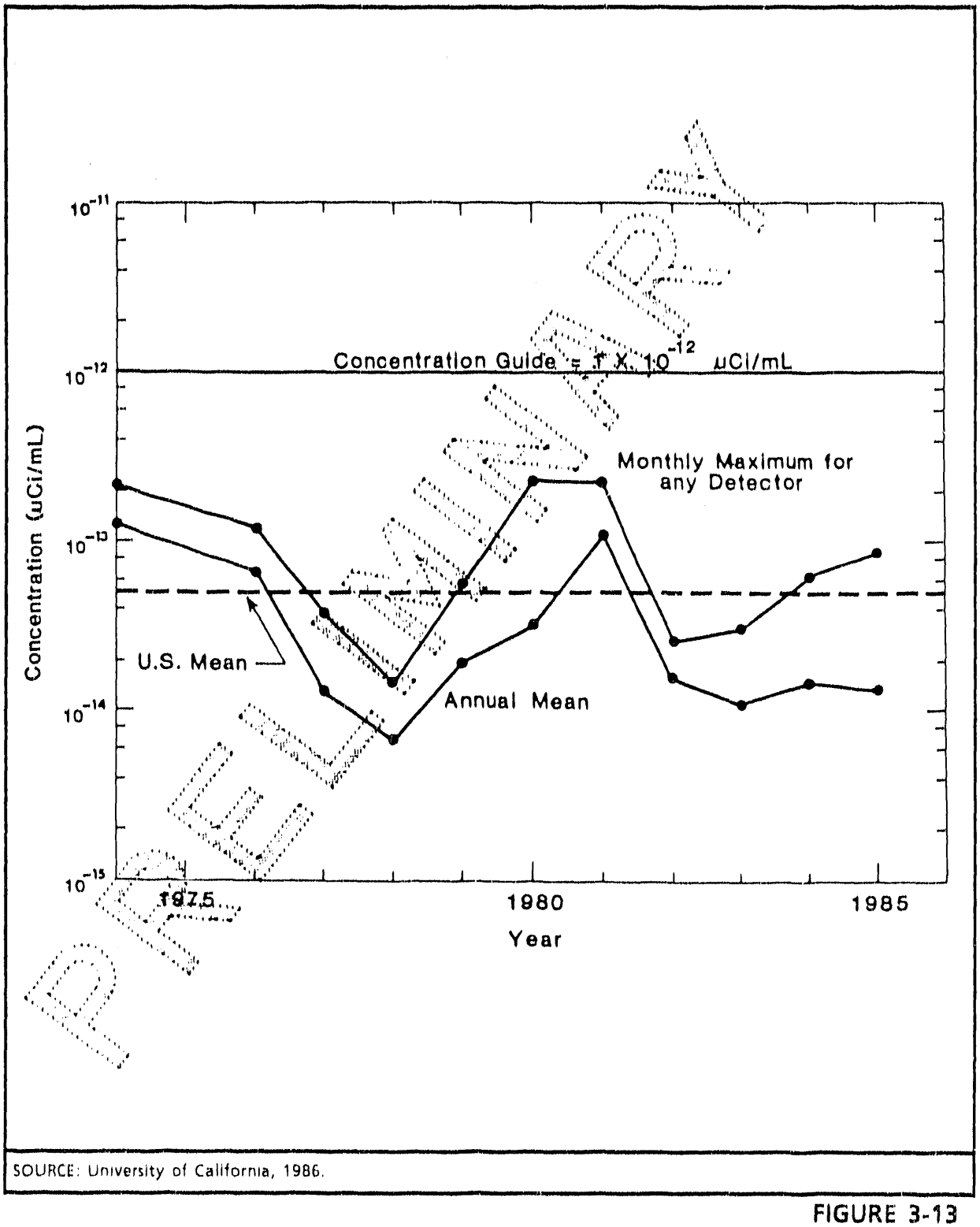
ANNUAL VARIATION IN AIR CONCENTRATION OF ^{239}Pu
FOR THE LIVERMORE SITE AND VICINITY
LLNL – LIVERMORE, CALIFORNIA



SOURCE: University of California, 1986.

FIGURE 3-12

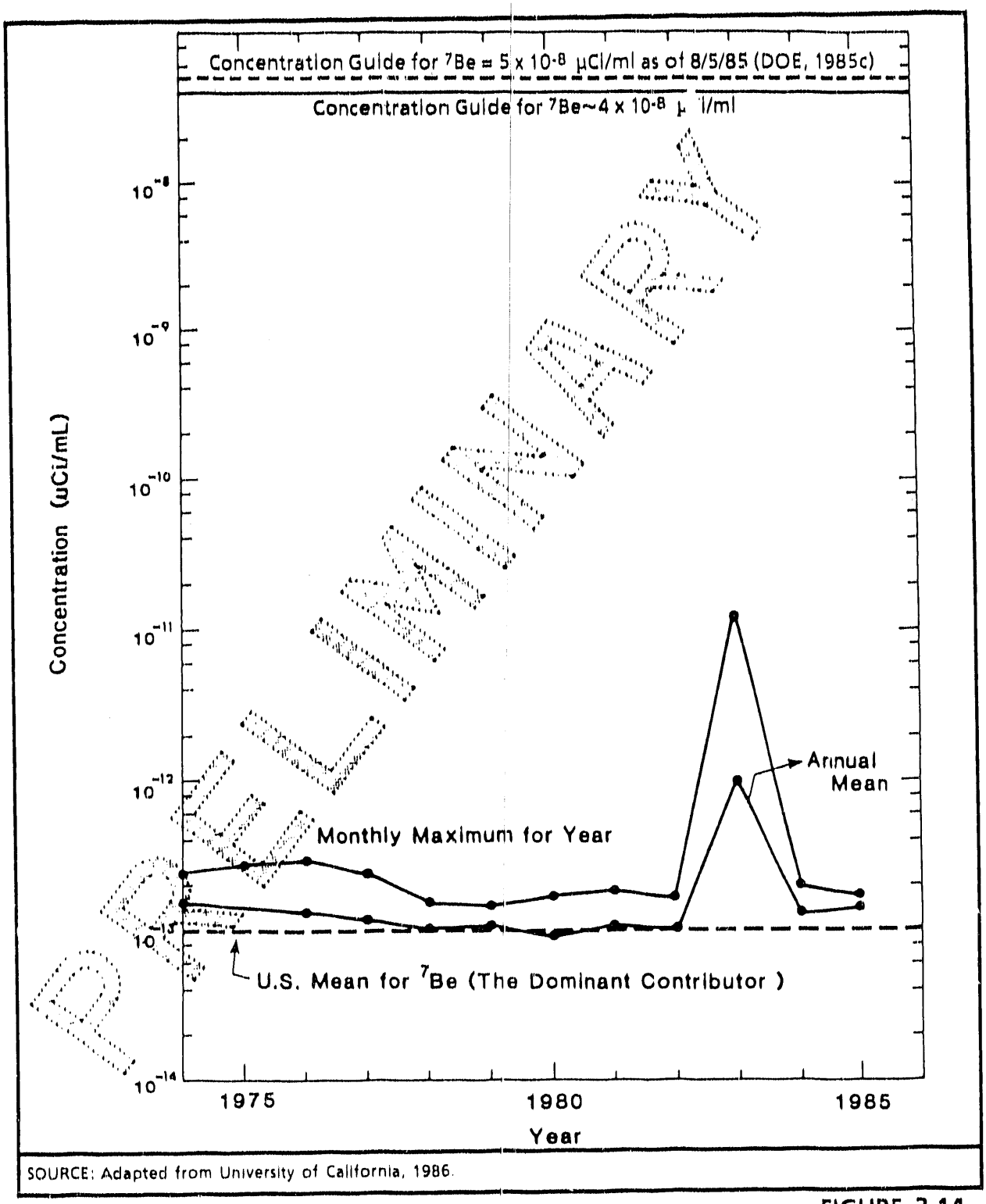
ANNUAL VARIATION IN AIRBORNE ALPHA ACTIVITY
IN THE VICINITY OF SITE 300
LLNL – LIVERMORE, CALIFORNIA



SOURCE: University of California, 1986.

FIGURE 3-13

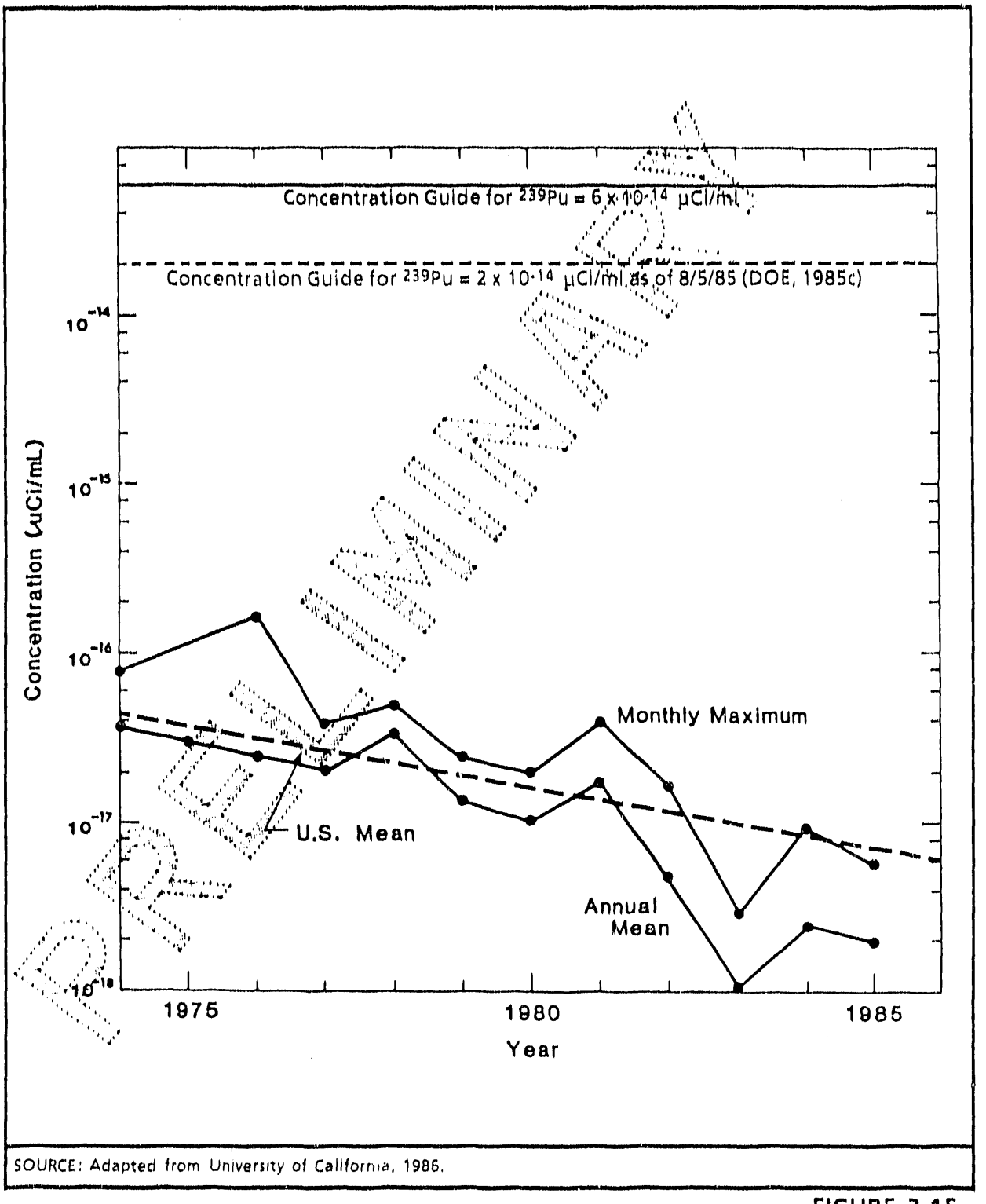
ANNUAL VARIATION IN AIRBORNE BETA ACTIVITY
IN THE VICINITY OF SITE 300
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Adapted from University of California, 1986.

FIGURE 3-14

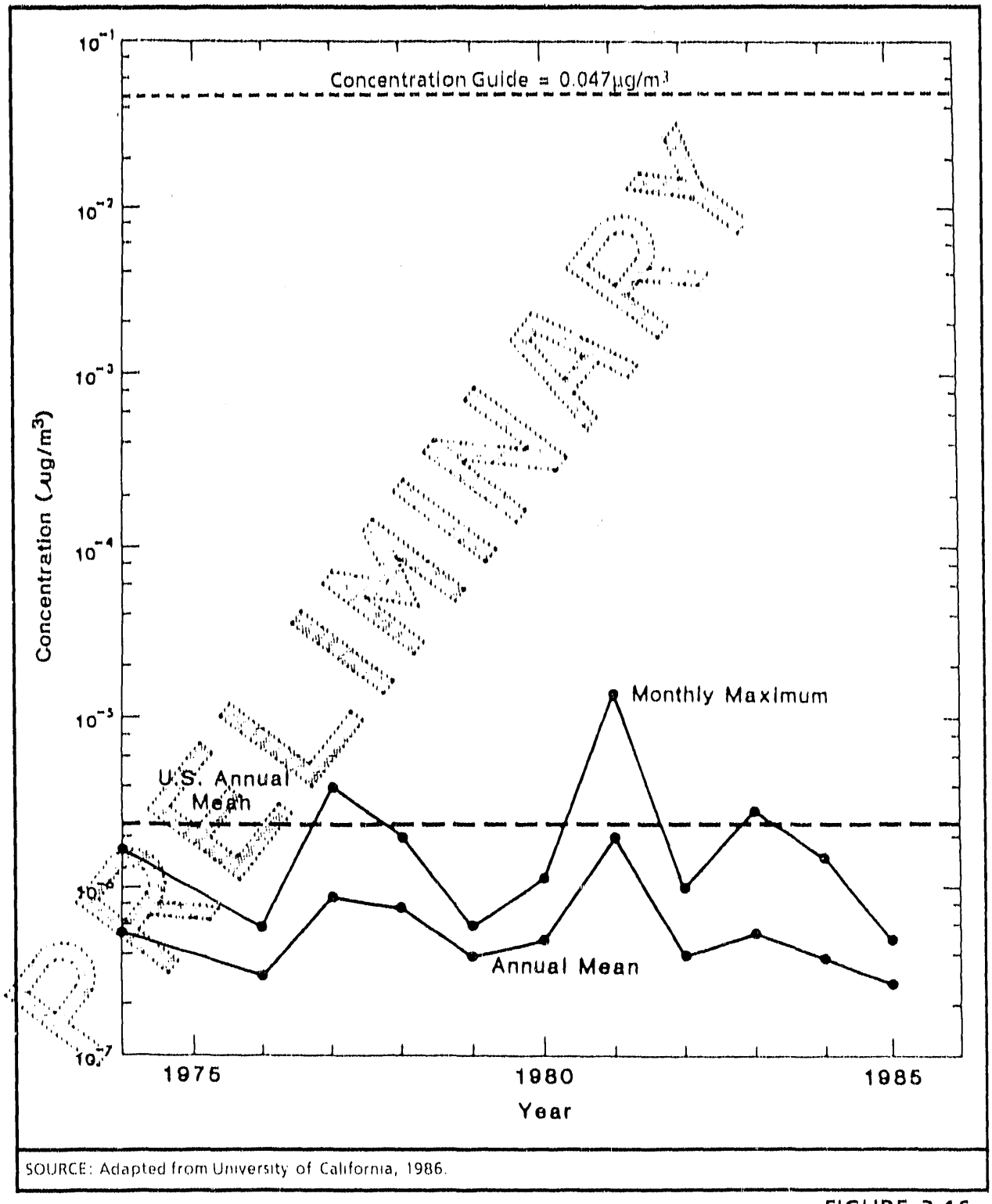
ANNUAL VARIATION IN ATMOSPHERIC GAMMA ACTIVITY IN VICINITY OF SITE 300 LLNL – LIVERMORE, CALIFORNIA



SOURCE: Adapted from University of California, 1986.

FIGURE 3-15

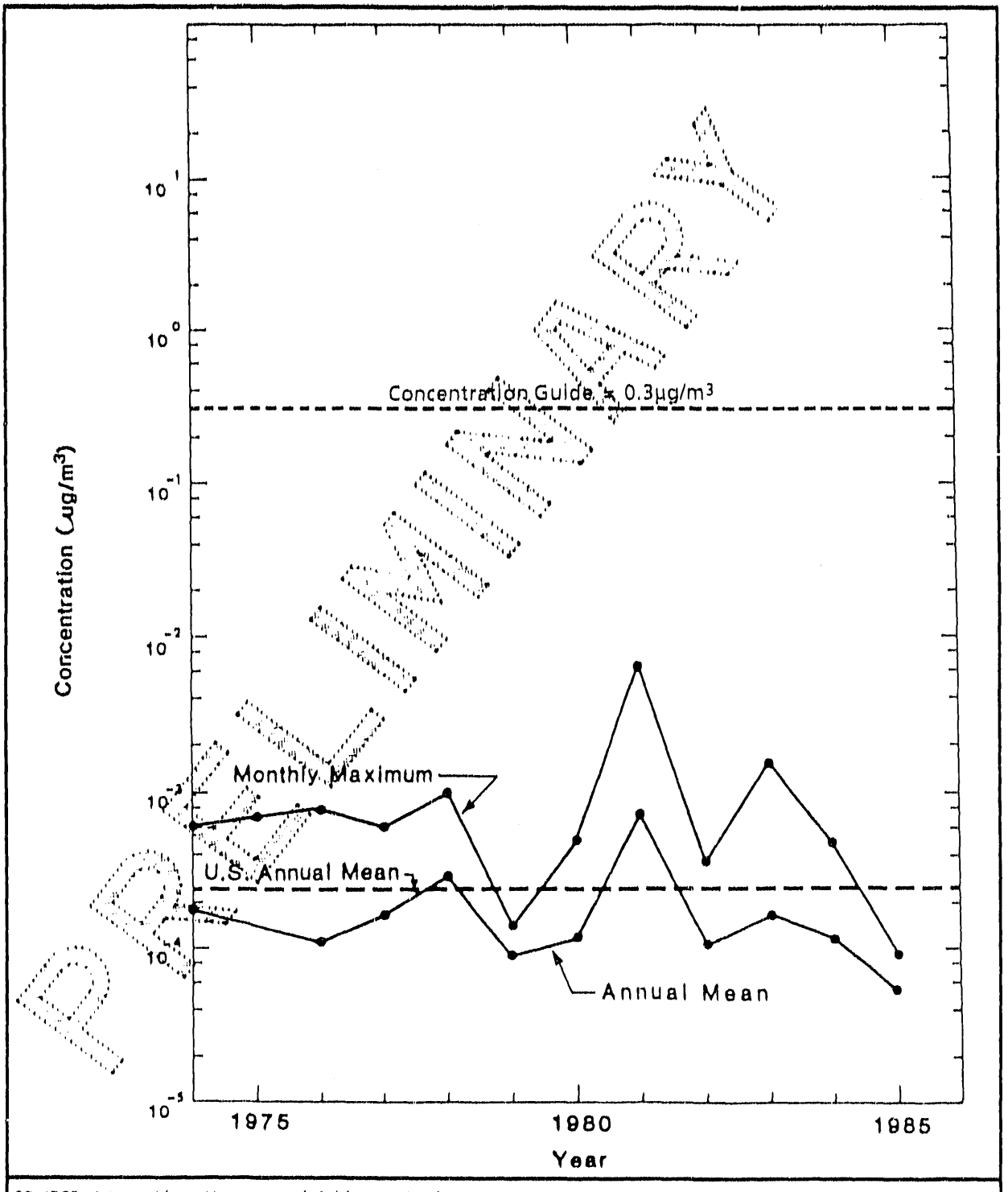
ANNUAL VARIATION IN AIRBORNE ^{239}Pu AT SITE 300
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Adapted from University of California, 1986.

FIGURE 3-16

ANNUAL MEAN AND MONTHLY MAXIMUM OF THE ANNUAL VARIATION IN AIRBORNE ^{235}U IN THE VICINITY OF SITE 300
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Adapted from University of California, 1986.

FIGURE 3-17

ANNUAL MEAN AND MONTHLY MAXIMUM OF THE ANNUAL VARIATION IN AIRBORNE CONCENTRATION OF ^{238}U (D-38) IN THE VICINITY OF SITE 300 LLNL – LIVERMORE, CALIFORNIA

concentration levels remain many orders of magnitude less than the DOE concentration guide recommended level (Griggs and Buddemeier, 1986), and are below expected background levels. Concentrations of both isotopes have decreased steadily since peaking in 1981 (University of California, 1986).

Other airborne emissions have also generally been demonstrating a decreasing trend over recent years. The primary concern associated with these emissions is that of public radiation exposure through various pathways. Environmental radiation exposure pathways related to air other than direct inhalation include deposition on soils and vegetation (cow pastures, vineyards, and flowering species). This deposition can lead to contamination of milk, wine, and honey. All of these pathways are discussed in greater detail in Section 4.3.2. Summary of air pathway doses using maximum calculated exposures yields a 0.03 mrem dose at the Main Site and no dose above background at Site 300.

The concentration of beryllium in the air, both at the source and near LLNL property boundaries, has always been monitored as a part of LLNL's safety program. Monthly, halves of the filters from sampling locations at the LLNL perimeter, Site 300, and in the city of Tracy are composited by sample location. Following sample preparation, the beryllium content of the solutions is determined by atomic absorption analysis. The concentrations, which average less than 1 percent of the ambient concentration limit established by the BAAQMD, can be accounted for by re-suspension of the surface soil containing naturally occurring beryllium. In addition, soil samples are occasionally collected near potential sources for verification of this argument.

Unusual Tritium Concentrations

The 1986 perimeter monitoring for tritiated water (HTO) showed two periods of elevated concentrations, which raised the overall average from 2.8×10^{-11} µCi/ml in 1985 to 12.3×10^{-11} µCi/ml in 1986.

The first spike occurred in early September (see Table 3-6) and was noticed at sample Stations 1 and 2 (see Figure 3-3). Slightly elevated concentrations were noticed at one station (S-2) (Figure 3-5) west of Sandia National Laboratories Livermore (SNLL) and at a remote station (V7) located about 5 miles northeast of the site. There is no apparent reason for the fact that Station 12 (midway between Stations 1 and 2) and Station V4 (midway between the site and Station V7) did not report high values during this period.

TABLE 3-6

UNUSUAL TRITIUM-IN-AIR CONCENTRATIONS
(10^{-11} µCi/ml)
LAWRENCE LIVERMORE NATIONAL LABORATORY-LIVERMORE, CALIFORNIA

		Sample Station Number					
		1	2	12	13	14	15
January–August, 1986	Samples	19	20	19	20	19	21
	Range	ND–6.0	ND–6.7	ND–7.2	ND–8.6	ND–6.9	ND–5.5
Sept.–Dec., 1986	Samples	9	10	10	11	10	14
	Range	ND–5.5	ND–5.9	ND–8.5	0.6–7.1	ND–6.5	ND–3.4
1986 Average Without Outliers		2.8	1.8	3.0	2.1	2.9	2.2
OUTLIERS		62.2	43.0				
September		12.2	34.6	–	18.5	–	12.4
October		–	–	–	–	–	10.9
November		–	–	–	–	–	9.1
December		–	–	–	320	448	367 315
1986 Average Including Outliers		5.8	5.4	3.0	15.1	19.9	24.4

Source: Holland et al., 1987.
Note: ND - not detected

Higher concentrations occurred in late December. Stations 13, 14, and 15 all reported high values as did Station V7. (Station S-2 at SNLL reported slightly elevated concentrations.) The value at Station 14 for this period was the highest perimeter value for 1986, 448 x 10^{-11} µCi/ml. Although this is only 2.2 percent of the DOE-derived concentration guideline (DOE, 1986), it is 100 times the average concentration at this station for the remaining 28 samples taken in 1986. (Three QC samples were taken in 1986 in addition to the 26 regular biweekly samples.)

A review of stack emissions and operations records at LLNL and SNLL has not identified any malfunction or other release that might have caused the high concentrations. Efforts to identify the origin of the elevated values are continuing. Considering the erratic nature of the values, especially the September values, the possibility of contamination of the samples in the laboratory appears to be a possible explanation.

3.1.4 Findings and Observations

3.1.4.1 Category I

None

3.1.4.2 Category II

None

3.1.4.3 Category III

None

3.1.4.4 Category IV

1. Calculation of Dose Assessments. The combined off-site radiation dose resulting from LLNL and SNLL air emissions is not reported in the annual Environmental Monitoring Reports (EMRs).

   The LLNL EMR reports only its own site-specific radiation doses. Although this is administratively correct and acceptable, it is misleading (from an off-site dose calculation standpoint), given the proximity of the two sites and the similarity of operations. LLNL acknowledges this dilemma in its 1986 EMR, stating, "This report . . . assesses the

environmental impact of both laboratories," but then goes on to contradict itself by calculating an LLNL-specific dose. This calculation, by footnote, specifically excludes the emission of 760 Ci (as HTO) from SNLL. SNLL's release is significant relative to LLNL's 774 Ci (as HTO) release. However, it must be acknowledged that the dose at the site boundary and the dose to the nearest resident (which were listed in the 1986 report as 0.26 percent and 0.22 percent of the Federal emission standard, respectively) would still be less than 1 percent of the Federal emission standard, if the SNLL emissions were included.

2. Air Emissions From Vapor Degreasers and Part Cleaners. Evaporation of solvents from vapor degreasers and parts cleaners is accelerated by leaving the tanks uncovered when not in use. During the Survey, team members noted five buildings with uncovered units not in use. The parts cleaners were located in Buildings 383, 419, 438, and 511, and a vapor degreaser was located in Building 865 at Site 300.

   The Survey team estimates that since a typical parts washer is in use less than 10 percent of the hours in a full day, covering the unit when not in use reduces evaporation loss by about 90 percent as compared with the loss from an uncovered unit. Regulation 8-16-303 of the Bay Area Air Quality Management District (BAAQMD, 1986) requires a cover and its use "when not processing work" in a parts cleaner. Regulation 8-16-301 describes similar requirements for vapor degreasers.

3. Contamination of Tritium in Ambient Air Samples. Two incidents in 1986 of high tritium levels at the LLNL perimeter that might have indicated unmonitored releases are thought by the Survey team to be the result of contamination of samples in the laboratory. Both LLNL and SNLL have examined operating records and stack emissions but, to date, no evidence of any malfunction or other release has been found. Table 3-5 presents a summary of these data.

   The first "spike" occurred during the first two weeks of September at two monitors, Stations 1 and 2 on Figure 3-3, when levels of 40 to 60 x 10^{-11} µCi/ml were reported. Slightly elevated levels were noticed at one SNLL perimeter monitor (S-2 on Figure 3-5) and one valley location (Station 7) (10 and 23 x 10^{-11} µCi/ml, respectively). There is no explanation for the low concentrations (1.4 x 10^{-11} mCi/ml) at Station 12, which is located between Stations 1 and 2, or at Station 4, which is located midway between LLNL and Station 7. Increased concentrations detected during the last two weeks in September (Stations 1, 2, 13, and S-1) and the first two weeks in October (Stations S-2, 7, 9, 17) also followed an erratic pattern.

Much higher concentrations (274 to 448 x 10^{-11} µCi/ml) occurred in late December. Stations 13, 14, 15, and 7 reported the highest value for 1986 at each station. Station S-2 also reported its highest level for the year, a level of 52 x 10^{-11} µCi/ml.

The above values raised the annual mean of perimeter stations at LLNL from 2.8 x 10^{-11} µCi/ml in 1985 to 12.3 x 10^{-11} µCi/ml, based on all data available. (The 1986 LLNL monitoring report, which cites 2.5 x 10^{-11} µCi/ml as the annual mean tritium concentration at the LLNL perimeter, discarded 12 out of 176 data points that were considered to be anomalies or "outliers.")

The annual mean for off-site monitors (including the two SNLL perimeter monitors) increased from 1.2 x 10^{-11} µCi/ml in 1985 to 4.4 x 10^{-11} µCi/ml in 1986.

The maximum monthly average for any monitoring station was 150 x 10^{-11} µCi/ml (Station 14 in December), up from 9.3 x 10^{-11} µCi/ml in 1985. Considering the erratic nature of the data, contamination of samples in the laboratory appears to be a possible explanation.

LLNL and SNLL are still reviewing records in attempting to resolve this issue. Relocation of the laboratory handling the ambient air samples to an area remote from tritium sources has been discussed at DOE laboratories for many years in attempting to remove laboratory contamination as an explanation of abnormal concentrations of tritium in ambient air samples.

4. Monitoring of HEPA Filters. The HEPA filters at Buildings 321 and 419, if damaged while in use, would allow radioactive particles to be discharged, since there is no continuous monitoring of the pressure drop across these filters. Pressure-drop monitoring can alert maintenance when a filter is damaged or overloaded. Although the use of these monitors is standard operating practice in most LLNL buildings, the filters at Building 321 apparently were installed without such devices. While most filters in Building 419 have pressure-drop indicators, the indicators are in poor condition and unreadable.

Only about 4 percent (35 out of 900) of the HEPA filters at LLNL lack the continuous pressure-drop monitoring. Without these indicators, damage could result in a filter efficiency below the normal 99.97 percent. The reduced efficiency would not be detected until the time of the annual testing.

5. Testing of HEPA Filters. The HEPA filter mounted outside the ceramics shop (Building 322) could, if damaged, allow particles containing beryllium and/or radionuclides to be discharged because it has never been subjected to annual testing.

   HEPA filters are normally installed upstream of an exhaust fan; therefore, the standard test for filtration efficiency was developed for use at slightly negative pressures. Testing of a HEPA filter mounted downstream of an exhaust fan (as this filter is) would require a modified test.

6. Unpermitted Sources. Several parts cleaners and vapor degreasers at LLNL and the oil shale crusher (Building 410) lack the registration/permits required by the Bay Area Air Quality Management District. Although no environmental problems are apparent, lack of proper registration or permits can nevertheless lead to paperwork-type fines.

7. Perimeter and Off-site Ambient Air Sampling. Results obtained from this program may be affected by off-site sampling stations that are not locked; thus samples could be tampered with. The perimeter and off-site ambient air sample results may be suspect for the following reasons:

   - Off-site station boxes are not locked.
   - No procedures are in place for reporting equipment malfunctions.
   - Air flow is not continuously measured, resulting in inaccurate flow measurements (e.g., a power outage would not be recorded and compensated for in the flow measurements; hence, contaminant concentrations would be underestimated).

3.2 Soils

3.2.1 Background Environmental Information

Section 3.2 presents soil-related environmental problems as determined by the Survey team. The major focus of this section will be radionuclide contamination because it is only those parameters for which routine soil sampling occurs. Soil sampling for organic and inorganic contaminants is conducted in response to CERCLA- or RCRA-type investigations or activities, particularly groundwater studies. Descriptions of these types of investigations are presented in more detail in Section 4.5.

There are no regulations that limit the concentrations of uranium or thorium in soils. However, there is some guidance available from both the U.S. Nuclear Regulatory Commission (NRC) and the

Department of Energy (DOE). The NRC, in a memorandum pertaining to a Branch Technical Position on the disposal or on-site storage of residual thorium or uranium, established derived concentration limits for various disposal options (NRC, 1981). One of these options applies to wastes with sufficiently low concentrations of uranium or thorium that they would present no health risk and thus may be disposed of in any manner. The acceptable concentrations for this disposal option were derived by the NRC using radiation dose guidelines recommended by the Environmental Protection Agency (EPA, 1977) for protection against transuranium elements present in the environment. The derived concentration limits are natural thorium, 10 pCi/g; depleted uranium, 35 pCi/g; enriched uranium, 30 pCi/g; and natural uranium, 10 pCi/g. The concentration limits for natural thorium and natural uranium are based on the assumption that all the daughter products of these elements are present in secular equilibrium. The radium isotopes are the daughter products that are used to establish the limits.

DOE has established guidelines for residual radioactivity at Formerly Utilized Sites Remedial Action Program (FUSRAP) and Remote Surplus Facilities Management Program (SFMP) sites (DOE, 1985a; 1985b). The guidelines specify concentrations for thorium-232, thorium-230, radium-228, and radium-226 of 5 pCi/g averaged over the first 15 cm of soil below the surface and 15 pCi/g averaged over 15 cm thick layers of soil more than 15 cm below the surface. These guidelines take into account the in-growth of the daughters and assume secular equilibrium. For other radionuclides or mixtures, the soil concentration guidelines must be derived, on a site-specific basis, from a basic dose limit of 100 mrem/yr to an individual, from all pathways.

There are no regulatory standards for nonradiological contaminant concentrations in soil as there are for drinking water supplies or for air. A determination of "safe" or "acceptable" levels in soils depends on contaminant migration pathways (e.g., wind or water erosion or leaching to the groundwater) and potential human exposure routes (e.g., ingestion of soils by children or farm animals, ingestion of contaminated groundwater, or inhalation of fugitive dust containing contaminants). Therefore, acceptable levels must be determined on a site-specific and chemical-specific basis.

The natural soils at the LLNL Main Site are derived from the alluvial deposits of the Livermore Valley. The LLNL Main Site is located within the boundaries of the Yolo-Pleasanton soil association (USDA, 1966). Weathering of the alluvial deposits has formed several distinct soil series that are recognized by the Soil Conservation Service. Soils of the Livermore and Positas series have formed near Arroyo Seco south of the site, while the Rincon, Zamora, and Livermore soils have formed on these alluvial materials near and within LLNL. The Pleasanton, Positas, Rincon, and Zamora soils are

moderately slow to slowly permeable gravelly and clayey loam, and the Livermore is rapidly permeable gravelly loam (USDA, 1966).

Published radionuclide "background" levels for California and the Livermore Valley soils are discussed in Section 3.2.3 relative to on-site soil sampling for environmental monitoring purposes.

3.2.2 General Description of Pollution Sources and Controls

Investigations of soil contamination at LLNL's facilities have, for the most part, been tied to groundwater contamination studies. In these areas, a number of samples of unconsolidated material were collected in the course of drilling the boreholes for well installation. This information is presented in more detail in Section 3.4, and is used primarily in the definition of contaminant plumes.

The sources of soil contamination (with organic compounds) are generally the same sources of groundwater contamination described in Sections 3.4 and 4.5. In addition, radionuclides released from various processes at the LLNL Main Site may be deposited on the soil and taken up by vegetation or ingested by animals.

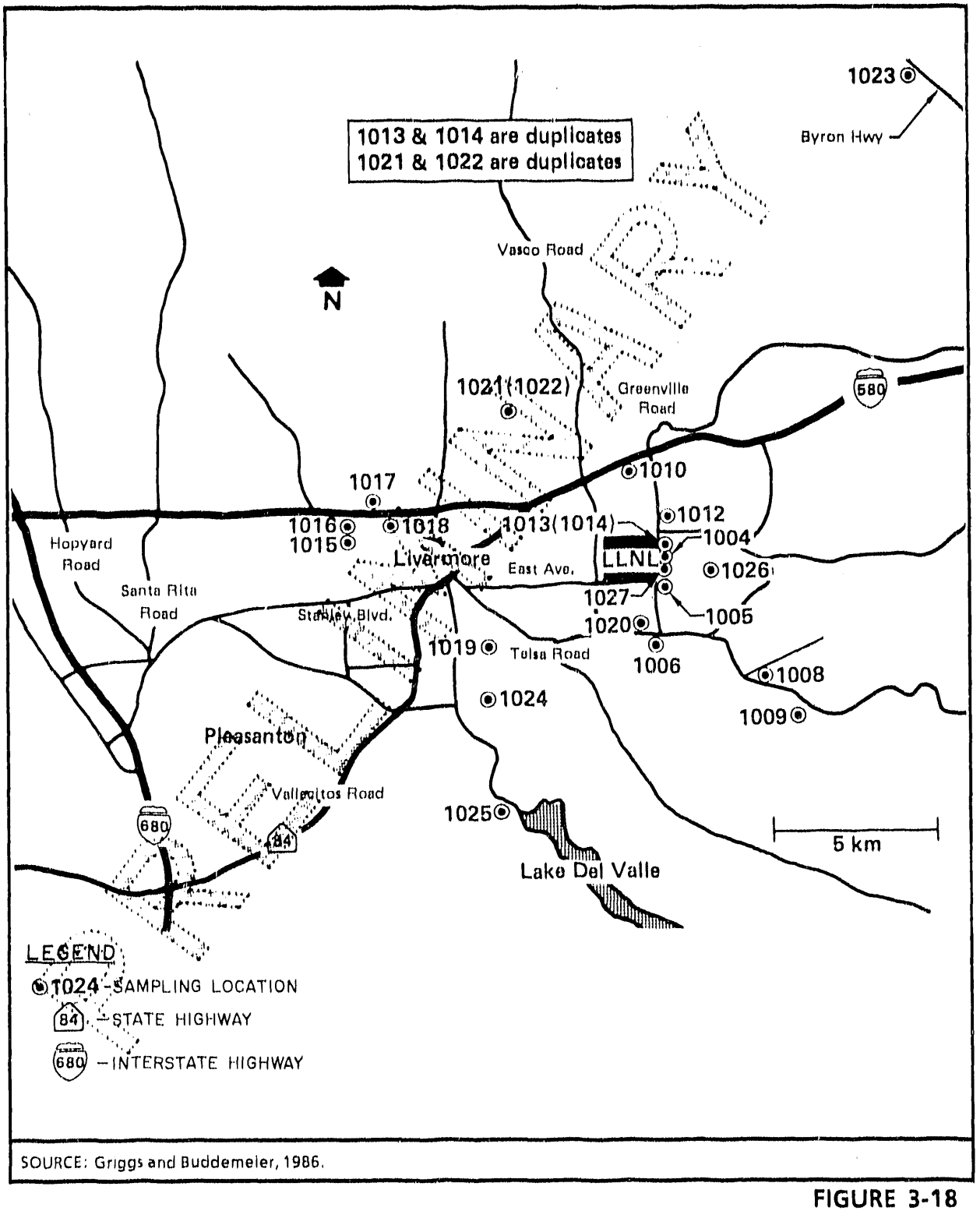
The source(s) of soil contamination at Site 300 are the following:

- Fallout from firing-table blasts
- Miscellaneous spills and abandoned waste

3.2.3 Environmental Monitoring Program

LLNL has had a formalized soil sampling program since 1971, when extensive range-finding analyses of various radionuclides were conducted. Since that time, random selection sampling, augmented by additional location sampling, when necessary, is conducted annually to evaluate both the impact of LLNL operations and to track natural and man-made sources of radioactive contamination such as fallout. There is no routine monitoring of soil for organic or inorganic constituents. This type of monitoring is performed on a project-specific basis, and is discussed in Section 3.4.

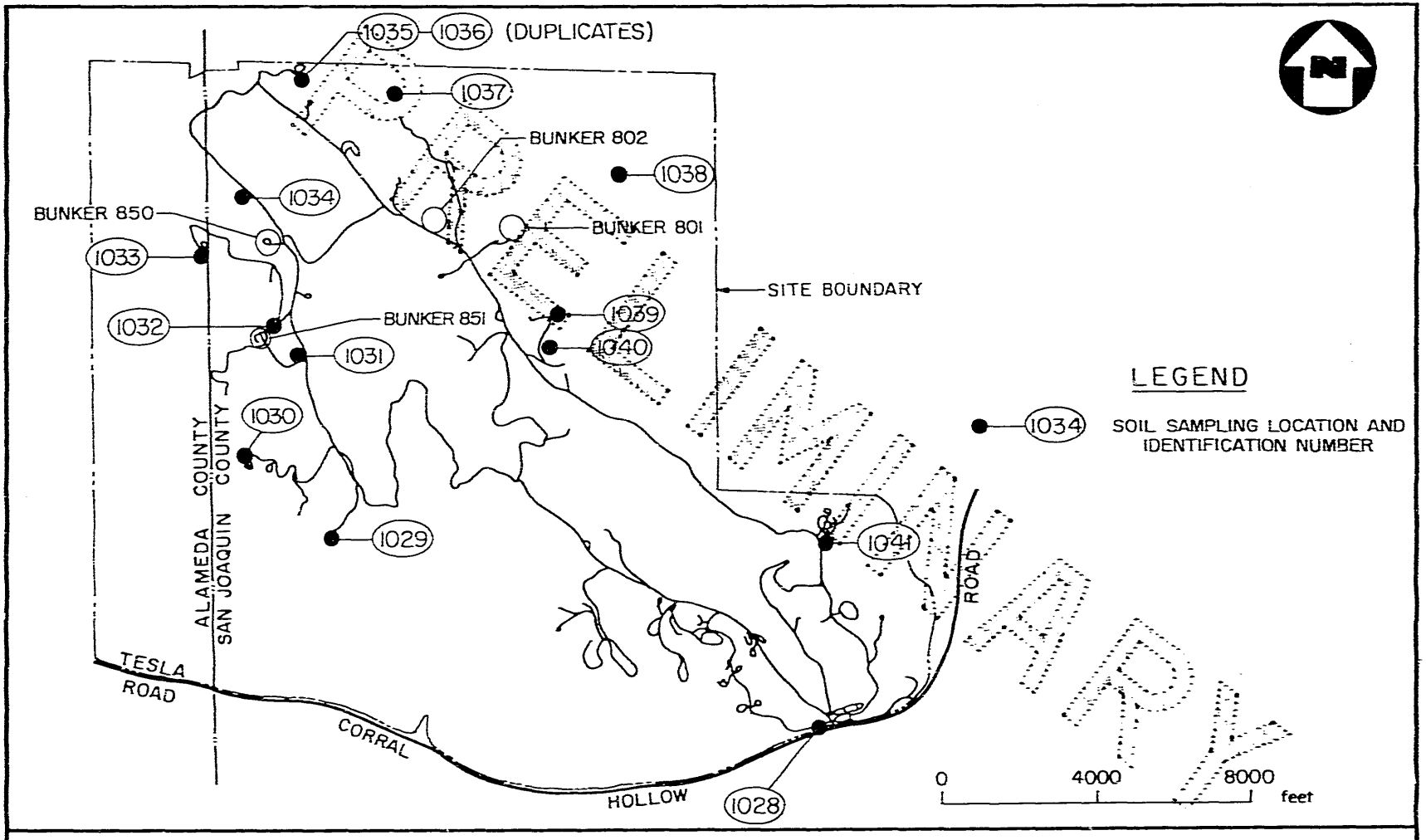
Figures 3-18 and 3-19 and Tables 3-7 and 3-8 show 1985 soil sampling locations and analytical results for the Livermore Valley and Site 300. It should be noted that all of the sampling locations shown for Site 300 are on the property owned by DOE. Because depleted uranium is used in high explosives testing at Site 300, sampling locations were located in areas where soil perturbations would be



SOURCE: Griggs and Buddemeier, 1986.

FIGURE 3-18

LIVERMORE VALLEY SOIL SAMPLING LOCATIONS
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Griggs and Buddemeier, 1986.

FIGURE 3-19

SITE 300 SOIL SAMPLING LOCATIONS
LLNL – LIVERMORE, CALIFORNIA

TABLE 3-7

VARIOUS RADIONUCLIDES IN SOIL - LIVERMORE VALLEY (SAMPLING DEPTH = 0 TO 5 CM) LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Location[a]	^{239}Pu [10^{-9} µCi/dry g ± 2σ (%)]	^{40}K [10^{-5} µCi/dry g ± 2σ (%)]	^{137}Cs [10^{-7} µCi/dry g ± 2σ (%)]	[µg/dry g ± 2σ (%)]	
				^{232}Th	^{238}U
1004	9.4 ± 6	1.1 ± 4	1.6 ± 7	5.1 ± 8	5.8 ± 5
1005	3.6 ± 9	1.2 ± 3	1.8 ± 7	6.6 ± 5	4.0 ± 26
1006	2.2 ± 11	2.6 ± 4	2.3 ± 7	14.7 ± 4	6.8 ± 34
1008	5.7 ± 8	1.2 ± 6	2.9 ± 4	5.3 ± 7	2.9 ± 38
1009	2.6 ± 10	1.3 ± 7	1.2 ± 16	6.4 ± 13	4.9 ± 62
1010	2.5 ± 9	1.4 ± 3	1.4 ± 9	6.8 ± 5	5.3 ± 24
1012	6.4 ± 6	1.4 ± 3	2.9 ± 5	6.9 ± 4	4.1 ± 26
1013[b]	7.0 ± 8	1.4 ± 3	2.4 ± 16	7.7 ± 6	3.7 ± 26
1014	7.0 ± 7	1.3 ± 3	2.4 ± 6	7.8 ± 4	4.6 ± 40
1015	4.9 ± 8	1.4 ± 3	1.5 ± 8	7.0 ± 5	4.5 ± 28
1016	2.9 ± 11	0.9 ± 3	1.1 ± 9	5.2 ± 5	3.6 ± 34
1017	0.3 ± 38	1.2 ± 3	0.1 ± 60	3.9 ± 5	2.7 ± 30
1018	1.0 ± 12	1.2 ± 3	0.7 ± 17	6.6 ± 5	4.4 ± 13
1019	0.9 ± 12	1.0 ± 6	0.4 ± 14	3.5 ± 11	2.0 ± 32
1020	2.1 ± 9	1.3 ± 3	1.0 ± 9	7.1 ± 5	5.5 ± 12
1021[c]	4.8 ± 10	1.3 ± 4	0.9 ± 14	7.1 ± 6	5.4 ± 11
1022	1.4 ± 17	1.3 ± 4	0.8 ± 11	6.8 ± 6	5.1 ± 11
1023	0.9 ± 16	1.4 ± 3	0.5 ± 18	7.1 ± 4	4.4 ± 14
1024	3.0 ± 10	0.7 ± 7	1.5 ± 19	1.7 ± 44	2.1 ± 40
1025	3.6 ± 10	1.1 ± 4	1.8 ± 4	4.7 ± 6	2.5 ± 66
1026	10.0 ± 7	1.0 ± 4	3.6 ± 4	5.2 ± 6	3.1 ± 28
1027	22.6 ± 6	1.2 ± 4	2.0 ± 6	7.1 ± 4	5.0 ± 30

Source: Griggs and Buddemeier, 1986.

[a] See Figure 3-18 for sample locations

[b] Samples 1013 and 1014 are duplicates.

[c] Samples 1021 and 1022 are duplicates.

TABLE 3-8

PLUTONIUM, CESIUM, AND URANIUM IN SOIL - SITE 300 (SAMPLING DEPTH = 0 TO 5 CM)
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Location[a]	^{239}Pu [10^{-9} µCi/dry g ± 2σ (%)]	^{137}Cs [10^{-7} µCi/dry g ± 2σ (%)]	^{238}U [µg/dry g ± 2σ (%)]
1028	0.7 ± 19	0.4 ± 22	6.2 ± 10
1029	0.9 ± 15	0.5 ± 17	5.8 ± 20
1030	1.2 ± 13	0.7 ± 14	2.7 ± 30
1031	0.5 ± 25	0.8 ± 30	8.5 ± 9
1032	1.4 ± 13	0.9 ± 12	350.0 ± 5
1033	6.6 ± 7	3.1 ± 5	4.8 ± 28
1034	1.4 ± 13	0.7 ± 12	5.7 ± 12
1035[b]	0.5 ± 21	0.3 ± 30	4.5 ± 16
1036	2.6 ± 11	1.2 ± 8	5.4 ± 30
1037	0.6 ± 15	3.5 ± 24	2.7 ± 24
1038	4.0 ± 10	1.8 ± 7	5.4 ± 26
1039	1.9 ± 8	1.2 ± 7	85.7 ± 4
1040	2.8 ± 10	1.8 ± 7	16.0 ± 19
1041	0.7 ± 12	0.5 ± 18	6.3 ± 11

Source: Griggs and Buddemeier, 1986.

a See Figure 3-19 for sample locations.

b Samples 1013 and 1014 are duplicates.

c Samples 1024 and 1022 are duplicates.

greatest to allow for evaluation of uranium distribution. This sampling strategy accounts for the high average results at Site 300 as compared to results from the Livermore Valley locations (36.4 µg/g ± 1.31 µg/g versus 4.2 µg/g ± 0.27 µg/g). There are no off-site Site 300 soils sampling locations reported for 1985.

DOE uses a level of 35 pCi/g uranium (dry) in remedial action programs for acceptance of decontaminated areas. This concentration is equivalent to approximately 105 µg/g U-238 and, as shown on Table 3-8, only one sampling location (1032) exceeded this guideline. Average sample results were approximately 35 percent and approximately 4 percent of this acceptance criteria for Site 300 and the Livermore Valley, respectively.

Table 3-9 compares Livermore Valley and Site 300 soil radionuclide sampling results with United States and California "background" concentrations for uranium-238 and thorium-232. Results indicate slightly elevated U-238 and Th-232 levels in the Livermore Valley when compared to published California "background" (4.2 µg U-238/g ± 0.27 µg/g versus 2.34 µg U-238/g ± 3.3 µg/g; 6.4 µg Th-232/g ± 0.09 µg/g versus 4.95 µg Th-232/g ± 4.13 µg/g) (Myrick et al., 1983). Site 300 on-site sampling results were higher than California "background" levels (36.4 µg U-238/g ± 1.31 µg/g versus 2.34 µg U-238/g ± 3.3 µg/g). Updated aerial radiation surveys for Site 300 are not available; however comparison of the data from these surveys with reported soil sampling data should provide fairly good agreement. Use of aerial survey information followed by soil sampling data to verify questionable or changing areas is probably the best sequence using these two soil radiation monitoring techniques.

3.2.4 Findings and Observations

3.2.4.1 Category I

None

3.2.4.2 Category II

None

3.2.4.3 Category III

1. Actual and Potential Soil Contamination from Miscellaneous Spills and Abandoned Wastes. At both Site 300 and the Main Site, the Survey team observed and viewed records of numerous

TABLE 3-9

COMPARISON OF RADIONUCLIDES IN SOIL
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Radionuclide	US[1] Average (Range) µg/g ± 2 STD. DEV.	California[1] AVG. (Range) µg/g ± 2 STD. DEV.	Livermore Valley[2] AVG. (Range)	Livermore Valley Average / California Average	Site 300[2] Average (Range)	Site 300 On-site Average / California Average
U-238	3.0 ± 2.49 (0.36 - 11.4)	2.34 ± 3.3 (0.57 - 3.9)	4.2 (2.0 - 6.8)	1.79	36.4 (2.7 - 350.0)	15.6
Th-232	9.0 ± 4.22 (0.92 - 31.2)	4.95 ± 4.13 (2.75 - 6.97)	6.4 (1.7 - 14.7)	1.29	--	--

Source: Developed by DOE Survey team.

(1) Myrick et al., 1983.
(2) Griggs and Buddemeier, 1986.

spills and abandoned waste areas that may be sources of soil, surface-water, and groundwater contamination. These sites are discussed further in Finding 4.5.2.4.1.

No comprehensive investigation of Site 300 has yet been performed to identify, characterize, and clean up spills and abandoned waste sites. The Survey team recorded the following locations of spills and abandoned wastes at Site 300 during the performance of Survey activities.

- GSA area near Well 7.
- GSA area between B-875 and B-878 on south side near Corral Hollow Road.
- GSA area north of B-875 along embankment, and drum rack.
- B-827C, D, and E drum rack drains and sumps.
- Buried drum behind B-827E drum rack.
- B-827A oil spills on pavement.
- B-805 drain on uphill side of Building 805.

This list should not be interpreted as a comprehensive compilation of spill sites. Such a compilation is beyond the scope of the Survey. These spills are also discussed in Section 4.5.2.

At the Main Site, the first step in identifying, characterizing, and cleaning up the spills and abandoned waste sites has already occurred. This compilation (December 1985) identified 52 known or suspected sources of contamination, which are listed in Table 4-22 and discussed in Section 4.5.2. These sources vary from large, well-characterized, and partially remediated sites such as the East Traffic Circle landfill, to confirmed reports of small drum spills for which no present visual evidence exists.

2. Firing-Table Gravel. Residual gravel and debris on the firing tables and bunkers at Site 300 may be a source of soil and groundwater contamination.

Wastes contaminated with uranium, lead, and beryllium have been released on and around the firing tables of the several test bunkers at Site 300. Known as "hydrodynamic diagnostics complexes," these firing tables are covered with gravel to serve as a cushion for the High Explosives (HE) "shot." Following each shot, the gravel is sampled to determine the level of uranium and beryllium contamination. The firing table gravel is usually removed and disposed of in a landfill before the limits established in LLNL's Hazards Control Department Standard Operating Procedure are achieved. Through this process, the firing tables at Site 300 generate a hazardous waste containing gravel and shot debris. This waste, which is disposed

of at one of the two dedicated Site 300 hazardous waste landfills, has been shown to generate a leachate with hazardous concentrations of metals, particularly lead, as shown by the listing of this waste on LLNL's Part A notification as a D008 hazardous waste (EP toxic for lead).

The firing-table gravel may present a contamination threat because a significant amount of the gravel that explodes off the firing table is not scraped up. The Survey team observed gravel deposited on outdoor stairs, rooftops, vehicles, and parking areas following the post-shot cleanup of contaminated gravel. This gravel may present a significant accumulated source of contamination because of repeated shots, and because resultant contaminated gravel and debris has not been removed from surrounding areas, this residual contaminated gravel may constitute essentially unpermitted disposal of a hazardous waste. Survey-related sampling of the firing table gravel is planned to determine whether the gravel at the firing tables is hazardous.

LLNL personnel believe that residual tritium at Bunker 850 has contaminated groundwater between Wells NC7-28 and NC7-44. Contaminants from gravel and debris may be transported from soil via surface water runoff and dust emissions. This finding may have significant implications for the ongoing practice of leaving some of the firing table gravel in place after a shot. If debris from B-850 is capable of contaminating groundwater, then debris from other bunkers may pose the same risk.

The firing tables are used for explosive testing of weapon components. Tests take place on a gravel bed. After each test the bed is wet down for dust suppression. This dust suppression water, as well as any precipitation or runoff, percolates through the firing table debris and gravel. These waters are not collected.

3. High Explosives Burn Pits (Site 300). The high explosives (HE) burn pits area near Building 829 may be a source of continuing or future soil and groundwater contamination. Waste HE or HE-contaminated waste is burned in cages located in pits, or in a device called an "iron horse."

Clarifier bags containing high-explosive wastes from the HE process areas are burned in the iron horse, which is similar in appearance to an elevated and elongated cement mixer. No provisions existed around the iron horse for rain or runoff protection; hence, HE-contaminated leachate may have been formed.

Waste HE and rubble contaminated with HE is burned at any given time in cages in one of three pits. Each pit is about 20 feet deep, about 25 feet long, and 15 feet wide. A steel,

chain-link cage is placed at the bottom of the pit, and the wastes are piled into the cage. When enough HE has accumulated for a burn, which may be a period of several months, the pile is ignited according to interviews of LLNL personnel conducted by the Survey team. Pit 1 is most active now, although all pits have been used. Pit 2 also received TCE- and PCE-contaminated wastes. Rainfall during the accumulation period will percolate through the waste. The result is a leachate that will infiltrate into the soil. There is no information available on the specific type or quantity of waste burned in the pits. Soil samples taken by LLNL indicate that contamination of the soil with HE constituents has occurred.

3.2.4.4 Category IV

None

3.3 Surface Water

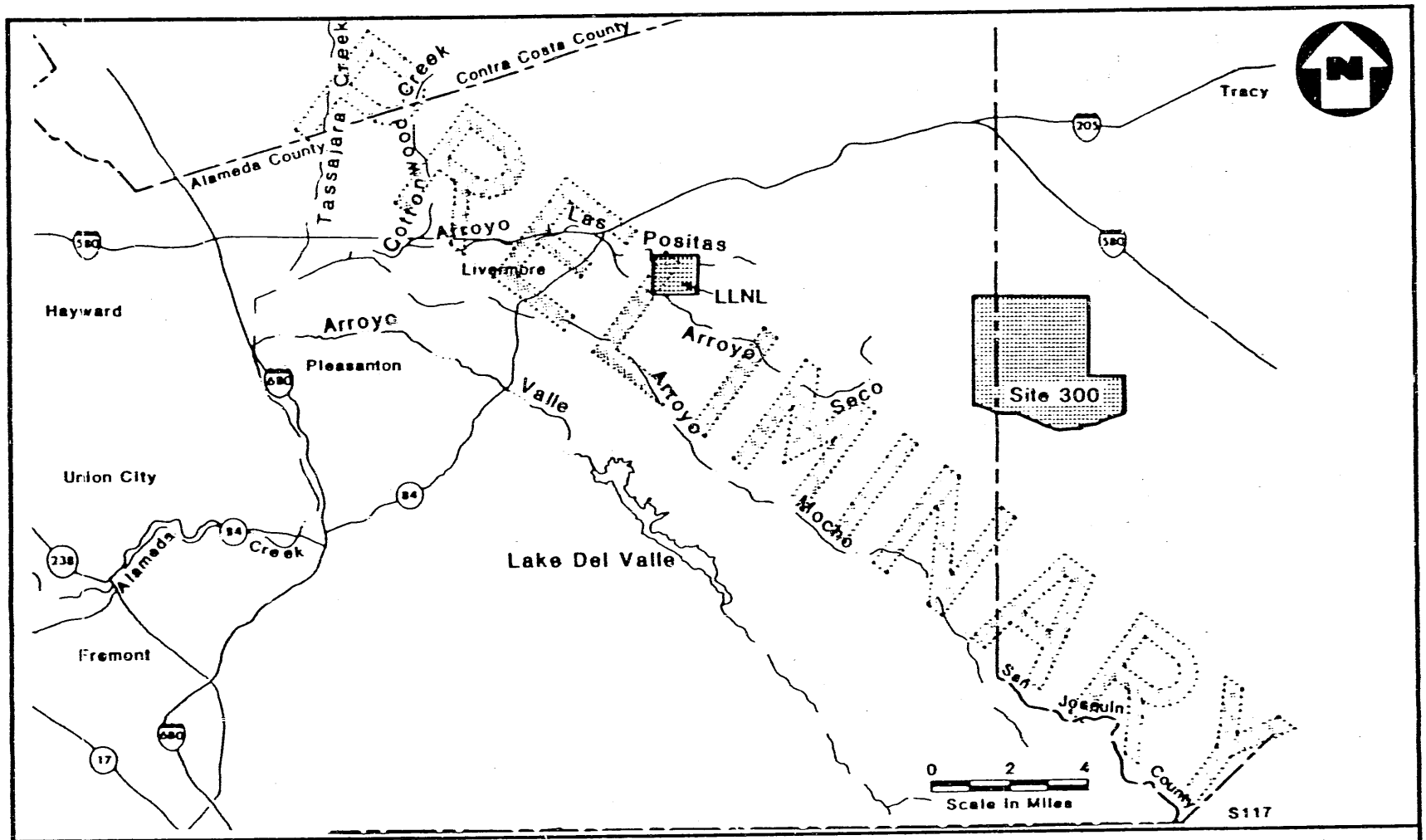
3.3.1 Background Environmental Information

LLNL Main Site

The Main Site lies entirely above the 100-year floodplains of the two arroyos (a watercourse in an arid region) draining or adjacent to the site. The 100-year flood would be contained in the channel of Arroyo Seco at the southeast corner of the site, and in off-site zones of Arroyo Las Positas near the northeast and northwest corners (Figure 3-20). As part of an erosion-control program in 1965, Arroyo Las Positas was channeled to flow north to the northeast corner of the site, then due west along the site's northern perimeter to an outlet at the northwest corner. The two arroyos merge along the Western Pacific Railroad tracks just east of the City of Livermore. These surface waters leave the Livermore Valley from the valley's southwest corner at Sunol, eventually draining into San Francisco Bay. None of the communities in the area rely on these surface water sources as a public drinking water supply.

Other water bodies in the vicinity of LLNL's Main Site include the South Bay Aqueduct 0.2 km (0.1 mile) southeast, the Patterson Pass water treatment facility 1.2 km (0.7 miles) east, Frick Lake (dry most of the year) 4 km (2.5 miles) north, Lake Del Valle 8 km (5 miles) south, and man-made lakes and ponds in the Shadow Cliffs Recreation Area 11 km (7 miles) west (Holland et al., 1987).

The arroyos are dry for more than half of the year, and flow slowly for the most part even during the wet season. Average annual rainfall at Livermore is reported (University of California, 1986) to be



SOURCE: University of California, 1986.

FIGURE 3-20

SURFACE-WATER HYDROLOGY OF THE LIVERMORE AREA
LLNL – LIVERMORE, CALIFORNIA

36 cm/yr (14 in/yr), but the Main Site received only about half that amount in 1986. The LLNL Main Site channels all storm-water runoff through open drains and storm sewers (designed to direct a 10-year flow) toward three receptors: to Arroyo Las Positas at multiple points along the northern edge of the site; to a ditch running along the western part of the site and eventually discharging to Arroyo Las Positas at the northwest corner; and from a small area in the southwestern corner, to Arroyo Seco.

The LLNL Main Site has endeavored to divert all process or utility wastewaters from entering the storm drain system, and has succeeded to the point where there are no continuous releases to the arroyos. Recently, plans have been developed to tie several intermittent discharges to the sanitary sewer system (e.g., backwashes from the LLNL swimming pool and blowdown from the cooling towers at Building 325 area). These wastewaters currently are released to the storm drainage system.

The bulk of the site's process rinses and other wastewaters are released, along with all sanitary wastes, to LLNL's sanitary sewer system for processing at the City of Livermore Water Reclamation Plant (LWRP). Currently, the total sanitary discharge from LLNL (including the flow from Sandia National Laboratory) ranges from 8 to 10 percent of the LWRP capacity. A small portion of the LWRP treatment plant effluent is used locally to irrigate a nearby golf course, the Livermore airport, landscaping on I-580, and nearby agricultural land. Such usage accounts for about 15 percent of the total treated water available. The major portion of the total effluent is transported out of the valley via a pipeline to San Francisco Bay (Holland, et al., 1987).

LLNL provides continuous monitoring equipment at the Main Site to identify any potentially harmful radioactive or metallic pollutants in their effluent. Radiation detectors measure radionuclides, an X-ray fluorescence monitor tracks selected metals, and a pH probe continuously measures pH. All three devices are designed to trigger an alarm in the LLNL firehouse (which was chosen because it is staffed around-the-clock) and to activate a dedicated composite sampler to collect samples for confirmatory analysis.

Potable water at the Main Site comes principally from one of two public water sources:

- The City of San Francisco's Hetch Hetchy water system.
- Zone 7 of Alameda County's Flood Control and Water Conservation District.

The Hetch Hetchy system's Mocho Shaft, 11 km (6.8 miles) south of LLNL, is connected to three storage tanks at the south end of Sandia National Laboratory Livermore (SNLL). Water for all

domestic, plant, and fire protection uses is then delivered by gravity and distributed throughout LLNL and SNLL via an underground piping grid system. Together the three tanks hold approximately 5 million liters (1.3 million gallons), or about one day's supply for the two sites during peak usage periods in July and August.

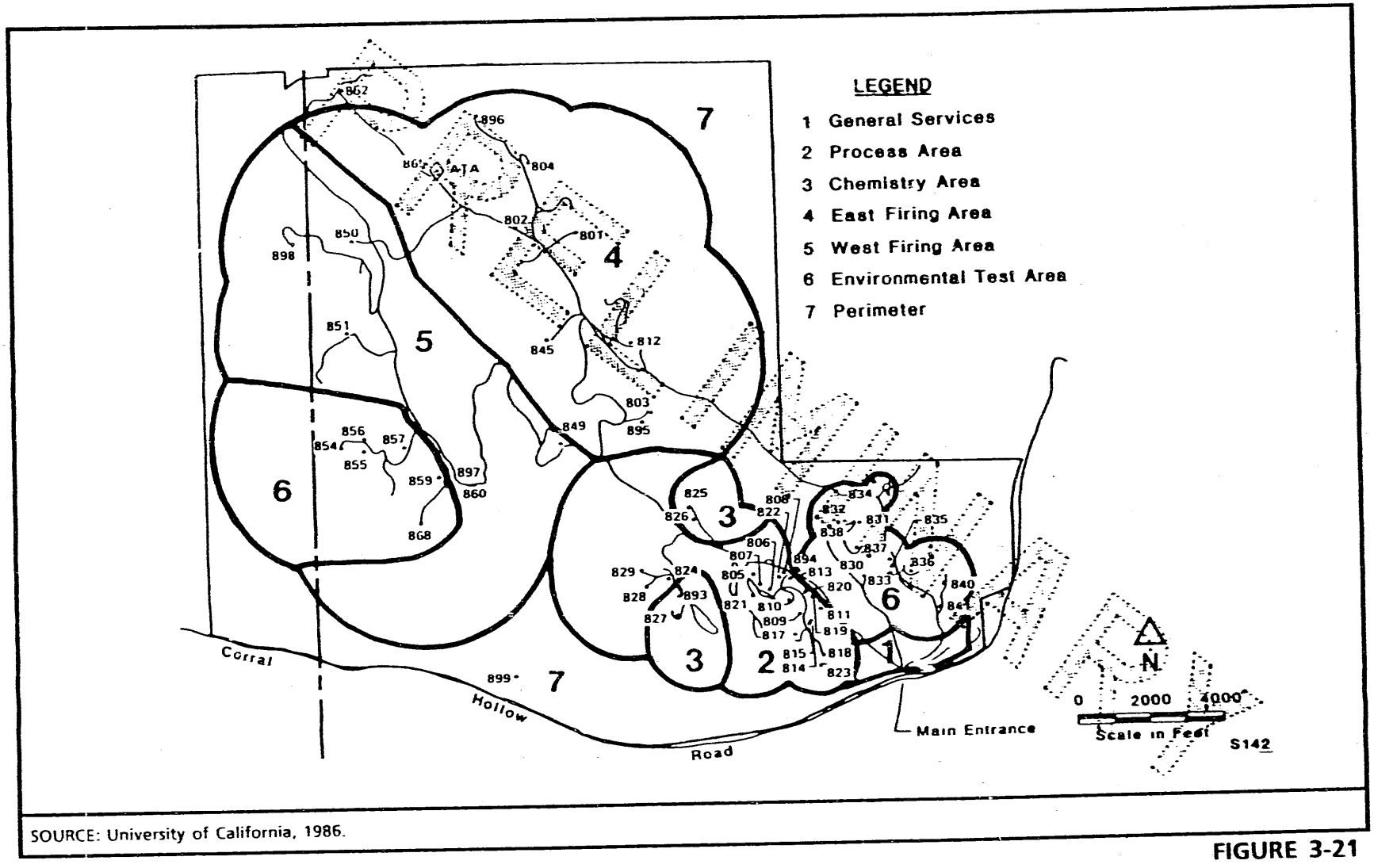
The Main Site operators prefer to use Hetch Hetchy water when available because it is lower in dissolved solids and trace metals concentrations, but for 1 or 2 months each year (partly because of emergencies or necessary repairs to the Hetch Hetchy system, partly because of contractual commitments), LLNL and SNLL switch over to Zone 7 water. The Zone 7 distribution main is connected to the site water distribution system by a pumping station near the northern boundary.

LLNL Site 300

Site 300 lies in the sparsely populated hills of the Diablo Range about 29 km (18 miles) ESE of the Main Site (see Figure 2-3). Elevations range from 150 to more than 500 meters (490 to 1,640 feet) above sea level, and the terrain is characterized by canyons, ravines, and sloping plateaus. Annual rainfall historically averages 26 cm/yr (10.2 in/yr), but the last few years have been well below average. More than 80 percent of the site lies in San Joaquin County, with only the westernmost part lying in Alameda County. Elk Ravine cuts diagonally across the site from northwest to southeast, while Corral Hollow Road defines the southern boundary. The ravines form natural pathways for surface-water runoff during the wet season, while Corral Hollow Creek drains the canyon and hills lying to the west and south of Site 300. All site runoff paths lead to Corral Hollow Creek, either directly or via Elk Ravine. The creek in turn flows eastward, eventually reaching the San Joaquin River. Such flows occur only during the rainy season; the stream bed is dry most of the year.

Site 300 is the only known natural habitat for the wildflower Amsinckia grandiflora, which was believed to be extinct until discovered in 1938 on what is now the southwest portion of Site 300. The known habitat is not used for any routine activities and is clearly marked to protect the plants. There is also a 40 hectare (100-acre) wildlife preserve along the east side of the site, which was transferred to the California Department of Fish and Game in 1975.

The only water bodies in year-round use at Site 300 are the man-made retention basins and sewage treatment pond associated with on-site activities. The site is divided into a General Service Area (GSA) at the southeast corner adjacent to Corral Hollow Road, and to programmatic operation areas distributed throughout the site (Figure 3-21). GSA houses all administrative and support functions (e.g., police/security; fire protection; medical; administration offices; crafts; stores; mechanical,



SOURCE: University of California, 1986.

FIGURE 3-21

PROGRAM OPERATIONS AREAS AT SITE 300
LLNL – LIVERMORE, CALIFORNIA

chemical and plant engineering operations; a cafeteria; and a service station). Programmatic operations emphasize high explosives (HE) formulation, pressing, machining, and environmental testing; high-speed photography, and detonation on firing tables.

Process wastewaters are controlled by impoundment in lined lagoons after preliminary clarification, or by collection in retention tanks for sampling, analysis, and possible transfer to the Main Site for treatment and/or disposal. The annual evaporation rate of 1,520 mm/yr (60 in/yr), coupled with the low annual rainfall rate, gives a net evaporation rate of 1,240 mm/yr (49 in/yr), sufficient to evaporate all but a very minor portion of the site's wastewaters.

An active program has been instituted to intercept and divert surface runoff around potentially contaminated areas, and to drain and close unlined surface impoundments. Dry wells were formerly used to dispose of certain wastewaters, (e.g., photo-processing rinses and craft shop wastewater), but all have been closed and other methods were developed for disposing of such wastewaters. Certain cooling waters are still released to the ground, a practice permitted by the regulatory authority under Waste Discharge Order No. 82-105 (CRWQCB, 1982).

Approximately 13,200 to 15,000 liters (3,500 to 4,000 gallons) of sanitary wastewater is discharged to an on-site oxidation pond in the GSA each day. The pond is lined with an asphaltic liner and is designed to accommodate up to 26,000 liters (7,000 gallons) per day. During dry weather, water must be added to the pond to maintain an effective working depth. Conversely, in the winter when evaporation is minimal, additional capacity is available in the form of a smaller overflow pond. This pond is rarely used. Domestic waste from outlying programmatic facilities is discharged into nearby septic tanks, which discharge in turn to leach beds.

Site 300 uses on-site wells to provide potable water for all process and human needs. Twelve wells are available, but current operations require only 6 or 7 wells to serve site needs. Water is stored in any of ten storage tanks, fed by gravity to distribution mains, then to the buildings for fire protection and all other uses. Backflow check valves and air gaps prevent flow reversal and limit the possibility of contaminating the wells or other parts of the potable water system. Chemical and bacteriological analyses are performed routinely in compliance with state requirements (CAL, 1977).

3.3.2 General Description of Pollution Sources and Controls

All major sources of polluted or contaminated wastewaters at both LLNL sites have been identified, and appropriate controls are being applied. LLNL relies on several key principles to gain control of toxic, hazardous, or radioactive wastewaters:

- Segregation of concentrated liquids for separate handling.

- Retention of dilute wastewaters until sampling and analysis of the wastewaters can be used to indicate whether treatment is required prior to release to the LWRP.

- Continuous, automated alarms and a sophisticated monitoring system for detection of unexpected releases of metals or radioactivity.

- Close liaison between program managers and hazardous waste/environmental specialists to identify potential problems unique to each building or experiment.

The following paragraphs provide basic information on process-related and non-process wastewater sources for each site.

LLNL Main Site

Wastewater sources at the Main Site are scattered throughout the hundreds of buildings and the thousands of experiments ongoing at any given time. The major sources, especially those which are found in several separate programs, are emphasized here. Control techniques are directed toward segregation at the source rather than dilution and/or treatment. Common sources include the following:

- Degreasers using solvents to clean metal parts
- Electroplating baths and rinsing operations, using acidic or alkaline solutions
- Oils, solvents, and cutting fluids from machine shops
- Metal cleaning and bright dip solutions
- Etchants from printed circuit-board fabrication
- Backwashes from filters and ion exchange columns
- Photoprocessing solutions and rinsewaters
- Steam plant and boiler blowdowns
- Wet spray booths at painting operations
- Cooling tower blowdowns
- Decontamination solutions
- Wastewater treatment plant effluents

Degreasing solvents are used to clean equipment and metal or glass parts at a number of plant locations, including Buildings 131, 141, 176, 231, 241, 321, 381, 383, 391, 403, 432, 511, and 519. The most widely used solvent is 1,1,1-trichloroethane, although methylene chloride, Freon, acetone, kerosene, methyl ethyl ketone, tetrachloroethylene, and proprietary mixtures are also effective. Spent solvents are segregated at the individual laboratories for disposal by Hazards Control personnel. Only dilute rinses are discharged into retention tanks or sanitary sewers.

Electroplating of chromium, nickel, copper, and other metals onto base materials is practiced at Buildings 141, 321, 322, and 438. Spent concentrates (acids, bases, and cyanide baths) are collected separately and either treated at the Hazardous Waste Management (HWM) Section's liquid waste treatment facility at Building 514, or, more often, by a commercial facility approved by the State of California. Only dilute rinsewater from Buildings 321 and 322 is collected and treated at the ion exchange facility serving Building 322. Other plating rinses are collected in retention tanks, sampled, analyzed, then treated at the HWM treatment facility as required or released to the sanitary sewer system. Cyanide wastes are routed to separate tanks for holding, analysis, and control at the same treatment facility. Rinsewater batches that exceed specified limits are pumped to a portable tanker and directed to the HWM facility

Oils, solvents, and cutting fluids are segregated according to chlorinated and flammable categories, then controlled as solid waste materials for disposal under RCRA regulations and State of California requirements. (Refer to Section 4.1.1 for details.) Machine shops are found in a number of locations, including Buildings 194, 231, 261, 321, 367, 383, and 432. Waste materials are placed in designated staging areas near each source for pick-up by HWM personnel.

Metal-cleaning and bright-dip operations using chromic, nitric, hydrochloric, or sulfuric acid solutions to clean and brighten metal are found in Buildings 165, 212, 251, 341, 345, 383 (now abandoned), 438, 443, and 511. As in the case of electroplating, spent concentrates are collected and disposed of through HWM channels, either to on-site treatment or to off-site commercial facilities for management. Dilute rinsewaters are typically collected in retention tanks for sampling and analysis prior to release, although a few small-volume operations have sent rinses directly to the sanitary sewers.

Printed circuit-board etchants, notably in Buildings 113 and 438, are collected separately and segregated from other plating or cleaning solutions. Volumes are small, typically less than 19 liters (5 gallons), and are easily handled in carboys. The limited amount of rinsing of circuit boards generates very low volumes of rinsewaters, which either collect in retention tanks for sampling and analysis or flow directly to the sanitary sewer.

Backwashing of filters at the Low Conductivity Water (LCW) stations (Buildings 291 and 325) and the LLNL swimming pool (Building 318) generates batches of dirty water for disposal. Also, the backwashing of ion exchange resin beds at Buildings 194, 291, and 325 contributes a significant load. Filter backwashes at Building 291, along with cooling tower blowdowns and condensates from air traps, are routed to the sanitary sewer. Building 325 and the swimming pool filters are currently backwashed to storm drains, but plans are being made to re-route these releases to the sanitary sewers. Ion exchange column backwashes are segregated for collection, pumped out, and hauled to a permitted commercial liquid waste disposal site.

Photoprocessing operations are spread out into a number of buildings, including 111, 113, 121, 231, 255, 261, 294, 298, 327, 328, 341, and 345. Some operations are large, 24-hour automated processing centers (e.g., Building 113), but most are relatively small, low-volume generators of wastewaters. In all cases, solutions containing recoverable silver are segregated and sent to on-site processing operations in Building 404 for reclamation of the silver. Other spent concentrates are handled in carboys or labpacks by Toxic Waste Control (TWC) personnel. Most rinsewaters are small volume sources, and so are routed directly to the sanitary sewers. In a few cases, provisions exist for holding back a batch of solution for alternative disposal. For example, Building 113 has a cellar sump that can provide retention for several hours in the event that a spill of higher concentration solutions reaches the floor or sink drains. An automatic pump lifts the wastewater from the sump if operations are normal, and concentrations of contaminants are low. The pumps can be overridden manually, and the sump contents transferred to portable holding tanks when higher concentrations persist.

The LLNL Main Site steam plant in Building 401 was permanently shut down on June 3, 1986, and will be dismantled. This plant formerly provided steam for all but the newest buildings on-site. A new steam plant (Building 416) will contain two boilers to generate steam for 8 to 10 nearby buildings. Smaller gas-fired units will be used throughout the site to serve all other buildings. The few discharges originating from steam plant operations (e.g., water softener backwash or boiler blowdowns) will be cooled in a retention tank and released to the sanitary sewer.

Paint shops in Buildings 341 and 418 use wet spray booths with a recirculated water curtain to control fumes and overspray. A caustic powder is added to the recycled water to keep paint in suspension. Some settling occurs in the recycle sump. A paint sludge results, which is collected and disposed of as hazardous waste by HWM. When the water gets too dirty, it is released to the sanitary sewer (once per month at Building 418, less often at Building 341).

Periodic wastewater blowdowns for recirculating cooling water systems at Buildings 291, 325, 435, and from small systems throughout the site are directed to the sanitary sewer system. While Hetch Hetchy water is used as the make-up to these systems, recycle rates can be maintained at 90 percent or higher. Thus volumes released to the sewer are minimized to an average daily rate of between 20,000 and 25,000 gallons per day. Zone 7 make-up water is blown down at a higher rate because of its higher conductivity and dissolved solids content, so average release volumes are increased to 25,000 to 30,000 gallons per day. During the warm weather months (July, August, and September), average daily releases more than double because increased losses due to evaporation require increased make-up volumes, especially when Zone 7 water is used.

Decontamination activities at Building 419 generate varying types of wastes, including soap and water rinses, dilute spent solvents, and wet residues from sandblasting. Solvents and sandblasting residues are separately handled by HWM, whereas dilute rinses are held in a retention tank system pending sampling and analysis to guide release to treatment at Building 514 or to the sanitary sewer system. Normal operations were not observed during the on-site Survey because wet decontamination was limited as the result of modification of the retention tank piping and collection system.

Other Main Site sources tend to be unique to a single building or program. For example, laser isotope separation operations in the Building 490 complex utilize laser dyes (principally rhodamine) in ethanol solution. A new collection and retention tank system has been installed to control waste releases from any leaks in the ethanol recycle system. The Building 490 complex also includes a Freon recirculating system used in cooling the process equipment. Two Freon holding tanks (one for clean make-up, the other for "dirty" used coolants) have been relocated within a well-bermed area, complete with a locked drain to the sanitary sewer. The berms provide good confinement in the event of a leak or spill.

Inertial confinement fusion operations in Building 391's coating laboratory require use of a tetraethyl orthosilicate (TEOS) gel solution in a dip tank (200-300 gallons per year). A TEOS still in the building is used to boil off water and recover the TEOS-ethanol mixture. Building 391 also uses 5 percent HF solutions with NH_4OH as an etchant. Rinsewaters are collected in 55-gallon drums and transferred to HWM control for disposal.

In addition to all the sources cited above, the LLNL Main Site also has hundreds of individual laboratory rooms where small volumes of typical acids, bases, and solvents are routinely used, including the hazards control laboratory in Building 253; chemistry operations in Buildings 222, 231, 241, and 332; and nuclear chemistry facilities in Buildings 151 and 251. Each potential source has

been identified and merged into the HWM collection system for waste concentrates, and each building has access to a retention tank system if dilute rinses can be reasonably expected to require sampling and analysis prior to disposal to the sanitary sewer or transfer to the HWM liquid waste treatment plant at Building 514.

This latter facility can handle diverse wastewaters in any of six 9,700 liter (1,500 gallon) treatment tanks. There is also one 113,500 liter (30,000 gallon) retention tank for temporary storage of incoming wastewater when all treatment tanks are full. Interconnecting pipes give the operator great flexibility within the system. Treatment chemicals are added to any tank via a pumping system. The key component of the treatment system is a rotary vacuum filter using a diatomaceous earth precoat to separate precipitated metals and other fine suspensions from the effluent. Incoming batches of wastewater (which had previously been sampled and analyzed while in retention tanks associated with the program) are treated chemically to precipitate and coagulate metal ions. This slurry is then fed to the rotary drum filter. Clean water is pulled through the surface, while solids remain embedded within the 5-cm thick diatomaceous earth precoat. As the drum rotates, a thin surface layer is constantly shaved off, collected in a barrel, and disposed of as solid hazardous waste (through routine channels via Building 812). The "clean" liquid phase is not released directly to the sanitary sewer, but instead is returned to a treatment tank and reanalyzed prior to release. If analysis indicates that additional treatment is required, the batch is sent through treatment again. Otherwise, it is released to the sanitary sewer. Certain mechanical problems with the filtration system, which formerly permitted some wastewater to pass through the system untreated, have been corrected and all wastewaters can now be closely controlled to ensure acceptability for release (DOE, 1986).

LLNL Site 300

Site 300 has several sources similar to those at the LLNL Main Site, especially within its GSA. These include

- Machine shops in the 806/807 Complex, the 827/828 Complex, and at 875.
- Metal cleaning/bright dip operations at GSA's Buildings 873, 874, and 875.
- Wet spray booth at the paint shop (GSA's Building 872).

- Photoprocessing solutions and rinses from Buildings 801, 823, 850, 851, 865, and GSA's 872.

- Cooling tower blowdowns at scattered locations around the site, including Buildings 801, 815 (now replaced with a non-evaporated cooler), 826, 827, and 865.

These locations share the same characteristics as similar operations at the Main Site, although typically on a much smaller scale. Wastewaters, except for cooling tower blowdowns, are collected in retention tank systems and transferred to two on-site evaporation ponds or to the Main Site for treatment as required. In some specific cases, Site 300 wastewaters are moved from their on-site sources to other clarifier and/or evaporation lagoon systems on site. For example, washings from high explosives formulation at the 823 Complex are held in a new 5,000-gallon retention tank, collected by a water wagon, and transferred to the 806/807 Complex clarifier and surface impoundment system.

Cooling tower blowdowns are not collected, but are released to the ground, since regulatory requirements at Site 300 permit this type of disposal (CRWQCB, 1982). The only other major source of wastewaters on-site consists of sewage. The GSA has a lined oxidation lagoon for controlling sewage from that complex, whereas the more remote site locations are permitted to use septic tanks and leach fields or cesspools for control.

3.3.3 Environmental Monitoring Program

LLNL Main Site

Monitoring requirements for LLNL with respect to wastewater discharges are currently established by the City of Livermore's Water Reclamation Plant under Section 13 of the City Code. The superintendent of the LWRP has imposed general discharge limits on flammables; toxics; pH; solids or viscous matter that could obstruct flow; noxious or malodorous substances; temperatures in excess of 40°C (104°F); pH less than 6.8 or greater than 8.5; freon extractables greater than 100 mg/l, biological oxygen demand (BOD) levels greater than 300 mg/l, total suspended solids (TSS) greater than 300 mg/l, incremental addition of total dissolved solids (TDS) greater than 325 mg/l or chlorides greater than 75 mg/l during a single cycle use of the water supply; radioactivity of such half-life or concentration as may exceed state or Federal regulatory agency limits applicable to the POTW user; and any other substance that may upset treatment plant operations, cause the POTW to violate its NPDES permit requirements, or render the POTW's sludge or effluent to be unsuitable for reuse or reclamation. Specific numerical limitations have been established for other pollutants as follows:

Metals		Non-Metals	
Arsenic	0.1 mg/l	Cyanide	1.0 mg/l
Cadmium	0.2 mg/l	TICH*	0.02 mg/l
Copper	2.0 mg/l	Phenolic Compounds	1.0 mg/l
Chromium, Total	1.0 mg/l	PCBs	0.01 mg/l
Lead	1.0 mg/l		
Mercury	0.01 mg/l		
Nickel	1.0 mg/l		
Silver	0.2 mg/l		
Zinc	3.0 mg/l		

Source: City of Livermore, 1983.
*Total identifiable chlorinated hydrocarbons

In addition to the previously mentioned parameters, three radionuclide effluents are analyzed as they leave LLNL and the LWRP. Table 3-10 summarizes this comparison data. Concentration reductions as a result of dilution and treatment of these indicator radionuclides range from 83 to 97 percent. As shown, all results are well below concentration guidelines at the LLNL and LWRP discharge points.

Except for occasional excursions outside the narrow pH limits (6.8 to 8.5), the LLNL sanitary effluents show a very high degree of compliance with LWRP requirements. Daily composites are combined to generate monthly and quarterly composites for analysis. Although only the quarterly results are required to be submitted to LWRP, LLNL tracks metals for each monthly composite. In addition, gross alpha, gross beta, and tritiated water measurements are made each day. Table 3-11 provides a summary of the analytical data for the regulated pollutants and for selected other pollutants.

Data review indicates nearly total compliance with limits on all metals, typically reporting concentrations at 10 to 20 percent of the permitted limit. The only exceedance noted was a single mercury concentration of 0.019 mg/l reported in the July-September quarter of 1982. The LWRP limit on mercury is 0.01 mg/l. With respect to non-metals, full compliance was achieved for all parameters with the possible exception of the incremental addition limits on total dissolved solids (TDS) and chlorides. Since the numerical limits of 325 and 75 mg/l, respectively, are net limits, analyses reports should include TDS and chloride concentrations in the water supply for comparison with the sewer

TABLE 3-10

VARIOUS RADIONUCLIDES IN EFFLUENTS OF
LLNL AND LIVERMORE WATER RECLAMATION PLANT (LWRP)
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Month	HTO [10^{-6} µCi/ml ± 2σ(%)]		^{137}Cs [10^{-11} µCi/ml ± 2σ(%)]		^{239}Pu [10^{-12} µCi/ml ± 2σ(%)]	
	LLNL	LWRP	LLNL	LWRP	LLNL	LWRP
January	1.8 ± 41	1.4 ± 83	5.3 ± 100	1.9 ± 100	8.8 ± 12	0.5 ± 89
February	3.9 ± 52	0.6 ± 80	4.9 ± 28	2.9 ± 100	6.1 ± 24	0.2 ± 100
March	45.7 ± 34	5.1 ± 58	12.5 ± 11	1.8 ± 100	2.2 ± 25	0.1 ± 100
April	2.0 ± 40	0.7 ± 72	10.0 ± 27	3.6 ± 100	5.1 ± 21	0.5 ± 91
May	4.9 ± 55	0.8 ± 80	6.0 ± 7	2.3 ± 100	62.9 ± 7	0.5 ± 51
June	2.4 ± 36	0.8 ± 71	58.3 ± 4	3.6 ± 100	9.8 ± 15	0.2 ± 75
July	3.4 ± 34	0.6 ± 78	7.7 ± 15	3.7 ± 100	3.6 ± 16	0.1 ± 89
August	2.4 ± 31	0.5 ± 84	5.6 ± 30	1.9 ± 100	3.2 ± 29	0.2 ± 76
September	9.0 ± 30	1.1 ± 65	2.9 ± 60	0.8 ± 100	3.5 ± 15	0.3 ± 50
October	2.4 ± 35	0.6 ± 82	9.4 ± 30	0.6 ± 100	4.5 ± 13	0.3 ± 57
November	3.7 ± 43	1.0 ± 81	13.9 ± 16	0.6 ± 100	3.9 ± 21	0.2 ± 82
December	4.7 ± 45	1.1 ± 70	5.6 ± 28	0.6 ± 100	3.1 ± 12	0.1 ± 100
Annual Average	7.2	1.2	11.8	2.0	9.7	0.3
% SDM	171	105	127	60	174	56
CG (µCi/ml)	2×10^{-3}	2×10^{-3}	3×10^{-6}	3×10^{-6}	3×10^{-7}	3×10^{-7}
%CG	4×10^{-1}	6×10^{-3}	4×10^{-3}	7×10^{-4}	3×10^{-3}	1×10^{-4}
% Reduction from LLNL		83		83		97

Source: Griggs and Buddemeier, 1986.

SDM - Standard Deviation of the Mean
CG - Concentration Guideline

TABLE 3-11

PHYSICAL/CHEMICAL CHARACTERISTICS OF LLNL EFFLUENT IN 1986
(ALL CONCENTRATIONS IN MG/L)
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE CALIFORNIA

	Quarter				Annual Avg.	POTW Req.
	1	2	3	4		
Oil & Grease	15	6	<5	16	<11	100
BOD	80	100	20	116	79	300
COD	131	203	28	195	139	-
TSS	45	19	16	29	27	300
TDS	207	269	370	180	256	+ 325
Chloride	35	35	70	3	36	+ 75
Arsenic	(0.00)	0.004	0.001	<0.001	<0.003	0.1
Cadmium	0.0018	0.005	0.002	0.0027	0.003	0.2
Copper	0.04	0.07	0.07	0.09	0.07	2.0
Chromium	0.02	0.05	0.02	0.07	0.04	1.0
Lead	0.02	0.012	0.015	<0.26	<0.08	1.0
Mercury	0.0009	0.0011	0.0005	0.0013	0.001	0.01
Nickel	<0.05	<0.05	<0.05	<0.008	<0.04	1.0
Silver	0.005	0.007	0.04	0.028	0.02	0.2
Zinc	0.08	0.16	0.16	0.16	0.14	3.0
Cyanide	<0.02	<0.02	<0.02	<0.02	<0.02	1.0
TICH	ND	ND	ND	ND	ND	0.02
Phenolics	<0.05	0.18	0.13	0.09	<0.11	1.0
PCBs	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.01
TOC	63	66	11	63	51	-
Ammonia (N)	26	38	11	47	31	-
Sulfate	61	88	98	62	77	-

Source: Adapted from Holland et al., 1987.
+ Incremental addition no greater than concentration indicated
- Not regulated
ND None Detected

effluent. On two occasions in 1985 and one occasion in 1986 (note the third quarter TDS concentrations on Table 3-11), the stated concentrations were exceeded in quarterly samples, but may have been acceptable when corrected for background TDS and chlorides in the incoming water. This analysis is especially important when Hetch Hetchy water is not available and other sources must be used.

The continuous monitoring system provides LLNL with warnings when pH, metals, or radioactivity limits may be out of bounds and has enabled LLNL personnel to notify LWRP operators when temporary diversion of sewage effluents was necessary. This enables operators to protect publicly owned treatment works (POTW) microorganisms and to keep the plant from violating its National Pollutant Discharge Elimination System (NPDES) requirements. Known significant releases of metals, acids, or bases to the sanitary sewer system over the last 20 years are summarized as follows:

Date	Problem	Source	Impact
3/67	Acid Release	B321 Plating Shop	Decreased efficiency of sludge digesters.
9/6/67	Chomium Release	Unknown	LLNL paid to clean up one digester.
9/20/67	Chromic Acid/ Copper Release	Bright Dip Operations	No details.
4/68	Copper Cyanide Release	B321 Plating Shop	Half of bacteria in trickling filter killed.
2/10/71	Low pH	Unknown	Flow diverted. No other impact.
10/20/71	Low pH	B321- Leaking Tank	No impact (no diversion needed).
3/10/75	Low pH	HNO_3 from Sandia 913	Flow diverted. No other impact.
7/28/84	Nickel Release	Sandia	Flow diverted. No other impact.
9/11/86	High pH (10.5)	25 lbs Tide from B49?	No impact (no diversion needed).
9/18/86	Nickel/Chromium Release	Originally B322; transferred to B514 for treatment, but released inadvertently.	Sludge rendered unfit for use. Hauled away. LLNL cost = $150,000 City of Livermore cost = $2,500

Source: Adapted from DOE, 1986.

The most recent release was the subject of a detailed investigative report with recommendations for minimizing the likelihood of such incidents in the future (DOE, 1986). Refer to Finding 3.3.4.4.3 for additional details on this release. Changes have been made at the treatment facility to prevent recurrences in the future.

The LLNL Main Site submitted a required preliminary Baseline Monitoring Report to the LWRP superintendent in September 1985, but the final version is still forthcoming. There are no current

NPDES reporting requirements, although EPA has proposed that storm water runoff be regulated under NPDES rules. LLNL is planning to provide whatever information is required under the final rule requirements for storm drains. In the interim, LLNL staff has begun to collect data for use in responding to requirements. Several routine sampling points have been established on-site as follows:

- East ditch run-on (for use as background data).
- Drainage retention basin.
- Site runoff at northwest corner.
- Arroyo Seco entering LLNL, at its midpoint, and leaving LLNL.

Attempts have been made to collect the first major storm flow at the start of the wet season, and at least one other flow during the second or third month of the season. Samples are analyzed for nitrates, phosphorus, cyanides, phenolic compounds, oils and greases, surfactants, sulfates, total identifiable chlorinated hydrocarbons (TICH), pesticides, gross alpha, gross beta, and tritium. Analytical results thus far indicated that no contamination of any consequence is leaving the site via storm drains or surface runoff. In fact, typical results indicate that run-on is more contaminated than runoff for certain chemical parameters at detectable levels. Refer to Table 3-12 for details. Radioactivity measurements are all below 15 percent of the concentration guide levels, with tritium at less than 0.2 percent of the guide.

LLNL Site 300

Wastewater discharge requirements for Site 300 are spelled out in California Regional Water Quality Control Board (CRWQCB) Order No. 80-183 as amended, and in CRWQCB's Waste Discharge Order No. 85-188 for the surface impoundments. These requirements prohibit the release of any direct discharges, other than cooling water and treated sewage effluents, to surface waters or surface water drainage courses. The order restricts the volume of wastewaters to the quantities specified in the Order, and establishes a monthly groundwater monitoring requirement and annual reporting requirement. No monitoring requirements are given, either for the cooling water releases or the various septic tanks, cesspools, leach fields, or oxidation basins. Process wastewaters are all disposed of via evaporation, except for one small, 120-gallon-per-day, photo laboratory rinsewater source, which is allowed to enter the sanitary system for Building 851.

CRWQCB Order No. 85-188 establishes the requirements for the two Class II, double-lined, surface impoundments' monitoring system (wells, pressure-vacuum lysimeters, and a leachate collection system); inspection; geomembrane aging tests; and rodent/vegetation controls. Monitoring thus far

TABLE 3-12

CONTAMINANTS IN STORMWATER
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Contaminant	Unit	East Boundary Influent	Drainage Retention Basin	Northwest Corner Effluent
Chemical Oxygen Demand	mg/l	85	31	88
Total Organic Carbon	mg/l	31	6	21
Oil and Grease	mg/l	8	<5	9
Fluoride	mg/l	0.19	<0.1	0.26
Chloroform	µg/l	<1	<1	<1
Trichlorofluoromethane	µg/l	3	3	3
2,4-D	µg/l	11	<0.5	3.2
Arsenic	µg/l	<1	<1	<1
Barium	µg/l	<100	<100	<100
Beryllium	µg/l	<10	<10	<10
Cadmium	µg/l	<10	<10	<10
Chromium	µg/l	<20	<20	<20
Lead	µg/l	<1	<1	<1
Mercury	µg/l	<0.1	<0.1	<0.1
Selenium	µg/l	<1	<1	<1
Silver	µg/l	<10	<10	<10
Gross Alpha	10^{-9} µCi/ml	≤6.7	≤6.7	≤6.7
Gross Beta	10^{-8} µCi/ml ± 2σ (%)	2.7 ± 62	≤2.0	3.2 ± 54
Tritium	10^{-7} µCi/ml ± 2σ (%)	≤4.2	17.5 ± 31	≤7.5

Source: Adapted from Holland et al., 1987.

indicates low concentrations of all parameters of interest. Lagoon water concentrations are low in both metals and high explosives (HMX, RDX, TNT, and PETN). While sulfates, chlorides, alkalinity, and nitrates are present in moderate quantities, background samples show comparable concentrations. Uranium concentrations were also measurable at the same levels as the background, a fact which indicates the presence of naturally-occurring uranium. All analyses are conducted on water retained in the lagoons or in the leachate collection system. There is no discharge flow from the lagoons to surface water.

Surface water runoff from Site 300 is channeled into Elk Ravine or Corral Hollow Creek. Low annual rainfalls in the area keep such runoff to a minimum. The limited opportunities for sampling and analyzing runoff indicate that there is probably no significant off-site migration of pollutants via this route, but it is too early to draw firm conclusions until additional data are acquired.

3.3.3.1 Drinking Water Standards

LLNL Main Site

Since LLNL purchases its potable water from outside suppliers, the Main Site needs to do only limited monitoring and analyses to protect the integrity of the system. Chlorination is practiced during certain times of the year to ensure that sufficient residual levels are maintained, and bacteria counts are occasionally made to confirm the effectiveness of protection. LLNL pursues an effective program of self-evaluation, including periodic inspections of the system. An ongoing effort to eliminate possible sources of contamination involving installation of vacuum breakers or approved back-siphonage protection valves is proving effective. LLNL has examined all avenues of possible radioactivity contamination of potable water to protect employees from risk from such sources. Radiation monitoring is routinely conducted to characterize the drinking water used on site.

LLNL Site 300

The principal drinking water source at Site 300 is a series of on-site wells. Therefore, an extensive monitoring program is necessary to comply with the provisions of 40 CFR 141, National Interim Primary Drinking Water Regulations, and CAC Title 22, California Domestic Water Quality and Monitoring Regulations. All wells supplying drinking water are monitored for 13 metals, nitrates, fluorides, pesticides, trihalomethanes, chlorinated hydrocarbons, fecal coliform, tritium, gross alpha and beta, and if indicated, radium-226 and -228. Most tests are required annually, but coliform counts are run monthly, whereas beryllium, trihalomethanes, and radioactivity indicators are run

quarterly. This drinking water monitoring program provides Site 300 with effective control of potable water systems.

As mentioned, LLNL monitors on-site and off-site surface water for gross alpha, gross beta, and tritium concentrations in the Livermore Valley and at Site 300. Sampling locations and gross alpha and gross beta results are shown in Figures 3-22 and 3-23 and in Tables 3-13 through 3-16. As can be seen, many of the results are reported as less than detectable, and all averaged results except one were less than 20 percent of the appropriate concentration guide (CG). The single location with an average result higher than 20 percent of the concentration guide was a gross alpha radioactivity reading at 66 percent of the guide at an on-site Site 300 location. Tritium sampling results are shown in Tables 4-13 and 4-14 and discussed in Section 4.3.2 with associated dose calculations.

3.3.3.2 Other Environmental Monitoring Data

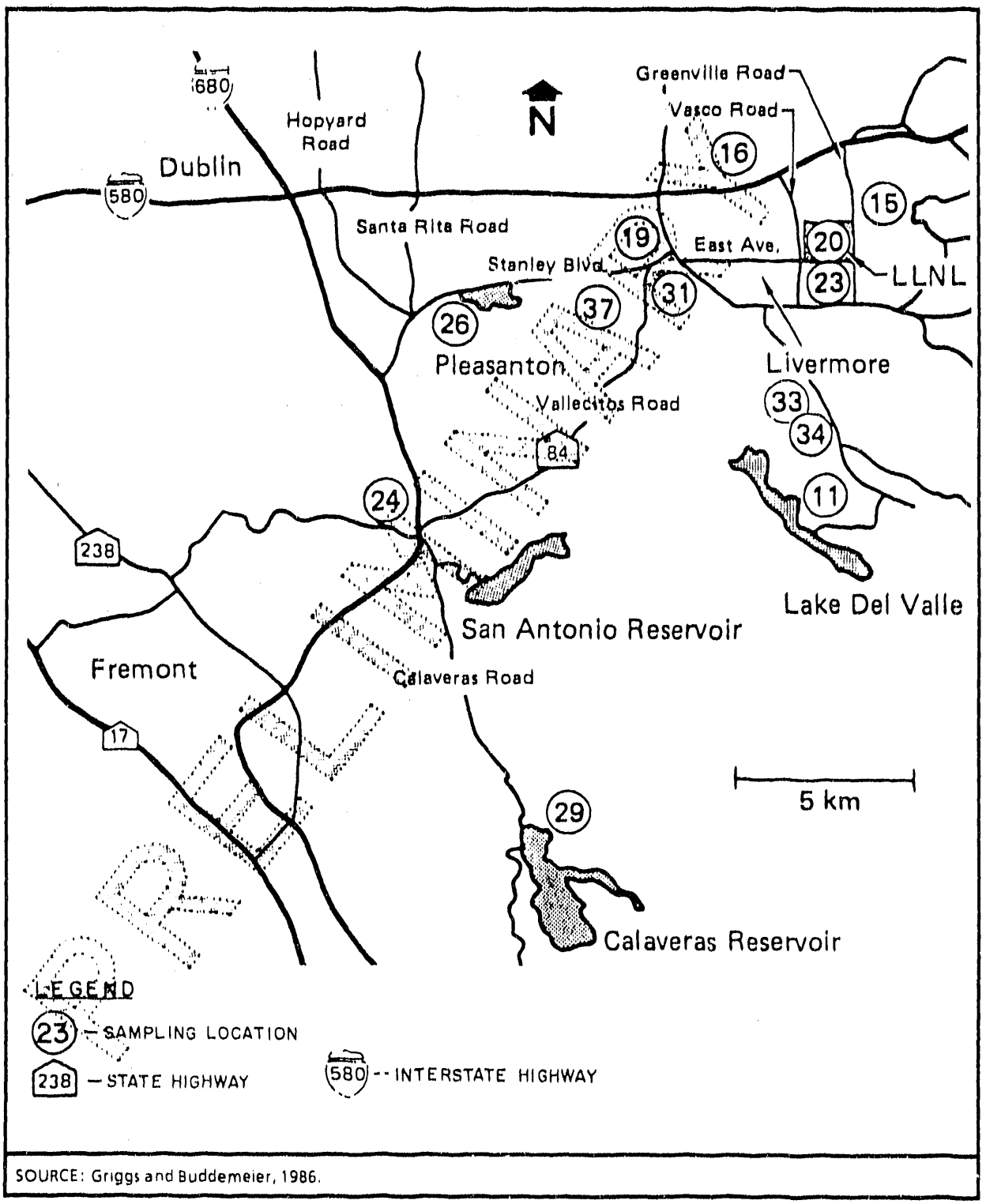
In addition to data gathering required to comply with permits and CRWQCB orders, LLNL collects data on radioactivity in drinking waters, vegetation, foodstuffs, honey, and wine from a number of locations in the Livermore Valley. Results of analysis were compared to levels observed in neighboring areas outside the valley. Where positive values were determined, concentrations were at or only slightly above those reported as background. Contributions from the sampled sources indicate that increased doses are less than 0.1 to 0.3 mrem per year, whether from drinking water sources, meat or milk consumption, honey, or wine.

Radioactivity measurements for two water samples at Site 300 yielded higher than average gross alpha readings, which proved to be naturally occurring uranium. Even so, concentrations of uranium were well below criteria specified in DOE Order No. 5480.1. These sources are shown on Figure 3-24 as Location 4, a well in the GSA, and Location 21, a spring-fed pond near Building 8.2 complex. The figure shows one more water sampling point (Location 24) than the previous figure, added in 1986, so that data are acquired for Corral Hollow Creek downstream of all Site 300 GSA activities. The general trend shown as a result of these additional radioactivity measurements is that off-site migration of radioactivity via surface water routes is not a problem at either site.

3.3.4 Findings and Observations

3.3.4.1 Category I

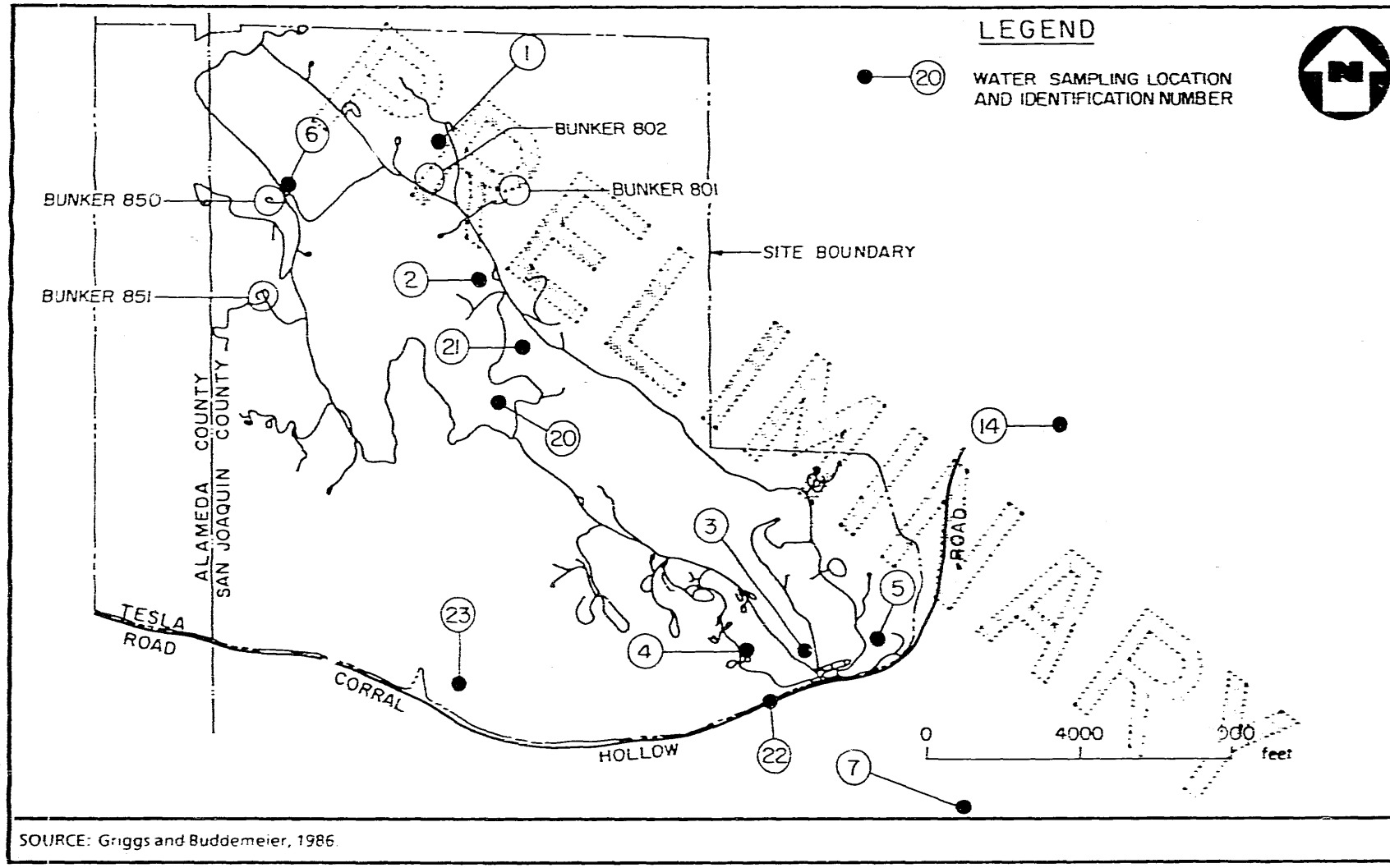
None



SOURCE: Griggs and Buddemeier, 1986.

FIGURE 3-22

LIVERMORE VALLEY WATER SAMPLING LOCATIONS
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Griggs and Buddemeier, 1986.

FIGURE 3-23

SITE 300 WATER SAMPLING LOCATIONS
LLNL – LIVERMORE, CALIFORNIA

TABLE 3-13

GROSS ALPHA ACTIVITY IN WATER
LIVERMORE VALLEY
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Location[1]	Number of Samples	[10^{-9} µCi/ml ± 2σ(%)]			% SDM[2]	% CG[3]
		Maximum	Minimum	Average		
11	4	≤ 4.5	≤ 2.8	≤ 3.6	22	12
15	4	≤ 4.5	≤ 2.8	≤ 3.6	22	12
16	4	≤ 8.1	≤ 2.8	≤ 5.4	42	18
19	4	≤ 4.5	≤ 2.8	≤ 3.6	22	12
20	4	≤ 4.3	≤ 0.3	≤ 3.0	61	10
23	4	≤ 4.5	≤ 2.8	≤ 3.6	22	12
24	4	≤ 4.5	≤ 2.8	≤ 3.6	22	12
26	4	≤ 4.5	≤ 2.8	≤ 3.6	22	12
29	4	≤ 4.5	≤ 2.8	≤ 3.6	22	12
31	4	≤ 4.5	≤ 2.1	≤ 3.4	31	11
33	4	≤ 4.5	≤ 2.8	≤ 3.6	22	12
37	4	≤ 4.5	≤ 0.4	≤ 2.1	98	7

Source: Griggs and Buddemeier, 1986.

(1) See Figure 3-22 for sample locations
(2) SDM = Standard Deviation of the Mean
(3) Concentration guide: CG = 3×10^{-8} µCi/ml

TABLE 3-14

GROSS ALPHA ACTIVITY IN WATER
SITE 300
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Location[1]	Number of Samples	[10^{-9} µCi/ml ± 2σ(%)]			% SDM[2]	% CG[3]
		Maximum	Minimum	Average		
3	4	≤ 3.8	≤ 2.9	≤ 3.4	12	11
4	8	37.0 ± 34	≤ 2.9	19.9	51	66
5	8	13.0 ± 66	≤ 2.9	≤ 4.9	68	16
6	1	≤ 3.3	≤ 3.3	≤ 3.3	0	11
7	4	≤ 6.5	≤ 2.9	≤ 4.2	38	14
14	8	≤ 6.5	≤ 2.9	≤ 4.2	26	14
20	2	≤ 3.7	≤ 3.0	≤ 3.3	15	11
21	4	≤ 4.5	≤ 2.9	≤ 3.6	19	12
22	8	13.0 ± 66	≤ 2.9	≤ 4.9	68	16
23	4	≤ 4.5	≤ 2.9	≤ 3.6	19	12

Source: Griggs and Buddemeier, 1986.

(1) See Figure 3-23 for sample locations.
(2) SDM = Standard Deviation of the Mean.
(3) Concentration Guide = CG = 3×10^{-8} µCi/ml.

TABLE 3-15

GROSS BETA ACTIVITY IN WATER
LIVERMORE VALLEY
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Location[1]	Number of Samples	[10^{-9} µCi/ml ± 2σ(%)]			% SDM[2]	% CG[3]
		Maximum	Minimum	Average		
11	4	≤ 10.0	≤ 8.6	≤ 9.6	7	10
15	4	≤ 10.0	≤ 8.6	≤ 9.6	7	10
16	4	≤ 20.0	≤ 8.6	≤ 14.6	42	15
19	4	≤ 10.0	≤ 8.6	≤ 9.6	7	10
20	4	≤ 10.0	4.5 ± 37	≤ 8.6	32	9
23	4	≤ 10.0	≤ 8.6	≤ 8.6	7	9
24	4	≤ 10.0	≤ 8.6	≤ 9.6	7	10
26	4	≤ 10.0	≤ 8.6	≤ 9.6	7	10
29	4	≤ 10.0	≤ 8.6	≤ 9.6	7	10
31	4	≤ 10.0	1.6 ± 38	≤ 7.6	53	8
33	4	≤ 10.0	≤ 8.6	≤ 9.6	7	10
37	4	≤ 10.0	≤ 1.6	≤ 7.0	57	7

Source: Griggs and Buddemeier, 1986.

(1) See Figure 3-22 for sample locations
(2) SDM = Standard Deviation of the Mean
(3) Concentration Guide = CG = 1 x 10^{-7} µCi/ml

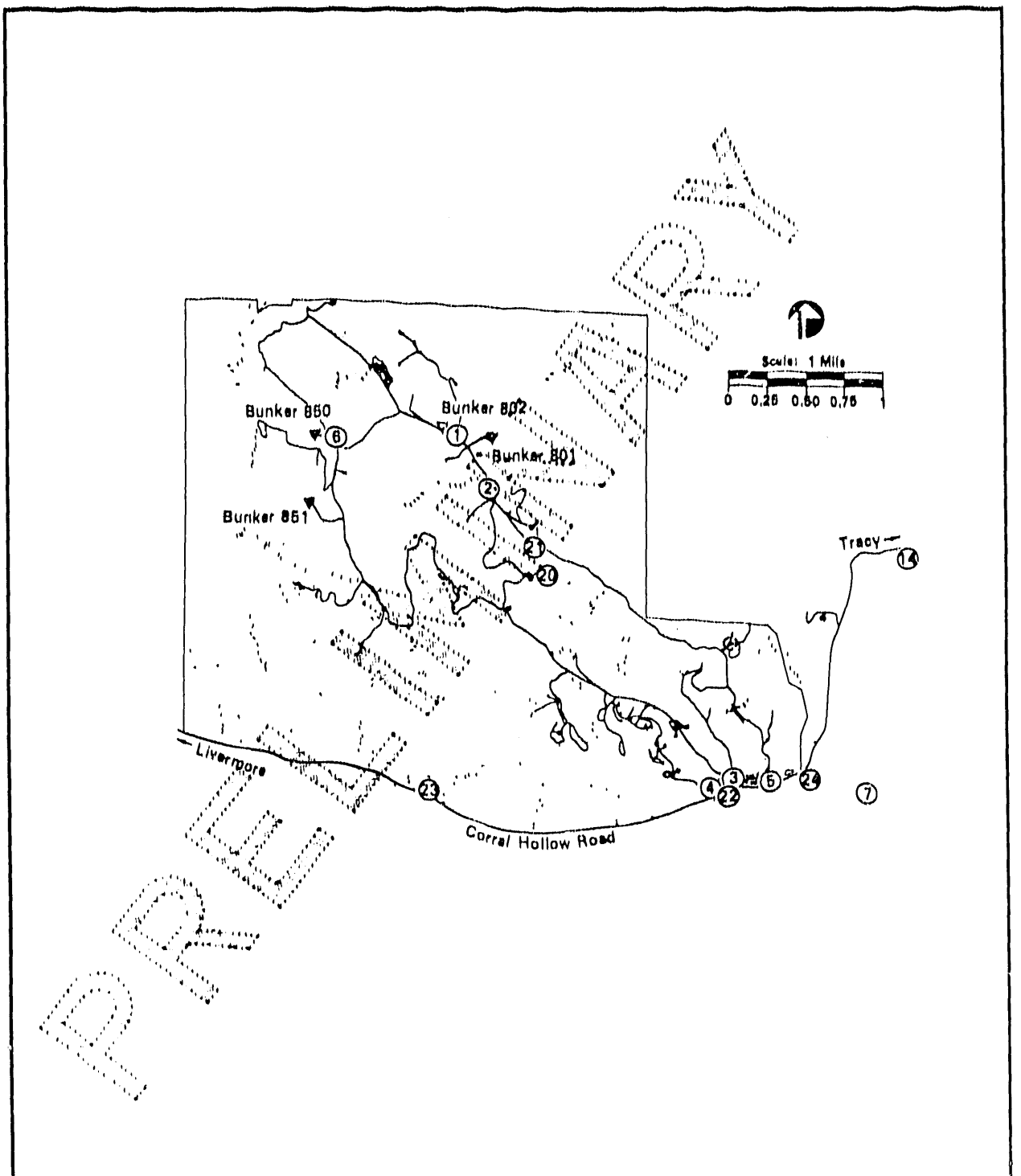
TABLE 3-16

GROSS BETA ACTIVITY IN WATER
SITE 300
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Location(1)	Number of Samples	[10^{-9} µCi/ml ± 2σ(%)]			% SDM(2)	% CG(3)
		Maximum	Minimum	Average		
3	4	12.0 ± 64	≤ 8.6	≤ 10.3	13	10
4	8	31.0 ± 33	≤ 8.6	16.8	45	17
5	8	12.0 ± 70	≤ 8.6	≤ 10.0	11	10
6	1	≤ 11.0	≤ 11.0	≤ 11.0	0	11
7	4	≤ 21.0	≤ 8.6	≤ 11.9	31	12
14	8	≤ 21.0	≤ 8.6	≤ 11.0	37	11
20	2	≤ 16.0	≤ 9.9	≤ 12.9	33	13
21	4	≤ 11.0	≤ 8.6	≤ 9.8	10	10
22	8	≤ 11.0	≤ 8.6	≤ 9.7	5	10
23	4	≤ 11.0	≤ 8.6	≤ 9.8	10	10

Source: Griggs and Buddemeier, 1986.

(1) See Figure 3-23 for sample locations
(2) SDM = Standard Deviation of the Mean
(3) Concentration Guide = CG = 1×10^{-7} µCi/ml



SOURCE: Holland et al., 1987

FIGURE 3-24

SITE 300 WATER SAMPLING LOCATIONS
LLNL – LIVERMORE, CALIFORNIA

3.3.4.2 Category II

None

3.3.4.3 Category III

1. Integrity of the Sanitary Sewer is Suspect. Contamination of aquifers and soils underlying the LLNL/SNLL sites with heavy metals, radionuclides, toxic organics, and fecal coliform may be occurring as the result of exfiltration from the breaks in the sanitary sewer because the integrity of the sanitary sewer system is open to question.

   Untreated sewage and potentially hazardous or radioactive constituents may escape the sanitary sewer system through cracks in the sewer lines resulting from seismic activity or other damaging events such as acid releases or negligent construction activities. Normally "clean" retention tank flows and cooling waters cause no real environmental problems, but untreated sewage is always present. In the event that there is an accidental release of hazardous wastes (e.g., the chromium/nickel discharge of September 18, 1986), thousands of gallons could percolate into the ground even though the main flow is carefully impounded prior to entering the LWRP. This potential problem applies to the LLNL on-site sanitary sewer system, the SNLL system, and the trunk line carrying the combined wastewaters to the LWRP.

   In an effort to estimate the magnitude of this problem, the Survey team attempted to balance incoming water with water discharged or evaporated for the year 1986 for both LLNL and SNLL. Results are summarized in Table 3-17. Average gallons per week were calculated using daily measurements made by LLNL personnel and estimates made by SNLL. The comparison was based on weekly measurements because daily flows vary widely between weekdays and weekends, while monthly flows were affected by the number of days per month and the number of weekends. Holidays have some impact on all measurements, but this proved to be minor.

   Incoming flow rates were not available for June, but all other weekly averages increased gradually from January to July, then returned to their original levels by December. The peak inlet flow in July is more than 2.5 times the low wintertime flows. Sanitary sewer flow rates followed a similar trend in a narrower range, with July maximum flows at 1.5 times the December lows. Evaporative losses were based on 10 cycles of concentration at LLNL and eight cycles of concentration at SNLL. Peaks paralleled the inlet water flows. The "percent accounted for" is the total flow leaving the sites via either of two main routes: the sanitary

TABLE 3-17

1986 WATER BALANCE FOR LLNL AND SNLL
(ALL VALUES SHOWN ARE AVERAGE FLOWS EXPRESSED
IN MILLION GALLONS/WEEK)
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Month	Flow In	Flow to LWRP*	Evaporative Losses		Total Out	Percent Accounted For
			LLNL	SNLL		
January	4.10	2.61	0.96	0.32	3.89	94.9
February	4.30	2.97	1.10	0.37	4.44	103.3
March	4.66	2.96	0.93	0.41	4.30	92.3
April	5.82	2.93	0.99	0.46	4.38	75.3
May	6.93	2.88	1.38	0.51	4.77	68.8
June	No Data	3.30	1.98	0.55	5.83	--
July	10.42	3.35	2.40	0.60	6.35	60.9
August	9.56	3.26	1.95	0.57	5.78	60.5
September	7.53	3.30	1.55	-0.53	5.38	71.4
October	7.32	2.97	1.49	0.46	4.92	67.2
November	6.89	2.67	1.18	0.42	4.27	62.0
December	4.11	2.22	0.84	0.36	3.42	83.2
Jan/Feb/Mar	4.35	2.85	1.00	0.37	4.22	97.0
Apr/May/June	6.38	2.91	1.19	0.49	4.59	71.9
July/Aug/Sept	9.17	3.30	1.97	0.57	5.84	63.7
Oct/Nov/Dec	6.11	2.61	1.17	0.41	4.20	68.7

Source: Developed by DOE Survey team.

* Livermore Water Reclamation Plant.

sewer or the evaporative losses from cooling, divided by the incoming water flow, expressed as a percentage. July and August had the largest gaps between incoming and outgoing water, with about 39 percent unaccounted for. The bulk of this missing water is irrigation water, which either evaporates, percolates, or flows out to the arroyos. But even in periods when irrigation demands are reduced (e.g., December), more than 15 percent of the incoming water does not appear in evaporative losses or sanitary sewage. This would represent about 100,000 gallons per day (GPD) in December. Also, the data for February indicate that about 20,000 GPD more water was evaporated or released via the sanitary sewer than was actually pumped on site.

One possible explanation is that some of the normal flow through the sewer flow monitor at LLNL during the rainy season (e.g., February) is infiltration from groundwater farther upstream at LLNL or SNLL, whereas exfiltration occurs in the dry months of the year, including December 1986. Another possibility is that the unaccounted-for volumes are entirely irrigation losses. This would mean that July irrigation demands are 582,000 GPD for 7 days a week.

LLNL staff are aware of this potential problem. The FY 1988 Environmental Compliance and Cleanup Conceptual Design Reports list "Sanitary Sewer Rehabilitation" as a line item for budgetary consideration. The reports speak of "a direct correlation between precipitation and increased sewer flows" and state that "because of the significant amounts of known infiltration, exfiltration of sewage into the soil/groundwater can be expected during dry periods" (emphasis added). The reports go on to address the need for an exfiltration and inflow study and an assessment of sewer conditions, including a video camera survey (Ragaini, et al., 1986). Any exfiltration threatens the underlying aquifers, while infiltration taxes the capacity of the sanitary system and increases POTW surcharges, which are based on flow rates.

2. Analytical Lag Times for Retention Tank Contents. Priority pollutants may be released to the LWRP without LLNL personnel being aware of it because persons responsible for deciding which analyses are needed to correctly characterize chemical constituents in wastewaters are unduly influenced by the additional analytical lag times required. Certain organics are rarely requested even if they are present in the process because technicians are reluctant to add two or three more weeks to their analytical turn-around times.

Lag times are reported to range from a minimum of 2 to 3 days at a few priority locations (where there is only one retention tank), such as at Building 131, up to a maximum of 15 working days at the 490 Complex. Several program areas have insufficient capacity in their

retention tank systems now, so responsible parties at those facilities hesitate to consider any requests that could delay transfer of accumulated wastewater. The problem is most acute at the single-retention-tank facilities.

LLNL is aware of the problems to which long lag times contribute, and an upgrade of analytical services at Hazards Control is in progress. However, past experience with similar problems indicates that even the upgraded program will be hard-pressed to keep pace, since demand for additional analyses will increase as laboratory capability expands. Survey-related sampling of selected retention tanks is planned.

3. Arroyo and Creek Sediments May be Contaminated. In the past, contaminated process wastewaters were periodically released to the ground or to storm drains at both the Main Site and at Site 300. Surface runoff is currently analyzed for radioactivity and limited water chemistry parameters, but concentrations of metals and organics have not been determined. Groundwater is known to be contaminated, but LLNL has not characterized arroyo and creek sediments to determine if they may be a continuing source of surface or groundwater contamination. Survey-related sampling is planned for both the LLNL Main Site and Site 300.

4. Sewage Treatment Pond Sludges at Site 300 May be Contaminated. Toxic and hazardous pollutants (oils, heavy metals, solvents) from certain Site 300 operations and services were formerly released to the sewage treatment lagoon, with occasional carryover into the adjacent overflow pond. Toxic or hazardous pollutants may have become concentrated in the pond sludges, from which leachable pollutants could be transported off-site to Corral Hollow Creek or to the underlying aquifer during rainfall events. These sludges have not been adequately characterized to enable accurate evaluation of potential impacts from this problem. Survey-related sampling is planned. Refer to Finding 4.5.2.3.14 for further details relative to this finding.

5. Site 300's Building 865 Complex May be Contaminated with Oily Wastes. Oily matter and possibly other pollutants have been released to the ground in the area of Building 865 complex at Site 300. A potential exists for contaminants to be carried downgrade by surface water runoff during storm events, or to percolate into the groundwater. Since these releases may still occur inadvertently, the possible impact from such contamination should be assessed to determine whether further action is necessary to control this source. Thus far, no attempts to characterize the source or evaluate impacts have been made. Survey-related sampling is planned.

3.3.4.4 Category IV

1. Proximity of Floor Drains or Sinks to Process Tanks. Evidence exists of accidental releases of toxic metal solutions to the sanitary sewer system via laboratory and shop floor drains and sink drains. Such releases endanger normal operations at the Livermore POTW and could result in penalties and associated cleanup costs. In the event of a sudden spill or a slow leak, toxic solutions could enter the sanitary sewer system despite warnings and training to prevent such an occurrence.

   Aggressive acid solutions containing toxic metals such as chromium or copper are often part of bright-dip or metal-cleaning operations. In several cases, these processes are located in proximity to floor drains, which are connected to the sanitary sewer rather than to the retention tank systems. Such configurations were observed at Building 383 (currently inactive) and Building 345, where a visible stain indicated where solution drip pans had overflowed and reached the floor drains. Sanitary sinks adjacent to process operations were noted in Buildings 165, 212 (Room 161), 438, and 511 (Room 101). A dual-purpose sink in Building 165 had a unique, custom-made valve handle to give the operator a choice of draining sink contents either to a carboy for HWM collection or to the sanitary sewer, but problems exist concerning disposal of rinsewater from alternative uses of this sink. The valve setting could be overlooked, and hazardous chemicals could be drained to the sanitary sewer inadvertently.

2. Inadequate Labeling of Sinks. In several buildings, toxic or hazardous liquids can be inadvertently dumped to the sanitary sewer system because sinks are not properly identified as sanitary or retention tank connections. This is especially a problem in those laboratory rooms where both types of sinks exist side-by-side. Labeling in such cases varies from none to complete. Releases could easily occur via some unlabeled drain.

3. Lack of Adequate Written Instructions and/or Training of New Technicians. Inadvertent releases of toxic and hazardous materials have occurred as the result of misunderstandings between process operators and technicians, environmental or hazardous waste control specialists, and wastewater treatment plant operators. The most recent serious example occurred on September 18, 1986, when a chain of errors led to the release of 36 kg (80 lb) of chromium and 90 kg (200 lb) of nickel. The incident necessitated diversion and special handling for about 3,800,000 liters (1,000,000 gallons) of wastewater and 130,000 liters (35,000 gallons) of sludge at the LWRP. The cost to LLNL was $150,000, and $2,500 to the City of Livermore. In addition, the LWRP was out of compliance with its NPDES limits for two days. The health and safety technician at Building 322 assumed that an overnight spill was of the

same chemical nature as a previously analyzed batch awaiting treatment. Instead of submitting new samples for analysis, he reported the earlier results again. As a result of incorrect analytical data, treatment at Building 514 was ineffective and incomplete, and a portion of highly contaminated water was released (DOE, 1986).

Most workers are thoroughly familiar with the requirements of their jobs. This problem appears to be limited to the training and oversight of new employees or transfers from other programs. Since LLNL is a constantly changing entity, relatively untrained people may be more common than suspected. Lack of proper training for new or recently transferred employees may result in recurrences of such accidental releases.

4. Inadequate Berms and/or Dikes Around Retention Tank Systems. Releases of hazardous wastes from retention tank systems can reach the environment more readily in cases where secondary containment does not exist or is inadequate. In particular, lack of berms or dikes enables spills of liquid hazardous wastes to be transported to the nearest storm sewers and the arroyos draining the Main Site and Site 300. Numerous examples were found, including Buildings 161, 231 (the methylene chloride dip tank), 235, and 423, and at Site 300, Building 865. In some cases, existing berms were opened or cracked. Building 235 had a drain pipe (no shutoff valve) passing through the berm to release rainwater accumulations. The new retention tank system at Building 490 had good secondary containment, but the fully closed drain valve was leaking. Other new systems (e.g., Building 519) have no containment for fire suppression water in the event of an emergency. All these situations are potential pathways for off-site migration of radioactive and chemical contaminants. Refer to Finding 4.1.2.4.1 for other examples of this problem.

5. Analysis of Retention Tank Contents May Not Be Representative. Some environmental risk exists in those few cases where only one retention tank serves a facility that continues to generate wastewaters while awaiting analytical results for a partially filled tank. A decision to release a tankful to the sanitary sewer may be improper if a slug of concentrated liquid was transferred to the tank following sampling. For example, concentrates are usually at least ten times richer in concentration than rinses. If a single retention tank of limited capacity (800 to 1,200 gallons) is sampled when it is half full because of a long analytical turnaround time, sampling occurs at 400 to 600 gallons. Even if the tank is then dumped when three-quarters full, and if the additional quarter tank is a concentrate, the actual concentrations released to the sewer can be four times greater than the "analyzed" concentrations. This can lead to an unpermitted release and possible diversion at the POTW. Locations where this could arise include Building 113 sump and Buildings 131 and 281.

Building 281 actually has two retention tanks, but because of a valving problem, the two tanks are functioning as one, creating the same situation as a single tank user. Refer to Finding 4.1.2.4.6 for additional information on the problem of nonrepresentative analyses for tank contents.

3.4 Hydrogeology

3.4.1 Background Environmental Information

This section presents groundwater-related environmental problems identified by the Survey team. This section focuses on radioactive and nonradioactive contamination of groundwater and presents subsurface information as it relates to groundwater problems.

Where impacts on the aquifers are discussed, they are presented in relation to the aquifer's suitability as a source of drinking water. The Maximum Contaminant Levels (MCLs) and the Maximum Contaminant Level Goals (MCLGs), promulgated under the Safe Drinking Water Act, as well as relevant and applicable state standards, are used as guidelines for defining aquifer contamination problems. These are technological and health-based criteria for ingestion of groundwater from public suppliers. MCLs are enforceable criteria, but MCLGs are recommended guidelines based on human health considerations only. In addition, the California Department of Health has established action levels for a number of organic contaminants in groundwater.

The Lawrence Livermore National Laboratory is located in the southeastern portion of the Livermore Valley, approximately 65 km (40 miles) east of San Francisco. The Main Site is located in Section 12, 1T3S, R2E, Mt. Diablo Base and Meridian. Site 300 is located in the eastern Altamont Hills about 27 km (15 miles) southeast of the LLNL Main Site.

3.4.1.1 Physiographic Setting

The Livermore Valley is an east-west oriented topographic and structural depression that trends nearly normal to the strike of the central California Coast Range, within which it is located. The valley is 25 km (16 miles) long and an average of 11 km (7 miles) wide. The floor of the valley is relatively flat except for occasional small hills, which rise about 46 m (150 feet). Some of these hills may be the result of uplifts of older materials along faults.

The Livermore Valley is drained by westward-flowing intermittent streams. West of Pleasanton, these streams join to form Arroyo de Laguna, which is a tributary to Alameda Creek. Alameda Creek eventually flows into San Francisco Bay.

The LLNL Main Site was constructed on the smooth valley floor, which slopes gently toward the northwest. Elevations on the site vary from a low of 174 m (570 feet) at the northwest corner to 206 m (675 feet) at the southeast corner. Slopes are generally less than 3 percent, except at the banks of Arroyo Seco and other drainage ditches.

Site 300 is located on the eastern side of the Altamont Hills in the Coast Range Province. There are no permanent streams on the site, but Corral Hollow Creek, just south of the site, flows in the rainy season. Slopes are steep, and the site is characterized by a deeply dissected terrain consisting primarily of erosional features.

3.4.1.2 Geology

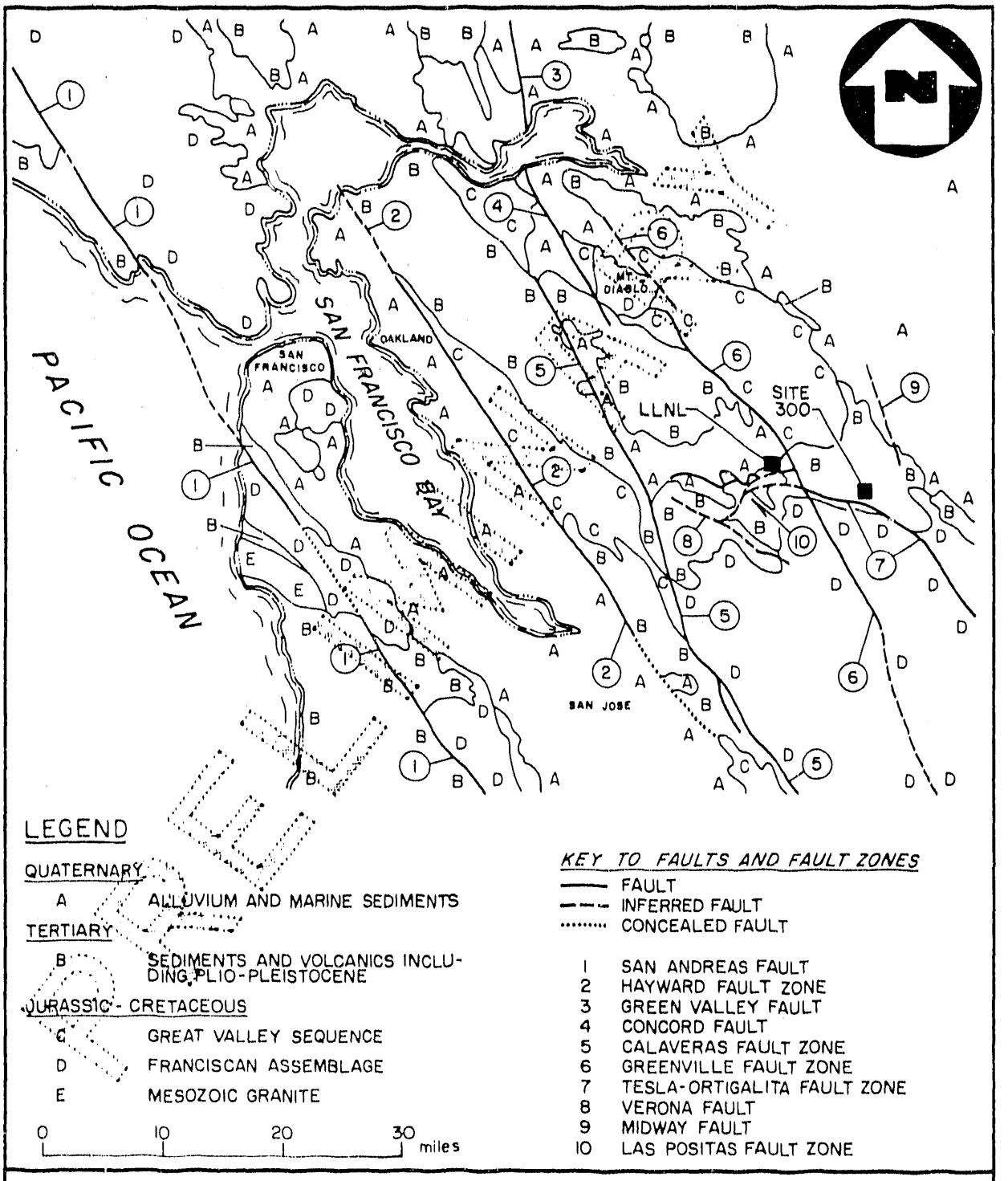
Main Site

The Livermore Valley is located within the California Coast Range province, which consists of a system of subparallel mountain ranges and valleys that trend north-northwest. Figure 3-25 presents the general site location in relation to the major structural features of the California Coast. The Coast Range is aligned with a number of active faults, three of which are considered to be major: the San Andreas, the Sur-Nacimiento, and the Coast Range thrust. These faults have juxtaposed three distinct lithologic blocks in a complex structural and chronological history.

The Franciscan Assemblage (Jurassic and Cretaceous age) is the bedrock formation at the LLNL sites. It is composed of a weakly metamorphosed, greenish-gray sandstone that weathers to a greenish-brown. The rock is massively bedded and highly jointed and has been extensively deformed. It is exposed at the ground surface in Mt. Diablo and in the Diablo Range.

Overlying the Franciscan Assemblage in the Livermore Valley are marine sedimentary rocks (Cretaceous to late Tertiary age) and alluvial deposits (late Tertiary to Holocene age). A generalized stratigraphic section for the Livermore Valley is presented in Figure 3-26.

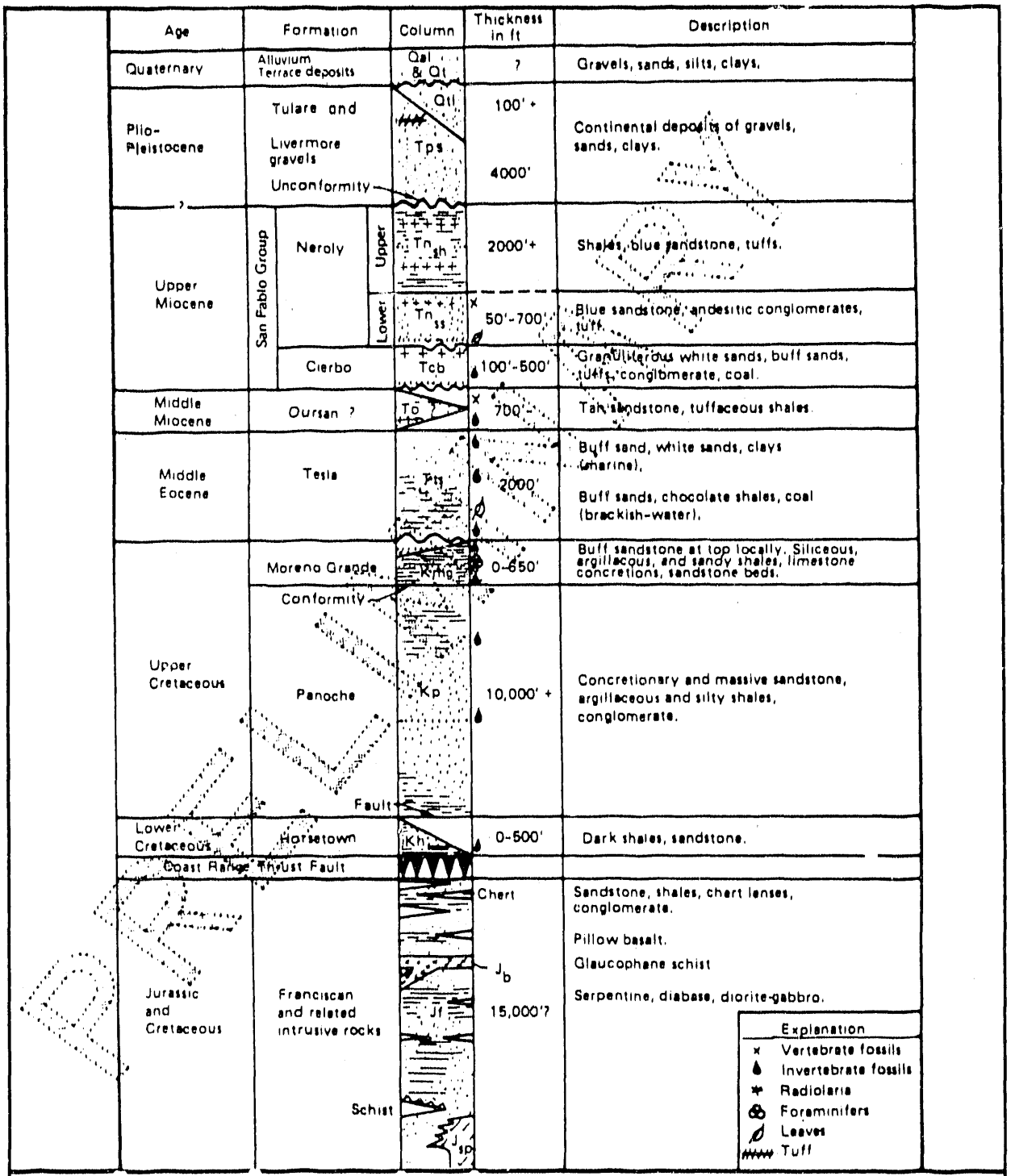
Unmetamorphosed marine sediments, known collectively as the Great Valley Sequence (Cretaceous age), lie in fault contact with the Franciscan Assemblage throughout the valley. These rocks are



SOURCE: University of California, 1986.

FIGURE 3-25

LIVERMORE VALLEY AND CALIFORNIA COAST RANGE
LLNL - LIVERMORE, CALIFORNIA



SOURCE: Carpenter et al., 1984

FIGURE 3-26

GENERALIZED STRATIGRAPHIC SECTION - TESLA QUADRANGLE LLNL – LIVERMORE, CALIFORNIA

variably cemented, greenish-gray to brown, concretionary sandstones that are interbedded with dark gray shale and conglomerate.

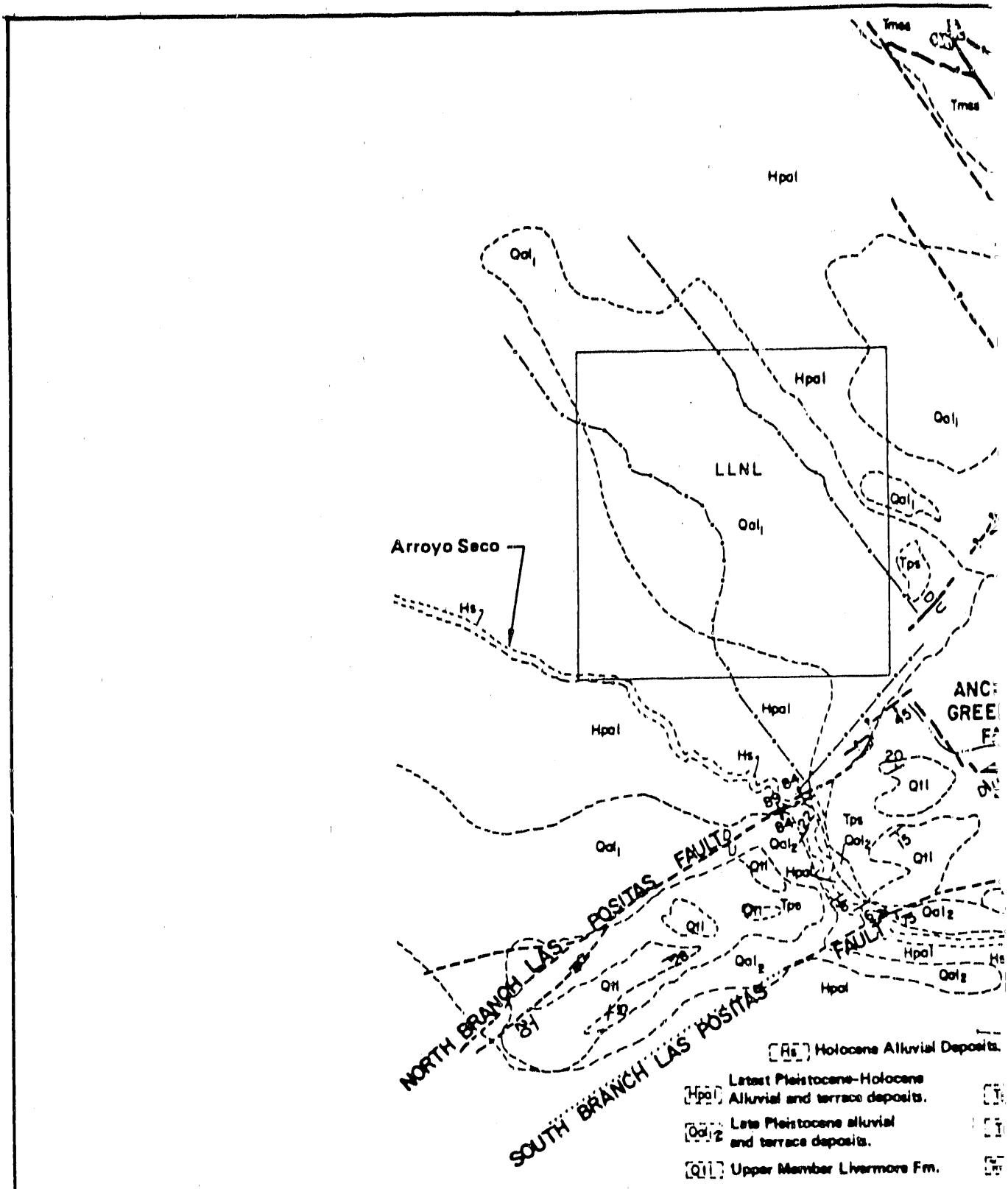
Stratigraphically overlying the Great Valley Sequence is a series of marine sediments of Eocene to Upper Miocene ages. The Tesla Formation (map unit Tts) is of Eocene (possibly late Paleocene) age. Its thickness is highly variable because it was deposited on an erosion surface of the Great Valley Sequence. The Tesla Formation is exposed south of Corral Hollow Creek, but pinches out rapidly north of there.

In the vicinity of the LLNL Main Site, the Livermore Valley is filled with up to 1.2 km (.7 mile) of fluviatile and lacustrine sediments of Pliocene to Holocene age. This thick sequence has been subdivided into the Plio-Pliestocene Livermore Formation and several alluvial deposits. Like many sedimentary deposits, these units vary laterally and vertically in composition.

The Lower Livermore Formation (Pliocene age) consists primarily of greenish or bluish gravels, which may be interbedded with fine-grained sediments (map unit Tps). The Upper Livermore Formation (Pliestocene age) consists of interbedded brown to reddish-brown silt, clays, sands, and gravels (map unit Qtl). The Upper Livermore Formation is also known as the Tulare Formation. The Livermore Formation ranges in thickness from about 30.5 to 1,219.2 m (100 to 4,000 feet).

There are four recognized post-Livermore units in the Livermore Valley. The oldest are terrace deposits 3 to 10 m (10 to 33 feet) above the present-day bed of the Arroyo Seco (map unit Qal_2). These deposits are silty clay and silty gravel of Franciscan origin. There is also a slightly younger unit of valley fill and terrace deposits found in exposure along Arroyo Seco (map unit Qal_1). They consist of silty gravels and capped by yellow and light-brown sandy clays and silts.

Two younger units occur in the vicinity of LLNL low terrace and correlative alluvial deposits of late Pleistocene to Holocene age (Figure 3-27, map unit Hpal), and local accumulations of floodplain and stream channel deposits (map unit Hs). The floodplain deposits are typically dense, oxidized, and have a prominent soil profile. The channel deposits consist of dark-brown, organic-rich silty-clay, sand clay, and sandy silt with occasional lenses of sand and gravel. These channel deposits range in thickness from 60 cm (2 feet) in the southeastern portion of the laboratory to 3 to 5 m (10 to 17 feet) near Arroyo Seco and the natural course of Arroyo Las Positas. The older alluvial deposits are typically dense, oxidized, and have a prominent soil profile development. Figure 3-27 shows the LLNL Main Site area.



SOURCE: Dresen and Nichols, 1986.

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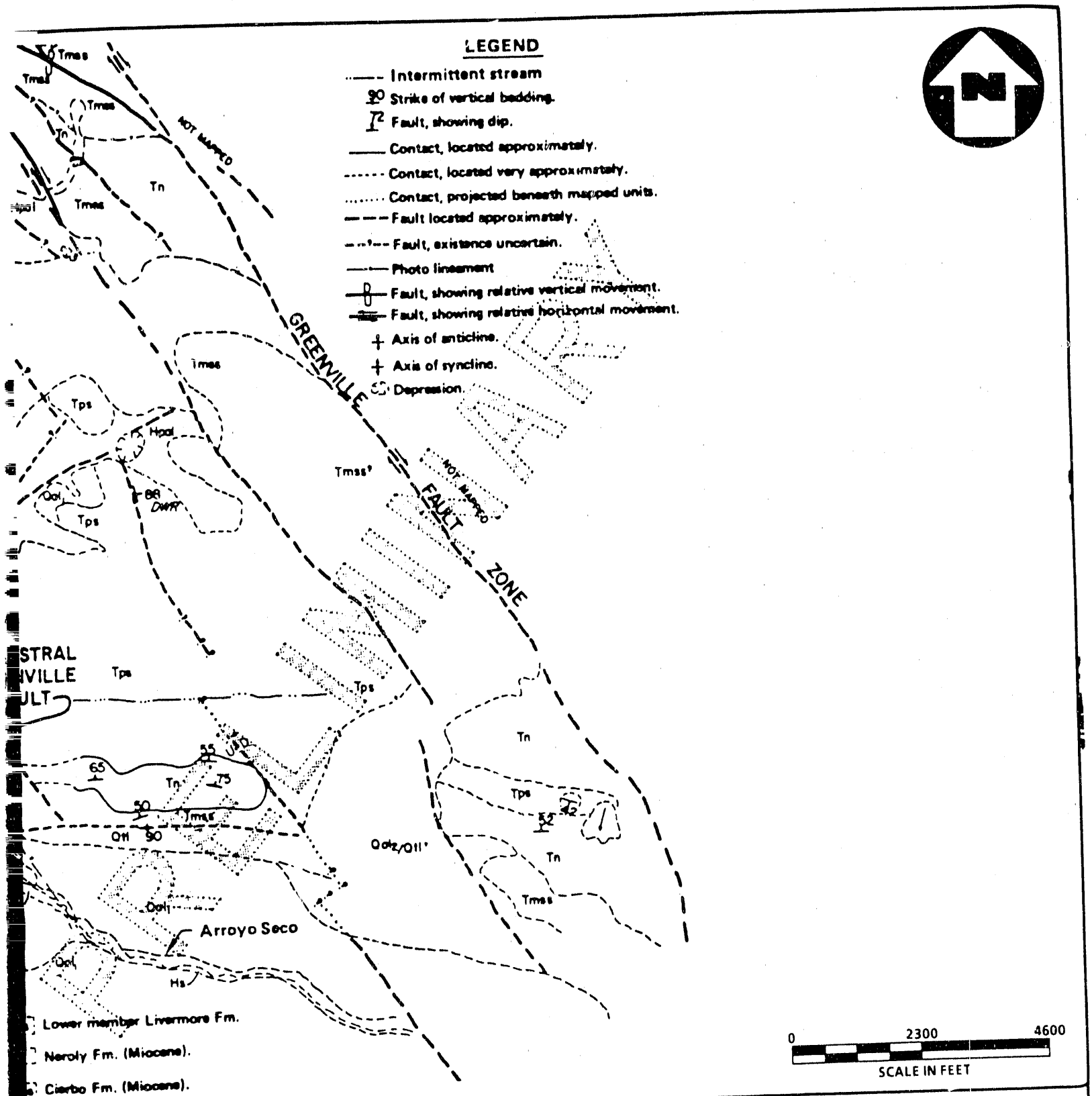


FIGURE 3-27

MAP OF LLNL AND VICINITY
VERMORE, CALIFORNIA

The Cierbo Formation and the overlying Neroly Formation of Upper Miocene age make up the majority of the bedrock at the site. Minor outcropings of the upper Cretaceous Morena Shale and Panoche Formation occur in the northern and eastern area along the site boundaries. The Cierbo (map unit Tcb or Tmss) consists of poorly-consolidated white sands with iron-oxide-filled fractures and shale interbeds. The Cierbo Formation is up to 300 feet (90 m) thick at Site 300. The Cierbo is exposed along Patterson Pass Road. The Neroly Formation (map unit Tn) is a distinctive bluish sandstone with lenses of andesite-bearing conglomerate, tuff, and tuffaceous shale beds. The Neroly Formation is up to 450 feet thick. It is the Neroly Formation that underlies all of the disposal pits at Site 300. The base of the Neroly is marked by a 30- to 60-foot-thick claystone unit. Some authors have included a unit of red and green claystones as the upper part of the Neroly Formation. These claystones contain nonmarine conglomerates, sandstones, and clays.

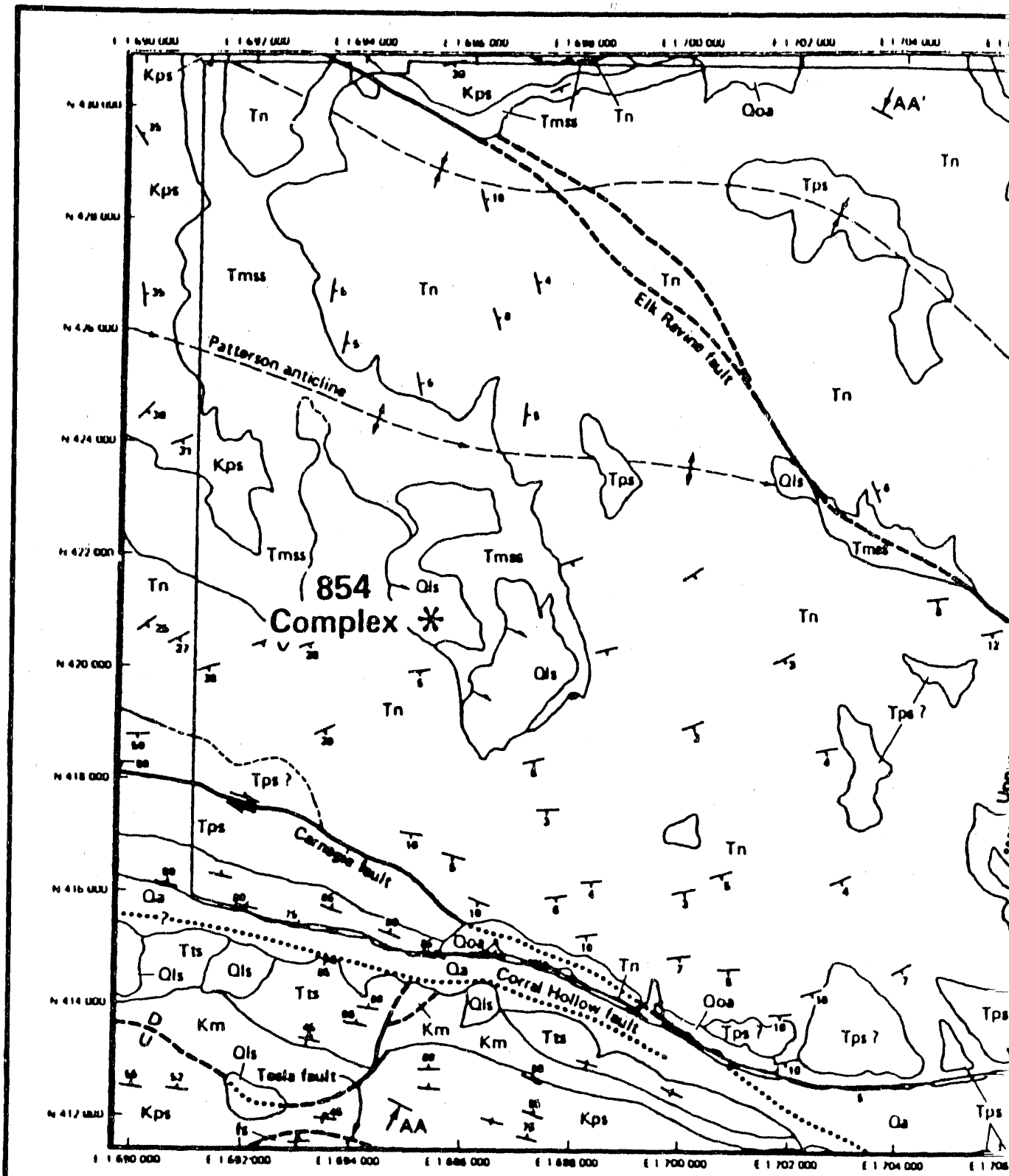
Alluvial and colluvial materials of Pleistocene to Holocene age overlie bedrock. Terrace deposits are found near Pit 6, whereas colluvial materials and ravine fills cover most of Site 300 where bedrock does not outcrop. In the past, these materials have the source material for landslides at Site 300. Figure 3-28 is a generalized geologic map of the Site 300 area.

3.4.1.3 Structural Geology

Main Site

The Coast Range has a complex history of folding and faulting along the continental margin. Several episodes of folding have occurred in the past and may be continuing into the present time. Most of the faults in the area are northwest-trending strike-slip faults where the dominant motion is horizontal with a smaller vertical component. The Livermore Valley is bounded on the west by the Calaveras Fault and on the east by the Greenville Fault, which are both considered to be active faults. North and south of the valley, the Diablo Range is formed by large, doubly plunging antiforms with cores of Franciscan rocks. The valley is a complex synclinal structure, with beds that generally thicken toward the center of the valley.

The Calaveras Fault is a right-lateral strike-slip fault that branches from the San Andreas Fault near Hollister and trends northwestward to the San Ramon Valley. It is located about 17 km (11 miles) west of the LLNL Main Site at its closest approach. This fault has been active, and was the site of a major earthquake in 1861 (magnitude 6 +). The fault acts as a groundwater barrier in the Dublin area, with higher water levels on the west side of the fault zone. Up to 15 mm/yr (0.6 in/yr) creep has



SOURCE: Carpenter et al., 1983.

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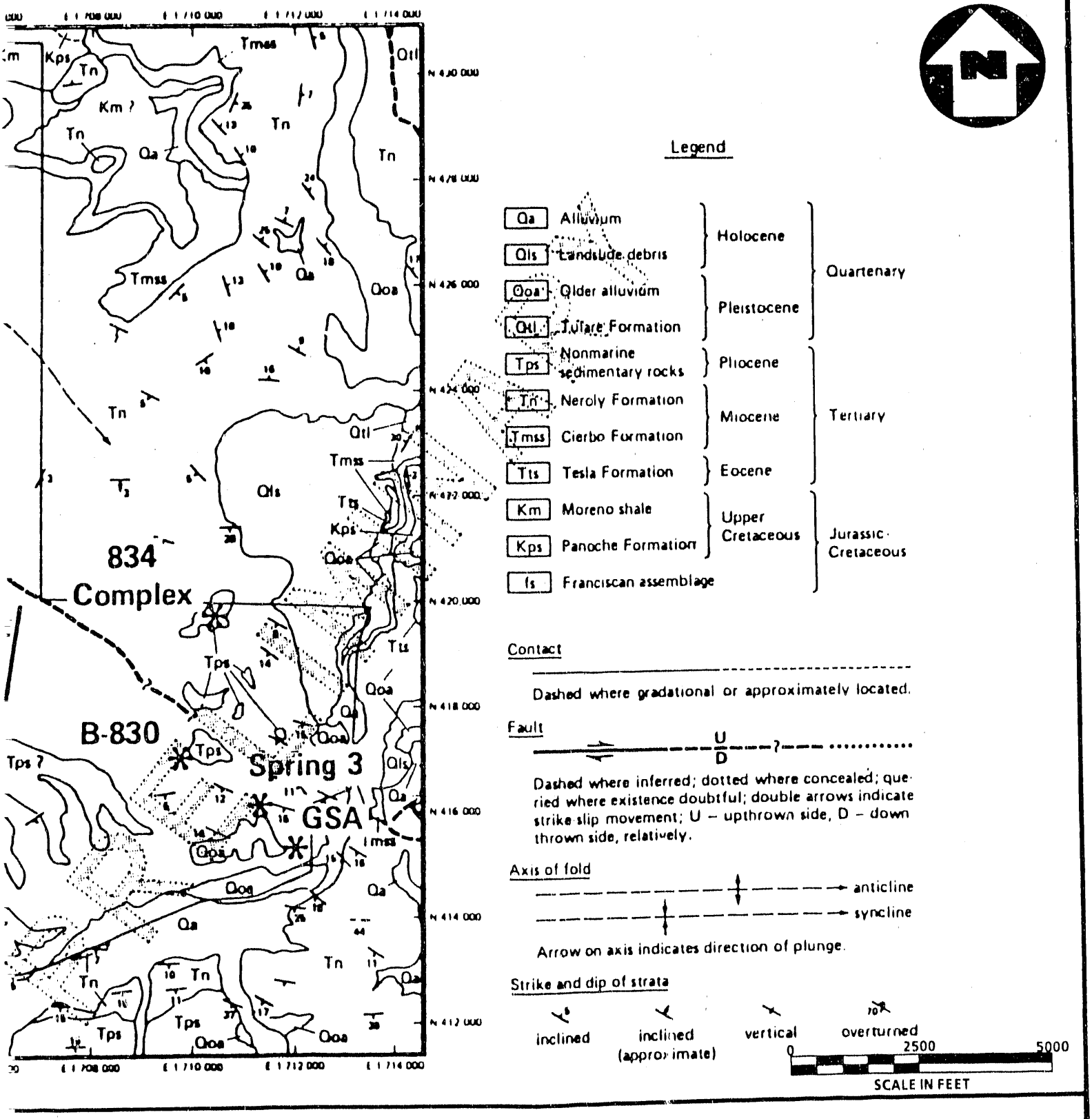


FIGURE 3-28

AP OF THE SITE 300 AREA
'ERMORE, CALIFORNIA

been observed on this fault, with an average annual slip rate of 7 mm/yr (0.3 in/yr). A maximum probable earthquake of magnitude 7.3 has been predicted for this fault.

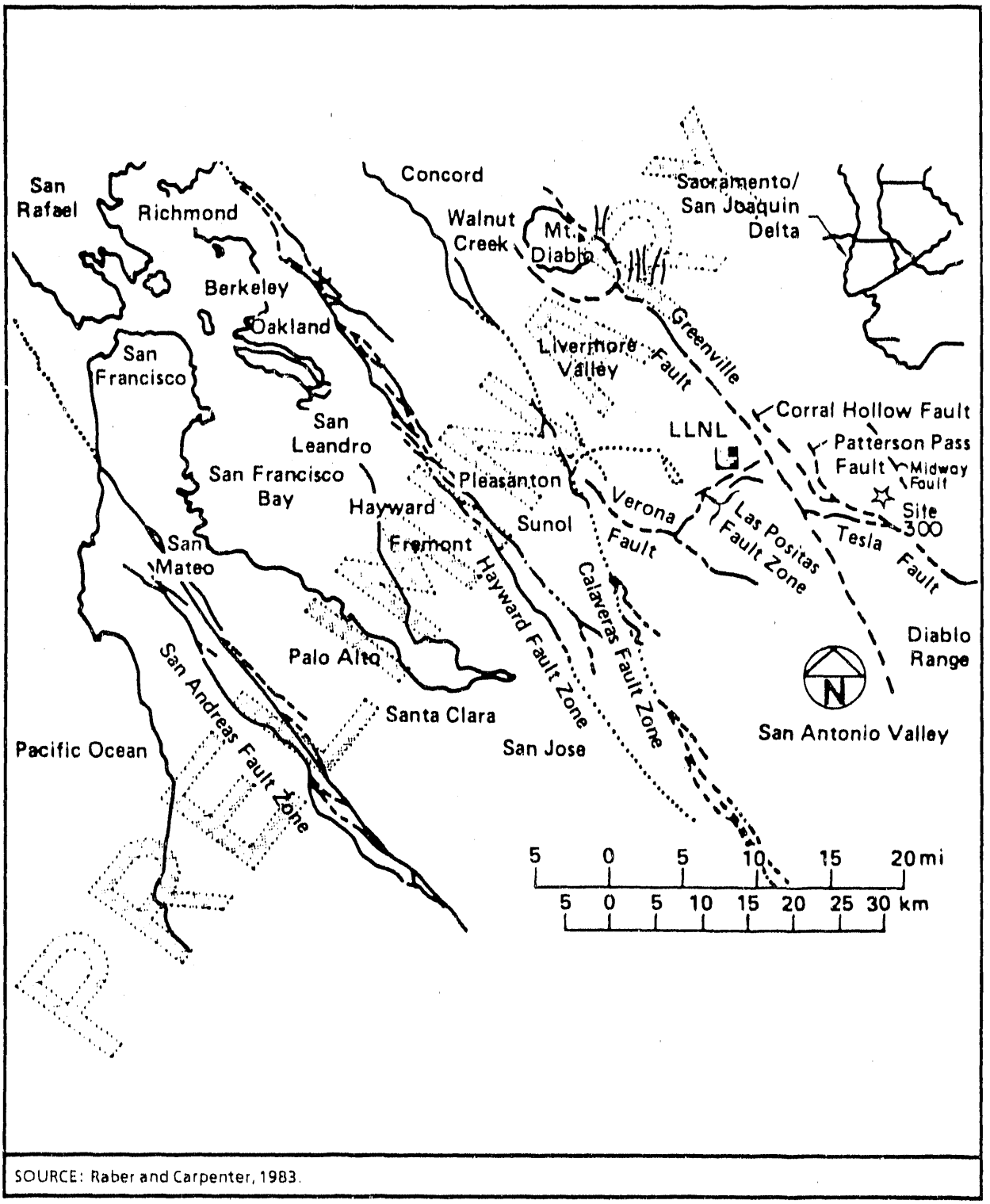
The Greenville Fault Zone is a set of northwest-trending right-lateral strike-slip faults that extends southeast from Mt. Diablo to San Antonio Valley. A recently active strand of the Greenville Fault lies (foldout)about 1.1 km (3,500 feet) northeast of the LLNL Main Site. The fault is a young tectonic feature that truncates or offsets all other faults and folds that cross it, with the exception of the Las Positas Fault Zone. The current slip rate has been estimated at 0.02 to 0.28 in/yr. The maximum credible earthquake has been estimated at magnitude 6.6 ± 0.2. In January 1980, two earthquakes of magnitude 5.8 and 5.3 on the Greenville Fault caused structural damage to several buildings at the laboratory, and were strongly felt at Site 300.

In addition to the Calaveras Fault and the Greenville Fault, two other active faults have been identified in the area: the Las Positas Fault and the Verona Fault. Figure 3-29 presents the locations of the identified faults in this portion of the valley. The Las Positas Fault trends northeastward and creates a groundwater barrier. The northern branch of this fault crosses the southern portion of SNLL and coincides with a break in slope between the valley floor and hills to the south. It is a left-lateral strike-slip fault, with an average slip rate calculated to be 0.04 mm/yr (0.016 in/yr). The maximum credible earthquake on this fault is estimated to magnitude 6.0 ± 0.5.

The Verona Fault is a thrust fault about 10 km (6 miles) long. It trends northwestward like others in the region. Multiple displacements have occurred in the past 70,000 years. Average annual slip rates have been estimated at 0.2 mm/yr (.008 in/yr). The maximum credible earthquake on this fault has been estimated at a magnitude of 6.0.

In addition to these four active faults, 20 other faults have been identified in the Livermore Valley. Studies of these faults indicate either that these faults do not disturb late Quarternary sediments (and are therefore considered to be inactive) or that their existence is doubtful. Based upon these considerations, none of these faults have the potential to seismically affect the Lawrence Livermore National Laboratory.

The major geologic hazard associated with the presence of the active faults is strong ground shaking as a result of a major earthquake on either a regional or local fault. Surface rupture as a result of sympathetic displacement on a nearby inactive strand of the Greenville Fault is a remote possibility. Secondary seismic hazards, such as soil liquefaction, are unlikely at this site.



SOURCE: Raber and Carpenter, 1983.

FIGURE 3-29

MAJOR FAULT ZONES OF THE SAN FRANCISCO BAY REGION
LLNL – LIVERMORE, CALIFORNIA

The structure of Site 300 is dominated by a broad anticline, which has an axis that trends roughly east-west, and plunges gently to the east. Bedding planes dip gently along either side of this structure. A broad syncline occurs north of Elk Ravine, with a similar trend (Raber and Carpenter, 1983).

Two major faults cross Site 300. The Elk Ravine Fault, which has branches beneath both Pit 1 and Pit 2, can often be located by changes in the dip of bedding planes that are not related to the anticlinal or synclinal structures. The Elk Ravine Fault shows no evidence of Holocene displacement, and is therefore regarded as being inactive (Raber and Carpenter, 1983).

The Carnegie Fault underlies the southern portion of Site 300. Steeply dipping beds of the Upper Cierbo and the Lower Neroly Formations are juxtaposed against gently south-dipping beds of the Neroly Formation. This fault passes beneath the Pit 6 area. There is no evidence of movement along this fault since the late Pleistocene; therefore it, too, is regarded as being inactive (Raber and Carpenter, 1983).

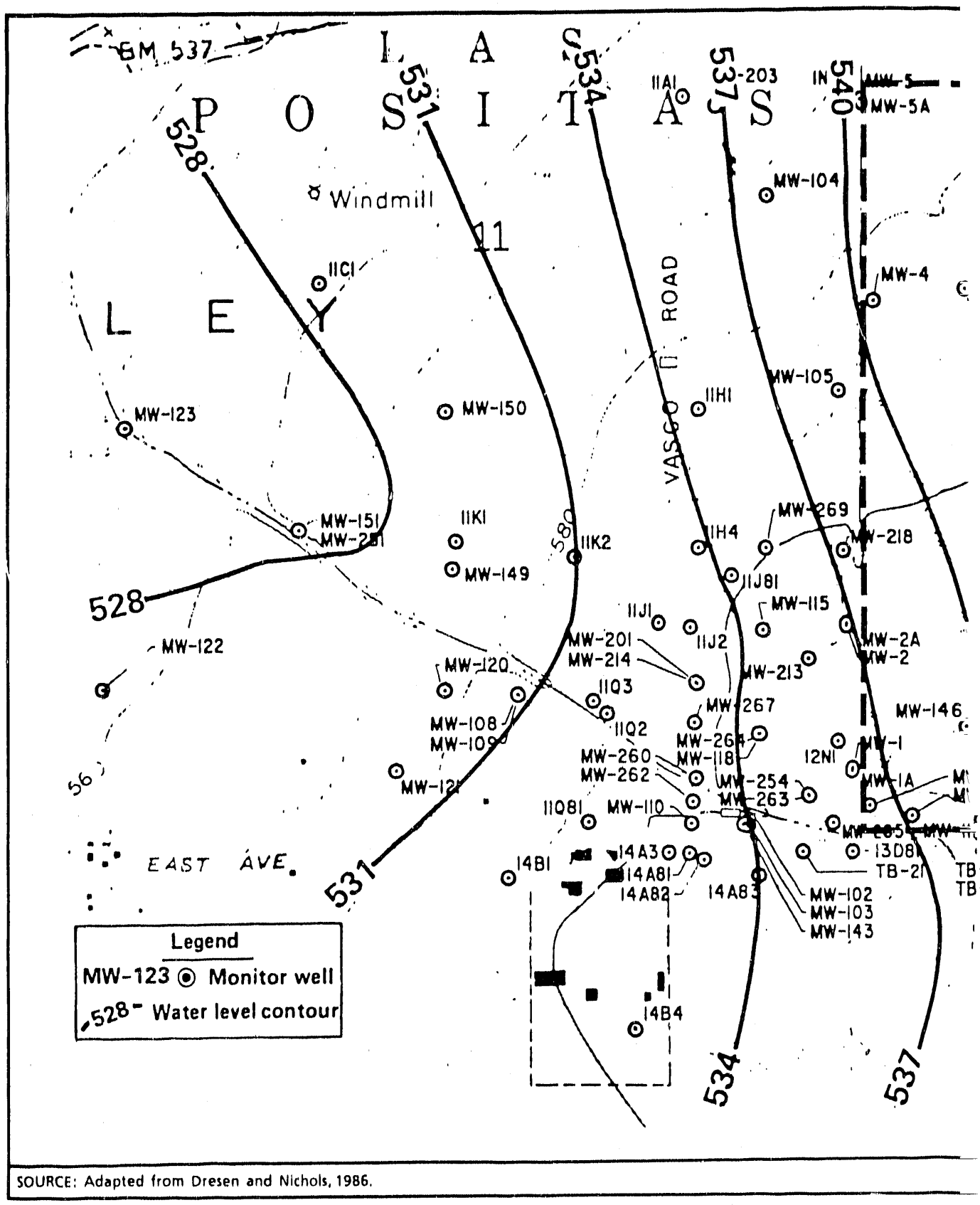
3.4.1.4 Groundwater Regime

Main Site

Groundwater table surface elevations range from approximately 575 feet mean sea level (MSL) (a depth of 50 feet) in the northeast corner of the site to approximately 535 feet MSL (a depth of 80 feet) in the southwest corner of the site. Groundwater flows generally from the eastern portions of the site to the west or the northwest. Figure 3-30 is a groundwater contour map prepared in September 1986. It shows the general flow directions as well as some apparent anomalous areas.

Near the East Traffic Circle is a recharge mound resulting from infiltration at the retention pond during the spring. The lateral and vertical extent of this mound fluctuates in response to rainfall (Dresen and Hoffman, 1986).

An apparent groundwater depression exists in the southeastern corner of the site. It is reported that three factors combine to form this anomaly (Dresen and Hoffman, 1986). The primary cause appears to be lack of full recovery from past regional pumping of the Lower Livermore Formation.



SOURCE: Adapted from Dresen and Nichols, 1986.

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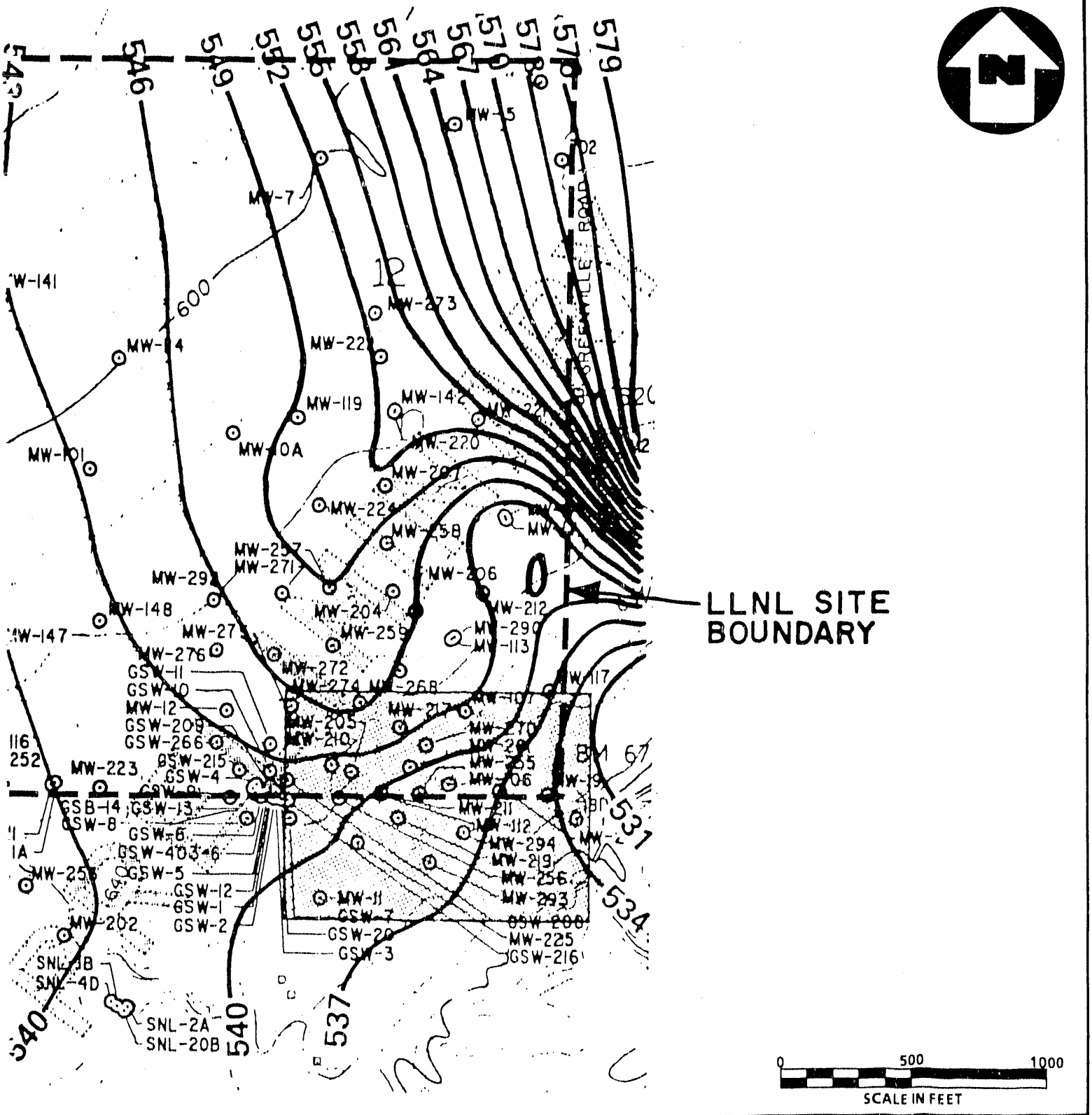


FIGURE 3-30

MAP - MAIN SITE - SEPTEMBER 1986
RMORE, CALIFORNIA

Within the alluvial sediments, there is a downward vertical gradient throughout the Main Site. Water levels in wells screened in the alluvial sediments are typically several feet higher than those in wells screened in the Lower Livermore Formation. Within the alluvial sediments or within the Upper Livermore Formation, the vertical gradient is less pronounced, but still downward in direction.

The highly variable nature of the alluvial sediments in this area (because of their deposition as a series of interfingered alluvial fans) has resulted in a number of lenticular, interconnected aquifers. Water-bearing strata are the coarser-grained sediments such as the sands and gravels, while the silts and clays act as aquitards. A typical subsurface cross section is presented in Figure 3-31. Although this particular section is from the area west of the laboratory, generally following Arroyo Seco to the northwest, it is representative of the mixed subsurface strata beneath the site.

Aquifer tests performed in 1983 (Stone and Ruggieri) determined that the aquifers exhibit leaky characteristics. Permeability tests performed on 10 wells gave a range of permeability of 1.1×10^{-4} cm/sec to 5.1×10^{-3} cm/sec.

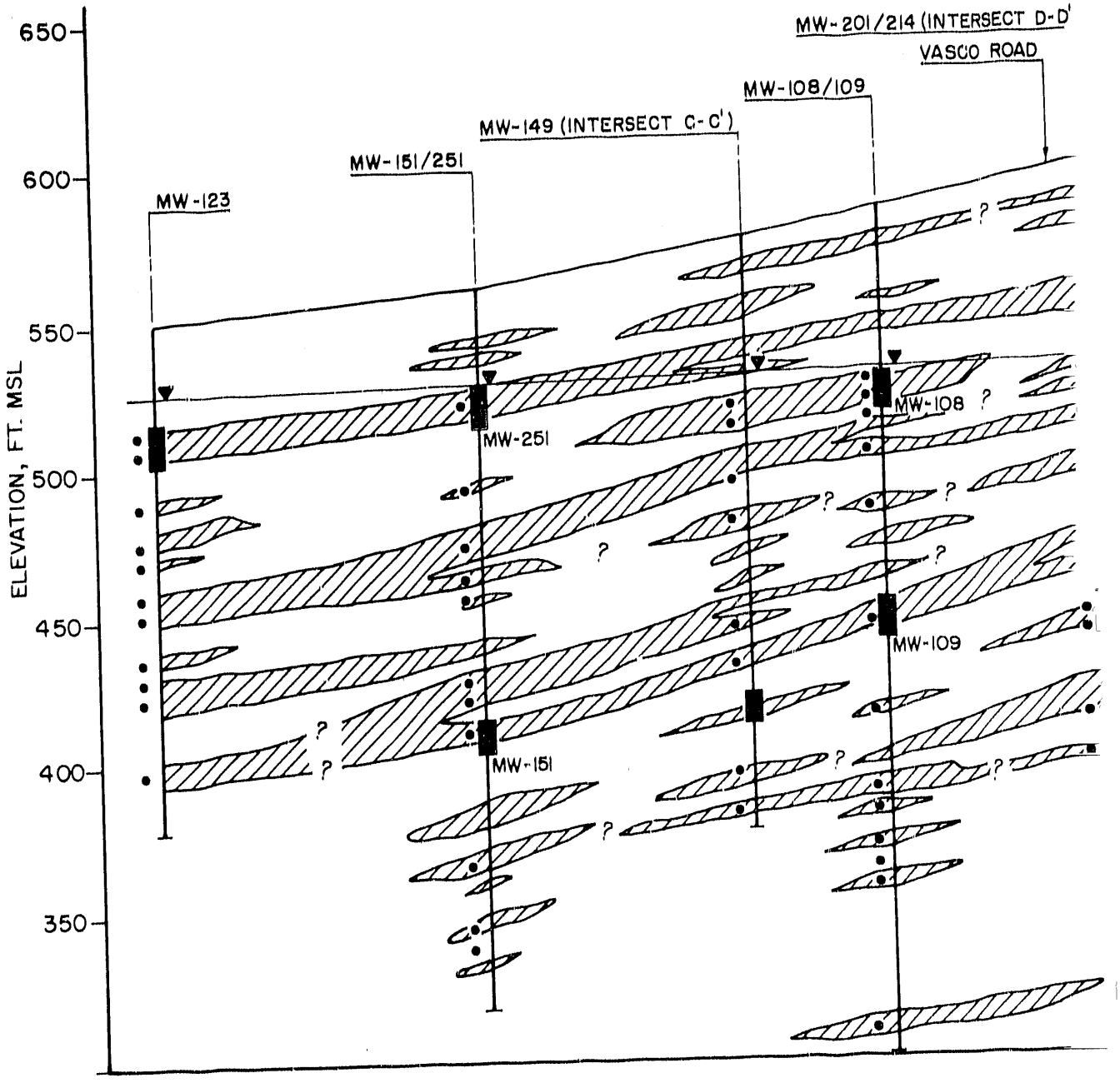
Site 300

At Site 300, water generally flows downdip through sandstone and conglomerate beds. The Elk Ravine Fault has a significant effect upon the groundwater regime. West and southwest of the Elk Ravine Fault, groundwater appears to exist as a single perched body 20 to 40 feet deep in the valleys and as much as 300 feet deep beneath ridges. The northwestern boundary of this perched water body is beneath Pit 7. No deeper groundwater system has been identified in the Pit 7 area.

Northeast of the fault, multiple aquifers have been identified. The uppermost aquifer is a water-table aquifer in the sandstones and conglomerate of the Neroly Formation. The deeper aquifers are confined and occur in sandstone beds in the Lower Neroly and the Cierbo. Water in these aquifers flows downdip toward the northeast. The southwest branch of the Elk Ravine appears to be acting as a groundwater barrier, based on the difference in depth to water (23 feet southwest of the fault versus 52 to 64 feet northeast of the fault) and a change in vertical head potential (Raber and Carpenter, 1983).

A local drainage divide occurs near the crest of the Patterson Anticline (see Figure 3-28), leading to the assumption that the direction of flow in the confined aquifer is also to the south, or downdip on the southern flank of the anticline.

NORTHWEST



SOURCE: Adapted from Dresen and Nichols, 1986.

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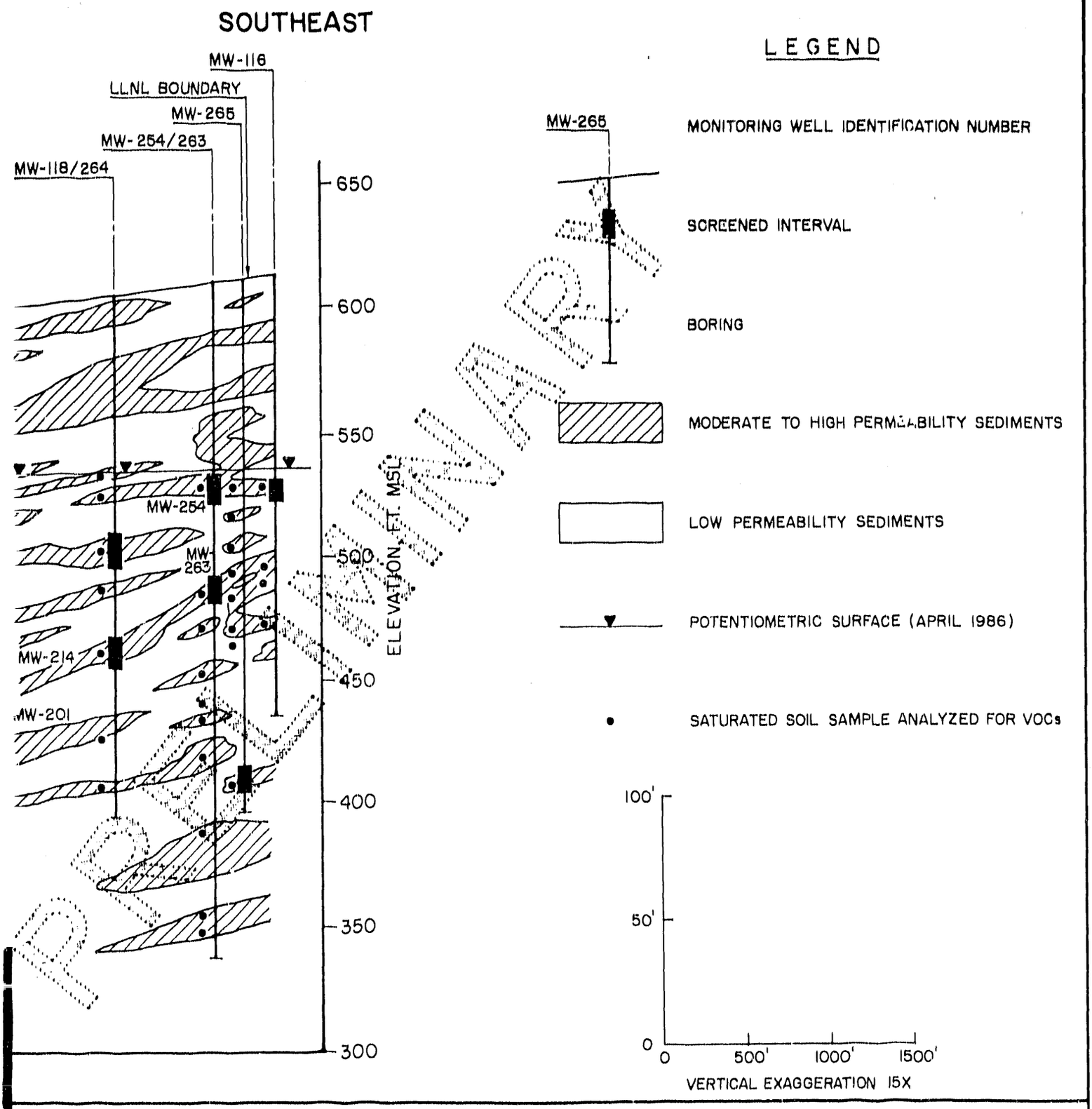


FIGURE 3-31

BSURFACE CROSS SECTION
ERMORE, CALIFORNIA

3.4.1.5 Groundwater Quality and Use

Main Site

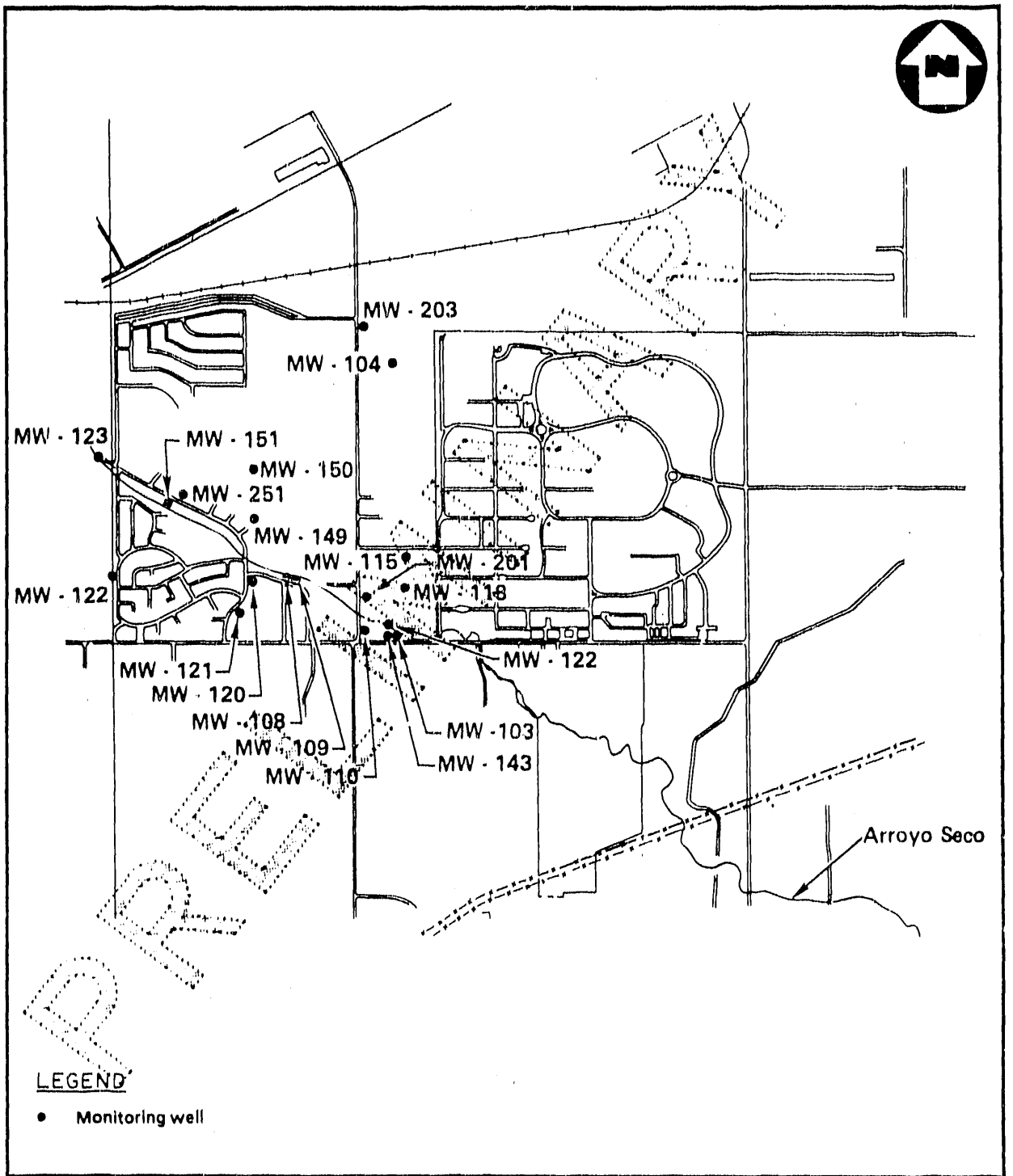
The most prevalent use of groundwater in this area is for irrigation of cropland. In many cases the depth and construction of irrigation wells is not known. At the present time, irrigation wells have not been found to have an effect on contaminant migration at the site (i.e., contaminants are not being drawn off-site in response to pumping wells), probably because these wells are screened in deeper aquifers to ensure a steady water supply. In addition, because these wells are screened over a large interval, the high flows may dilute any contaminants that may enter the water-bearing zone to below the limits of detection. The water used for irrigation is generally of good quality.

Less than 1-mile west of the LLNL Main Site, there is a residential development. Some of the residents are using wells for their water supply, but most are using the public (surface water) supply from Livermore. There is a contaminant plume moving toward these homes (see Section 3.4.2.1), and residences using wells that have been identified as in danger of contamination have been supplied with bottled water provided by LLNL.

Although there is no routine monitoring of groundwater for water quality parameters at the Main Site, a number of wells downgradient of the Main Site were analyzed for the primary drinking water standards and selected organic contaminants in 1985. Figure 3-32 shows the locations of these wells. Primary drinking water standards were not exceeded in any of the wells; however, state action levels for some chlorinated hydrocarbons (trichloroethylene, tetrachloroethylene, and 1,1-dichloroethylene) were exceeded in some wells. Analytical results are presented in Table 3-18. These analyses were conducted as wells were completed, and LLNL does not plan to continue sampling them for the water-quality parameters.

Site 300

At Site 300, groundwater is used for cattle and a few domestic supply wells. LLNL itself uses groundwater for drinking water at the GSA area. In addition, the State of California has a public supply well at a recreational vehicle area on the south side of Corral Hollow Road and a Ranger Station on the west side of Site 300. The depth of these wells is uncertain, but they are not yet affected by activities at Site 300. TCE contamination ranging from 0.9 to 52 µg/l has been detected at the GSA supply well, which is discussed further in Section 3.4.4.3.



SOURCE: Griggs and Buddemeier, 1986.

FIGURE 3-32

DOWNGRADIENT MONITORING WELLS ANALYZED FOR WATER QUALITY PARAMETERS - 1985
LLNL – LIVERMORE, CALIFORNIA

TABLE 3-18

DRINKING WATER SUITABILITY PARAMETERS FOR OFF-SITE MONITORING WELLS DOWNGRADIENT FROM LLNL'S MAIN SITE LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Analysis	Standard	Well (Date Sampled, 1985)									
		MW102 (2/22)	MW103 (2/22)	MW104 (2/22)	MW108 (5/2)	MW109 (5/2)	MW110 (6/10)	MW115 (6/10)	MW118 (10/11)	MW120 (9/13)	MW121 (10/16)
Arsenic (mg/l)	0 05	0 016	0 020	<0 0001	<0 001	<0 001	<0 001	<0 001	<0 001	<0 001	<0 001
Chromium (mg/l)	0 05	0 021	0 011	<0 0025	<0 0025	<0 038	<0 014	<0 016	<0 011	<0 042	<0 012
Lead (mg/l)	0 05	<0 001	<0 001	<0 001	<0 001	<0 002	<0 001	<0 001	<0 001	<0 001	<0 001
Mercury (mg/l)	0 002	<0 0001	<0 0001	<0 0001	<0 0001	<0 0001	<0 0001	<0 0001	<0 0001	<0 0001	<0 0001
Nitrate as NO_3 (mg/l)	45	22	20	33	42	45	17	32	42	19	23
Selenium (mg/l)	0 01	<0 005	<0 002	<0 002	<0 002	<0 002	<0 002	<0 002	<0 002	<0 002	<0 002
Gross α (pCi/l)	15	3 6 ± 1 4	29 ± 1 3	3 2 ± 2 0	7 1 ± 2 5	1 9 ± 1 5	1 9 ± 1 2	2 9 ± 1 4	1 ± 1 6	1 1 ± 1 0	1 0 ± 1 3
Gross β (pCi/l)	50	7 1 ± 11	1 7 ± 7 8	9 6 ± 1 2	0 8 ± 9 8	5 5 ± 9 8	1 5 ± 8 2	2 5 ± 9 7	1 2 ± 10	4 5 ± 8 9	5 0 ± 9 4
1,1,1-trichloroethane (ppb)	200 00	<1	3	<1	<1	6	<1	<1	<1	<1	<1
1,1,1-dichloroethylene (ppb)	0 4	2	2	<1	<1	48	<1	<1	5	<1	<1
Tetrachloroethylene (ppb)	4 00	<1	4	<1	<1	200	<1	<1	100	<1	<1
Trichloroethylene (ppb)	5 00	<1	2	<1	<1	7	<1	<1	3	<1	<1

TABLE 3-18
DRINKING WATER SUITABILITY PARAMETERS FOR OFF-SITE MONITORING WELLS DOWNGRADIENT FROM LLNL'S MAIN SITE
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
PAGE TWO

Analysis	Standard	Well (Date Sampled, 1985)								
		MW122 (10/16)	MW123 (10/28)	MW143 (5/23)	MW149 (10/11)	MW150 (10/11)	MW151 (10/25)	MW201 (11/26)	MW203 (12/6)	MW251 (10/25)
Arsenic (mg/l)	0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (mg/l)	0.05	0.013	0.013	0.048	0.0023	0.018	0.015	0.017	<0.0001	0.014
Lead (mg/l)	0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury (mg/l)	0.002	0.0003	0.0001	0.0001	0.0002	0.0002	<0.0001	<0.0001	<0.0001	<0.0001
Nitrate as NO_3 (mg/l)	45	44	62	17	18	28	36	19	44	40
Selenium (mg/l)	0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Gross α (pCi/l)	15	1.0±1.6	1.0±3.0	4.2	1.0±1.4	<1.0±1.8	<1.0±2.0	<1.0±1.8	<1.0±1.5	4.0±3.2
Gross β (pCi/l)	50	1.4±12.3	<1.0±1.8	-6.7±8.8	18.0±10.0	11.0±9.0	12.0±13.0	4.0±10.0	<1.0±14.0	20.0±18.0
1,1,1-trichloroethane (ppb)	200.00	1	1	3	<1	<1	<1	<1	1	1
1,1,1-dichloroethylene (ppb)	0.4	<1	<1	25	5	<1	<1	20		16
Tetrachloroethylene (ppb)	4.00	<1	<1	260	8	<1	<1	31		<1
Trichloroethylene (ppb)	5.00	<1	<1	15	<1	<1	<1	3		<1

Source: Griggs and Buddemeier, 1986.

NOTE: See Figure 3-32 for well locations. Standards are based on State of California Title 22, Chapter 15, regulations for metals, nitrate pesticides, and radioactivity in public water supplies and on State of California Department of Health Services recommended action levels for other compounds.

The following parameters were also analyzed for and would have been reported if any values had exceeded the indicated detection levels, all of which are below the applicable standards:

Cadmium	<0.001 mg/l	Lindane	<0.005 µg/l	2,4,5-TP (Silvex)	<0.1 µg/l
Silver	<0.001 mg/l	Methoxychlor	<0.02 µg/l	Other compounds detected by EPA 624/725 method	<1 µg/l
Tritium	<1000 pCi/l	Toxaphene	<1 µg/l		
Endrin	<0.1 µg/l	2,4-D	<0.5 µg/l		

3.4.2 General Description of Pollution Sources and Controls

3.4.2.1 LLNL Main Site

Several contaminant sources have been identified at the LLNL Main Site as contributors to known groundwater contamination problems. These sources are discussed in greater detail in Section 4.5. The LLNL staff has identified areas of groundwater contamination through detailed hydrogeological studies. This section presents a brief description of known sources of groundwater contamination at the LLNL Main Site that are presently being monitored. There are, however, approximately 50 other potential sources of groundwater contamination identified in Section 4.5.2.3. Significant former and ongoing sources of groundwater contamination are as follows:

- An area (or areas) in the southwestern corner of the property that is a source of trichloroethylene (TCE), tetrachloroethylene (PCE), and other volatile organic compounds, probably as a result of U.S. Navy activities.

- Underground tanks near Building 403, which leaked gasoline. Benzene, toluene, and xylene are found in the groundwater.

- Activities in or near Buildings 514, 518, and 612, which have resulted in TCE, PCE, and other volatile organic compounds reaching the groundwater.

- Wastes buried in the East Traffic Circle Landfill, which were excavated in 1985, but which had already resulted in localized groundwater contamination.

- Wastes emplaced in the "evaporation ponds" at the Taxi Strip and the Old Salvage Yard, which have leached volatile organics and radionuclides to the groundwater.

3.4.2.2 Site 300

At Site 300, several known sources of groundwater contamination, as well as some potential sources that have not been investigated, have been identified by LLNL. These sources are presented in greater detail in Section 4.5 but are summarized here. The following sources are presently being monitored:

- Spillage and leakage from buildings in the 834 Complex. This occurrence has resulted in a plume of TCE in the groundwater. Investigations at the 830 Complex and the General Services Area (GSA) have identified these areas as potential, minor, sources of TCE.

- Tritium-contaminated wastes buried in Pits 1, 3, 4, 5, and 7. These wastes have caused groundwater contamination. Building 850 may also be a source of tritium.

- High explosives (HE) wastewater lagoons where process waters containing HE compounds may have contaminated groundwater.

3.4.3 Environmental Monitoring Program

LLNL has an extensive investigation and monitoring program in place for the identified groundwater contamination problems. The following sections describe the drilling methods, well construction, sampling techniques, and sampling schedules for the groundwater investigations.

3.4.3.1 Drilling Methods and Well Construction

LLNL has developed a drilling technique called "depth sampling." This technique enables LLNL to evaluate contamination in several water-bearing zones without the use of protective casing or multiple boreholes. The technique is most useful where contaminant concentrations are less than 10 ppm. Depth sampling uses a mud-rotary drilling technique and a 94-mm wireline punch-coring system. The drilling mud prevents water from upper zones from entering the borehole. When a new water-bearing zone is reached, the drill bit is removed and new mud is mixed and circulated. A clean core barrel lined with clean brass tubes is used to collect a sample of the new water-bearing zone. The brass tubes are then retrieved with a wireline, sealed, labeled, refrigerated, and delivered to a laboratory (in most cases, Brown and Caldwell in Emeryville). The laboratory analyzes the soil sample overnight for volatile organics, and apprises the field geologist of results daily. This procedure continues until a clean zone is reached.

A well is then installed in the borehole, screened in specified contaminated zones. LLNL staff do not directly perform well drilling and installation. Weiss Associates, Inc., of Berkeley, California, usually provides the geologists as a contractor to the laboratory, except at Site 300, where Brown and Caldwell geologists have been used at Pit 6. All drillers are provided by PC Exploration, Inc. All wells constructed at the Main Site since 1984 are 5-inch-diameter PVC with threaded joints. Screen lengths are determined in the field. Wells are sealed from the top of the monitored zone to the ground surface. If the well yields more than 1 gallon per minute, it is fitted with a dedicated submersible

pump, while lower-yielding wells are given bladder pumps. The top of each well riser is sealed, and access holes are left for the sampling equipment.

At Site 300, drilling and sampling techniques are somewhat different than at the Main Site. Wells are drilled by PC Exploration, Inc., with a rotary drill rig. Air rotary methods are used when feasible, but when borings are too deep to remove cuttings by air alone, air-mist is used. HQ-size wireline core is used for all corings. A hollow-stem auger is used for sampling unconsolidated materials.

Many of the wells around the disposal pits were completed as multi-level sampling points, while other wells (e.g., in the GSA) were completed as single monitoring points. The multi-level wells are constructed with 3-1/2 inch-I.D., threaded PVC standpipe piezometers, pressure transducers, and Barcad samplers. Neutron-probe access tubes are also installed in at least one borehole at each pit to measure moisture content in the unsaturated zone.

Multiple aquifers within the same borehole are isolated using the following technique: when a confining layer is encountered, two sections of opposite-threaded stainless steel are emplaced, with the lower piece in the confining bed. The lower section is then filled with grout and allowed to cure. Drilling recommences with an open borehole to the desired monitoring zone. Barcad samplers are installed, and when the staff is certain there are no leaks, the upper section of casing is unthreaded and removed, and a PVC standpipe piezometer is installed to monitor the unconfined zone.

3.4.3.2 Sampling Techniques

At the Main Site, sampling tees are usually left in each protective casing for use by Brown and Caldwell sampling personnel. These tees screw into the pump discharge assembly. They enable the samplers to collect the discharge water in a tank from one side of the tee, and have a small-diameter PVC tube for sample collection on the other side of the tee.

For an existing well, the sampling methodology consists of first measuring the depth to water from the surveyed Point of Measurement (POM). Then, the pump is turned on to its maximum safe pumping rate in order to purge at least three calculated well volumes. Specific conductance, pH, and temperature are measured at the start of pumping and after each well volume has been removed. Once these parameters have stabilized, the well is sampled.

If the well is known to contain levels of volatile organic compounds that are two or more times higher than the state action levels (Table 3-19), the purge water is collected in a tank, sparged, and sent either to the cooling towers if the dissolved solids content is low, or to the drilling mud disposal pit if the dissolved solids are high. LLNL has shown that sparging reduces the VOAs to acceptable state standards. Purge water is discharged to the ground near the well if the VOAs are known to be less than twice the state action levels, under the assumption that the mixing of this water with the air will reduce the VOAs to the action levels.

Samplers frequently have a problem collecting gas-free samples for VOA vials for analysis. Water in the samples usually releases outgases in the vials at the ground surface. This release of outgas may be the result of either the great depth from which water is removed (similar to the "bends") or to agitation from the pumps. In any event, the levels of volatiles are probably underestimated because of this problem. However, repeated attempts at different sampling techniques have not resulted in significant differences in analytical results.

As at the Main Site, water levels at Site 300 are always measured prior to purging and sampling a well. Where Barcad samplers are in place, at least three sampler volumes are removed prior to sampling. Otherwise, purging continues until three well volumes are removed and pH, temperature, and specific conductance are stabilized.

3.4.3.3 Sampling Schedule and Analyses

Main Site

Upon completion of a well at the Main Site, a sample is collected for a complete analysis, including radioactivity. Afterward, samples are collected quarterly. If two subsequent quarters produce clean samples, that well is put on an annual sampling schedule. If the samples are contaminated, analysis continues on a quarterly basis for all identified parameters.

TABLE 3-19

ACTION LEVELS FOR SELECTED VOCs IN GROUNDWATER
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Compound	California DOHS Action Level (µg/l)	Recommended Maximum Contaminant Level (MCL) (µg/l)	Proposed Maximum Contaminant Level (PMCL) (µg/l)	Proposed Maximum Contaminant Level Goal (MCLG) (µg/l)
tetrachloroethylene	4	-	-	0
trichloroethylene	5	0	5	-
1,1-dichloroethylene	6	7	7	-
cis-1,2-dichloroethylene	16	-	70	-
trans-1,2-dichloroethylene	16	-	70	-
carbon tetrachloride	5	0	5	-
1,1,1-trichloroethane	200	200	200	-
1,1-dichloroethane	20	-	-	-
1,2-dichloroethane	1	0	5	-
methylene chloride	40	-	-	-
vinyl chloride	2	0	1	-

Sources: Dresen and Hoffman, 1986; EPA, 1985a.

Note: MCLs, PMCLs, and MCLGs are EPA criteria set by the Safe Drinking Water Act. MCLs are enforceable standards, PMCLs are based on technological feasibility of removing a contaminant, and MCLGs are strictly health-based criteria.

A complete analysis consists of the following:

Analyte	Method
Purgeable halocarbons	(EPA Method 601) (overnight turnaround from Brown and Caldwell)
Purgeable organics	(EPA Method 624)
Acid and base/neutral extractables	(EPA Method 625)
California Title 22 parameters, including 2,4,5-TP; 2,4-D; endrin; lindane; methoxychlor; and toxaphene	(EPA Method 608)
Gross alpha, gross beta, and tritium	------
Dissolved metals (priority pollutant list)	Graphite furnace AAS (EPA 600/4-79-020)
Fecal coliform	------
General minerals (major anions and cations, surfactants, specific conductance, TDS, total hardness, total zinc, and pH)	------
Boron	------

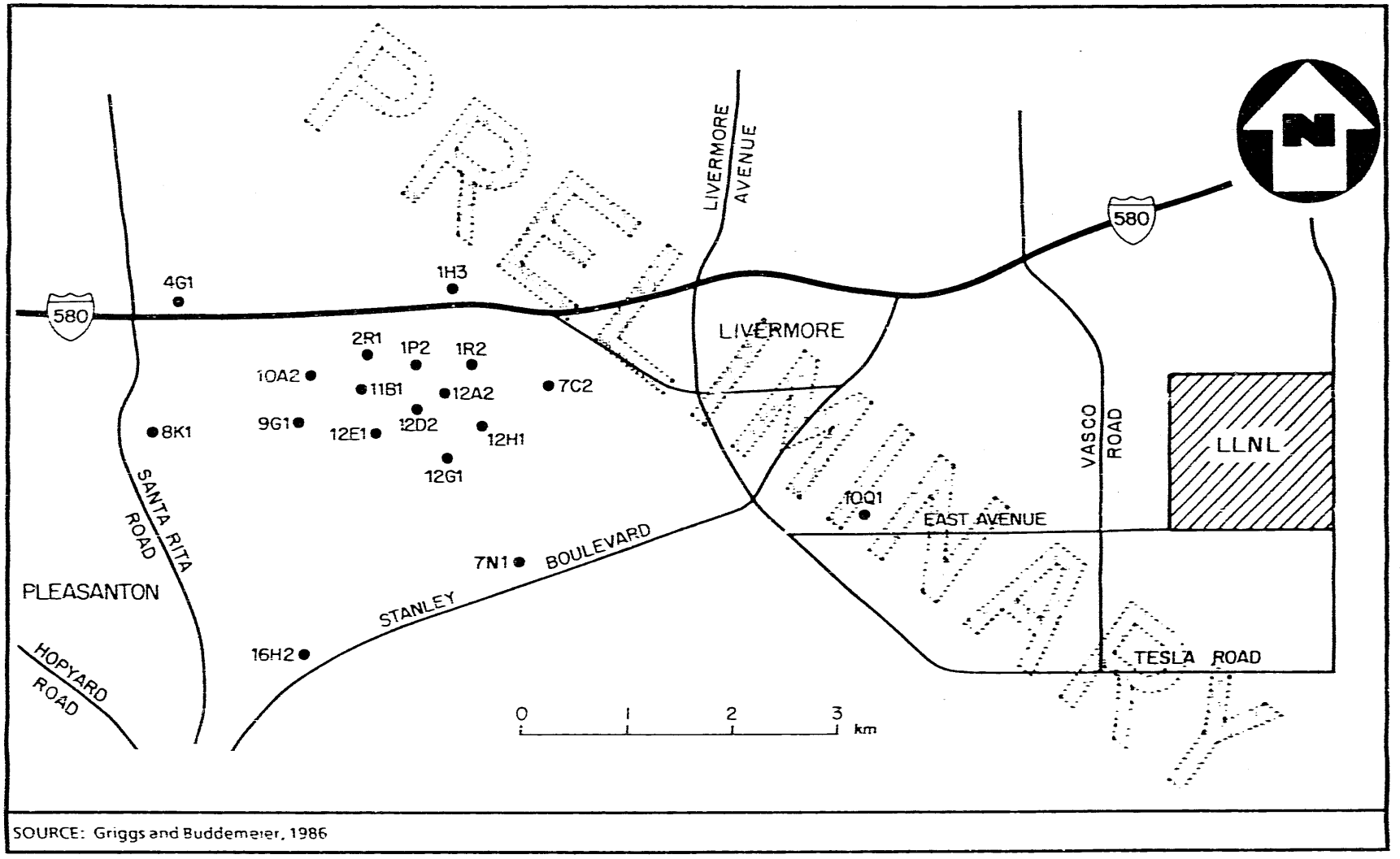
As of this date, the major contaminants found in the groundwater are volatile organics. It is primarily these contaminants for which subsequent quarterly samples are conducted.

Several wells in the Livermore Valley are sampled annually and analyzed for tritium. Figure 3-33 and Table 3-20 show groundwater sampling locations and associated 1985 tritium concentration data for the Livermore Valley. As shown on the table, all wells were below the established 2×10^{-5} μCi/ml concentration guide, ranging from 0.1 to 5 percent of that value.

Site 300

Upon completion of wells at Site 300, samples are collected and analyzed for volatile organics, metals, and various site-specific compounds, such as high explosives or radionuclides, as specified by the geologist and other site personnel. Wells are then sampled quarterly for the selected contaminants. Analytical parameters vary for each set of wells. Because the history of hazardous chemical use at Site 300 is reasonably well known, LLNL believes that it is not necessary to conduct initial complete analyses of Site 300 well samples as was performed for wells at the Main Site.

Routine compliance monitoring around landfills and surface impoundments at Site 300 is required by the California Regional Water Quality Control Board (CRWQCB) and the EPA. In addition to compliance monitoring, LLNL also conducts groundwater quality monitoring for drinking water parameters.



SOURCE: Griggs and Buddemeier, 1986

FIGURE 3-33

LOCATION OF WELLS SAMPLED FOR TRITIUM
LLNL – LIVERMORE, CALIFORNIA

TABLE 3-20

TRITIUM (HTO) IN GROUNDWATER - LIVERMORE VALLEY
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Well Identification[a]	Well Depth (m)	Activity [10-7 µCi/ml ± 2σ (%)]	% CG[b]
3S1E-1P2	15	6.88 ± 2.8	3
3S1E-1R2	17	0.97 ± 7.1	0.5
3S1E-1H3	24	0.22 ± 25.3	0.1
3S1E-2R1	10	2.72 ± 4.0	1
3S1E-4G1	16	0.57 ± 10.7	0.3
3S1E-8K1	32	0.74 ± 8.8	0.4
3S1E-9G1	49	2.31 ± 4.2	1
3S1E-10A2	27	5.54 ± 3.0	3
3S1E-11B1	43	9.58 ± 2.6	5
3S1E-12A2	23	1.36 ± 6.1	0.7
3S1E-12D2	14	6.89 ± 2.8	3
3S1E-12E1	84	0.94 ± 8.0	0.5
3S1E-12G1	27	2.84 ± 4.1	1
3S1E-12H1	104	0.78 ± 8.7	0.4
3S1E-16H2	29	0.68 ± 9.5	0.3
3S2E-7C2	15	1.44 ± 5.5	0.7
3S2E-7N1	41	0.75 ± 8.4	0.4
3S2E-10Q1	13	1.63 ± 5.3	0.8

Source: Griggs and Buddemeier, 1986.

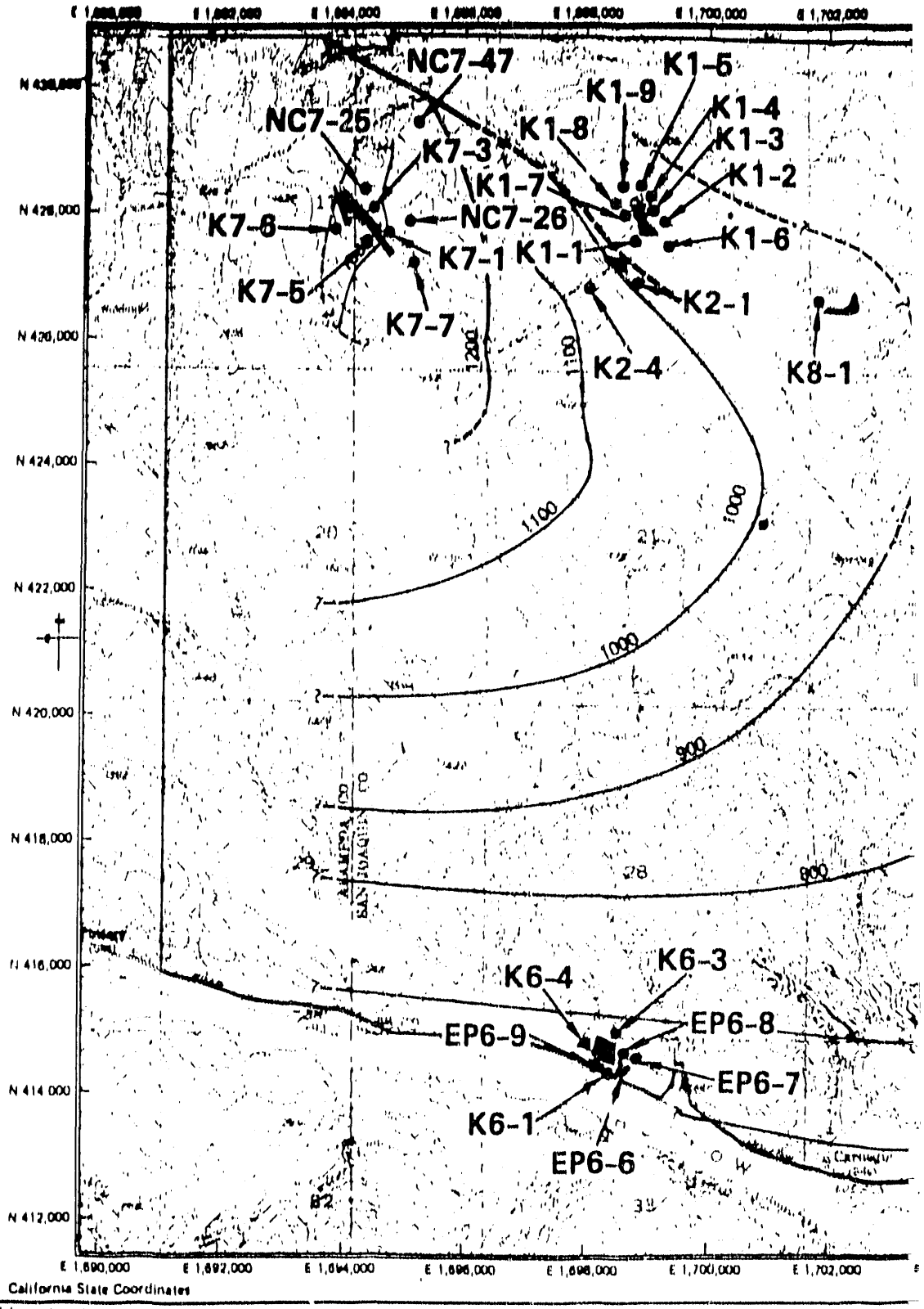
[a] See Figure 3-18 for sample locations.
[b] Concentration Guide = 2×10^{-5} µCi/ml.

RCRA groundwater monitoring is conducted in the vicinity of two active landfills (Pit 1 and Pit 7). Samples are analyzed for drinking water standards, groundwater quality parameters, and indicator parameters, as specified in 40 CFR 265.92. Figure 3-34 shows the location of the monitoring wells included in this program.

Five wells were included in the Pit 7 RCRA monitoring network in 1985. Three additional wells and three lysimeters were added to the system in late 1985. Background monitoring data for the five Pit 7 wells showed differences in specific conductance, total organic carbon (TOC), and total organic halide (TOX) between the Pit 7 upgradient and downgradient wells. Groundwater monitoring in the Pit 7 area has also shown that tritium and chlorinated solvents (TCE, PCE, and 1,1-dichloroethylene) are present in wells located downgradient from the pit. The solvent concentrations are in the low parts-per-billion range (maximum 15 ppb reported) and appear to be decreasing with time. It is suspected that new pumps installed in the wells may be the source of this contamination (Griggs and Buddemeier, 1986).

Tritium concentrations in some downgradient wells were substantially in excess of 20,000 pCi/l. A detailed tritium investigation was conducted in 1985 to better understand the tritium migration potential. The tritium investigation results are discussed in greater detail in Section 3.4.4. An anomalous measurement of 21 pCi/l of alpha radioactivity was also noted in the second quarter of 1985; water samples analyzed since that time show concentrations below the allowable 15 pCi/l. Although the Pit 7 monitoring wells are showing elevated concentrations of tritium and chlorinated organics, potable supply wells, which are located approximately 2 miles away from the landfill monitoring wells and tap different aquifers, show concentrations below the acceptable drinking water limits and action levels for organic contaminants. The drinking water suitability data for Pit 7 appears in Table 3-21.

In 1985, five wells were included in the Pit 1 RCRA monitoring network. Because of uncertainty about the direction of groundwater flow, four wells were added to the system late in 1985. Results from the four wells showed concentrations below drinking water maximum contaminant levels and state action levels. However, traces of organics such as phenol (41 µg/l), benzoanthracene (2 µg/l), di-ethyl phthalate (2 µg/l), chloroform (3 µg/l), and methyl pyrrolidinone (200 µg/l) have been detected in the fourth-quarter monitoring samples. These organics will be closely monitored to determine whether they are indicators of contamination or instead originate from local geological sources, laboratory analysis, or well installation materials.



SOURCE: Griggs and Buddemeier, 1986.

LOCATION OF LANDFILLS
LLNL – LIV

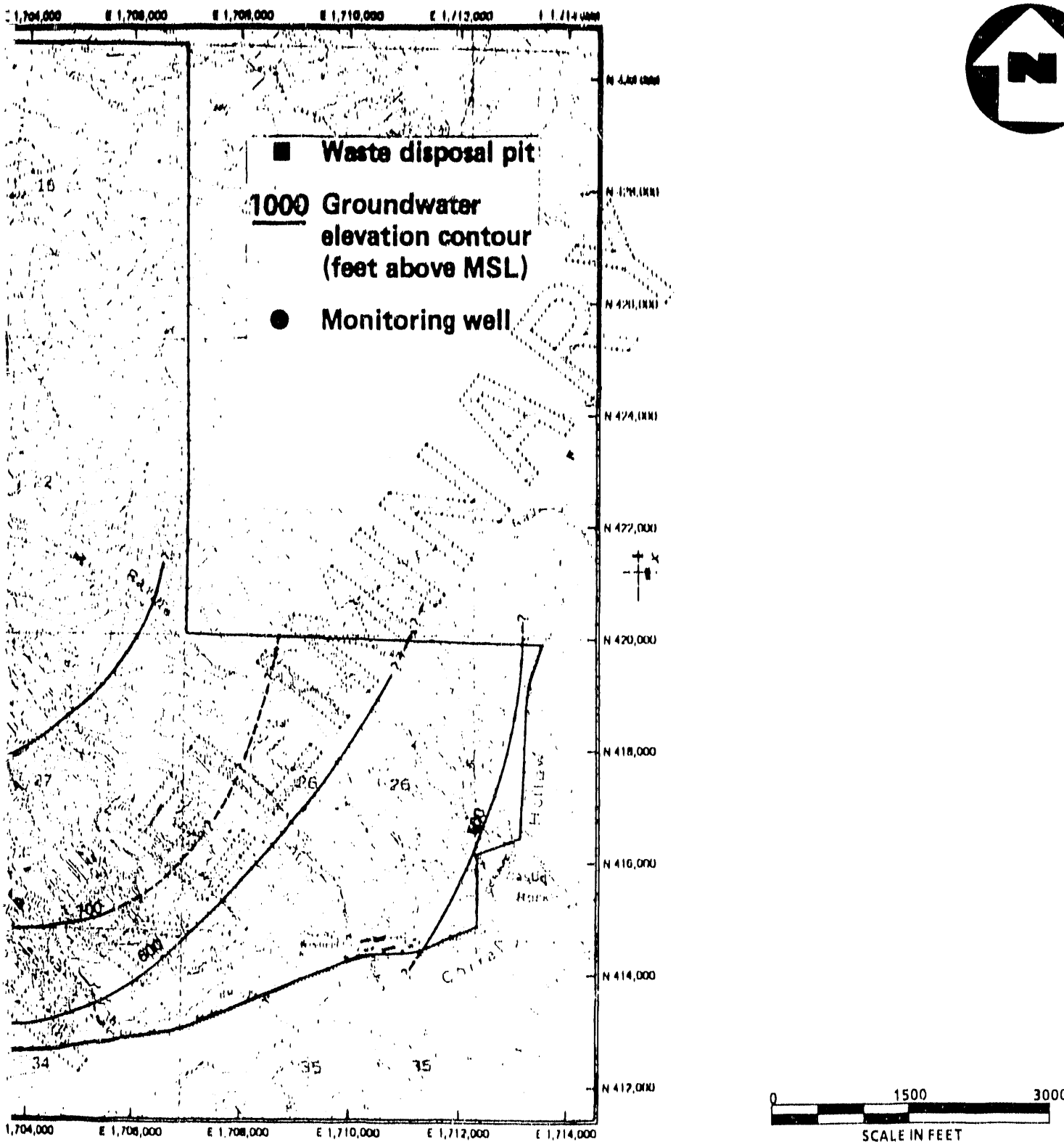


FIGURE 3-34

'ND MONITORING WELLS AT SITE 300
RMORE, CALIFORNIA

TABLE 3-21

DRINKING WATER SUITABILITY PARAMETERS FOR SITE 300 MONITORING WELLS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Well	Quarter	Parameter/Standard							
		Arsenic (mg/l)/0 05	Fluoride (mg/l)/1 4	Nitrate as N (mg/l)/10	Selenium (mg/l)/0 01	Radium (pCi/l)/5	Gross Alpha (pCi/l)/15	Gross Beta (pCi/l)/50	Coliform Bacteria (/100 ml)/4
K7-1	1	<0 001	0 52	9.9	<0 001	1 0 ± 0 1	6 ± 4	12 ± 5	<2
	2	0 005	0 39	9 5	<0 001	0 9 ± 0 1	21 ± 6	8 ± 3	a
	3	<0 001	0 46	9 5	<0 001	1 1 ± 0 1	0 ± 4	10 ± 4	a
	4	a	a	a	a	b	0 ± 4	11 ± 4	a
K7-3	1	<0 001	0 39	7 3	<0 001	0 ± 0 1	0 ± 3	6 ± 4	<2
	2	<0 001	0 29	7 1	<0 001	0 ± 0 1	0 ± 3	0 ± 2	a
	3	<0 004	0 36	7 3	<0 001	0 ± 0 1	0 ± 3	3 ± 3	a
	4	b	b	b	b	b	0 ± 5	6 ± 4	a
K7-5	1	<0 001	0 25	1 0	<0 001	0 3 ± 0 1	0 ± 3	9 ± 4	<2
	2	<0 001	0 21	0 20	<0 001	0 4 ± 0 1	0 ± 4	6 ± 2	a
	3	<0 001	0 21	0 16	<0 001	0 3 ± 0 1	0 ± 3	3 ± 3	a
	4	a	a	a	a	b	0 ± 5	7 ± 4	a
K7 6	1	<0 001	0 49	3 5	<0 001	0 2 ± 0 1	0 ± 3	6 ± 4	<2
	2	<0 014	0 34	3 6	<0 001	0 2 ± 0 1	0 ± 2	15 ± 3	a
	3	<0 010	0 42	3 4	<0 001	0 ± 0 1	0 ± 2	0 ± 3	a
	4	a	a	a	a	b	0 ± 4	5 ± 3	a
K7-7	1	<0 005	0 40	5 9	<0 001	0 ± 0 1	3 ± 3	6 ± 4	<2
	2	<0 008	0 35	5 9	<0 001	0 ± 0 1	6 ± 2	6 ± 2	a
	3	<0 030	0 42	6 0	<0 001	0 ± 0 1	0 ± 3	10 ± 4	a
	4	a	a	a	a	b	0 ± 2	7 ± 4	a

TABLE 3-21
DRINKING WATER SUITABILITY PARAMETERS FOR SITE 300 MONITORING WELLS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
PAGE TWO

Well	Quarter	Parameter/Standard							
		Arsenic (mg/l)/0 05	Flouride (mg/l)/1 4	Nitrate as N (mg/l)/10	Selenium (mg/l)/0 01	Radium (pCi/l)/5	Gross Alpha (pCi/l)/15	Gross Beta (pCi/l)/50	Coliform Bacteria (/100 ml)/4
K1-1	1	c	c	c	c	c	c	c	c
	2	0 012	0 34	7 9	0 002	a	a	a	a
	3	c	c	c	c	c	c	c	c
	4	0 008	0 39	9.5	<0 001	0 ± 1	0 ± 3	0 ± 4	a
K1 2	1	<0.001	0 36	5 9	<0.001	0 ± 0 1	3 ± 3	6 ± 4	<2
	2	0.017	0.31	6 4	<0.001	0 ± 0 1	12 ± 5	5 ± 1	a
	3	0 012	0 31	6 1	<0.001	0 ± 0 1	0 ± 4	5 ± 4	a
	4	0.016	0.32	5 7	0 004	0 ± 0 1	0 ± 2	4 ± 3	a
K1 3	1	<0 001	0 33	6 2	<0.001	0 ± 0 1	0 ± 4	5 ± 4	<2
	2	0 016	0.31	6 7	<0.001	0 ± 0 1	0 ± 2	5 ± 1	a
	3	0 007	0 29	6 4	<0 001	0 ± 0 1	0 ± 2	3 ± 2	a
	4	0 016	0.31	6 1	0 004	0 ± 0 1	0 ± 6	0 ± 4	a
K1-4	1	<0 001	0 39	3 5	<0 001	0 ± 0 1	0 ± 2	9 ± 4	<2
	2	0 012	0 36	3 9	<0 001	0 ± 0 1	0 ± 1	21 ± 1	a
	3	0 004	0 36	3 7	<0 001	0 ± 0 1	0 ± 2	3 ± 3	a
	4	0 012	0.36	3 5	0 002	0 ± 0 1	0 ± 2	0 ± 4	a
K1-5	1	<0 011	0 53	8 5	<0 001	0 ± 0 1	0 ± 2	4 ± 4	<2
	2	0 006	0 45	7 7	<0 001	0 2 ± 0 1	0 ± 2	3 ± 1	a
	3	0 011	0 45	8 3	<0 001	0 ± 0 1	0 ± 2	0 ± 3	a
	4	0 011	0 48	8 6	0 008	0 ± 0 1	0 ± 3	0 ± 3	a

TABLE 3-21
DRINKING WATER SUITABILITY PARAMETERS FOR SITE 300 MONITORING WELLS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
PAGE THREE

Source: Griggs and Buddemeier, 1986.

Notes: See Figure 3-34 for well locations. Standards are based on State of California Title 22, Chapter 15, regulations for public water supplies. None of the monitoring wells reported on here sample aquifers used for domestic water supply production. The following parameters were analyzed for and would have been reported if any values had exceeded the indicated detection limits, all of which are below applicable standards:

Barium	<0.1 mg/l
Cadmium	<0.01 mg/l
Chromium	<0.02 mg/l
Lead	<0.1 mg/l
Mercury	<0.001 mg/l
Silver	<0.01 mg/l
Endrin	<0.1 µg/l
Lindane	<0.005 µg/l
Methoxychlor	<0.2 µg/l
Toxaphene	<1 µg/l
2,4-D	<0.5 µg/l
2,4,5-TP (Silvex)	<0.1 µg/l

a Not analyzed.
b Analysis in progress at time of report.
c Not sampled, pump inoperative.

The two active landfills and six inactive landfills at Site 300 also have groundwater monitoring programs specified by Waste Discharge Order 80-184, issued by the CRWQCB. The order requires annual groundwater monitoring for gross alpha, gross beta, tritium, and beryllium at Site 300 landfill locations. Beryllium was not detected in any of the samples from the landfill monitoring wells. Gross alpha, gross beta, and tritium results for the Pit 1 and Pit 7 wells were discussed above. Wells in the Pit 6 and Pit 8 inactive landfill area did not show radioactivity levels above drinking water standards. One well water sample taken in the Pit 2 area (Well K2-1) showed an alpha concentration of 31 pCi/l in the first quarter of 1985; subsequent sampling has not shown any alpha activity. K2-1 samples have also shown tritium concentrations in excess of drinking water limits. An investigation has shown that tritium in this well originated in the Building 850 area and was transported to Pit 2 by subsurface and stream flow (Griggs and Buddemeier, 1986).

In addition to these regulatory monitoring requirements, the wells around inactive Pit 6 are being monitored to attempt to detect contaminants leaving the landfill. Records show that potentially hazardous wastes were buried in this pit between 1964 and 1973, including the following: capacitors suspected to be contaminated with PCB, beryllium- and mercury-contaminated materials, and miscellaneous chemicals. In 1985, monitoring results indicated that water samples did not exceed drinking water limits or state action levels. Traces of organics were noted in the first two quarters in the following maximum concentrations: 1,1,1-trichloroethane (3 µg/l), methyl pyrrolidinone (40 µg/l), acetone (20 µg/l), and unspecified ketones and esters (20 µg/l). These were not detected in the wells in the third and fourth quarter. Methylene chloride was detected once (4 µg/l) in the fourth quarter in one of the upgradient wells (Griggs and Buddemeier, 1986). Additional wells were installed at Pit 6 during the Survey, but results are not yet available.

In 1985, the CRWQCB issued new groundwater monitoring requirements as part of Waste Discharge Order 85-188 for LLNL's new Class II surface impoundment. The impoundment contains nonhazardous, high-explosives process wastewater. Samples from four wells and one lysimeter are analyzed quarterly for pH, total organic carbon, total organic halides, specific conductance, several explosives compounds (HMX, RDX, nitrate, nitrite), and metallic elements. The 1985 data indicate RDX concentrations of 45 µg/l, which is near the detection limit of 20 µg/l, in the upgradient well. All other data for the impoundment monitoring installations show both upgradient and downgradient concentrations that are within allowable limits.

3.4.4 Findings and Observations

3.4.4.1 Category I

None

3.4.4.2 Category II

None

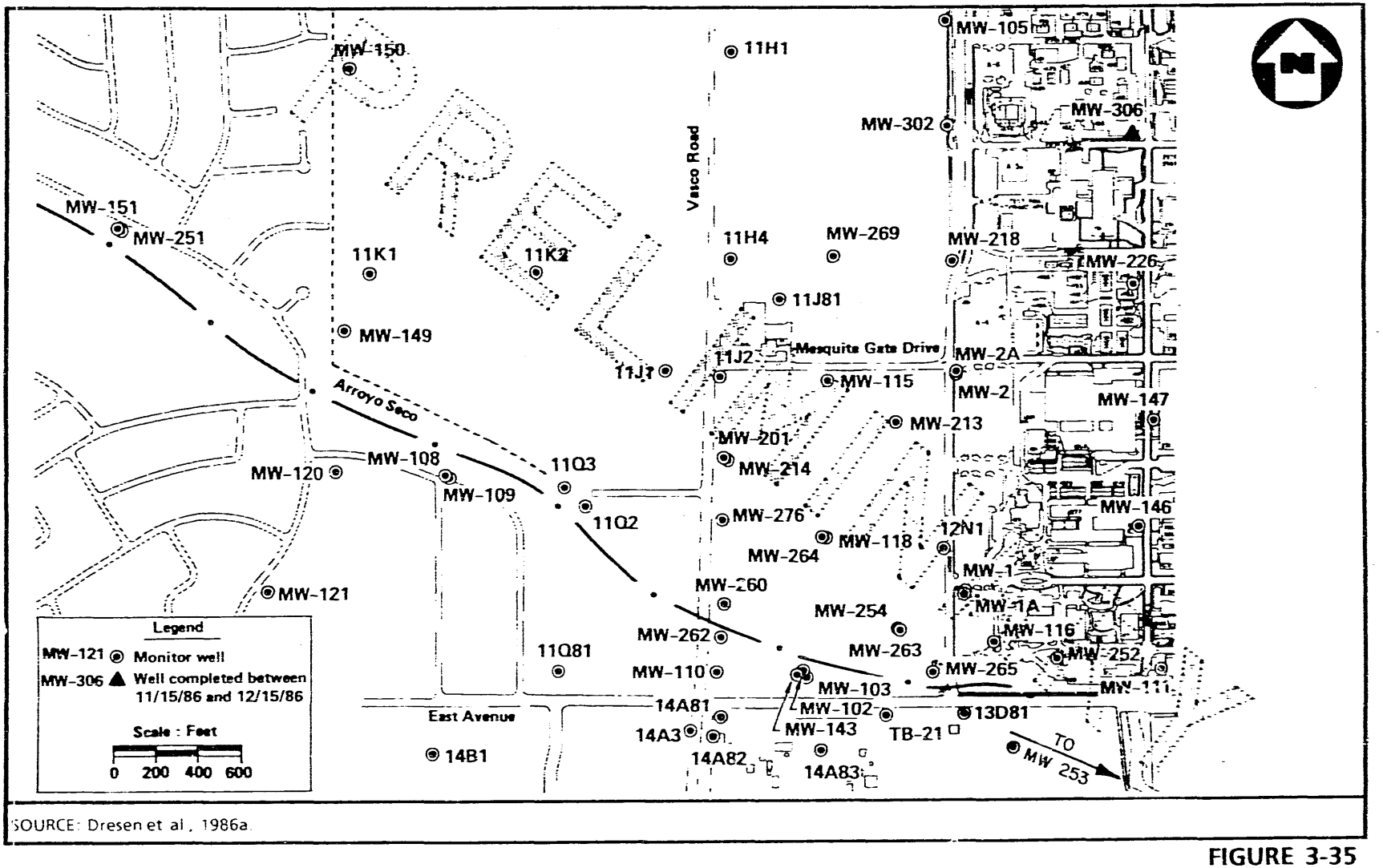
3.4.4.3 Category III

1. Groundwater Contamination at the Main Site. Past waste disposal practices have resulted in several known and/or potential continuing-release sources of groundwater contamination. Trichloroethylene (TCE) and other solvents are the primary contaminants identified in the groundwater. In the southwest section of LLNL, contamination plumes have been observed off-site and residential wells have been shut down. Details regarding the actual or potential sources of contamination are discussed in Section 4.5.

   Southwestern Area

   A plume of TCE and other volatile organic compounds is moving off-site from the southwestern corner of the property toward a residential development. After TCE was discovered in an off-site residential well, LLNL began an intensive investigation of groundwater contamination and potential sources in the area. The source investigation consisted of 140 borings, but did not come to any conclusions regarding the source of contamination. Based on a search of the U.S. Navy archives, it is now thought that Navy cleaning and degreasing activities were the source of this contamination (see Section 4.5 for more details). A total of 46 monitoring wells and 14 residential wells were used to delineate the horizontal and vertical extent of the plume. Well locations are shown in Figure 3-35. Well installation is continuing in an investigation of deeper contaminated zones.

   Eight volatile organic compounds--tetrachloroethylene (PCE), trichloroethylene (TCE), 1,1-dichloroethylene, trans-1,2-dichloroethylene, 1,1-dichloroethane, 1,2-dichloroethane, carbon tetrachloride, and methylene chloride--were detected in groundwater at



SOURCE: Dresen et al., 1986a

FIGURE 3-35

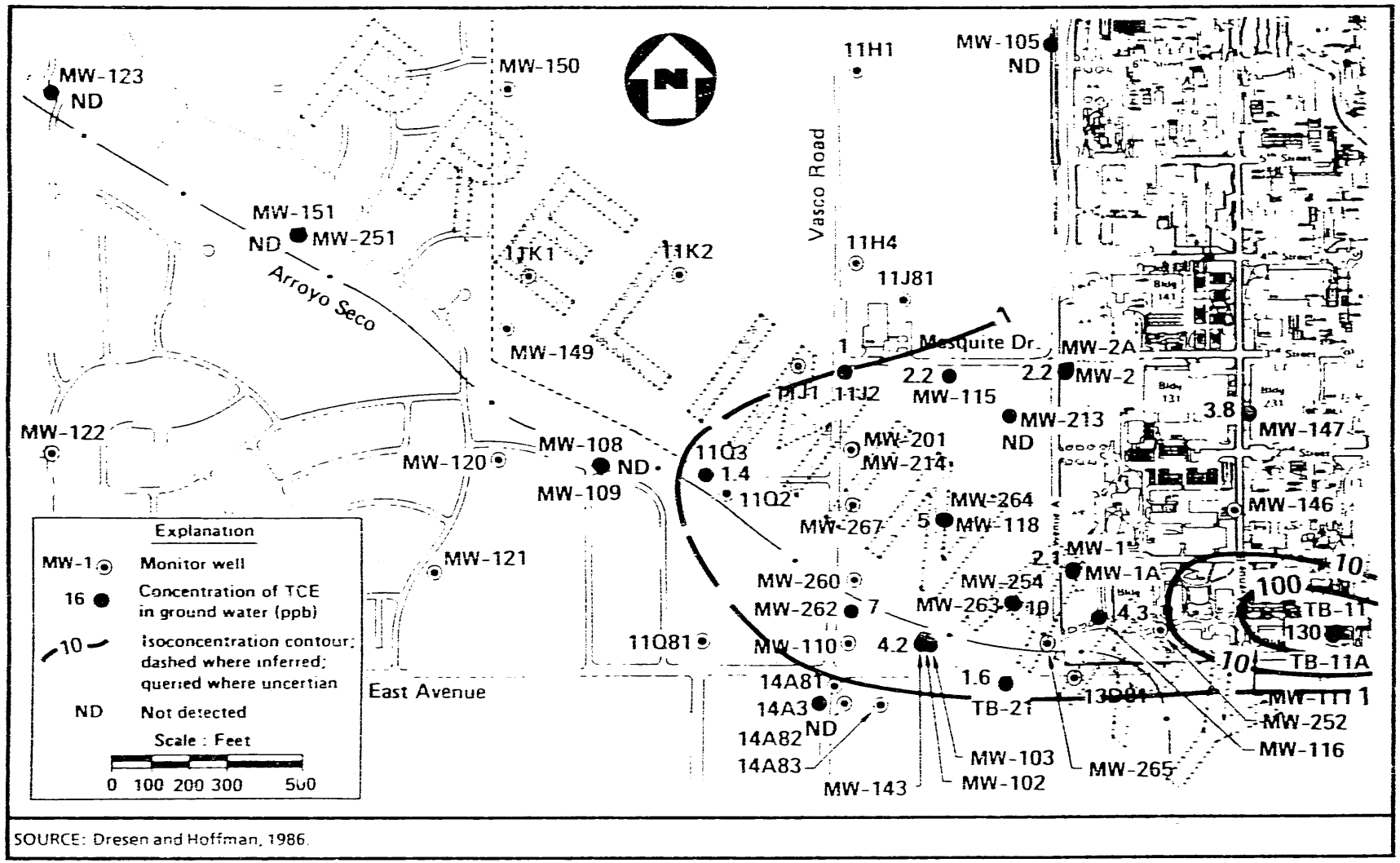
LOCATIONS OF MONITORING WELLS WEST OF LLNL MAIN SITE
LLNL – LIVERMORE, CALIFORNIA

concentrations that exceed California Department of Health Services action levels. The following table presents a summary of the analytical results from this investigation:

Compound	Action Level (µg/l)	Reported Maximum Concentration (µg/l)	Well Number
tetrachloroethylene	4	860	MW-116
trichloroethylene	5	130	TB-11
1,1-dichloroethylene	6	48	MW-109
1,2-dichloroethylene	16	30	MW-109
carbon tetrachloride	5	10	MW-2
1,1,1-trichloroethane	200	100	TB-11
1,1-dichloroethane	20	60	MW-109
1,2-dichloroethane	1	5.3	MW-118
methylene chloride	40	3,200	11Q2

Data from these wells indicate that organic compounds have migrated westward from the southwestern corner of the LLNL property through sandy materials. Well MW-253 was recently found to contain less than 1 part per billion (ppb) TCE, which may indicate that the plume is spreading southwestward toward the Sandia National Laboratory property. The western margin of the plume is about 4,000 feet west of the laboratory at a depth of about 200 feet. The plume is about 1,700 feet wide. At the southwest corner, contaminants are found at depths of about 90 feet. The presence of private wells within this plume may have provided preferred vertical pathways of migration and thus allowed the contaminants to reach greater depths in places. Many of these wells have been subsequently sealed by LLNL to avoid further cross-contamination of the aquifers.

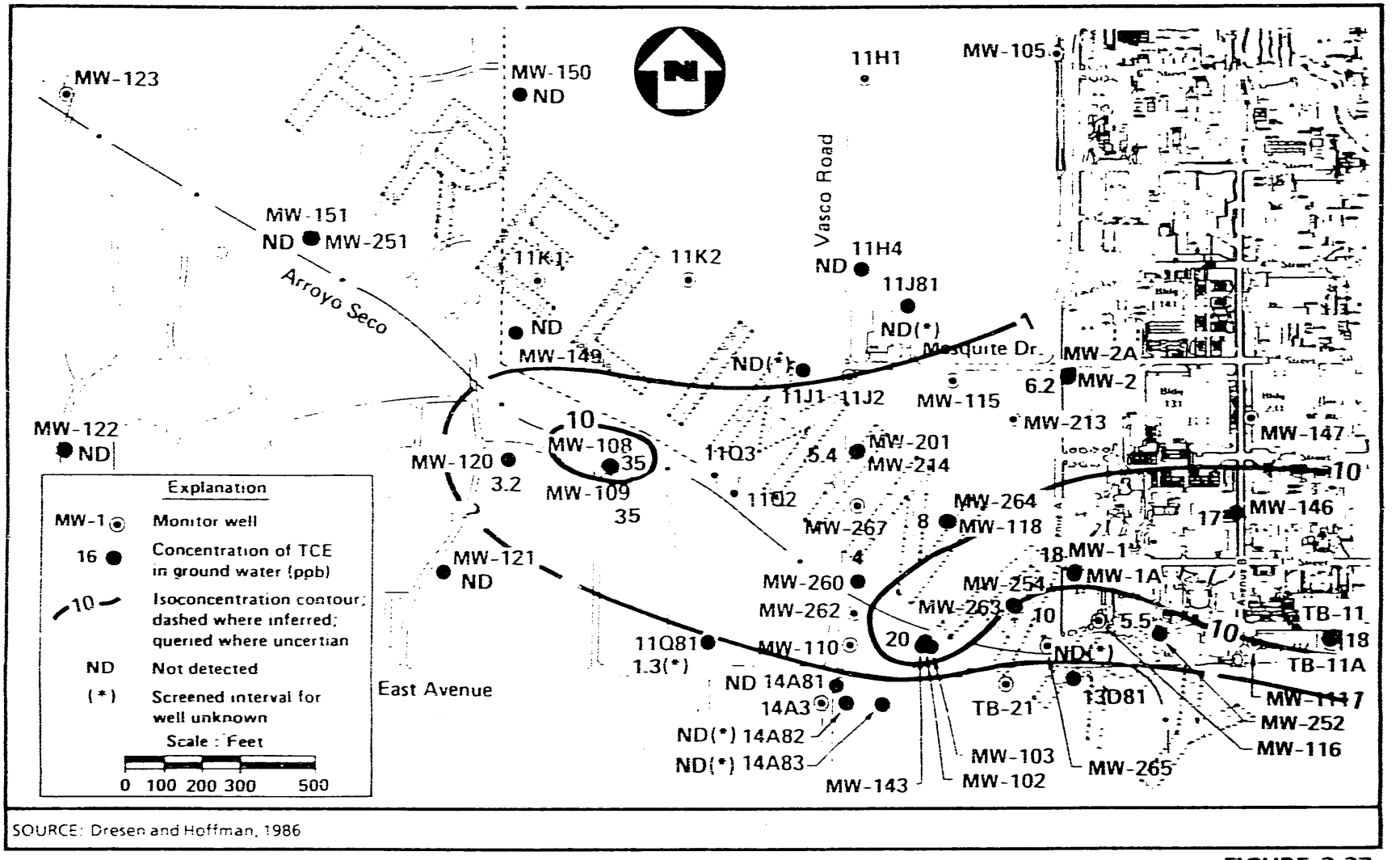
Multiple sources have been proposed for this plume, based on chemical fingerprinting and isoconcentration contour mapping. The TCE has migrated farthest from the laboratory property, from a postulated source somewhere near Building 212, as shown in Figures 3-36 and 3-37. PCE has not migrated quite so far, as shown in Figures 3-38 and 3-39, from a speculated source slightly downgradient of Building 212. A third source of volatiles has been speculated within the Rhonewood Subdivision. MW-251 contained 1,1-dichloroethylene, 1,1,1-trichloroethane, and chloroform, which were not found in any wells closer to LLNL.



SOURCE: Dresen and Hoffman, 1986.

FIGURE 3-36

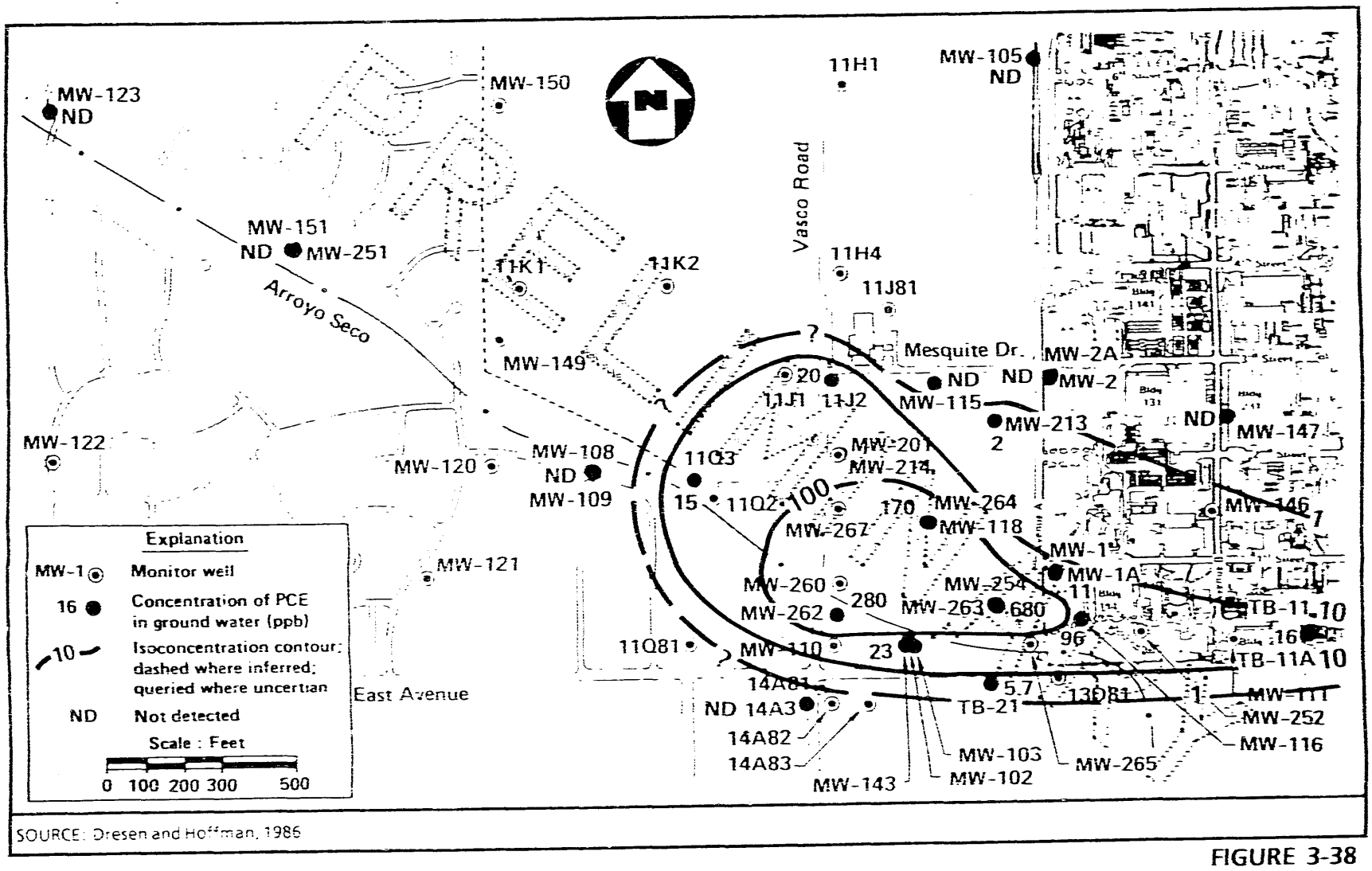
TCE IN SHALLOW GROUNDWATER WEST OF LLNL MAIN SITE
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Dresen and Hoffman, 1986

FIGURE 3-37

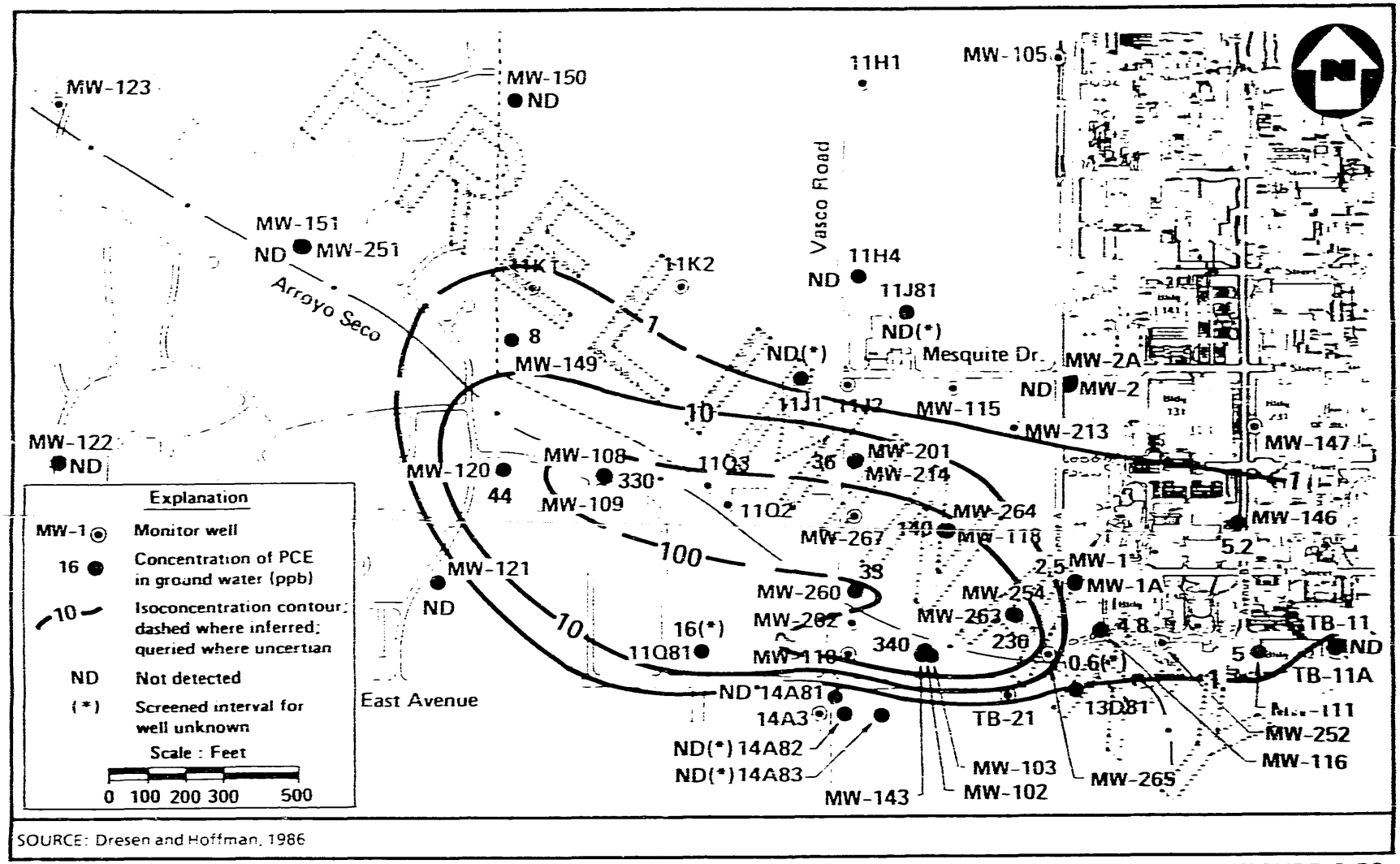
TCE IN DEEP GROUNDWATER WEST OF LLNL
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Dresen and Hoffman, 1986

FIGURE 3-38

PCE IN SHALLOW GROUNDWATER WEST OF LLNL MAIN SITE
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Dresen and Hoffman, 1986

FIGURE 3-39

PCE IN DEEP GROUNDWATER WEST OF LLNL MAIN SITE
LLNL – LIVERMORE, CALIFORNIA

The study of this plume is furthest along of any of the laboratory's investigations. Plans are under way for a groundwater pumping and treatment system that is intended to contain the plume. In addition, wells are being installed in clean aquifers underlying the contaminated zones, which will be used to monitor groundwater quality and potential breakthrough during pumping. No source removal is planned, because specific source areas could not be defined.

Gasoline Spill at Building 403

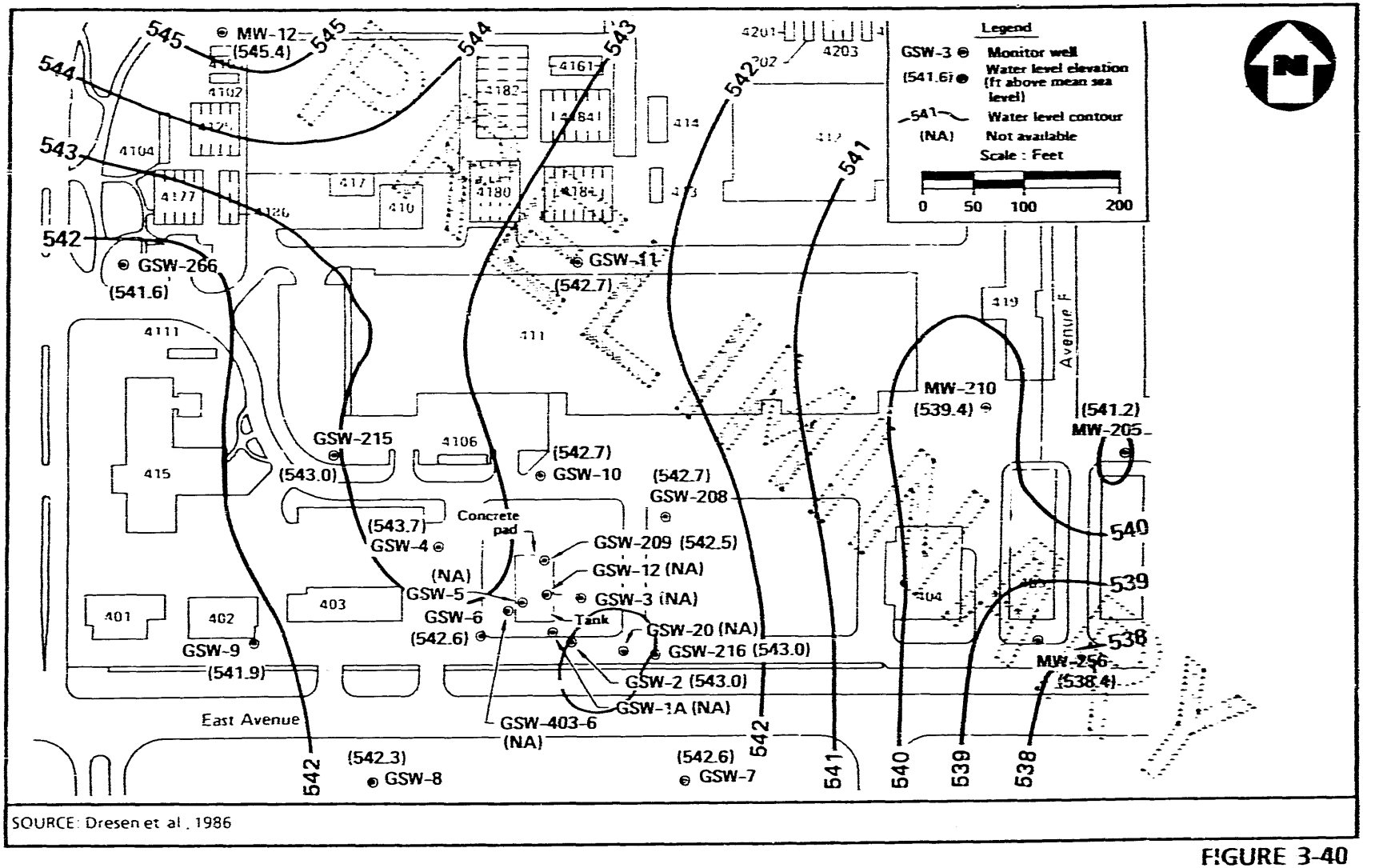
Groundwater beneath Building 403 has been contaminated with gasoline as a result of a spill. In 1979, approximately 17,000 gallons of leaded gasoline leaked from underground tanks near Building 403. Samples of saturated and unsaturated soil and groundwater were collected from 18 borings and 20 monitoring wells during the investigation to characterize the extent of the plume. Well locations are shown in Figure 3-40.

Analyses indicate that the gasoline constituents benzene, toluene, and xylene (BTX) have not migrated far from the original spill area, probably because they are retained in the vadose zone by fine-grained sediments. The plume extends only about 200 feet southwest; 250 feet west; and 500 feet northwest, northeast, and east from the leak. The relatively symmetrical appearance (Figure 3-41) of the plume is caused by the low hydraulic gradient in the area, which in turn, is due to the presence of a groundwater divide in this area (Figure 3-40). Table 3-22 is a summary of analytical results for selected VOAs.

Short-chain aliphatic hydrocarbons (compounds containing 4 to 8 carbons) were detected farther from the leak area than were the aromatics. The aliphatics are more mobile and may represent the leading edge of the plume. The hydrocarbons had not reached a depth of 185 feet as of 1986.

This plume is relatively small, although there are significant quantities of contaminated soil overlying the water table. More than 1 part per million (ppm) of BTX is found in soils at depths of 20 to 100 feet.

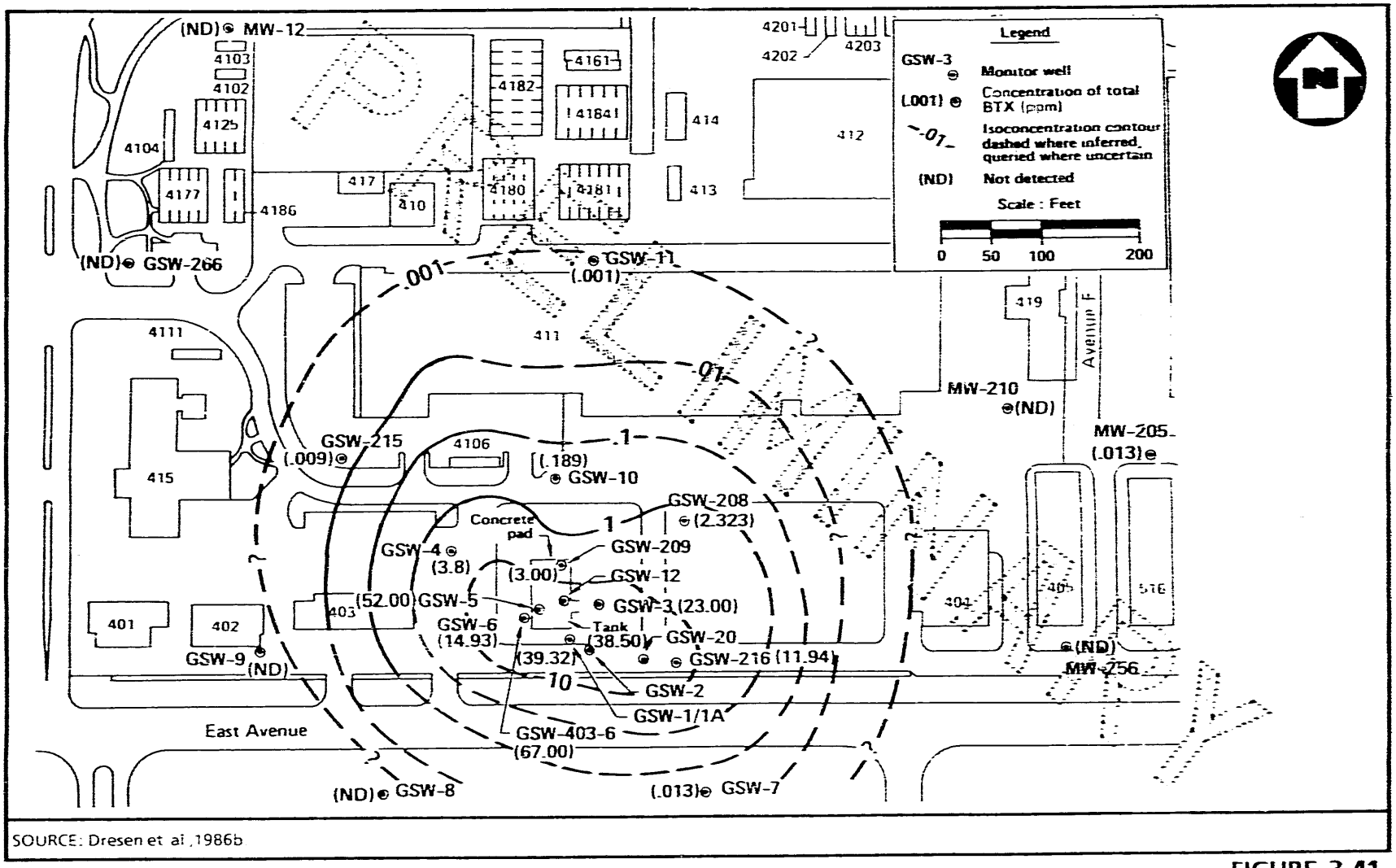
LLNL is currently investigating various remedial alternatives for this plume, including in-situ biodegradation and soil venting. These studies are in their infancy, and no feasibility studies have been prepared as yet.



SOURCE: Dresen et al., 1986

FIGURE 3-40

LOCATION OF MONITORING WELLS AND GROUNDWATER CONTOURS
(JUNE 1986) BUILDING 403 AREA
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Dresen et al.,1986b

FIGURE 3-41

TOTAL BENZENE, TOLUENE, AND XYLENE IN GROUNDWATER
BUILDING 403 AREA
LLNL – LIVERMORE, CALIFORNIA

TABLE 3-22

ANALYTICAL RESULTS - BUILDING 403 GASOLINE SPILL AREA
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Compound	Range of Detections (µg/l)										
	GSW-1	GSW-1A	GSW-2	GSW-3	GSW-4	GSW-5	GSW-6	GSW-7	GSW-8	GSW-9	GSW-10
Gasoline fingerprint	16,000-64,000	45,000-54,000	19,000-240,000	12,000-27,000	2,700-12,000	75,000-100,000	21,000-88,000	330	160	76-80	770-3,500
Benzene	9,000-44,000	3,200-7,600	11,000-66,000	7,400-28,000	1,100-4,100	21,000-46,000	1,200-8,800	3-15	77-180	ND-4	5-76
Toluene	140-4,200	1,200-3,900	200-3,700	10-450	120-500	23,000-38,000	1,300-9,100	ND	ND	ND	ND-71
Total xylenes	1,200-14,000	150-1,000	120-3,000	ND-4,800	200-720	8,000-11,000	2,900-15,000	ND	ND	ND	19-1,900
1,2-Dichloroethane	790-920	ND-150	160-990	ND-41	ND	1,400-2,600	150-260	ND	ND-38	ND	ND-7
Trichloroethylene	ND	ND-65	ND-4.2	ND-7.5	10-25	ND	ND-3.1	ND	ND	ND	28-54

TABLE 3-22
ANALYTICAL RESULTS - BUILDING 403 GASOLINE SPILL AREA
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
PAGE TWO

Compound	Range of Detections (µg/l)									
	GSW-11	GSW-12	GSW-13	GSW-4036	GSW-20	GSW-208	GSW-209	GSW-215	GSW-216	GSW-266
Gasoline fingerprint	ND-120	ND	7,500	220,000		2,600-17,000	4,400-14,000	390-1,700	13,000-120,000	ND
Benzene	ND-1	ND	350-400	27,000		1,300-5,100	320-1,800	ND-24	8,200-68,000	ND
Toluene	ND	ND	ND-4	6,200-26,000	ND-160	ND	ND-2,300	ND-2	ND-2,100	ND
Total xylenes	ND	ND	ND	14,000		ND-80	1,000-2,000	ND-5	95-2,000	ND
1,2-Dichloroethane	ND	ND	ND	250-2,200	19-82	110-130	ND-130	ND	ND-99	ND
Trichloroethylene	39-47	ND-53	ND	ND	ND	4.1-19	4-21	ND	ND-3,000	ND-5

Source: adapted from Dresen et al., 1986b.
Notes: ND - Not found above detection limit

Southeastern Corner

Groundwater in the southeastern corner of the Main Site is contaminated with several volatile organic compounds. In 1985 and 1986, LLNL studied groundwater contamination in the vicinity of a number of known or suspected areas of contamination in the southeastern corner of the Main Site. Eleven wells were installed in this area to supplement two existing wells as monitoring points. Volatile organic compounds were found in wells near Buildings 518, 612, and 514. It is concluded that these buildings are potential sources of groundwater contamination. These sources are described in greater detail in Section 4.5. Table 3-23 presents a summary of the analytical results for PCE; 1,1,1-trichloroethane; 1,1-dichloroethylene; chloroform; and carbon tetrachloride, which were found at low concentrations (less than 100 µg/l) in two wells, while TCE was found at 2,000 µg/l in well MW-112. The plume is apparently migrating southward from this area. Figure 3-42 shows well locations and the approximate extent of the contaminant plume.

At the present time, there is a total of 17 wells in this area. Drilling is expected to continue in order to define the lateral and vertical extent of contamination in this area. The most recent activity in this area was hydraulic testing of several wells. A portable air stripper was used to remove volatiles from the water prior to discharge to the ground surface.

East Traffic Circle Landfill

Although excavation has removed all or part of the suspected source, groundwater in the area of the former landfill is contaminated with a number of volatile organic compounds. The former East Traffic Circle Landfill was excavated in 1984 and 1985 to provide an area for the construction of office buildings. Contaminated soil was removed from the area, and samples were collected from areas where contamination was visually evident (stains) or suspected (rusted drums observed) to confirm the levels of cleanup achieved (McConachie et al., 1986). Some soil contamination may have been left in place, however, because of the lack of a soil characterization program.

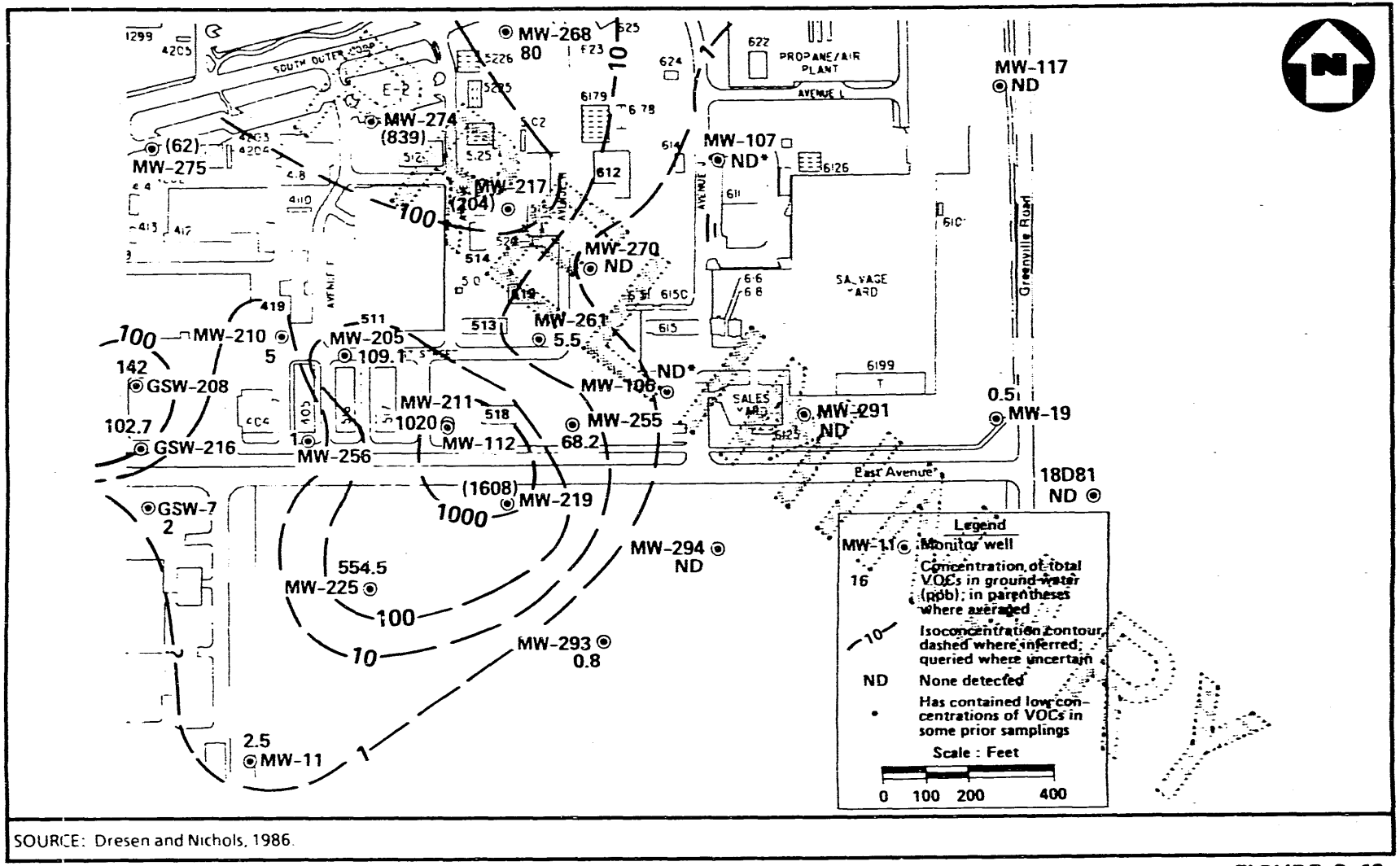
There has been a rather aggressive well installation program in place to investigate the extent of groundwater contamination in the vicinity of the landfill. This investigation is continuing at the present time. Table 3-24 presents a summary of analytical results for selected wells shown in Figure 3-43. TCE was found in concentrations as high as 1,200 µg/l (MW-222), and PCE was found in concentrations as high as 1,300 µg/l (MW-207).

TABLE 3-23

ANALYTICAL RESULTS - SELECTED WELLS IN THE BUILDING 518 AREA
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Compound	Range of Detections (µg/l)												
	MW-106	MW-107	MW-112	MW-205	MW-210	MW-217	MW-219	MW-225	MW-256	MW-261	MW-270	MW-274	MW-294
1,1-dichloroethylene	ND	ND	ND-36	ND	ND	7-22	5-9.3	ND-2.9	ND	ND	ND	ND	ND
trans-1,2-dichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trichloroethylene (TCE)	ND-5.0	ND-5.0	100-2,000	ND-250	ND	40-110	130-1,600	9-87	ND	ND-5.5	ND	720-950	ND
tetrachloroethylene (PCE)	ND-2.2	ND	ND-33	ND	ND	ND-12	ND-60	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	ND	ND	ND-11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-dichloroethane	ND	ND	ND	ND	ND	ND-3.3	ND	ND	ND	ND	ND	ND	ND
1,1,1-trichloroethane	ND	ND	ND-100	ND	ND	ND-2.1	ND	ND	ND	ND	ND	ND	ND
1,1,2-trichloroethane	ND-0.25	ND	ND	ND-2	ND	ND	ND	ND	ND	ND	ND	ND	ND
chloroform	ND-0.11	ND-2.8	ND-29	ND-7	2-15	1.8-12	ND	ND-0.8	1-2	2.4-12	ND-2.1	ND	ND
carbon tetrachloride	ND	ND	ND-50	ND-5.5	ND	15-83	11-30	ND-7.2	ND-20	ND	ND	ND-7.1	ND

Source: Adapted from Dresen et al., 1986a, c, and d.
ND Not found above detection limit



SOURCE: Dresen and Nichols, 1986.

FIGURE 3-42

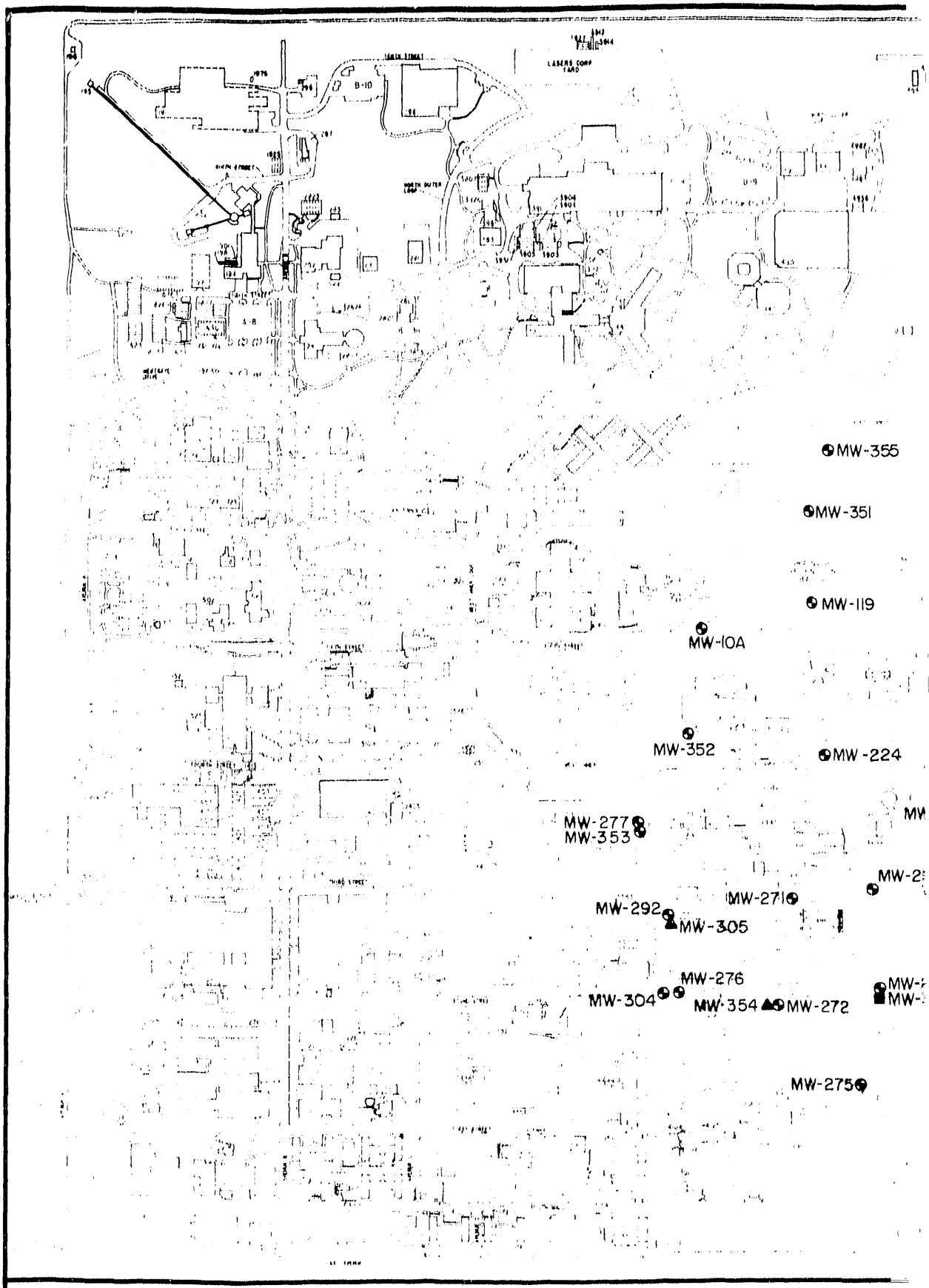
TOTAL VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER
BUILDING 518 AREA
LLNL – LIVERMORE, CALIFORNIA

TABLE 3-24

ANALYTICAL RESULTS - SELECTED WELLS IN THE EAST TRAFFIC CIRCLE LANDFILL AREA LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Compound	Range of Detections (µg/l)							
	MW-119	MW-142	MW-207	MW-220	MW-221	MW-222	MW-224	MW-273
1,1-dichloroethylene	ND-4 5	11-62	62-230	7.7-15	ND	5.0-28	ND	ND
trans-1,2-dichloroethylene	ND	ND-29	3-14	ND-1 2	ND	ND	ND	ND
trichloroethylene	ND-4.7	260-640	520-1,100	1.6-110	ND	1,000-1,200	3.2-5.0	ND-16
tetrachloroethylene	ND	ND-42	1,100-1,300	ND-2.6	ND	45-52	ND	ND
1,1-dichloroethane	ND	6-21	6-29	ND-2.9	ND	ND-0.81	ND	ND
1,2-dichloroethane	ND	ND-17.0	ND-28	ND-14	ND	ND-5.5	ND	ND
1,1,1-trichloroethane	ND-0 6	ND-0.60	ND-21	ND	ND	ND	ND	ND
1,1,2-trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
chloroform	ND	ND-14	ND-8	7.2-15	ND-0.9	38-58	ND-1	ND
methylene chloride	ND	ND	ND	ND	ND	45-47	ND	ND-0.7

Source: Adapted from Dresen et al., 1986a, c, and d
ND - Not found above detection limit



SOURCE: Dresen et al., 1986a.

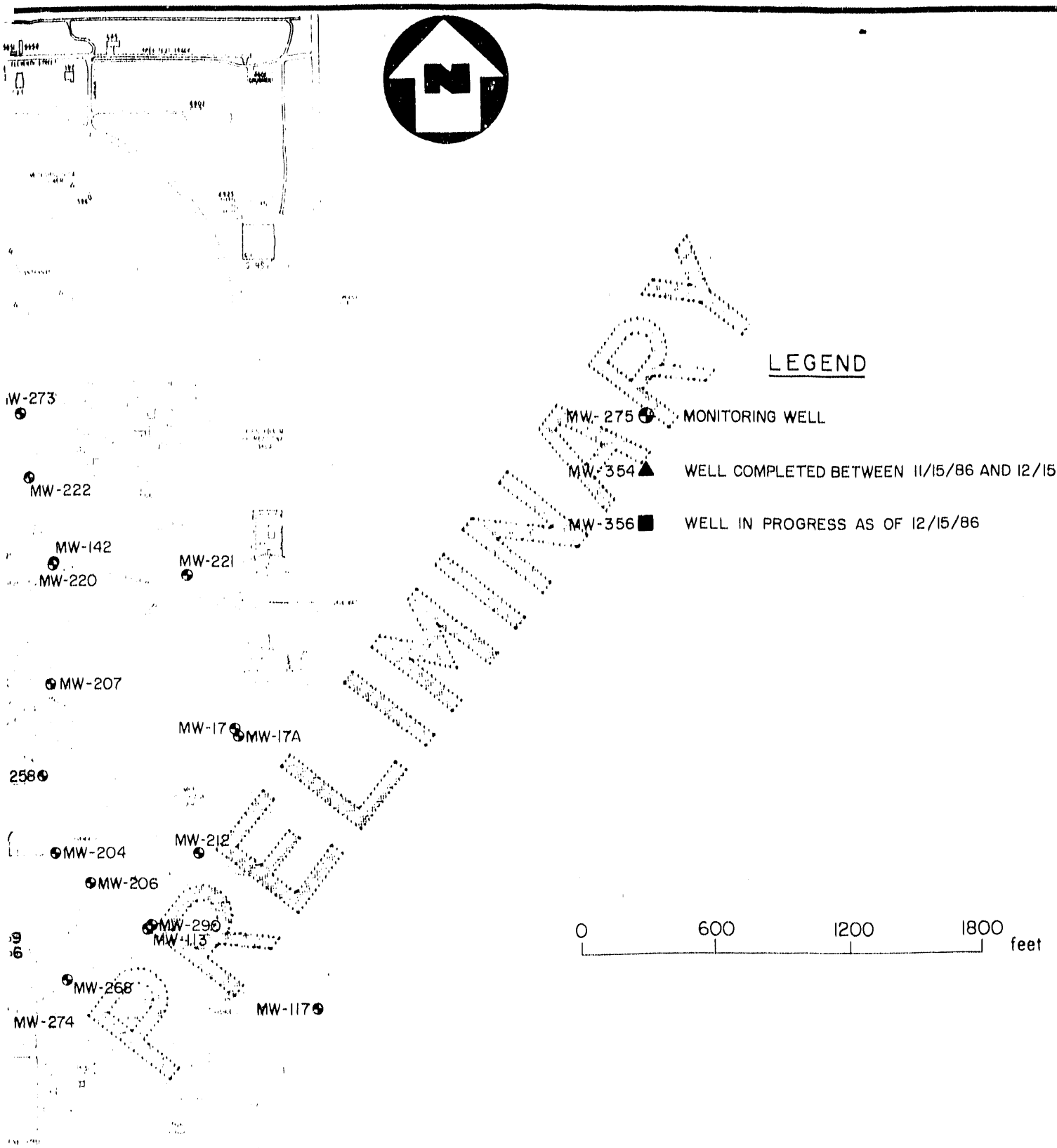


FIGURE 3-43

ELLS - EAST TRAFFIC CIRCLE
JL – LIVERMORE, CALIFORNIA

Taxi Strip/Old Salvage Yard

Soils from the Old Taxi Strip and Salvage Yard were removed, but there is residual volatile organic contamination of groundwater in this area. A number of wells have been installed to investigate the extent of contamination. Figure 3-43 presents well locations, and Table 3-25 is a summary of selected analytical results for some of these wells. MW-206, south of Building 5475, shows the highest levels of contamination (5,800 µg/l TCE, 730 µg/l PCE, 210 µg/l 1,1-dichloroethylene, and 280 µg/l chloroform, as well as 40 pCi/l of tritium). This well is located in the approximate area of the old "evaporation ponds," which, in an area with such a low water table and permeable sediments, were probably infiltration ponds. Several water-bearing zones are known to be contaminated, but thus far the data do not indicate the presence of a distinct plume. Additional wells are planned for the area.

2. Groundwater Contamination at Site 300. Past waste disposal practices and spills have resulted in three general areas of known groundwater contamination, many of which may be continuing sources. TCE is the major contaminant of concern, although there is a tritium problem in one area. Most importantly, the water supply of Site 300 could be jeopardized by the presence of TCE.

All of the areas discussed below may be potential sources of the TCE found in various environmental media at Site 300. Site 300 personnel are conducting a systematic investigation to pinpoint source area(s) and plume(s).

834 Complex - Site 300.

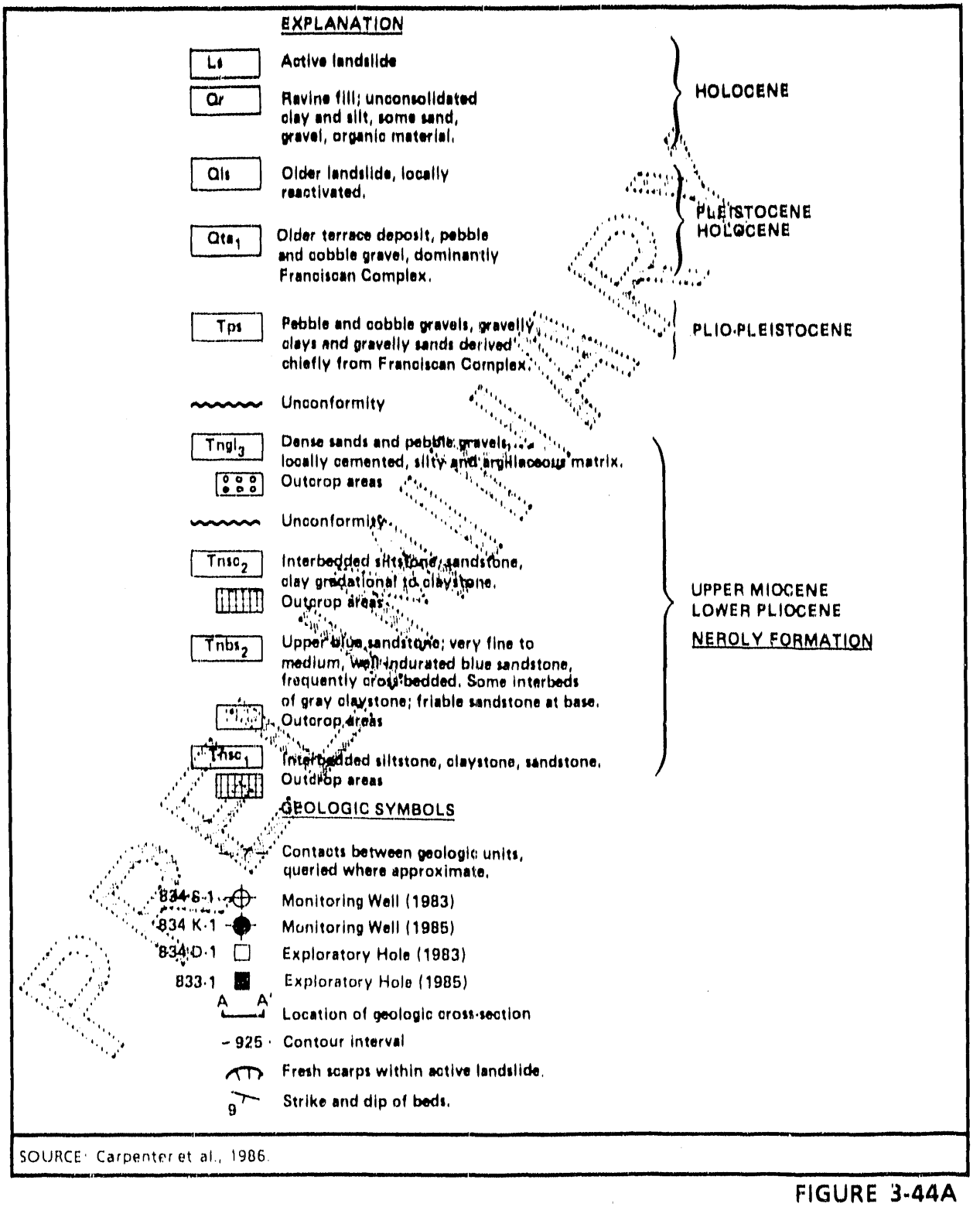
Since 1982, several wells have been installed in the 834 Complex area to investigate the presence of TCE in the shallow, perched groundwater. Up to 12,000 mg/kg of TCE was found in soil samples and up to 460 mg/l of TCE was found in groundwater samples in this area. Additional wells are being installed in a ring-like pattern around the 834 Complex to define the extent of contamination in the shallow aquifer. The shallow, contaminated water body apparently discharges slowly to a ravine south of the complex, and the downward migration of TCE is prevented by the presence of a silt and clay aquitard. The southern and western limits of the plume have not yet been identified. Buildings C and D in the complex are probable sources of the TCE. When the weather is sufficiently wet to extend the limits of the perched water body to that section of the 834 Complex, the contaminants in the soil can directly enter the groundwater (Carpenter et al., 1986). Figure 3-44 shows approximate well

TABLE 3-25

ANALYTICAL RESULTS FROM SELECTED WELLS IN THE OLD SALVAGE YARD/TAXI STRIP AREA LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Compound	Range of Detection (µg/l)									
	MW-113	MW-204	MW-206	MW-212	MW-257	MW-258	MW-259	MW-271	MW-272	MW-290
1,1-dichloroethylene	ND	ND	ND-210	ND	25-410	ND-4.3	ND-2	13-27	20-22	ND
trans-1,2-dichloroethylene	ND	ND	ND-60	ND	ND-1.6	ND	ND	ND	18-20	ND
trichloroethylene (TCE)	ND-1.5	4.2-11	760-5,800	ND	95-990	ND-29	420-740	110-200	35-40	ND
tetrachloroethylene (PCE)	ND-1.2	ND-2	180-730	ND	21-200	ND-0.9	ND-1	8.6-39	ND	ND
1,1-dichloroethane	ND	ND	ND-9.2	ND	ND-4.9	ND	ND	ND	ND-2.9	ND
1,2-dichloroethane	ND	ND-2.0	ND-140	ND	ND	ND	ND	ND	ND	ND
1,1,1-trichloroethane	ND-2.8	ND	ND-120	ND	ND-6.8	ND	ND	ND	.5-10.	ND
1,1,2-trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
chloroform	ND-15	3.1-15	ND-280	ND	3.1-18	2.9-22	ND-2	ND	2.7-4	ND-0.8
methylene chloride	ND	ND	ND-30	ND	ND-78	ND	ND	ND	ND	ND

Source: Adapted from Dresen et al., 1986a, b, and d.
ND Not found above detection limit



SOURCE: Carpenter et al., 1986.

FIGURE 3-44A

LEGEND FOR FIGURE 3-44B – SITE 300
LLNL – LIVERMORE, CALIFORNIA

SOURCE: Carpenter et al., 1986.

LOCATIONS OF MONITORING
LLNL – LIV

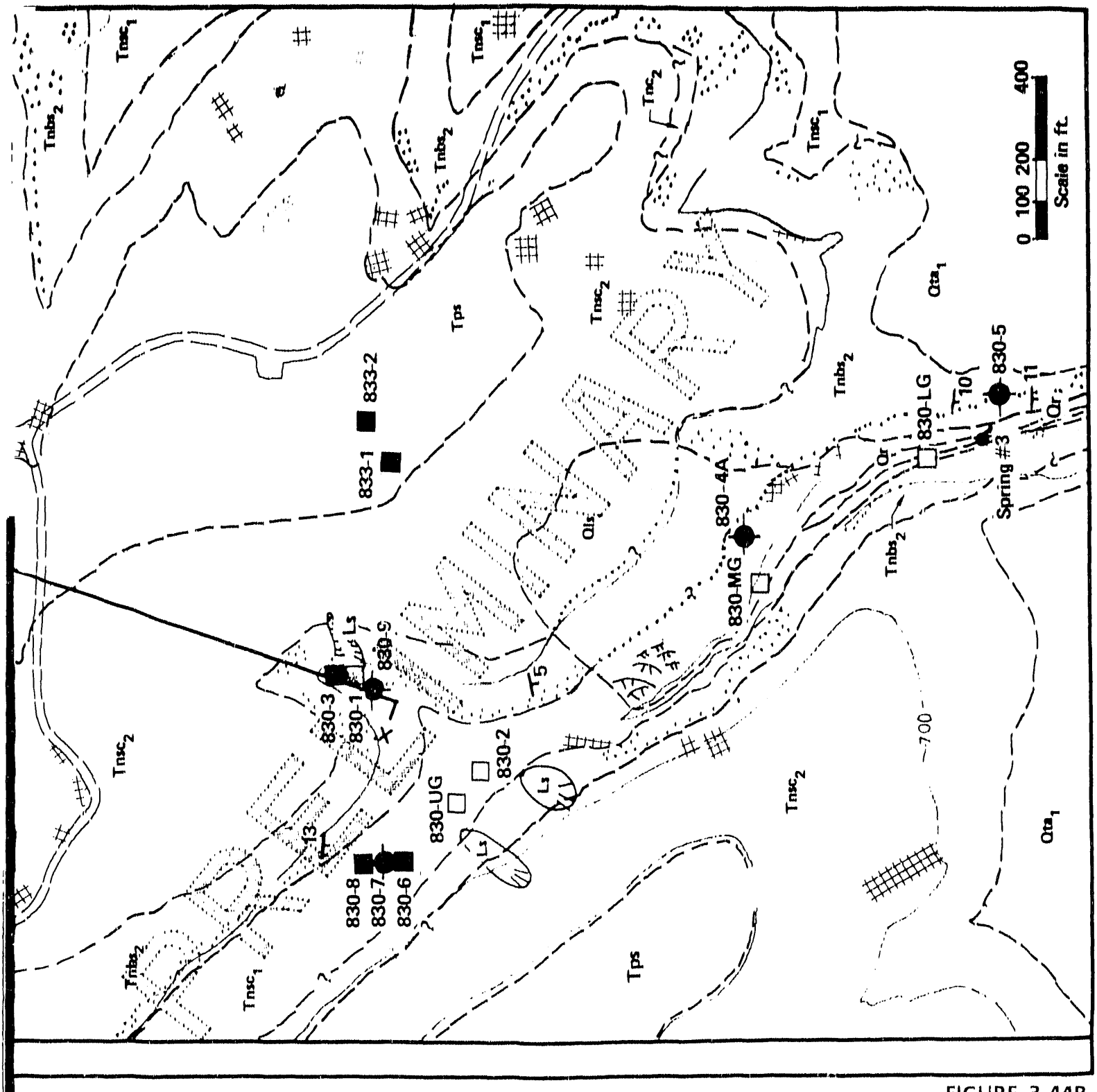


FIGURE 3-44B

VELLS AT 834 & 830 COMPLEXES – SITE 300
ERMORE, CALIFORNIA

locations in the 834 Complex. Table 3-26 presents a summary of the analytical results for soil, rock, and water samples in the 834 Complex area.

TCE has also been found in several other areas of Site 300. Of particular note is the presence of TCE in Well 7 in the GSA (0.9 to 52 µg/l with most samples between 1 and 5 µg/l from 1982 and 1983). The presence of TCE may be the result of cross-contamination from an earlier sampling event using the same equipment. TCE was not found in any soil samples collected in this area, so the source can only be speculated upon. Current work in this area consists of drilling at the site boundary to monitor off-site migration, as requested by LLNL's lawyers.

The 830 Complex lies between the GSA and the 834 Complex downhill from 834. Five boreholes and three wells were installed in this area, supplementing those installed in 1983, in order to determine if the low levels of TCE in Spring 3 could originate in this area. Very low levels of TCE have been observed in the B-830 area.

Building 833 is about 1,400 feet north of Spring 3. TCE may have been introduced to the soil during washdown operations at B-830. Two boreholes drilled near B-830 contained TCE, but no groundwater samples were obtained because of the great depth of the first water-bearing zone.

Six borings and one piezometer provide data on TCE contamination in the 854 Complex. Several of the soil samples contain TCE at concentrations as high as 31 ppm. No water was encountered in the piezometer boring. Based on available information, it appears that TCE has not yet reached groundwater as a result of attenuation by the soil matrix.

Site 300 Landfills

The groundwater under all landfill areas (also referred to by LLNL as "pits") except "Pit 6" is contaminated with tritium at levels exceeding the state drinking water standard (20,000 pCi/l), by an order of magnitude (200,000 pCi/l) in some cases. Figures 3-45 and 3-46 illustrate the distribution of tritium contamination in the vadose zone and groundwater at the Site 300 landfill area. Tritium appears to be associated with Pit 2, but not Pit 1, on the east side of the site. On the west side of the site, a large tritium plume appears to be emanating from the Pit 3/4/7/5 complex. LLNL believes that Pit 3 is the primary source of contamination in this pit complex on the western border of Site 300.

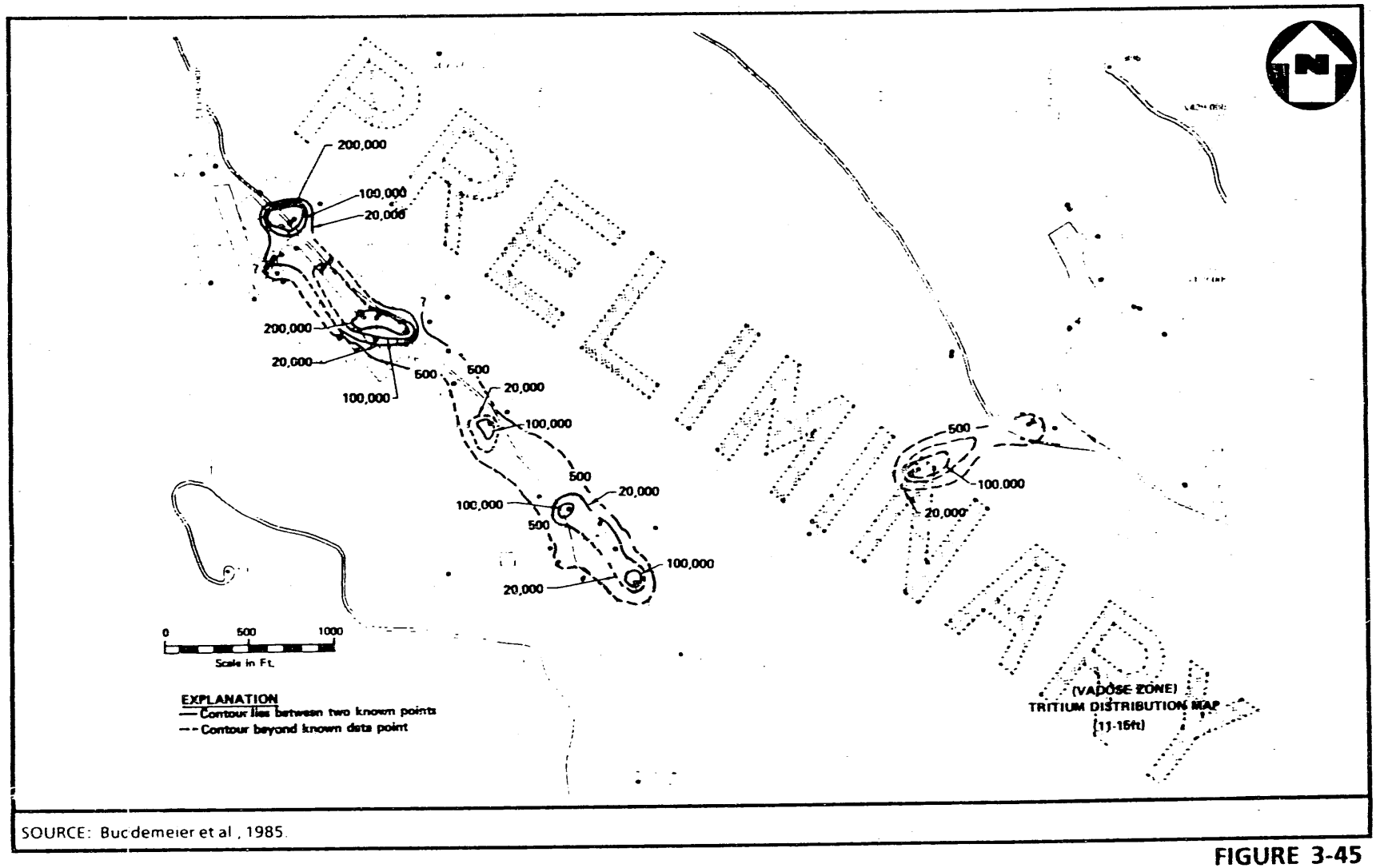
TABLE 3-26

VOLATILE ORGANIC COMPOUNDS IN SELECTED SOIL, ROCK, AND GROUNDWATER SAMPLES
BUILDING 834 COMPLEX - SITE 300
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Compound	Soil/Rock - Maximum Detection (ug/kg)/Depth of Maximum Detection (feet)						
	834B-1A	834C-1	834D-1	834E-1	834G-1A	834J-1	834S-1
trichloroethylene	13,000 (20.2)	12,000,000 (3.2)	260,000 (7.8)	320 (30.2)	280 (3.3)	52,000 (15.5)	2,800 (35.1)

Compound	Groundwater - Maximum Detection (ug/kg) (1983 - 1986)						
	834J-1	834S-1	834R-1	834M-1	834S-2A	834S-3	834S-4
trichloroethylene	30,000	460,000	1,300	19	2,000	62,000	--
tetrachloroethylene	130	1,000	--	--	35	--	--
1,1-dichloroethylene	13	30	--	--	--	--	--
trans-1,2-dichloroethylene	21	6,300	--	--	40	--	--
1,1,1-trichloroethane	10	55	--	--	--	--	--
1,2-dichloroethane	1	200	--	--	--	--	--
methylene chloride	5	5	--	--	--	--	--
chloroform	15	27	--	--	--	--	--
trichlorofluoromethane	2	7	--	--	--	--	--
toluene	62	37	--	--	--	--	--
ethylbenzene	21	7	--	--	--	--	--
carbon tetrachloride	5	1	--	--	--	--	--
total xylene	6	40	--	--	--	--	--

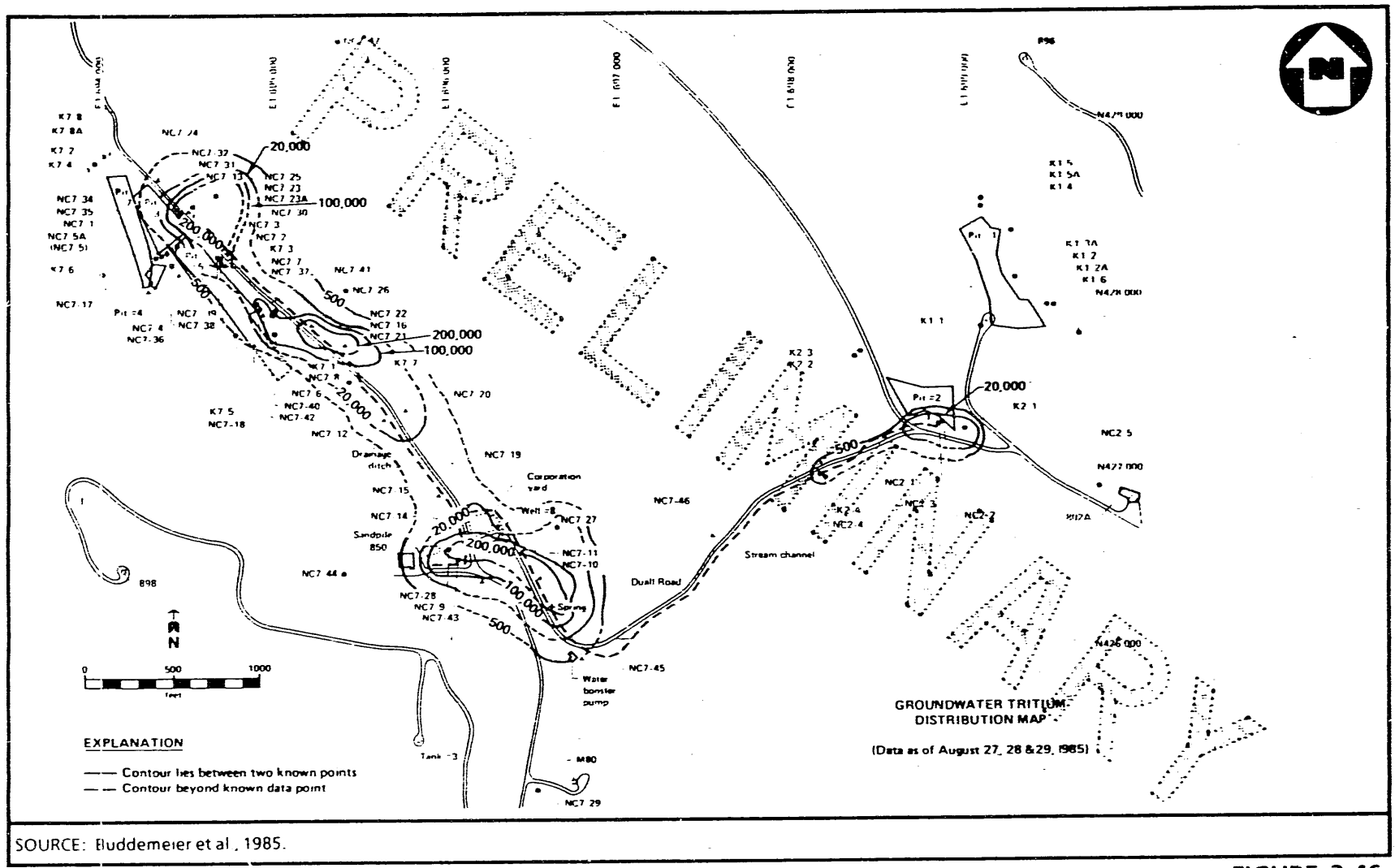
Source. Adapted from Carpenter et al., 1986.



SOURCE: Buddemeier et al., 1985.

FIGURE 3-45

TRITIUM ACTIVITY (pCi/l) IN THE VADOSE ZONE
WEST FIRING AREA – SITE 300
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Buddemeier et al., 1985.

FIGURE 3-46

TRITIUM ACTIVITY IN GROUNDWATER – AUGUST 1985
WEST FIRING AREA – SITE 300
LLNL – LIVERMORE, CALIFORNIA

Groundwater in this area flows eastward or northeastward along the bedding planes of the Neroly Formation. Flow velocities are on the order of tens of meters per year through fracture systems. Precise characterization of contaminant velocities is under way. Beneath the Pit 7 complex, groundwater occurs only in a shallow perched zone and at a depth greater than 300 feet. The limits of tritium plumes in the vadose zone and water have been determined from a number of wells, borings, and lysimeters. One major plume originates in Pit 3 and trends northeastward with the perched groundwater flow. One or more tritium sources areas may be found in Pit 5, but they have not been defined. However, contamination east and southeast of Pit 5 appears to be moving northeastward. Figures 3-45 and 3-46 show well locations and the approximate extent of the tritium plumes.

Building 850 may be a potential source of tritium near Pit 7, where firing-table experiments were conducted. Tritium appears to be moving eastward in the regional aquifer.

Much of the tritium now found in the groundwater is speculated to have reached the water during 1982 and 1983, which were exceptionally wet years. However, tritium near Building 850 has been reaching the groundwater since before 1970. In addition, a more recent pulse input of tritium appears to have been superimposed on the pre-existing pattern.

Table 3-27 lists 1985 groundwater monitoring data for tritium at Site 300 in comparison to the drinking water standard of 20,000 pCi/l.

Estimates suggest that an amount of tritium on the order of 10 Curies is now in groundwater and soil moisture outside the source areas. The amount of total tritium in the sources is unknown, but a few hundred curies is an estimated upper limit. If the estimate is conservative, a significant fraction of the source of tritium may already have been dispersed to the groundwater system. Migration rates in the regional groundwater system suggest that a time period of 20 to 50 years will be required before the contaminant plumes approach the Site 300 boundary. Dispersion and radioactive decay will act to reduce contaminant concentrations during the transport process. The present location and flow direction of the contamination poses no short-term threat to any water supply or potable water aquifer either on Site 300 or in the downgradient direction off-site (Buddemeier et al., 1985). The present distribution of tritium presents a minimal hazard to any water supply or potable water aquifer at Site 300 or off-site in a downgradient direction.

TABLE 3-27

TRITIUM IN GROUNDWATER AT SITE 300
LAWRENCE LIVERMORE NATIONAL LABORATORY
LIVERMORE, CALIFORNIA

Well Number	Quarter	HTO (pCi/l)	% of Drinking Water Standard (20,000 pCi/l)
K7-1	1:	27,000 ± 1000	135
	2:	17,000 ± 1000	85
	3:	27,000 ± 1000	135
	4:	22,000 ± 1000	110
K7-3	1:	102,000 ± 5000	510
	2:	63,000 ± 3000	315
	3:	96,000 ± 5000	480
	4:	71,000 ± 4000	355
K7-5	1:	0 ± 1000	0
	2:	0 ± 1000	0
	3:	0 ± 1000	0
	4:	0 ± 1000	0
K7-6	1:	0 ± 1000	0
	2:	0 ± 1000	0
	3:	0 ± 1000	0
	4:	0 ± 1000	0
K7-7	1:	32,000 ± 1000	160
	2:	28,000 ± 1000	140
	3:	46,000 ± 2000	230
	4:	35,000 ± 2000	175
K1-1	1:	a	-
	2:	0 ± 1000	0
	3:	a	-
	4:	0 ± 1000	0
K1-2	1:	0 ± 1000	0
	2:	0 ± 1000	0
	3:	0 ± 1000	0
	4:	0 ± 1000	0
K1-3	1:	0 ± 1000	0
	2:	0 ± 1000	0
	3:	0 ± 1000	0
	4:	0 ± 1000	0

Source: Buddemeier et al., 1985
a = Dry Well

3. Potential Groundwater Contamination at Site 300. Pit 6 is a likely source of future groundwater contamination, based on knowledge of the waste disposal activities that occurred in the pit. Investigations in the Pit 6 area were recently completed. Four wells installed initially in this area showed no evidence of groundwater contamination, in spite of the variety of disposal activities known to have occurred in the pit. Wells were recently installed on both sides of the Carnegie Fault to determine whether it is a preferred pathway for the migration of contaminants from the pit or a groundwater barrier. No contamination has been found in any of these wells.

Because of the wide variety of wastes buried here (including PCB capacitors), groundwater contamination was suspected. However, it appears that soil contamination is currently the bigger problem and may eventually result in groundwater contamination.

3.4.4.4 Category IV

None

4.0 NON-MEDIA-SPECIFIC FINDINGS

This section discusses findings and observations pertaining to waste management, toxic and chemical materials, radiation, quality assurance, and inactive waste sites and releases. These discussions do not include a background environmental information section because the areas addressed are not necessarily tied to one medium, as was the case with the discussions in Section 3.0. These discussions include an environmental monitoring program section, where appropriate and where information was available. The findings for hazardous, radioactive, mixed, and solid waste management are summarized in the section addressing waste management.

4.1 Waste Management

4.1.1 General Description of Pollution Sources and Controls

4.1.1.1 Hazardous Waste Management

DOE Orders 5480.2 titled Hazardous and Radioactive Waste Management, issued December 13, 1982, and 5820.2 titled Radioactive Waste Management, issued December 6, 1984, are the principal DOE orders regulating waste management at DOE sites. The Resource Conservation and Recovery Act (RCRA) of 1976, and the 1984 RCRA amendments and associated regulations issued by the U.S. Environmental Protection Agency (EPA) establish the standards used as the basis for evaluating hazardous and mixed waste handling and facilities.

The State of California also regulates hazardous wastes. The main body of California regulations are identical to those of USEPA. However, California has a broader definition of hazardous waste than does the EPA. California lists waste oil as a hazardous waste, and has created a Toxic Threshold Limit Concentration (TTLC) for certain hazardous constituents. Waste exceeding the TTLC for any constituent is a hazardous waste. Thus, wastes in California can test hazardous either by waste composition or by failing a leaching test. In addition, California has established limiting concentrations for toxic constituents in waste leachates, called Soluble Threshold Limit Concentrations (STLC), which are analogous to those in the EPA Extraction Procedure. California also includes PCBs as a hazardous constituent which, if exceeded in either the STLC or the TTLC at levels of 5 ppm and 50 ppm respectively, makes the waste subject to hazardous waste regulations. This increases the number and quantity of wastes that must be handled as hazardous or mixed wastes by LLNL. California also regulates underground storage tanks more strictly than the EPA.

LLNL is a multiprogram laboratory involved in multidisciplinary fundamental and applied research and development activities over a broad range of scientific and technical fields. The primary program has been the design of nuclear weapons, although major programs include research in Defense Systems, Laser Isotope Separation, Magnetic Fusion Energy, Biomedical and Environmental Research, and Energy and Resources. The degree of current activity and type of research programs are in a constant state of flux as individual experiments begin and end.

At both the LLNL Main Site and Site 300, the large number of continually changing research programs results in a wide variety of wastes generated at a large number of laboratory buildings. Wastes from laboratory buildings are usually in small volumes with most containing toxic, radioactive, or hazardous constituents or combinations of these types of constituents. Support facilities, including general plant maintenance shops, machine shops, plating shops, and plastic shops, also generate wastes, often in larger volumes than the laboratory facilities. Table 4-1 lists waste streams with descriptions of handling methods, by major program areas or functions, for buildings where wastes are generated. The quantity estimates may not be indicative of future generation rates because of the changing nature of laboratory programs. This table illustrates the complex variety of wastes; sources, and treatment, storage and disposal methods utilized by LLNL in handling hazardous waste.

The large variety of hazardous wastes generated at LLNL can be grouped into general classes of wastes. Table 4-2 gives a general description of 17 classes of hazardous waste and estimated generation rates.

Some activities within the laboratory generate waste streams that are similar in composition, even though they are generated by different program activities. Photochemical process waste streams from the many photographic facilities at both the Main Site and Site 300 are virtually identical in composition and are handled similarly. Machine shop wastes (coolant, oils, solvents, etc.) are similar in composition to the wastes from local area shops and Mechanical Technician Shops. Table 4-3 gives a summary of 20 facilities or operations that generate waste streams similar in composition or type.

Site 300, located 15 miles east of the LLNL Main Site, is a high explosives (HE) and materials testing site. Two active landfills (Pits 1 and 7) receive solid waste from the detonation of test assemblies at seven active firing tables. Contaminated rubble collected from the pits includes gravel, wood, plastic, concrete, and metal contaminated by depleted uranium, lead, and beryllium. Lead levels of the wastes exceed the California Soluble Threshold Limit Concentrations (STLC). Beryllium levels

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE SEVEN

Program	Bldg No.	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Chemistry	222	Chemistry	Solvents	5 gal/week	Stored (612)/Disposed by a commercial contractor
			Organic waste (HE)	Minimal	Milligram quantities to B227
			Cyanide waste	55 gal/6 months	Stored (612)/Disposed by a commercial contractor
			Metal waste (acid)	5 gal/week	Stored (612)/Disposed by a commercial contractor
			Beryllium waste	Minimal	Solidified/Shipped to NTS (very infrequently)
			Retention tank liquid	500 gal/week	Normally released to sanitary sewer after analysis; about 1,000 gal/year receive Chemical Treatment-Filtration/ Released to sanitary sewer; Sludge solidified/Shipped to NTS
			Laser dye wastes	NA	Stored (612)/Disposed by a commercial contractor
	223	Chemistry Engineering	Waste oil	55 gal/quarter	Stored salvage yard/Disposed by commercial contractor
			Solvents (chlorinated)	15 gal/quarter	Stored (612)/Disposed by a commercial contractor
			Solvents	55 gal/quarter	Stored (612)/Disposed by a commercial contractor
			Laser dye wastes		Stored (612)/Disposed by a commercial contractor.
	224	High Explosives Chemicals	None generated	---	---
	225	High Explosives Chemicals	None generated	---	---
	226	High Explosives Chemicals	Organic Waste (HE)	5 lb/year	Shipped to Site 300/Burned
	227	High Explosives Chemicals	Acid waste	100 gal/month	Stored (612)/Disposed by a commercial contractor.
			Organic waste (HE)	lb/month	Shipped to Site 300/Burned
			Retention tank liquid	3,000 gal/month	Normally released to sanitary sewer, infrequently may be Chemical Treatment-Filration/Released to sanitary sewer, Sludge solidified/Shipped to NTS
	228	Storage Magazine	None generated	---	---

TABLE 4-1
HAZARDOUS, MIXED AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE TWO

Program	Bldg No	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Administration	419	Decontamination	Solid radioactive waste Contaminated rinse water	40 CF/year 100 gal/week	Solidified, packaged/Shipped to NTS Chemical Treatment-Filtration/Released to sanitary sewer; Sludge solidified/Shipped to NTS
	513	Liquid Waste Storage	Contaminated oil, solvents, and corrosives	3,000 CF/month	Solidified, packaged/Shipped to NTS
	514	Waste Disposal	Contaminated sediment	60 CF/month	Solidified/Shipped to NTS
	518	Gas Cylinder Dock	—	—	None Generated
	612	Dry Waste (TWC)	TRU facility retention tank waste	200 gal/month	Chemical Treatment-Filtration/Released to sanitary sewer, Sludge solidified/Shipped to NTS
	614	Storage	None generated		—
	616	Salvage	None generated	—	—
	617	Salvage (tent)	None generated	—	—
	618	Salvage	Waste oils, Oil-water mixtures	NA	Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor
	619	Salvage	Waste oils	NA	Stored (612)/Disposed by a commercial contractor
	623	TWC Waste Storage	None generated	—	—
	624	TWC Waste Storage	None generated	—	—
	625	TWC Waste Storage/Shipping	None generated	—	

TABLE 4-1
HAZARDOUS, MIXED AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE THREE

Program	Bldg No	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Engineering	131	Engineering	Trichloroethylene	10 gal/month	Stored (612)/Disposed by a commercial contractor
			Solvents	5 gal/month	Stored (612)/Disposed by a commercial contractor
			Acid, caustic waste	10 gal/month	
			Gallium arsenide	5 gal/2 months	Stored (612)/Disposed by a commercial contractor
			Solid toxic waste		Stored (612)/Disposed by a commercial contractor
			Photochemicals	5 gal/week	Stored (612)/Disposed by a commercial contractor
			Rinse water (acid)		Stored (612)/Disposed by a commercial contractor
			TCE, TCA	5 gal/month	Stored (612)/Disposed by a commercial contractor
			Solvents	10 gal/month	Stored (612)/Disposed by a commercial contractor
			Spent fixer/developer	NA	Materials Management (404) Silver Recovery
			Metal finishing solutions	NA	Stored (612)/Disposed by a commercial contractor
			Retention tank rinse water	NA	
				2,000 gal/year	Normally to sanitary sewer after analysis, infrequently to Chemical Treatment Filtration/Released to sanitary sewer; Sludge solidified/Shipped to NTS
			Machine oil	25 gal/week	Stored (612)/Disposed by a commercial contractor
			Freon	3 gal/week	Stored (612)/Disposed by a commercial contractor
				2 gal/week	Evaporated
	141	Electrical Engineering	Printed circuit board rinse water	10,000 gal/month	Retention tank/Discharge to sewer
			Laboratory chemicals	NA	Stored (612)/Disposed by a commercial contractor
			Solvents (chlorinated)	10 gal/month	Stored (612)/Disposed by a commercial contractor
			Acid wastes	NA	Stored (612)/Disposed by a commercial contractor
			Caustic wastes	NA	Stored (612)/Disposed by a commercial contractor
			Solvents (flammable)	20 gal/month	Stored (612)/Disposed by a commercial contractor

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE FOUR

Program	Bldg No	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Engineering	196	HC Monitoring Station	None generated	---	---
	239	Radiography	None generated	---	---
	291	LCW Station	Sand filter backwash Regeneration waste Bleed-off	2,500 gal/week 1,000 gal/month 5 gpm	Released to sanitary sewer Disposed by a commercial contractor Released to sanitary sewer
	295	Water Pump House	None generated		
	297	Classified Waste Disposal	Waste paper	Varies	Generally recycled, occasionally to municipal landfill if contaminated with metal or plastic
	318	Emergency Water Storage (swimming pool)	Filter backwash	7,000 gal/week in summer, 2,000 gal/week in winter	Released to storm drain
	321A	Ion Exchange Plant	Acid waste Caustic waste	3,000 gal/month 3,700 gal/month	Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor
	321	Materials Fabrication Shop	Waste oil Solvents (flammable) Solvents (chlorinated) Solid radioactive waste (D-38) Retention tank rinse water Rinse water Liquid radioactive waste	150 gal/month 100 gal/month 200 gal/month 16 lb/year (1983) 500 gal/month 55 gal/day 55 gal/day	Stored salvage yard/Disposed by a commercial contractor Incineration/Ash to municipal landfill (some recycled) Stored (612)/Disposed by a commercial contractor Packaged/Shipped to NTS Chemical Treatment-Filtration/Released to sanitary sewer Sludge solidified/Shipped to NTS Solidified/Shipped to NTS Solidified/Shipped to NTS
	322	Plating Shop	Dilute rinse water Water Spent concentrated plating solutions	5,000 gal/day 12 drums/month NA	Ion Exchange and Filtration/Released to sanitary sewer Disposed by commercial contractor

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE FIVE

Program	Bldg No	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Engineering	325	Utilities Control	Sand filter backwash	2,500 gal/week	Released to sanitary sewer
			Anthracite filter backwash	12,000 gal/2 weeks	Released to storm drain
			IX regeneration waste	4,500 gal/month	Disposed by a commercial contractor
			Cooling tower bleed-off	10 gpm	Released to sanitary sewer
	326	Materials Fabrication Shop	Acid waste	10 gal/week	
	327	Nondestructive Testing	Waste emulsifier	55 gal/year	Stored (612)/Disposed by a commercial contractor
			Penetrants		
	343	High-Pressure Testing	Organic oils	NA	
	401	Steam Plant	Dilute test chemicals	Minute	Released to sanitary sewer
			Boiler blowdown	3-500 gal/week	Released to sanitary sewer
			Waste oils		Stored (612)/Disposed by a commercial contractor
	418	Paint Shop	Spray booth wastewater	2,000 gal/year	Released to sanitary sewer
			Waste sandblasting abrasives	3-55 gal drum/year	Stored (612)/Disposed by a commercial contractor
			Waste solvents and paint, sediments, thinners	20 gal/month	Stored (612)/Disposed by a commercial contractor
	435	Cooling Tower	Bleed-off	30 gpm	Released to sanitary sewer
			Sand filter backwash	1,000 gal/week	Released to sanitary sewer
	511	Crafts Shop	Transformer oils	NA	Stored (612)/Disposed by a commercial contractor
			Waste oils	NA	Stored (612)/Disposed by a commercial contractor
			Acid waste	5 gal/6 months	Released to sanitary sewer
			Solvents	5 gal/week	Stored (612)/Disposed by a commercial contractor
	512	Craft Materials Assembly	Road oil	15,000-20,000 gal/year	Stored salvage yard/Disposed by commercial contractor

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300 .
LIVERMORE, CALIFORNIA
PAGE SIX

Program	Bldg No	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Engineering	516	Classroom/Hobby Shop	Solvent	2 gal/month	Stored (612)/Disposed by a commercial contractor
	517	Offices and Storage	Thinners Waste oils	NA NA	Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor
	519	Equipment Maintenance	Waste oils	Five 55-gal drum/month	Stored (612)/Disposed by a commercial contractor
	520	P E Storage (Pest Control)	Pesticide waste Triple rinsed containers	3 gal/year One 55-gal drum/month	Stored (612)/Disposed by a commercial contractor Disposed in Pleasanton landfill
	622	Propane/Air Plant Propane/Air Plant Fuel Tanks Oil Storage Area Mocho Pump Station Boilers/Chillers Tanker Parking Areas Spoil Management	None generated None generated None generated None generated None generated None generated None generated None generated	— — — — — — — —	— — — — — — — —
	691	LODTM Facility Water System Sewerage System	Waste oil None generated None generated	15 gal/week — —	Stored salvage yard/Disposed of by commercial contractor
Chemistry	221	Chemistry Storage	None generated	—	—

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE SEVEN

Program	Bldg No	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Chemistry	222	Chemistry	Solvents	5 gal/week	Stored (612)/Disposed by a commercial contractor
			Organic waste (HE)	Minimal	Milligram quantities to B227
			Cyanide waste	55 gal/6 months	Stored (612)/Disposed by a commercial contractor
			Metal waste (acid)	5 gal/week	Stored (612)/Disposed by a commercial contractor
			Beryllium waste	Minimal	Solidified/Shipped to NTS (very infrequently)
			Retention tank liquid	500 gal/week	Normally released to sanitary sewer after analysis, about 1,900 gal/year receive Chemical Treatment-Filtration/ Released to sanitary sewer; Sludge solidified/Shipped to NTS
			Laser dye wastes	NA	Stored (612)/Disposed by a commercial contractor
	223	Chemistry Engineering	Waste oil	55 gal/quarter	Stored salvage yard/Disposed by commercial contractor
			Solvents (chlorinated)	15 gal/quarter	Stored (612)/Disposed by a commercial contractor.
			Solvents	55 gal/quarter	Stored (612)/Disposed by a commercial contractor.
			Laser dye wastes		Stored (612)/Disposed by a commercial contractor
	224	High Explosives Chemicals	None generated	—	—
	225	High Explosives Chemicals	None generated	—	—
	226	High Explosives Chemicals	Organic Waste (HE)	5 lb/year	Shipped to Site 300/Burned.
	227	High Explosives Chemicals	Acid waste	100 gal/month	Stored (612)/Disposed by a commercial contractor
			Organic waste (HE)	lb/month	Shipped to Site 300/Burned.
			Retention tank liquid	3,000 gal/month	Normally released to sanitary sewer, infrequently may be Chemical Treatment-Filtration/Released to sanitary sewer, Sludge solidified/Shipped to NTS.
	228	Storage Magazine	None generated	—	—

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE EIGHT

Program	Bldg No	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Chemistry	231	Development and Assembly	Solvents (chlorinated)	55 gal/year	Stored (612)/Disposed by a commercial contractor
			Resins, plastic	20 gal/year	Stored (612)/Disposed by a commercial contractor
			Solvents	55 gal/year	Stored (612)/Disposed by a commercial contractor
			Plasticizers		Stored (612)/Disposed by a commercial contractor
			Acid waste	2 gal/year	Chemical Treatment-Filtration/Released to sanitary sewer, Sludge solidified/Shipped to NTS
			D-38 metals		Packaged/Shipped to NTS
			Waste oil	55 gal/quarter	Stored salvage yard/Disposed by commercial contractor
			Retention tank liquids	1,000 gal/2 weeks	Normally released to sanitary sewer; about 6,000 gal/year treated by Chemical Treatment-Filtration/Released to sanitary sewer, Sludge solidified/Shipped to NTS
	232	Chemical High Pressure Laboratory	D-38 metals	4-55 gal drum/week	Packaged/Shipped to NTS
			Acid waste	5 gal/year	Stored (612)/Disposed by a commercial contractor
			Solvents	5 gal/year	Stored (612)/Disposed by a commercial contractor
	233	Classified Storage	None generated	---	---
	234	Process Research	None generated	---	---
	241	Refractory materials	Solid radioactive waste	55 gal/month	Packaged/Shipped to NTS
			Solvents (chlorinated)	15 gal/year	Stored (612)/Disposed by a commercial contractor
			Solvents	55 gal/month	Stored (612)/Disposed by a commercial contractor
			Rinse Water	1,500 gal/month	Released to sanitary sewer after analysis
	331	Gaseous Chemistry	Solid radioactive waste	55 gal/month	Packaged/Shipped to NTS
			Waste oil	5 gal/year	Stored salvage yard/Disposed of by commercial contractor
			Solvents	5 gal/year	Stored (612)/Disposed by a commercial contractor
			Tritium-contaminated waste oil	25 gal/year	Solidified, packaged/Shipped to NTS

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE NINE

Program	Bldg No	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Chemistry	332	Metallurgical Chemistry	Solvents (chlorinated) Solvents TRU solid rad waste TRU liquid rad waste Contaminated oil Retention tank liquid	20 gal/ year 30 gal/year 6-55 gal drum/week 100 gal/year 5 gal/week 1,200 gal/month	Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor Packaged/Shipped to NTS Solidified/Shipped to NTS Solidified/Shipped to NTS Released to sanitary sewer
	333	Chemistry Storage	None generated	---	---
Computations	113	Theoretical & Comp	Photochemicals Filters-Chromium and solid toxic waste Spent fixer/developer	5 gal/week 3 Filters/week	Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor Materials Management-(404) Silver Recovery
Energy & Resources	243	Energy Research	Brite dip tanks Waste oil	10 gal/year 5 gal/month	Stored (612)/Disposed by a commercial contractor. Stored salvage yard/Disposed by commercial contractor
	410	Oil Shale Research	Solvents Shale oil	5 gal/month 5 gal/month	Stored (612)/Disposed by a commercial contractor Stored (410) for TWC disposal
	690	Oil Shale Storage	None generated	---	---
Biomedical	361	Main Laboratory	Carcinogenic liquid Liquid rad waste Solid rad waste	100 gal/week 50 gal/week 55 gal/week	Incineration/Ash to municipal landfill Incineration/Ash to municipal landfill Packaged/Shipped to NTS
	362	Instruments	Retention tank liquid	500 gal /week	Chemical Treatment-Filtration/Released to sanitary sewer; Sludge solidified/Shipped to NTS.
	363	Tumor Laboratory	Carcinogenic waste	18 CF/week	Incineration/Ash to municipal landfill
	364	Main Small Animal	Clean animal carcasses and waste	10 CF/month	Incineration/Ash to municipal landfill
	365	Animal Toxicology	Carcinogenic waste Retention tank liquid	10 CF/month 1,000 gal/6 months	Incineration/Ash to municipal landfill Chemical Treatment-Filtration/Released to sanitary sewer; Sludge solidified/Shipped to NTS.

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE TEN

Program	Bldg No	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Biomedical	366	Health Effects Laboratory	Solvents Carcinogenic waste Solid carcinogenic waste	10 gal/week 10 gal/month 35 CF/month	Incineration/Ash to municipal landfill Incineration/Ash to municipal landfill Stored (612)/Disposed by a commercial contractor
	376	Machine Shop	Solvents Cutting oil	5 gal/month 1 gal/month	Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor
	377	Marine Biology	Solvents (non-chlorinated) Retention tank liquid Liquid radioactive waste	5 gal/month 300 gal/day 5 gal/month	Incineration/Ash to municipal landfill. Chemical Treatment-Filtration/Released to sanitary sewer, Sludge solidified/Shipped to NTS. Incineration/Ash to municipal landfill.
	378	Transuranic	Acid waste	10 gal/month	Stored (612)/Disposed by a commercial contractor
	379	Rad Spectrometry	None generated	---	---
	412	Biomedical Laboratory	Photochemicals Solvents Waste oil	 55 gal/6 months 10 gal/month	Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor To salvage yard or disposed by commercial contractor, depending on contaminant concentration
	413	Temperature Contractor	None generated	---	
	414	Cold Storage	None generated	--	---
	592	Cow Barn (ashing ovens)	None generated		
	593	Sheep Barn (ashing ovens)	None generated	--	
Physics	182	O Group	Waste oils Caustics	NA NA	Stored (612)/Disposed by a commercial contractor. Stored (612)/Disposed by a commercial contractor.

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE ELEVEN

Program	Bldg No	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Physics	194	Elec. Pos. Accelerator	Solid radioactive waste	55 gal/month	Packaged/Shipped to NTS
			Solvents	55 gal/3 months	Stored (612)/Disposed by a commercial contractor.
			Developer	minimal	Stored (612)/Disposed by a commercial contractor.
			Retention tank liquid	500 gal/year	Released to sanitary sewer
			Waste PCBs	100 gal/year	Stored (612)/Disposed by a commercial contractor.
	212	Accelerators	Solid radioactive waste	55 gal/month	Packaged/Shipped to NTS.
			Solvents	55 gal/3 months	Stored (612)/Disposed by a commercial contractor
			Tritiated oil/solvents	5 gal/3 months	Incineration/Ash to municipal landfill.
			Retention tank liquid	500 gal/6 months	Released to sanitary sewer
	292	RTNS II	Liquid radioactive waste	1,000 gal/year	Evaporated, incinerated, or solidified/Shipped to NTS
			Spent tritium targets	40 gal/month	Packaged/Shipped to NTS.
			Solid radioactive waste	55 gal/3 months	Packaged/Shipped to NTS.
			Tritium cartridges	15/year	Packaged/Shipped to NTS.
			Rinse water	5,000 gal/year	Chemical Treatment-Filtration/Released to sanitary sewer; Sludge solidified/Shipped to NTS
			Solvents	10 gal/year	Stored (612)/Disposed by a commercial contractor
Lasers	161	LIS Development Laboratory	Solid radioactive waste	2-55 gal drum/month	Packaged/Shipped to NTS.
			Solvents	20 gal/month	Stored (612)/Disposed by a commercial contractor
	162	Laser Research	None generated	--	
	165	Special Research	NaOH waste	55 gal/3 months	Stored (612)/Disposed by a commercial contractor.
	166	Laser Research	Solvent	NA	---
	167	Laser Research	Solvent oils	NA	
	168	Laser Research	None generated	---	---
	169	Special Research	None generated	---	---

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE TWELVE

Program	Bldg. No.	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Lasers	171	Laser Research	Dye waste	20 gal/month	Incinerated or Stored (612)/Disposed by commercial contractor
			Solvents	10 gal/month	Stored (612)/Disposed by a commercial contractor
			Acid waste	5 gal/month	Stored (612)/Disposed by a commercial contractor
	172	Laser Research	Solvents		Stored (612)/Disposed by a commercial contractor
			Solvent oils		Stored (612)/Disposed by a commercial contractor.
	173	Welding Shop	Acid waste	5 gal/year	Stored (612)/Disposed by a commercial contractor.
	174	Laser Research	None generated	---	---
	175	MARS Experiment	Dye waste	5 gal/month	Incinerated or stored (612) /Disposed by commercial contractor
			Acid waste	5 gal/month	Stored (612)/Disposed by a commercial contractor
			Solid radioactive waste	Six 55-gal drum/mo	Packaged/Shipped to NTS
			Wastewater	1,800 gal/month	Released to sanitary sewer
	176	Machine Shop	Solvents (chlorinated)	55 gal/month	Stored (612)/Disposed by a commercial contractor
			Solvents	55 gal/month	Stored (612)/Disposed by a commercial contractor
	177	LIS Laboratories	Solvents	10 gal/month	Stored (612)/Disposed by a commercial contractor
			Contaminated acid	5 gal/month	Solidified/Shipped to NTS
			Dye waste	30 gal/month	Stored (612)/Disposed by a commercial contractor
	298	Fusion Target Development	Solid radioactive waste	One 55-drum/month	Packaged/Shipped to NTS
			Solvent (chlorinated)	20 gal/month	Stored (612)/Disposed by a commercial contractor
			Solvent	20 gal/month	Stored (612)/Disposed by a commercial contractor
			Waste oil	5 gal/6 months	Stored salvage yard/Disposed by commercial contractor
	381	Laser Fusion Laboratory	Dye waste	5 gal/6 months	Incinerated or disposed by commercial contractor.
	383	Laser Machine Shop	Solvent	5 gal/month	Stored (612)/Disposed by a commercial contractor.

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE THIRTEEN

Program	Bldg. No.	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Lasers	391	High Energy Laser	Silica Ethanol Solvents	50-55 gal/month 55 gal/3-months	Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor
	611	Flash Lamp Facility	PCB Capacitors	5/month	Stored (625)/Disposed by a commercial contractor.
Mag. Energy Fusion	423	MFE Shop	Waste Oils	NA	Stored (612)/Disposed by a commercial contractor
	424	Electric Substation	None generated		
	431	MFTF-B ETA	Solvents/Waste Oil Solvents/Waste Oil	55 gal/month 55 gal month	Stored (612) Disposed by a commercial contractor Stored (612) Disposed by a commercial contractor.
	432	MFE Shops	Waste Oil Solvent (chlorinated)	10 gal/month 10 gal/month	Stored salvage yard/Disposed by commercial contractor Stored (612)/Disposed by a commercial contractor
	434	MFE Shops	None generated		
	435	MFE Research	Mercury-contaminated trash Mercury waste	 1 pint/month	Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor
	436	MFE Capacitor Bank	Waste PCB capacitors and oil	Varies (upon failure)	Infrequent; Stored (625) for disposal by commercial contractor
	438	MFE Fabrication Shop	Solvent Lacquer thinner Acid waste Caustic waste Developer Spent fixer/developer	5 gal/month 20 gal/month 55 gal/month 55 gal/month 20 gal/month	Stored (612)/Disposed by a commercial contractor. Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor Materials Management (404) Silver Recovery
	443	Coil Shop	Epoxy Solvents Acid waste	NA NA 55 gal/month 5 gal/month	Non-rad stored (612)/Disposed by commercial contractor; Rad-solidified/Shipped to NTS. Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE FOURTEEN

Program	Bldg No	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Mag Energy Fusion	445	MFE Magnet Laboratory	Waste Oils	NA	Stored (612)/Disposed by a commercial contractor
	446	Power Supply	None generated	---	
Defense Systems	111	Experimental Physics	Developer Spent fixer/developer	4 gal/month	Stored (612)/Disposed by a commercial contractor Materials Management (404) Silver Recovery
	121	Experimental Physics	Dye Waste Solvent Developer Solvent (chlorinated)	1 gal/month 1 gal/month 5 gal/month 2 gal/month	Incinerated or Stored (612)/Disposed by commercial contractor Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor Stored (612)/Disposed by a commercial contractor
	151	Nuclear Chemistry	Liquid radioactive waste Solvents Solid radioactive waste Scintillation vials	120 gal/month < 5 gal/month 6-55 gal drum/week	Solidified/Shipped to NTS Packaged/Shipped to NTS Incineration/Ash to municipal landfill if non rad, tritium, or C-14; otherwise Solidified/Shipped to NTS
	152	Emergency Gen House	None generated	---	
	251	Heavy Elements	Rad solid waste TRU waste	2-55 gal drum/mo 6 55 gal drum/year	Packaged/Shipped to NTS Packaged/Shipped to NTS
	341	Physics Research	Solid radioactive waste Oils Solvents	4-55 gal drum/year NA NA	Packaged/Shipped to NTS Stored (612)/Disposed by a commercial contractor. Stored (612)/Disposed by a commercial contractor
	345	Detonator Research	HE waste (High Explosives)	72 CF/week	Shipped to Site 300/Burned
Special Projects	261		Solid radioactive waste	1-55 gal/month	Packaged/Shipped to NTS
Site 300 General Services Area	819	Herbicide Preparation and HE Decontamination	Oils and solvents	25 gal/month	Stored salvage yard/Disposed by commercial contractor

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE FIFTEEN

Program	Bldg No	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Site 300 General Services Area	872	Paint Shop	Flammable solvents Rinse water	20 gal/month 350 gal/month	Stored by TWC/Disposed by commercial contractor Stored by TWC/Disposed by commercial contractor
	873	Electrical and Pipe Shops	Oils Acidic rinse water	8 gal/month 100 gal/month	Stored by TWC/Disposed by commercial contractor Stored by TWC/Disposed by commercial contractor
	874	Machine and Welding Shops	Oils Flammable solvents Acids	25 gal/month 20 gal/month 10 gal/month	Stored by TWC/Disposed by commercial contractor Stored by TWC/Disposed by commercial contractor Stored by TWC/Disposed by commercial contractor
	879	Motor Pool	Oils Flammable Solvents	25 gal/month 20 gal/month	Stored by TWC/Disposed by commercial contractor Stored by TWC/Disposed by commercial contractor
Site 300 Process Area	806	High Explosives Machining	HE-contaminated wastewater Clarifier sludge and machine turnings HE, reactives, and contaminated trash	4,200 gal/month 25 lbs/burn 70 lbs/burn	Clarifier/Surface impoundment Open burning at Site 300 Open burning at Site 300
	807	High Explosives Machining	HE-contaminated wastewater Clarifier sludge and machine turnings HE, reactives, and contaminated trash	2,000 gal/month 25 lbs/month 20 lbs/month	Clarifier/Surface impoundment Thermal treated at Site 300 Thermal treated at Site 300.
	815	The Boiler House	Boiler blowdown		
	817	High Explosives Pressing	HE-contaminated washwater Clarifier sludge and machine turnings HE, reactives, and contaminated trash	4,100 gal/year 25 lbs/month 80 lbs/month	Clarifier/Surface impoundment Thermal treated at Site 300 Thermal treated at Site 300

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE SIXTEEN

Program	Bldg No	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Site 300 Process Area	823	X-Ray	Photochemicals	5 gal/month	Stored (612)/Disposed by a commercial contractor
			Photolab rinsewater	4,000 gal/month	Retention tank/Ship to LLNL for disposal
			Spent fixer/developer		Materials Management (404) Silver Recovery
Site 300 Advanced Test Accelerator (ATA)	865	ATA	Wastewater	2,000 gal/month	Shipped to LLNL for treatment/Wastewater to sanitary sewer.
			Oils	100 gal/month	Oil and freon stored (612)/Disposed by commercial contractor Stored salvage yard/Disposed by a commercial contractor
Site 300 Firing Test Area	801	Flash X Ray	Contaminated shot debris	30 yards/month	Buried in an approved landfill, Site 300
			Oils	100 gal/month	Stored salvage yard/Disposed by a commercial contractor
			Laboratory reagents/liquid	2 gal/month	Stored (612)/Disposed of by a commercial contractor
			Photochemicals	10 gal/month	Stored (612)/Disposed of by a commercial contractor
			Photolab rinse water	1,500 gal/month	Retention tanks/Shipped to LLNL for disposal.
			Washdown wastewater	1,000 gal/month	Shipped to LLNL/Released to sanitary sewer.
			Spent fixer/developer		Materials Management (404) Silver Recovery
	834	Thermal Environment Testing	None generated	---	---
	850	Hydrodynamic Testing	Contaminated shot debris	30 yards/month	Buried in an approved landfill, Site 300.
			Solid radioactive waste	10 lbs/month	Buried in an approved landfill, Site
			HE contaminated trash	30 lbs/month	Open burning at Site 300
	851	Hydrodynamic Testing	Contaminated shot debris	30 yards/month	Buried in an approved landfill, Site 300
			Solid radioactive waste	10 lbs/month	Buried in an approved landfill, Site 300
			Reactive laboratory chemicals	3 gal/month	Stored (612)/Disposed by a commercial contractor
			Photolab rinse water	1,500 gal/month	Retention tanks/Shipped to LLNL for disposal
			Spent fixer/developer	NA	Materials Management (404) Silver Recovery
			Oils	25 gal/month	Stored salvage yard/Disposed by a commercial contractor
			Caustic	100 gal/month	Stored (612)/Disposed by a commercial contractor
			HE-contaminated trash	30 lbs/month	Open burning at Site 300

TABLE 4-1
HAZARDOUS, MIXED, AND RADIOACTIVE WASTE STREAMS
LLNL MAIN SITE AND SITE 300
LIVERMORE, CALIFORNIA
PAGE SEVENTEEN

Program	Bldg No	Building Name	Waste Material	Waste Quantity	Method(s) of Treatment, Storage, & Disposal
Site 300 Firing Test Area	854	Dynamic Test Complex	None generated	---	---
Site 300 Chemistry Test Process Area	825	High Explosives Pressing	HE-contaminated washwater	2,200 gal/month	Clarifier/Surface impoundment
	826	High Explosives Pressing	HE-contaminated washwater	2,200 gal/month	Clarifier/Surface impoundment
	827	HE machining, testing	HE-contaminated washwater	4,400 gal/month	Clarifier/Surface impoundment
			Clarifier sludge and machine turnings	25 lbs/month	Open burning at Site 300
			Chlorinated solvents	20 gal/month	Stored (612)/Disposed by a commercial contractor
			HE, reactives, and contaminated trash	60 lbs/month	Open burning at Site 300
	828	HE Machining	HE-contaminated wastewater	2,100 gal/month	Clarifier/Surface impoundment
			Clarifier sludge and machine turnings	25 lbs/burn	Open burning at Site 300
			HE, Reactives, and contaminated trash	40 lbs/month	Open burning at Site 300
	829	Thermal Treatment	None generated	-	---

Sources: Dreicer, 1985; LLNL, 1984; LLNL, 1985a; LLNL, 1985b; LLNL, 1986

CF = Cubic feet
NA = Not Available
NTS = Nevada Test Site
TWL = Toxic Waste Control
TCE = Tetrachloroethylene
HC = High Conductivity
LCW = Low Conductivity Water
LIS = Laser Isotope Separation
MFE = Magnetic Fusion Energy
TRU = Transuranic

TABLE 4-2

HAZARDOUS WASTE CLASSES, CONSTITUENTS, AND GENERATION RATES
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Waste Class	Description	Constituents	Generation Rates (Liters/Year)
1	Organic Sludges	Urethanes, isocyanate, solvent, epoxy, poly oils, silicones, polyester, amines, solvent sludges, and coal tars.	9,888
2	Solvents & Organic Solutions	TCE, methyl ethyl ketone, toluene, acetone, methanol, 1,1,1-trichloroethane, kerosene, ethylene glycol, isopropanol, PCE, dichlorine, propanol, aminol, ethanol, tetrahydrofuran, petroleum ether, methylene chloride, phenol, mineral spirits, freon, Stoddard solvent, lacquer thinner, Alodine, water, pump oil, KEL-F resin, MCM.	104,323
3	Oils and Greases	Hydraulic oil, grease, petroleum jelly, soybean oil, vacuum pump oil, chlorinated hydrocarbons, immersion oil, cutting oil, recyclable automotive and truck oils.	80,813
4	Oil and Water Mixtures	Dow foam emulsion, water, oil, coolant, chlorinated hydrocarbons, water-soluble oil, machining oils, and tool bit coolants.	2,273
5	Organic and Oily Wastes	Ethanol, laser dye, Freon, water, Dowtherm J, ethylene glycol, carbon tetrachloride, coal tar, isopropanol, sodium hydroxide, methanol, oil, methylchloroform, lube oil, MEK, 1,1,1-trichloroethane, drilling mud oil, mixed plastic resins, Phenidone, microdeveloper.	4,018
6a	Metal Solutions	Sulfuric acid, potassium chromate, sulfamic acid, potassium dichromate, copper, chromium, alodine, chromic acid, nickel, cobalt, ammonium hydroxide, silver, zinc, cadmium, nitrate, calcium carbonate, chloride, fluoride, sulfate, phosphate, nitrogen/ammonia, aluminum, boron, magnesium, manganese, strontium.	12,406,657
6b	Metals, Sludges, and Other Residuals	Lithium, oil, mercury, spent etchant, boron, aluminum, antimony, arsenic, barium, beryllium, cadmium, magnesium, strontium, tin	4,766

TABLE 4-2
HAZARDOUS WASTE CLASSES, CONSTITUENTS, AND GENERATION RATES
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
PAGE TWO

Waste Class	Description	Constituents	Generation Rates (Liters/Year)
7	Miscellaneous Chemicals & Products	Photochemicals, resins, tributyl phosphate, laser dye, epoxy resins and hardener, isonate, dibutyl phthalate, sodium aluminum hydroxide, sodium stannous hydroxide, trisodium phosphate, ethane, fire-fighting foam, carcinogens, potassium cyanide, silver recovery chemicals, Xerox toner, sodium hydroxide, silicones, urethanes, isocyanates, polyesters, amine and solvent sludges, Dion 3-900 resins.	34,186
8	Paint and Organic Residuals	Phosphoric acid, oakite, lacquer thinner, paint thinner, mineral spirits	NA
9	Aqueous Solutions With Organics	Chlorinated hydrocarbons, methanol, water, ethanol, acetone, spent aqueous waste streams from Biomedical carcinogen studies, water-Freon and oil-water mixtures, DOW DB-31 emulsifiers, 3M fluorochem surfactant FC-135.	110,004
10	Anion Complexes	Potassium carbonate, sodium tartrate, sodium cyanide, copper cyanide, potassium cyanide.	10,745[a]
11	Inorganic Sludges and Residuals	Tetraisopropyl titanate, tetrabutyl zirconate	60
12	Pesticide Wastes	Pesticide wastes are disposed of off-site through FIFRA-approved disposal procedures.	NA
13	PCB Wastes	Oil, PCBs, water, chlorinated hydrocarbons, PCE, TCE, MCM	NA
14	Halogenated Organic Waste Solvents	Chlorinated Solvents	21,586
15	Spent Acid Solutions	Copper sulfate, activated carbon, nitric acid, muriatic acid, fluoroboric acid, chromic acid, sulfuric acid, phosphoric acid, hydrofluoric acid.	450
16	Spent Alkali Wastes	Ammonia, sodium hydroxide, ammonium hydroxide	439
17	Waste Waters Not Classified Elsewhere	Sodium phosphate solution, detergent soap solution, micro developer, carcinogens.	28,112

Source: Heckman, 1984a.
[a] Kilograms/Year

TABLE 4-3

WASTE STREAM CLASSES BY PROCESS/OPERATION
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Process/Operation	Description
General Plant	Ion exchange regeneration wastes, ion-exchange resin backwash, Freon solvents, mercuric organic solvents, drilling mud from test wells, paint shop aqueous wash solutions
Machine Shops	Oils, coolants, spent organic solvents, spent bright dip solutions
Plating Shops	Plating shop rinsewaters, spent plating solutions, solvents
Experimental Circuit Board Facility	Metal contaminated acid solutions, sodium hydroxide, solvents
Plastic Shops	Plastic monomers and solvents in sludges, epoxy resins, solvents, isocyanate plastic, dibutyl phthalate
Photochemical and Reproduction	Photochemicals, spent Kodak photo solutions, dichromate black, Xerox toner
Salvage Operations	Recyclable oil from motor pool, heavy equipment, and vacuum pumps; solvents
Biomedical and Environmental Sciences	General laboratory chemicals, spent solutions containing carcinogens, organic solvents, acids, oils
Special Materials Operations	Solvents, vacuum pump oils, laboratory chemicals
Nuclear Chemistry	Caustics, organic solvents, acid wastes, oil/solvent mixtures
Experimental Physics	Acid cleaning solutions, caustic solutions, solvents, waste oil, plastic resin/solvents
Laser Facilities	Oils, solvents, solvent-contaminated rinsewaters, metal-containing aqueous wastes
Laser Isotope Facilities	Laser dye solutions, acid solutions, solvents
Hazards Control Analytical Laboratory	Acid beryllium solution, solvent beryllium solution
Chemistry and Materials Sciences	Oils, non-chlorinated solvents, chlorinated solvents, mixed laboratory chemicals
Magnetic Fusion Energy	Chlorinated solvents, organic chemicals, oils, acids
Laser Isotope Separation (LIS) Low Specific Activity (LSA) Wastes	D-38 contaminated solid wastes
Biomedical Animal Carcasses	Mice, rats, hamsters, rabbits
Classified Non-Toxic Incinerable Solid Wastes	Paper, plastic cover sheets, film negatives
LSA Solid Wastes (Laboratory-wide)	Drums and 7A boxes of dry, usually compactible, LSA radioactive waste

Source: Heckman, 1984b.

have been at or less than the STLC. Gravel was analyzed for explosives (HMX, RDX, and TNT), and levels were found to be consistently below 1 ppm. These wastes also contain radioactive constituents from uranium. Soil and groundwater beneath and adjacent to the firing tables may have been contaminated by hazardous leachates. After each test, the firing table is wetted down for dust suppression. This dust suppression water, as well as any precipitation or runoff from adjacent areas, percolates through the firing table and debris. These waters are not collected (see Finding 3.2.4.3.2).

Wastewater discharged to lagoons from five buildings contains small amounts of HE solids, which are filtered through fabric filters from the wastewaters. The filtered sludge is then destroyed in burn pits by open burning. Contamination of soil under the burn pit has occurred with high explosives constituents (see Finding 4.5.2.3.12).

A hazardous waste storage area is operated in the General Services Area (GSA). Wastes are periodically shipped from the storage area to the Main Site (B-612) for further processing.

Three open burn pits are used for the thermal destruction of explosive wastes and explosives-contaminated trash by open burning. Explosive wastes include sludges generated from five on-site wastewater clarification systems and explosive-contaminated wastes from both the Main Site and Site 300 buildings. Contamination with high explosives constituents of soil under the burn pits has occurred (see Finding 3.2.4.3.3).

Waste Accumulation Areas

The fact that both the Livermore Site and Site 300 are characterized by a large number of sources generating relatively small quantities of hazardous wastes, has resulted in the need for numerous waste accumulation areas (WAAs) at both sites. Waste accumulation areas are designated places where wastes are temporarily accumulated prior to pickup and transportation to the 612 storage facility for long-term storage prior to treatment at on-site or off-site facilities. At Site 300, wastes from WAAs are taken to the storage area and then transported to B-612 at the Main Site. Each waste accumulation area serves a building or a group of buildings. These areas accumulate not only hazardous wastes, but also radioactive and mixed wastes. Most waste accumulation areas at both the Main Site and Site 300 are permanent, although their use and type of wastes accumulated will vary according to program activity. Table 4-4 lists the waste accumulation areas for the Main Site.

TABLE 4-4

WASTE ACCUMULATION AREAS,
MAIN SITE AND AIRPORT
LLNL - LIVERMORE, CALIFORNIA

Waste Accumulation Area	Building(s) Served
002	Airport
113	113
131	121, 131
141	141
141 - Storage Tanks(6)	141
151	151
151 - Tanks (2)	151
161	161
169	169
212	212
227	227, 222, 223
231 - East	231, 232, 233, 234, 235
231 - Central	231, 232, 233, 234, 235
231 - Tanks	231, 232, 233, 234, 235
241	241, 243
253	253
254	254
255	255
281	281
292	292
292 - North	292
298	298
298 - Tank	298
321 - South	321
321 - East	321
322 - Tanks	322
331 - Sorting	331
331 - Pickup	331

TABLE 4-4
WASTE ACCUMULATION AREAS,
MAIN SITE AND AIRPORT
LLNL - LIVERMORE, CALIFORNIA
PAGE TWO

Waste Accumulation Area	Building(s) Served
332 - Tanks	332
361	361
403	403
404	404
411	411
418	418
431	431
436	436
438 (unofficial)	438
442	442
511	511
513	513
518 (unofficial)	518
519	519
691	691

Source: DOE Survey team.

Both California and USEPA regulations allow the accumulation of hazardous waste, without a RCRA permit, in temporary accumulation areas for periods up to 90 days. The basic requirements are that incompatible wastes be separated and that all containers holding hazardous wastes be labeled as hazardous waste containers. The accumulation start date must be noted, and wastes cannot be accumulated for longer than 90 days. Adherence to permitted storage area requirements such as impermeable surfaces and spill containment capacity is not required. However, these measures are good management practice in any area storing hazardous waste.

Waste Generation and Transportation Procedures

In laboratories, hazardous, radioactive, and mixed waste; acids; caustics; and solvents are usually initially accumulated in small containers, (e.g., 5-gallon carboys). Dry wastes containing radioactive constituents are segregated in separate containers lined with plastic bags (Heckman, 1984b). It is considered the generator's responsibility to know the contents of each waste container. The building's health and safety coordinator is responsible for ensuring that wastes placed in waste accumulation areas are properly packaged and labeled at the point of origin. In the waste accumulation area, solid wastes are collected in removable top barrels. Liquids such as cutting oils are collected in non-removeable-head drums.

On-site transportation of wastes from the waste accumulation areas to the 612 storage yard is handled by LLNL Hazardous Waste Management (HWM) personnel. Pallets of waste are transported on a flatbed truck. The normal pickup run is made each Thursday.

Prior to the weekly pickup, the Health and Safety Technician who is responsible for a waste accumulation area (WAA) prepares a list of containers to be picked up at each area, and requests HWM to pick them up. This list is used by the HWM technician accompanying the truck driver on the pickup to identify those containers to be picked up. When containers are loaded on the truck, the representative of HWM checks the load from the WAA before the truck leaves.

Once pickups have been made and the wastes delivered to 612, procedures specify that the HWM technician who went on the waste pickup run ensure that all the waste containers are properly logged, marked, segregated, and moved to the location where they will be handled. In practice, pallets of wastes are unloaded into the receiving area and segregated as time permits. It is also the technician's responsibility to notify the responsible Health and Safety Technician of any problems encountered during the waste pickup run.

Underground Storage Tanks - Retention Tanks

LLNL does not discharge process wastewaters containing hazardous substances or radioactive constituents to surface waters. Wastewaters that contain hazardous or radioactive constituents are discharged to temporary holding (retention) tanks, most of which are underground tanks. Full tanks are sampled and analyzed for constituents such as pH, metals, and radioactive constituents. If the concentrations are below regulatory limits, the contents are discharged to the Livermore Sanitary Wastewater System. If concentrations are above limits, the contents will usually be treated at the B-514 Liquid/Wastewater Treatment Facility. Retention tanks are usually paired so that when one is full and waiting for disposal, the second tank is used.

Most retention tanks receive wastewaters from laboratory sinks and floor drains where hazardous and/or radioactive substances are handled. Drains and sinks from photolabs and machine shops are also usually connected to retention tanks. It is LLNL policy that the sinks connected to retention tanks are not to be used for disposal of concentrated wastes containing hazardous or radioactive constituents (e.g., acids, uranium, etc.). However, dilute rinsewaters containing hazardous wastes and/or radionuclides are discharged to retention tanks.

Acid rinse water and tank contents from the 322 Plating Shop and the 325 and 291 Ion Exchange wastewaters are routinely transported by commercial vendors to off-site facilities for treatment. Arrangements are made by HWM. These tanks receive large volumes of concentrated wastewaters, which cannot be treated at on-site liquid waste treatment facilities.

Both Section 9002 of RCRA and California law (Cortege Bill) require that all underground storage tanks and sumps containing "regulated" substances or petroleum products must be registered with the state. California law requires leak testing of all existing underground tanks without leak detection. LLNL has performed the required leak testing, since most tanks do not have leak detection capability, and has taken out of service or repaired those tanks that did not pass the test. New tanks are built with leak detection. Table 4-5 gives a list of tanks and sumps at the Main Site and Site 300, both registered and nonregistered (Henry, 1986). The table describes tank capacities, design, construction material, material stored, and capacities.

612 Facilities

Radioactive and nonradioactive hazardous wastes are received at the 612 yard from throughout the Main Site and Site 300. Most wastes are received on Thursdays during the weekly waste pickup run.

TABLE 4-5

REGISTERED TANKS AND SUMPS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Reg Number	Year Installed	Year Closed	Capacity (Gallons)	Construction Material	Material Stored	Description of System	Tank, Single Wall	Tank, Double Wall/ Vaulted	Sump, Open Top	Sump, Double Wall/ Vaulted	Piping, Single Wall	Piping, Double Wall/ Vaulted
231-41R*	1985	----	600	Polypropylene	Rinse: acid, rad, metals	Sump				X	X	X
235-41R*	1985	----	1,200	Fiberglass	Wastewater, rad, metals	Sump				X		X
111-11D	1980	----	350	Steel	Diesel	---	X				X	
113-11D	1980	----	350	Steel	Diesel	---	X				X	
131-11D	1970	----	280	Steel	Diesel	---	X				X	
131-12D	1977	----	12,500	Fiberglass	Diesel	---	X				X	
131-13D	1977	----	12,500	Fiberglass	Diesel	---	X				X	
131-21R	1971	----	4,000	Concrete	Rinse: acid, rad, metals	Retention System			X		X	
131-41A	1959	----	1,000	Stainless Steel	Ammonia	For Blueline Machinery	X				X	
141-11G	1960	1981	1,000	Steel	Gasoline	Filled with sand						
141-41R	1980	----	450	Concrete	Acid rinsewater, metals	Retention system			X		X	
141-42R	1980	----	450	Concrete	Acid rinsewater, metals	Retention system			X		X	
141-43R	1980	----	450	Concrete	Acid rinsewater, metals	Retention system			X		X	
151-11D	1964	1985	1,000	Steel	Diesel	---						
151-21R	1972	----	4,000	Steel clad concrete	Rinse: acid, rad, metals	Retention system	X				X	

TABLE 4-5
REGISTERED TANKS AND SUMPS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
PAGE TWO

Reg Number	Year Installed	Year Closed	Capacity (Gallons)	Construction Material	Material Stored	Description of System	Tank, Single Wall	Tank, Double Wall/ Vaulted	Sump, Open Top	Sump, Double Wall/ Vaulted	Piping, Single Wall	Piping, Double Wall/ Vaulted
151-22R	1983	—	4,000	Steel clad concrete	Rinse: acid, rad, metals	Retention system	X				X	
151-41R	1967	—	380	Concrete	Acid, base, rad	Sump			X			X
152-41D	1983	—	4,000	Fiberglass	Diesel	—	X				X	
161-31R	1976	—	135	Polyethylene	Rinse: acid, rad, metals	Retention system			X		X	
175-31R	1980	—	1,000	Steel	Rinse: acid, rad, metals	Retention system	X				X	
194-11D	1959	—	280	Steel	Diesel	—	X				X	
194-31R	1967	—	300	Concrete	Rad wastewater	Sump			X		X	
212-31R	1958	—	50	Concrete	Tritiated wastewater	Sump			X		X	
212-41R	1958	—	50	Concrete	Tritiated wastewater	Sump			X		X	
212-42R	1962	—	50	Concrete	Tritiated wastewater	Sump			X		X	
212-43W	1976	1982	200	Concrete sleeve	Drum rack drainage	Drywell						
222-21R	1970	—	9,800	Concrete	Rinse: acid, rad, metals	Retention system			X		X	
222-22R	1970	—	9,800	Concrete	Rinse: acid, rad, metals	Retention system			X		X	
229-11G	1943	1950	25,000	Concrete	Gasoline	Filled with sand						
229-12G	1943	1950	25,000	Concrete	Gasoline	Filled with sand						
229-13G	1943	1950	25,000	Concrete	Gasoline	Filled with sand						

TABLE 4-5
REGISTERED TANKS AND SUMPS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
PAGE THREE

Reg. Number	Year Installed	Year Closed	Capacity (Gallons)	Construction Material	Material Stored	Description of System	Tank, Single Wall	Tank, Double Wall/ Vaulted	Sump, Open Top	Sump, Double Wall/ Vaulted	Piping, Single Wall	Piping, Double Wall/ Vaulted
229-14G	1943	1950	25,000	Concrete	Gasoline	Filled with sand						
231-11D	1983	----	3,200	Steel	Diesel	---	X				X	
231-12D	1983	----	3,000	Fiberglass	Diesel	---	X				X	
231-13D	1978	----	12,500	Fiberglass	Diesel	---	X				X	
231-14D	1978	----	12,500	Fiberglass	Diesel	---	X				X	
231-31R	1959	1985	500	Concrete	Rinse: acid, rad, metals	Filled with sand						
231-33R	1959	1985	250	Concrete	Rinse: acid, rad, metals	Filled with sand						
239-11D	1967	----	280	Steel	Diesel	---	X				X	
241-11D	1957	----	500	Steel	Diesel	---	X				X	
241-31R	1959		345	Brick	Rinse: acid, rad, metals	Retention system			X		X	
251-11D	1967	----	500	Steel	Diesel	---	X				X	
251-21R	1967	----	25,000	Concrete	Standby	Sump for fire sprinkler			X		X	
251-31R	1968	----	300	Steel primary	Rinse: acid, rad, metals	Retention system				X	X	
251-33R	????	----	300	Steel primary	Rinse: acid, rad, metals	Retention system				X	X	
253-11D	1965	----	280	Steel	Diesel	---	X				X	
255-11D	1970	----	350	Steel	Diesel	---	X				X	
271-41D	1982	---	2,000	Steel	Diesel	---	X				X	

TABLE 4-5
REGISTERED TANKS AND SUMPS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
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Reg Number	Year Installed	Year Closed	Capacity (Gallons)	Construction Material	Material Stored	Description of System	Tank, Single Wall	Tank, Double Wall/ Vaulted	Sump, Open Top	Sump, Double Wall/ Vaulted	Piping, Single Wall	Piping, Double Wall/ Vaulted
281-31R	1955	---	1,000	Steel primary	Rinse: acid, rad, metals	Retention system		X			X	
281-32R	1955	---	1,000	Steel primary	Rinse: acid, rad, metals	Retention system		X			X	
281-41R	1957	---	1,500	Steel primary	Wastewater, rad	Retention system		X			X	
281-42R	1957	---	1,500	Steel primary	Wastewater, rad	Retention system		X			X	
281-43R	1957	---	45	Concrete	Wastewater, rad	Retention system			X		X	
281-440	1957	1980	10,000	Aluminum	Reactor cooling water	Primary cooling water						
281-450	1957	1980	3,000	Aluminum	Reactor cooling water	Primary cooling water						
281-460	1957	1980	100	Stainless steel	Ion exchange column	Primary cooling water						
281-470	1957	1980	100	Steel	Ion exchange column	Primary cooling water						
281-480	1957	1980	100	Steel	Ion exchange column	Primary cooling water						
281-490	1957	1980	100	Steel	Ion exchange column	Primary cooling water						
281-500	1957	1980	350	Aluminum clad concrete	Fuel rods in water	Open top tank						
291-21X	1981	----	5,000	Concrete	Deionizer waste	Deionizer			X		X	

TABLE 4-5
REGISTERED TANKS AND SUMPS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
PAGE FIVE

Reg Number	Year Installed	Year Closed	Capacity (Gallons)	Construction Material	Material Stored	Description of System	Tank, Single Wall	Tank, Double Wall/ Vaulted	Sump, Open Top	Sump, Double Wall/ Vaulted	Piping, Single Wall	Piping, Double Wall/ Vaulted
291-41D	1983	---	1,000	Fiberglass	Diesel	---	X				X	
292-31R	1974	---	1,000	Concrete	Tritiated water	Retention system			X		X	
298-11D	1982		350	Steel	Diesel	---	X				X	
298-41R	1983	---	300	Fiberglass	Rinse, acid, rad, metals	Retention sytem	X				X	
310-31R	1956	---	500	Steel	Rad wastewater	Retention system	X				X	
318-11D	1981	---	250	Fiberglass	Gasoline	---	X				X	
321-11D	1976	---	500	Steel	Diesel	---	X				X	
321-31R	1958	---	200	Concrete	Acid rinsewater rad	Retention system			X		X	
321A-11X	1971	---	3,000	Concrete	Plating shop caustic waste	Ion exchange plant			X		X	
321A-12X	1971	---	3,700	Concrete	Plating shop acid waste	Ion exchange plant			X		X	
321A-13X	---	---	3,000	Concrete	Plating shop waste	Ion exchange plant			X		X	
322-21X	1985	---	3,000	Concrete	Concrete plating shop waste	Retention system				X	X	
322-41X	1975	---	59,000	Concrete	Plate shop spills	Floor pits			X			
325-21X	1972	---	2,500	Concrete	Deionizer waste	Deionizer			X		X	
331-11D	1955		280	Steel	Diesel	---	X				X	

TABLE 4-5
REGISTERED TANKS AND SUMPS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
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Reg Number	Year Installed	Year Closed	Capacity (Gallons)	Construction Material	Material Stored	Description of System	Tank, Single Wall	Tank, Double Wall/ Vaulted	Sump, Open Top	Sump, Double Wall/ Vaulted	Piping, Single Wall	Piping, Double Wall/ Vaulted
332-11D	1960	---	1,000	Steel	Diesel	---	X				X	
332-12D	1976	---	1,500	Steel	Diesel	---	X				X	
332-13D	1981	---	2,000	Steel	Diesel	---	X				X	
332-32R	1961	---	1,000	Steel primary	Rinse: acid, rad, metals	Retention system		X			X	
332-33R	1961	---	1,000	Steel primary	Rinse: acid, rad, metals	Retention system		X			X	
361-11D	1973	1985	1,000	Steel	Diesel	---						
361-31R	1981	---	500	Concrete	Water through to sewer	Retention system, ceased 1984						
361-32R	1981	---	500	PVC primary	Water through to sewer	Retention system, ceased 1984						
361-33R	1981	---	500	PVC primary	Water through to sewer	Retention system, ceased 1984						
362-31R	1963	---	150	Steel	Rinse: acid, rad, metals	Retention system			X		X	
365-11D	1977	---	6,000	Fiberglass	Diesel	---	X				X	
365-31R	1979	---	350	Steel	Rinse: acid, rad,metals	Retention system	X				X	
377-31R	19[illegible]	---	500	Concrete	Acid rinsewater, rad	Retention system			X		X	
377-32R	1969	---	250	Concrete	Acid rinsewater, rad	Retention system			X		X	
377-41S	1969	---	2,000	Fiberglass primary	Seawater	Intermittent use		X				X

TABLE 4-5
REGISTERED TANKS AND SUMPS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
PAGE SEVEN

Reg. Number	Year Installed	Year Closed	Capacity (Gallons)	Construction Material	Material Stored	Description of System	Tank, Single Wall	Tank, Double Wall/ Vaulted	Sump, Open Top	Sump, Double Wall/ Vaulted	Piping, Single Wall	Piping, Double Wall/ Vaulted
377-42S	1969	—	2,000	Fiberglass primary	Seawater	Intermittent use		X				X
377-43S	1969	—	6,000	Fiberglass primary	Seawater	—		X				X
377-44S	1969	—	6,000	Fiberglass primary	Seawater	—		X				X
381-11D	1973	—	12,500	Fiberglass	Diesel	—	X				X	
391-11D	1973	—	12,500	Fiberglass	Diesel	—	X				X	
401-11D	1943	—	10,000	Stainless steel	Diesel	—	X				X	
401-12D	1943	—	10,000	Steel	Diesel	—	X				X	
401-13D	1943	—	10,000	Steel	Diesel	—	X				X	
402-11G	1979	—	10,000	Fiberglass	Gasoline	—	X				X	
402-12G	1979	—	10,000	Fiberglass	Gasoline	—	X				X	
403-11G	1943	1979	12,000	Steel	Gasoline	Filled with sand						
403-12G	????	1979	12,000	Steel	Gasoline	Filled with sand						
403-13G	????	1979	12,000	Steel	Gasoline	Filled with sand						
411-11D	1960	—	1,000	Steel	Diesel	—	X				X	
412-31R	1955	1976	1,000	Steel primary	Rad wastewater	Empty		X			X	
412-32R	1955	1976	1,000	Steel primary	Rad wastewater	Empty		X			X	

TABLE 4-5
REGISTERED TANKS AND SUMPS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
PAGE EIGHT

Reg. Number	Year Installed	Year Closed	Capacity (Gallons)	Construction Material	Material Stored	Description of System	Tank, Single Wall	Tank, Double Wall/ Vaulted	Sump, Open Top	Sump, Double Wall/ Vaulted	Piping, Single Wall	Piping, Double Wall/ Vaulted
419-31R	1976	1985	500	Fiberglass primary	Rinse: acid, rad, metals	Retention system						
419-32R	1976	1985	500	Fiberglass primary	Rinse: acid, rad, metals	Retention system						
419-41R	1984	1985	100	Steel primary	Rinse: acid, rad, metals	Retention system						
419-42E	1983	----	300	Fiberglass	Acid rinsewater	Retention sytem			X			
424-41D	1979	----	300	Steel	Diesel	--	X					X
431-11D	1965	----	280	Steel	Diesel	--	X					X
435-11E	1978	----	280	Steel	Diesel	--	X					X
451-11D	1977	----	500	Steel	Diesel	Tank, not underground					X	
490-41D	1983	----	2,000	Fiberglass	Diesel	--	X				X	
490-41R	1983	----	5,000	Fiberglass primary	Cooling water, rad	Retention system		X			X	
490-42R	1983	----	1,000	Fiberglass primary	Cooling water, rad	Retention system		X				X
490-43R	1983	----	1,000	Fiberglass primary	Rad wastewater	Retention system		X			X	
514-31R	1967	----	135	Concrete	Storm runoff/spills	Yard			X		X	
514-32R	1963	----	200	Concrete	Storm runoff/spills	Tank Farm			X		X	

TABLE 4-5
REGISTERED TANKS AND SUMPS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
PAGE NINE

Reg Number	Year Installed	Year Closed	Capacity (Gallons)	Construction Material	Material Stored	Description of System	Tank, Single Wall	Tank, Double Wall/ Vaulted	Sump, Open Top	Sump, Double Wall/ Vaulted	Piping, Single Wall	Piping, Double Wall/ Vaulted
514-33R	1963	----	350	Steel	Wastewater, rad, metals	Treatment system			X			
592-31O	1963	1973	100	Concrete	Animal waste	---						
612-41R	1982	---	25	Stainless primary	Wastewater, rad, metals	Retention system				X	X	
1705-11D	1978	----	350	Steel	Diesel	---	X				X	
611-42G	1985	----	12,000	Fiberglass	Gasoline	---		X				
611-41G	1985	----	12,000	Fiberglass	Gasoline	---		X				
514-41R	1985	----	560	Carbon steel	Wastewater, rad, metals	Retention system	X				X	
511-41D	1979	----	500	Unknown	Diesel	---	X					
492-41R	1984	----	2,580	Carbon steel	Wastewater, ethanol	Retention system			X		X	
491-41R	1984	----	2,580	Carbon steel	Wastewater, rad	Retention system			X		X	
281-41D	????	----	280	Unknown	Diesel	---	X				X	
490-46R	1984	----	180	Stainless steel	Wastewater, solvent	Retention system		X			X	
490-45R	1984	----	180	Stainless steel	Wastewater, solvent	Retention system		X			X	
490-44R	1984	----	1,460	Carbon steel	Wastewater, rad	Sump				X		X
169-41R	????	----	500	Carbon steel	Wastewater, oil	Retention system	X				X	

TABLE 4-5
REGISTERED TANKS AND SUMPS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
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Reg Number	Year Installed	Year Closed	Capacity (Gallons)	Construction Material	Material Stored	Description of System	Tank, Single Wall	Tank, Double Wall/ Vaulted	Sump, Open Top	Sump, Double Wall/ Vaulted	Piping, Single Wall	Piping, Double Wall/ Vaulted
850-41D	1962	----	300	Carbon steel	Diesel	---	X					
836-41D	????	----	280	Carbon steel	Diesel	---	X					
814-41D	1972	----	300	Carbon steel	Diesel	---	X					
805-41D	1978	----	300	Carbon steel	Diesel	---	X					
611-41L	1985	----	1,000	Fiberglass	Waste oil	Retention system		X				X
611-41D	1985	--	10,000	Fiberglass	Diesel	---		X				X

Source: Henry, 1986.

Wastes are received at the southwest corner, where pallets are unloaded from the truck into a waste staging area that is partially bermed. The incoming wastes are then sorted by categories as follows:

1. Oxidizers (including perchloric and nitric acids)
2. Acids
3. Caustics
4. Flammable liquid solvents
5. Outdated ether
6. Alkali metals
7. Flammable solids
8. PCB-contaminated oil and equipment
9. Radioactive wastes
10. Unknown chemical waste
11. Solids
12. Labpack wastes - further separated into hazard class.

Wastes are sorted so that individual categories are physically separated from each other. Reactive chemicals, including oxidizers, outdated ethers, alkalis, flammable solids, acids, caustics, and some flammable solvents, are stored in individual cells in a reinforced concrete building (614). Other wastes are stored in the yard by category. Waste storage areas are bermed to provide containment, although berms are not always complete.

Construction of a new hazardous waste storage facility was completed early in 1987. This facility will be used for storage of nonradioactive hazardous wastes prior to shipment to off-site commercial facilities. The existing 612 yard will continue to be used for waste receiving and staging and for long-term storage of mixed wastes.

612 Incinerator

The hazardous waste incinerator and associated storage area is located within the 612 Solid Waste Handling Area. The incinerator is a dual-chamber type including an ignition chamber, combustion chamber, mechanical waste charging system, and liquid waste injection system. Initial combustion of waste occurs in the ignition chamber. By-products from the ignition chamber flow to the combustion chamber where combustion is completed. Nonhazardous waste generated from biomedical research activities consisting of animal carcasses, paper and plastic laboratory wastes, and classified paper film and microfiche are incinerated. Hazardous wastes consisting primarily of

solvents contained in scintillation vials are also incinerated. Table 4-6 describes the types of wastes incinerated according to sources.

The storage area for the incinerator is located adjacent to the incinerator inside a fenced area within the 612 complex. LLNL has applied for a RCRA Part B permit for the incinerator. A trial burn plan has also been submitted.

514 Liquid Waste Treatment Plant

The Building 514 area is used to treat large-volume, low-level liquid wastes collected primarily from retention tanks. These treated aqueous waste streams can be defined as a characteristic waste (corrosive, reactive, ignitible, EP toxic) that may be contaminated with radionuclides, metals, coolant oils, and may require oxidation or pH adjustment. Table 4-7 describes the characteristics and origins of wastes normally treated at B-514, as described in the 1985 LLNL Hazardous Waste Operation Plan.

Capacity at the 514 facility is limited, so first priority is given to wastewater containing radionuclides, since off-site commercial facilities are not used for treatment of such wastes. Nonradioactive wastes are treated as capacity is available.

The treatment scheme uses peroxide to oxidize metals at acidic pH, alkaline precipitation of metals, and filtration through a Dorr-Oliver filter to remove precipitates. Filtrate from the Dorr-Oliver filter is held in a tank and analyzed to determine if it meets the limits prior to discharge to the sanitary system. If sanitary discharge limits are not met, the filtrate is retreated.

Dorr-Oliver sludge containing radioactive constituents formerly went to the Nevada Test Site (NTS). At this time all sludges are being stored at 612, since the sludge sometimes fails the TTLC test and therefore is classified as a California hazardous waste. New NTS waste acceptance criteria prohibit the acceptance of hazardous wastes; therefore, Dorr-Oliver sludge can no longer be shipped to NTS.

LLNL has developed a conceptual design for a "Decontamination and Waste Treatment Facility" (DWTF) to replace the 514 Liquid Waste Treatment Facility as well as the existing decontamination facility (used for radioactive decontamination) and other facilities used for solidifying oils and wastewaters containing radioactive constituents. The DWTF would also treat virtually all hazardous wastes now shipped off-site to commercial facilities.

TABLE 4-6

ORIGINS OF INCINERATED WASTES
LAWRENCE LIVERMORE NATIONAL LABORATORY
LIVERMORE, CALIFORNIA

Waste Source	Waste Material Produced
Hazards Control	Carcinogens, Aqueous Waste
Calibration Standards	Solvents
Medical	Biological Wastes
Trailer parks/Tube banks	Scintillation Vials (plastic)
Materials Fabrication Shop	Solvents (flammable)
Main Laboratory	Carcinogenic Liquid, Dye Waste
Tumor Laboratory	Carcinogenic Waste
Animal Toxicology	Carcinogenic Waste
Health Effects Laboratory	Solvents, Carcinogenic Waste
Nuclear Chemistry	Solvents

Source: LLNL, 1986

TABLE 4-7

WASTEWATERS TREATED AT 514
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

ADMINISTRATION

Source	Description	Treatment	Typical Contaminants
419	Contaminated rinsewater	Chemical treatment-filtration/released to sewer-sludge solidified and handled as a "mixed waste."	*
612	Transuranic (TRU) Facility	Chemical treatment-filtration/released to sewer-sludge solidified and handled as a "mixed waste."	*

ENGINEERING

131	Rinsewater from retention tank	Normally released to sewer (treated if it does not meet sewer limits).	* No tritium
291	Cooling tower bleed-off	Normally released to sewer (treated if it does not meet sewer limits).	*
321	Rinsewater from retention tank	Chemical treatment-filtration/released to sewer-sludge solidified and handled as a "mixed waste."	* No metals
322	Dilute rinsewater	Normally released to sewer (treated if it does not meet sewer limits).	* TDS, Norm total identifiable chlorinated hydrocarbons (TICH)
325	Cooling tower bleed-off	Normally released to sewer (treated if it does not meet sewer limits).	* No metals

CHEMISTRY

222	Rinsewater from retention tank	Normally released to sewer (treated if it does not meet sewer limits).	*
228	Rinsewater from retention tank	Normally released to sewer (treated if it does not meet sewer limits).	*
231	Acid wastes	Chemical treatment-filtration/released to sewer-sludge solidified and handled as a "mixed waste."	* TICH, Ag, Be, W, Y, & Hf
231	Rinsewater from retention tank	Normally released to sewer (treated if it does not meet sewer limits).	* TICH, Ag, Be, W, Y, & Hf
241	Rinsewater from retention tank	Normally released to sewer (treated if it does not meet sewer limits).	* Be No tritium
332	Rinsewater from retention tank	Normally released to sewer (treated if it does not meet sewer limits).	*

TABLE 4-7
WASTEWATERS TREATED AT 514
LAWRENCE LIVERMORE NATIONAL LABORATORY
PAGE TWO

BIOMEDICAL

Source	Description	Treatment	Typical Contaminants
362	Rinsewater from retention tank	Chemical treatment-filtration/released to sewer-sludge solidified and handled as a "mixed waste."	*
365	Rinsewater from retention tank	Chemical treatment-filtration/released to sewer-sludge solidified and handled as a "mixed waste."	*
377	Rinsewater from retention tank	Chemical treatment-filtration/released to sewer-sludge solidified and handled as a "mixed waste."	*

PHYSICS

194	Rinsewater from retention tank	Normally released to sewer (treated if it does not meet sewer limits).	* No tritium
212	Rinsewater from retention tank	Normally released to sewer (treated if it does not meet sewer limits).	* No metals
292	Rinsewater from retention tank	Chemical treatment-filtration/released to sewer-sludge solidified and handled as a "mixed waste."	* No tritium

LASERS

175	Rinsewater from retention tank	Normally released to sewer (treated if it does not meet sewer limits).	* No tritium
298	Rinsewater from retention tank	Normally released to sewer (treated if it does not meet sewer limits).	* TICH, Be & Ag

DEFENSE SYSTEMS

151	Rinsewater from retention tank	Normally released to sewer (treated if it does not meet sewer limits).	* No metals
251	Rinsewater from retention tank	Normally released to sewer (treated if it does not meet sewer limits).	* No metals No tritium

ATA

865	Wastewater	Chemical treatment-filtration/released to sewer-sludge solidified and handled as a "mixed waste."	* No rad

Source: LLNL, 1985c.
*These waste streams, if hazardous, are either corrosive, EP toxic, or radioactive. The metals contaminants are copper, chromium, nickel, zinc; alpha, beta, and tritium are the radioactive components; pH is out of limits for discharge to the sewer unless otherwise noted.

Ag - Silver
Be - Beryllium
Hf - Hafnium
TDS - Total Dissolved Solids
TICH - Total Identified Chlorinated Hydrocarbons
W - Tungsten
Y - Yttrium

The DWTF will consist of new buildings, facilities, and equipment, including a liquid waste process building, decontamination and solid waste processing and packaging building, rotary kiln incinerator with enclosure, solid waste receiving and classification building, and a uranium burn pan with enclosure. Construction of the facility is expected to be completed by 1991, assuming that funding is provided in 1987. The DOE published in the Federal Register on March 18, 1987, a notice that DOE intends to prepare an Environmental Impact Statement (EIS) to assess the environmental effects of constructing and operating the DWTF.

RCRA Permits

RCRA Part B permit applications have been submitted for the Main Site and Site 300. The permit application for the Main Site describes the following hazardous waste management facilities:

1. Building 514 Liquid Waste Disposal
2. 612 Building
3. 614 Storage Building
4. 623 Waste Gas Storage Facility
5. 625 PCB Storage Facility
6. 321 Ion Exchange Plants
7. 612 Storage Yard
8. 612 Incinerator

RCRA Part B permit applications were not made for the 513 Solidification Facility, where mixed wastes containing listed hazardous waste (chlorinated solvents, oils) and characteristic hazardous waste (reactive uranium, corrosives, etc.) are solidified.

LLNL filed a revised RCRA Part A permit for Site 300. The revised Part A application included

1. Three open burn pits
2. Pit 1 and 7 landfills
3. A container storage area

The original Part A application included five wastewater treatment systems that generate a listed RCRA waste. These were deleted, since the clarifiers generate but do not treat RCRA wastes and therefore are not RCRA facilities.

Five surface impoundments were listed on the original Part A permit application. These impoundments were deleted when analytical results showed that they did not receive RCRA-listed or characteristic wastes. Drywells originally used for the disposal of wastewaters were deleted, since they were permanently closed and abandoned with the approval of the California Regional Water Quality Board. (See Finding 4.5.2.3.15 for further details.)

The Site 300 RCRA Part B permit application was submitted for the two landfills and for the container storage area. Part B applications were not filed for the burn pits because final standards under 40 CFR 264 were not yet established by the EPA. Currently the burn pits are operating under interim status, as are the landfills and container storage area. Final RCRA permits have not been issued for any LLNL facilities.

4.1.1.2 Radioactive Waste

DOE Order 5480.2 defines radioactive waste as solid or fluid materials of no value containing radioactivity; discarded items such as clothing, containers, equipment, rubble, residues or soils contaminated with radioactivity; or soils, rubble, equipment, or other items containing induced radioactivity, such that the levels exceed safe limits for unconditional release. Numerical limits are not specified in the DOE definition. At LLNL all waste that is exposed to radioactive material or to a system exposed to radioactivity considered radioactive and is analyzed before a decision is made regarding disposal.

LLNL handles most low-level radioactive wastes within the hazardous waste management system. WAAs are used for both radioactive and hazardous waste. Radioactive wastes are transported to the B-612 Hazardous Waste Storage Facility by hazardous waste management personnel for processing and storage prior to shipment to off-site DOE facilities. The retention tank system receives wastewater containing both radioactive and/or hazardous constituents, which are subsequently treated at the B-514 liquid waste treatment plant. Certain radioactive wastes such as scintillation vials, solvents, and biological wastes are incinerated at the B-624 incinerator in the hazardous waste management area. The facilities and procedures described in Section 4.1.1.1 also generally apply to radioactive wastes

LLNL generates 500 to 1,000 m^3 of solid radioactive waste/year. This waste is primarily experimental apparatus, disposable clothing, wipes, and building equipment.

Most solid radioactive waste not containing hazardous wastes is compacted at 612, then containerized and shipped for burial to the Nevada Test Site (NTS). NTS has recently promulgated Waste Acceptance Criteria that prohibit acceptance of radioactive wastes containing hazardous constituents (i.e., mixed wastes). As a result, certain wastes formerly shipped to the NTS, such as Dorr-Oliver filter cake and listed wastes (e.g., solvent, oils solidified at Building 514) are now being stored on-site.

Planned environmental releases of radioactivity from solid waste at LLNL occurs only from the incineration at the B-624 incinerator of animals injected with tritium and scintillation vials. Airborne releases are limited to 0.50 Ci/day, with the limit attained by limiting the total radioactive content of the wastes incinerated. Wastes are characterized for radioactive constituents prior to incineration.

Liquid radioactive wastes are processed by solidification, precipitation/filtration, incineration, or evaporation. Approximately 500,000 to 700,000 liters of radioactive liquid waste are generated yearly. These wastes vary in toxicity from low-level tritiated water (less than 10^{-2} μCi/ml) to highly contaminated plutonium-239 acids (as high as 5 mCi/ml). Most liquid waste is wastewater generated in decontamination operations on equipment, retention tanks receiving wastewater from radioactive work areas, and cutting fluids from the uranium and beryllium machine shop areas. Machine shop personnel containerize spent cutting fluid in 55-gallon drums. Decontamination and washdown wastes are placed in tanks for transport to the 514 Liquid Waste Treatment Facility. Small quantities of liquid wastes result from biomedical studies with radioisotopes and sample counting solutions (liquid scintillation), which are mixed wastes; radioanalyses work at the chemistry buildings (151, 222, 251, 331, 332), and decontamination solutions such as trichloroethylene and Freons.

Table 4-8 describes radioactive waste sources by program area, types, quantities, and methods of treatment, storage, or disposal.

Decommissioning Livermore Pool-Type Reactor
and Rotating Target Neutron Source (RTNS) Shutdown

The Livermore pool-type reactor is being decommissioned in two phases. Under Phase I the reactor was defueled, with water and liquid wastes removed and processed. Phase II of the decommissioning plan was originally scheduled to begin in FY 85, after the 5-year cooldown period, but has not yet been started.

TABLE 4-8

RADIOACTIVE WASTE SOURCES, TYPES, QUANTITIES, AND TSD METHODS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Program	Bldg. No.	Building Name	Waste	Waste Quantity	Method(s) of Treatment, Storage, and Disposal
Administration	253	Hazards Control	Planchets Air Filters Solid Rad Wastes HEPA Filters Tritium Targets Liquid Rad Wastes	4 CF/Year 1 CF/Year 36 CF/Year 3 CF/Year 6 CF/Year 35 Gal/Year	Packaged/Shipped to NTS. Packaged/Shipped to NTS. Packaged/Shipped to NTS. Packaged/Shipped to NTS. Packaged/Shipped to NTS. Solidified/Shipped to NTS.
	254	Toxicology	Scintillation Vials	NA	Incineration/Ash to Municipal Landfill
	419	Decontamination	Solid Rad Wastes Contaminated Rinsewater	40 CF/Year 100 Gal/Week	Solidified, packaged/Shipped to NTS. Treated, sludge solidified/Shipped to NTS
	513	Liquid Waste Storage	Contaminated oil, solvents, corrosives	3,000 CF/Month	Solidified, packaged/Shipped to NTS
	514	Waste Disposal	Contaminated Sediment	60 CF/Month	Solidified/Shipped to NTS.
	612	Dry Waste (TWC)	TRU Facility Retention Tank Waste	200 Gal/Month	Treated, sludge solidified/Shipped to NTS.
Engineering	131	Engineering	Retention Tank Rinsewater	Very Rarely	Treated, sludge solidified/Shipped to NTS.
	321	Materials Fabrication Shop	Solid Rad (D-38) Liquid Rad Waste Contaminated Oils	16 lb/Year-1983 55 Gal/Day 55 Gal/Day	Packaged/Shipped to NTS. Solidified/Shipped to NTS. Solidified/Shipped to NTS.
Chemistry	222	Chemistry	Beryllium Waste Liquid Retention Tank	Minimal Minimal	Solidified/Shipped to NTS. Treated, sludge shipped to NTS.

TABLE 4-8
RADIOACTIVE WASTE SOURCES, TYPES, QUANTITIES, AND TSD METHODS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
PAGE TWO

Program	Bldg. No.	Building Name	Waste	Waste Quantity	Method(s) of Treatment, Storage, and Disposal
Chemistry, cont'd	231	Development & Assembly	Acid Waste D-38 Metals Retention Tank Liquid	2 Gal/Year	Solidified/Shipped to NTS. Packaged/Shipped to NTS. Treated, sludge shipped to NTS.
	232	Chemical High Pressure Laboratory	D-38 Metals	4 Drums/Week	Packaged/Shipped to NTS.
	241	Refractory	Solid Rad Waste	Drum/Month	Packaged/Shipped to NTS.
	331	Gaseous Chemistry	Solid Rad Waste Tritium-Oil	Drum/Month 25 Gal/Year	Packaged/Shipped to NTS. Solidified, packaged/Shipped to NTS
	332	Metals Chemistry	TRU-Solid TRU-Liquid Contaminated Oil	6 Drums/Week 100 Gal/Year 5 Ga. Veek	Packaged/Shipped to NTS. Solidified/Shipped to NTS. Solidified/Shipped to NTS.
Physics	194	Elec. Positive Acceleration	Solid Rad Wastes	Drum/Month	Packaged/Shipped to NTS.
	212	Accelerators	Solid Rad Wastes Tritiated Oil/Solvents	Drum/Month 5 Gal/Quarter	Packaged/Shipped to NTS. Incineration/Ash to municipal landfill.
	292	RTNS II	Liquid Rad Tritium Targets Solid Rad Waste Tritium Contamination Rinsewater	1,000 Gal/Year 40 Gal/Month Drum/Quarter 15 Gal/Year 5,000 Gal/Year	Evaporation, incineration, or solidified/shipped to NTS. Packaged/Shipped to NTS. Packaged/Shipped to NTS. Packaged/Shipped to NTS. Treated, sludge solidified/Shipped to NTS.

TABLE 4-8
RADIOACTIVE WASTE SOURCES, TYPES, QUANTITIES, AND TSD METHODS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA
PAGE THREE

Program	Bldg No	Building Name	Waste	Waste Quantity	Method(s) of Treatment, Storage, and Disposal
Lasers	161	L.I.S. Laboratory	Solid Rad	2 Drums/Month	Packaged/Shipped to NTS.
	175	MARS	Solid Rad	6 Drums/Month	Packaged/Shipped to NTS
	177	L.I.S. Laboratories	Contaminated Acid	5 Gal/Month	Solidified/Shipped to NTS.
	298	Fusion Target Bldg	Solid Rad	Drum/Month	Packaged/Shipped to NTS.
Magnetic Fusion	443	Coil Shop	Epoxy		Solidified/Shipped to NTS.
Defense Systems	151	Nuclear Chemistry	Liquid Rad Solvents Solid Rad & Scintillation Vials	120 Gal/Month <5 Gal/Month 6 Drums/Week	Solidified/Shipped to NTS. Packaged/Shipped to NTS. Incineration/Ash to landfill of non-rad, tritium or C-14, otherwise solidified.
	251	Heavy Elements	Solid Rad Liquid Rad TRU	2 Drums/Month 6 Drums/Year	Packaged/Shipped to NTS Dried or solidified/Shipped to NTS. Packaged/Shipped to NTS
	341	Physics Research	Solid Rad	4 Drums/Year	Packaged/Shipped to NTS

Sources: Holmes, 1985.
LLNL, 1984b.
LLNL, 1985a.
LLNL, 1985b.
LLNL, 1986.

TSD Treatment, Storage, and Disposal

The reactor would be removed in four steps. The first and second steps would consist of removal and demolition operations. Step I would include placing containment building support and safety facilities in operation; installing temporary personnel facilities; and removing experiment gear, uncontaminated equipment, and accessories. Step II would include removal of radioactive material left in the reactor vessel, the graphite thermal columns, the lead shields, the core grid support, and associated hardware. For Step III a subcontractor would be brought in to demolish the reinforced concrete reactor structure and the cooling tower. All radioactive wastes would be packaged and processed under the guidance of Hazards Control. Under Step IV remaining removal and cleanup work will be completed. Initiation of removal and demolition operations has been deferred due to lack of funding. Site personnel have expressed concern that future decommissioning will be more difficult because of attrition of personnel intimately familiar with the reactor.

The RTNS facility in Building 292 is scheduled to be shut down in 1987. If a warm shutdown is used, the vacuum system would be kept on and a fast restart could be accomplished. A cold shutdown would involve turning off all power, securing the system, and sealing the vacuum system so that there is no throughput. Some decontamination would be required, which would result in generation of radioactive waste. If the RTNS were to be decommissioned, costs in the range of $3 million to $6 million could be incurred.

Transuranic (TRU) Wastes

LLNL generates between 150 and 250 m^3 of TRU wastes per year. Most TRU wastes originate in the Plutonium Building (332) and the Heavy Element Building (251). Very little is generated from the rest of the LLNL facilities.

TRU waste is segregated from non-TRU waste in accordance with DOE Order 5820.2. Approximately 95 percent of TRU waste is contaminated by plutonium isotopes ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, and ^{242}Pu. The remaining TRU waste is contaminated by radionuclides such as ^{241}Am, ^{237}Np, ^{244}Cm, ^{248}Cm, ^{250}Cf, ^{252}Cf, and possibly some fission by-products.

Liquid wastes containing less than 150 mg/l plutonium from the Plutonium Facility are solidified at the decontamination facility (Building 419). Approximately 2 drums/year of solidified TRU waste are generated. Higher concentration plutonium wastes are either processed for plutonium recovery or solidified in glove boxes in Building 332. One-gallon paint cans which contain the solidified TRU waste are then packaged in 55-gallon (17 C galvanized steel) TRU waste drums.

By volume, contaminated trash is the predominant TRU waste. This consists of solid materials such as wiping tissues, paper, plastic, chemistry glassware, ceramics, metals, and small quantities of solidified metals or sludge. Contaminated trash TRU waste packages are sealed in 55-gallon TRU drums. Approximately 200 to 300 drums/year are produced.

Objects which, because of size, cannot be packaged in 55-gallon drums are placed into specified DOT 7A 4 by 4 by 7 foot steel boxes. Larger boxes may be required for some larger equipment. Approximately 25 to 40 boxes/year are generated.

LLNL established a TRU Waste Certification Program so that TRU wastes could be accepted at the Waste Isolation Pilot Plant (WIPP). This plan was submitted May 1, 1986, and approved on October 6, 1986.

Waste Solidification - Radioactive Waste/Mixed Wastes

Various radioactive liquid wastes are solidified. Water-based liquids are solidified using Portland cement with added sodium silicate. Acids and alkalis are adjusted to a pH range of 6 to 8 prior to solidification. Oil- or solvent-based liquids are solidified with Envirostone. Solidified wastes are then packaged into drums and sent to NTS (if radioactive) or WIPP (if TRU) for disposal.

Most liquid wastes, including mixed wastes, are solidified at the B-513 Solidification Facility. During the time that the survey was carried out, the Solidification Facility was not operating, since new equipment was being installed. Start-up of the new facility was scheduled for early 1987.

Smaller amounts of radioactive liquid wastes are solidified in other facilities. Low-level plutonium-containing liquids (< 150 mg Pu/l) are solidified at the 419 Decontamination Facility. More concentrated plutonium liquids are solidified in glove boxes in Building 332 or processed to recover plutonium. All solidified plutonium wastes are packed in TRU drums. Small quantities of tritium-contaminated oils are solidified in Building 331.

Liquid radioactive wastes that will be solidified by the new facilities are now being stored at 514 for periods in excess of 90 days. These wastes include mixed wastes such as oils (which are a listed California waste), chlorinated solvents (listed by USEPA and California as hazardous wastes), and various acids and alkalis (which are EP toxic hazardous wastes). The storage area is not permitted as a hazardous waste storage facility.

Until 1986 all solidified liquid wastes were shipped to NTS. However, in the future only solidified mixed wastes (i.e., radioactive acids), which are hazardous owing to one or more characteristics, will be sent to NTS. The hazardous characteristic of corrosiveness, etc., is removed by the solidification process. Once treated so that the hazardous characteristic is removed, the waste is no longer considered a hazardous waste. Conversely, oils and solvents, which are listed wastes even after solidification, are considered hazardous by definition until a delisting petition has been applied for and granted. They will not be sent to NTS and are now being stored temporarily until a disposal option is found or until a delisting application is made and granted by California.

Depleted uranium (D-38) metal turnings were oxidized on a uranium burn pan located in Building 231 by Materials Management. The resulting sludge was solidified by Hazardous Waste Management in 514, and the burn pan wastewaters treated at the 514 Liquid Waste Treatment Facility. In the second quarter of 1986, the burn pan was decommissioned. A small quantity of uranium turnings was solidified without oxidation. In both cases the solidified D-38 was sent to NTS.

NTS will continue to accept D-38 that has been oxidized and solidified. However, D-38 that has only been solidified will not be accepted by NTS, because the waste would still be considered hazardous because of its reactivity.

Since the decommissioning of the burn pan, 63 drums of D-38 had accumulated at Building 514 as of November 1986, and the inventory was increasing at the rate of approximately 1 drum/week. These uranium turnings are stored under oil to keep the uranium wastes from spontaneously combusting. This property of unoxidized D-38 makes it a reactive hazardous waste. At this time, with the absence of any uranium oxidation facilities, there are no treatment or disposal options and storage takes place in an unpermitted hazardous waste storage facility at 514. The permitting status of this facility cannot be resolved until California receives authorization from EPA to implement the Federal RCRA program for mixed wastes.

4.1.1.3 Mixed Wastes

LLNL generates a variety of mixed wastes, including reactive uranium wastes, corrosives such as acid and alkalis, EP toxic wastes such as Dorr-Oliver filter cake sludges from the 514 Liquid Waste Treatment Facility, EPA-listed solvents, and California-listed oils.

Treatment methods used include metal oxidation and precipitation at the 514 Liquid Waste Treatment Facility and solidification, principally at 514, and, to a lesser extent, at generating sources. Commercial facilities are not used for the treatment or disposal of mixed wastes.

Solidified mixed wastes and Dorr-Oliver filter cake sludges were formerly shipped to NTS as mixed wastes. The practice ceased in early 1986 when NTS required generators to certify that wastes sent to NTS did not contain any hazardous constituents. Solidified mixed liquid wastes containing listed wastes and Dorr-Oliver filter cake sludges from 514 are being stored indefinitely at 612.

California does not have a mixed waste regulatory program. However, to retain the authority from EPA to run the RCRA program, California must implement a mixed waste program in 1987. The state is in the process of developing such a program.

Lack of a mixed waste regulatory program creates a gray area in the regulation of hazardous wastes. It is clear that a hazardous waste with radioactive constituents should be treated as a hazardous waste. However, facilities such as LLNL have not been pressed by regulatory agencies to apply for RCRA Part B permits for mixed waste treatment, storage, and disposal facilities. DOE had until May of 1987 interpreted statuatory exemptions in RCRA for by-product wastes to exempt DOE facilities from the procedural (i.e., permitting, recordkeeping) aspects of RCRA for by-product wastes and used the technical requirement of RCRA as a guideline for handling mixed wastes. In May of 1987 DOE agreed with EPA that the DOE regulations would apply to the radioactive portions of mixed wastes and RCRA regulations to the non-radioactive portion of wastes. Thus LLNL will have to comply with the procedural aspects of RCRA (i.e., permitting) and strictly adhere to the technical requirements for mixed waste.

The RCRA Part B application for LLNL at the Main Site and Site 300 included facilities that manage mixed wastes, such as the 514 Liquid Waste Treatment Facility and Pits 1 and 7 at Site 300. However, storage and solidification facilities for mixed wastes at 514 were not included in the application. These facilities and any treatment facilities for reactive uranium wastes will have to be considered for RCRA Part B permitting when California promulgates mixed waste regulations.

Section 4.1.1.1, Hazardous Waste Management, and Section 4.1.1.2 on Radioactive Waste Management give additional details on mixed waste management at LLNL.

4.1.1.4 Solid Waste

LLNL generates approximately 40 to 50 m^3 of waste per workday, which consists of shredded computer printout paper, waste paper garbage, wood, and construction rubble. Solid wastes without radioactive or hazardous constituents are segregated both at generating points, and at collection areas from wastes containing such constituents. They are then transported by LLNL personnel and equipment to the Alameda County Sanitary Landfill Site. Waste is covered daily with clean earth and compaction performed by large dirt-moving equipment. Radioactive and toxic wastes are not sent to the landfill.

4.1.2 Findings and Observations

4.1.2.1 Category I

None

4.1.2.2 Category II

1. Lack of Treatment/Disposal Alternatives for Mixed Wastes. The lack of treatment/disposal alternatives for mixed wastes increases the potential that such wastes may be mishandled, or that hazardous/radioactive constituents may be released by failure of containers during long-term storage.

   Mixed wastes such as Liquid Waste Treatment Plant Dorr-Oliver sludges are being stored in inadequate facilities at 612, which is not in full compliance with some RCRA regulations (see Finding 4.1.2.2.2). Wastes formerly sent to NTS are now being held at LLNL, since NTS no longer accepts mixed wastes. Commercial off-site disposal facilities cannot be used, since they would not accept wastes containing radioactive constituents.

   Reactive uranium wastes are being stored in an unpermitted hazardous waste storage area in the 514 Solidification Building. These wastes are stored under oil, which is also a listed California hazardous waste. The storage area has no secondary containment. In December 1986, approximately 54 drums were stored and more were being accumulated. Until the second quarter of 1985, Materials Management oxidized the uranium to remove the hazardous characteristic of reactivity in a burn pan in Building 231. Burn pan wastewaters were treated at the 514 Liquid Waste Treatment Facility. Oxidized uranium was solidified at

514 and sent to NTS. Since the pan was decommissioned, these reactive uranium wastes have been accumulating. Hazardous Materials Management has requested funding for purchase of a new burn pan.

Solidification facilities at 514 and some generating points had been used for treatment of various radioactive wastes, including mixed wastes such as solvents, acids, and metal-bearing wastes. The solidified wastes were sent to NTS for disposal. LLNL is now installing new solidification facilities. In the meantime, radioactive and mixed wastes are accumulating at 514 in an unpermitted hazardous waste storage facility.

NTS will no longer accept mixed wastes even if they are solidified. Therefore, once the solidification facility is back in use, solidified mixed wastes will no longer be shipped to NTS and will have to be stored at LLNL.

Classified wastes that are potentially mixed wastes are accumulating in the 234 Classified Storage Facility. This facility is designed for classified material storage and not for waste storage. The storage area is already crowded, and additional containers of waste are accumulating. These classified wastes have not been tested for hazardous characteristics because of the physical nature of the waste. Hazardous Waste Management is investigating shredding techniques to both put the waste into a form suitable for testing and to reduce the waste volume.

Construction of a Decontamination and Waste Treatment Facility (DWTF) has been proposed. This facility would treat virtually all mixed or hazardous wastes generated by LLNL. The conceptual design report was issued in March 1985. However, funding of the plant ($38,000,000) has been delayed. Start-up of the plant is now projected to be in 1990 or 1991 if funding is obtained in the next fiscal year. In the interim, mixed wastes will continue to accumulate on-site.

2. 612 Storage Facilities. Inadequate storage facilities for hazardous/radioactive/mixed wastes at 612 can result in accelerated deterioration of containers and releases of hazardous radioactive constituents to the ground or surface water in the event of a spill.

- Lack of adequate roofed area in the waste staging area and any roofed area in the waste storage areas results in waste containers being exposed to rainfall and sun and thus increases the potential for deterioration of containers and subsequent release of their

contents. Rainfall can accelerate the corrosion of containers. The heat of the sun can cause contents of the containers to expand to the point where the container ruptures. Since incompatible wastes may be stored in proximity to each other in the staging area, ruptures of containers could result in the mixture of incompatible wastes.

- Lack of bermed containment in certain waste storage areas at 612 could result in the release of hazardous/radioactive wastes or constituents to the stormwater drain, such as oils, solvents, and metals.

  The staging area where wastes are temporarily stored after the weekly waste pick-up run prior to segregations is bermed on all four sides. However, one corner of the berm adjacent to the fence was removed during construction activities. Runoff from the staging area would enter the stormwater system. Survey-related sampling is planned.

  The segregated storage area next to the tent had a berm on only three sides. The labpack waste storage area and drumming operation area did not have berms.

- Cracked asphalt surfaces throughout 612 could result in the release of hazardous/radioactive wastes or constituents to the subsurface in the event of a spill. This was particularly evident in the waste staging area, waste storage areas, and the receiving yard. The asphalt surface was not designed for heavy loads or for maintaining integrity on the claylike subsurface. Cracks are present throughout the paved areas. Releases of hazardous waste could contaminate the subsurface via cracks in the pavement.

  The lack of adequate fire detection and suppression systems in the receiving and storage areas could result in the release of hazardous/radioactive constituents to environment in the event of a fire. The 612 facility receives and processes flammable wastes and reactive wastes. In the event of a fire or spontaneous combustion of a waste, existing fire detection and suppression systems may not be adequate for proper control.

  LLNL is in the process of building a second hazardous waste storage yard. However, this new facility will be used for the storage of hazardous wastes destined to be shipped to commercial treatment or disposal facilities. Initial waste staging and long-term storage of mixed and radioactive wastes will continue to take place at 612.

4.1.2.3 Category III

None

4.1.2.4 Category IV

1. Waste Accumulation Areas (WAAs). Lack of proper containment, cracked surfaces, and inadequate rainfall protection in waste accumulation areas used for temporary storage of hazardous/radioactive wastes could result in the release of hazardous radioactive constituents in the event of a spill.

   The existence of numerous individual hazardous/radioactive/mixed waste generating operations at LLNL has resulted in the need for areas where wastes can be accumulated. There are approximately 35 WAAs at the Main Site and more than 20 at Site 300. Wastes may be transported in solid or liquid form, in carboys, drums, bottles, packages, etc., from individual labs or facilities to a WAA. Sometimes drums in WAAs may be filled from smaller containers with oils, solvents, etc. Waste pick-ups are made from these areas on a weekly basis, if requested by the responsible health and safety technician, for shipment to the 612 Waste Storage and Handling Facility.

   California and USEPA hazardous waste regulations allow the temporary (less than 90 days) accumulation of wastes in WAAs. Standards for accumulation of wastes in these areas call only for proper labeling of hazardous waste containers, noting accumulation start dates and storage for less than 90-day storage. Requirements for containment, impermeable surfaces, and run-on/run-off controls, which apply to permitted storage areas, do not technically apply to WAAs. Since the wastes in the WAAs typically pose the same hazards as wastes in permitted storage areas, not implementing the above requirements increases the potential for a release of hazardous or radioactive constituents from WAAs. The degree of environmental protection afforded by WAAs was inconsistent throughout the site. Waste accumulation areas at Site 300 were often quite deficient or poorly maintained. WAAs in the Magnetic Fusion Energy program often were not officially designated by LLNL nor properly used.

Instances of improper use or inadequate physical construction of WAAs observed during the Survey include the following:

- 261: WAA not designated or marked
- 151: No containment
- 281: No containment
- 511: WAA not designated - WAA being built
- 231: Liquid waste tank, no containment, leakage (depending on location) would partially go to sump.
- 234: No containment
- 879: (Site 300) No containment, cracked surface
- 893: (Site 300 Storage yard) Drums of waste oil stored outside designated area
- 875: (Site 300 Maintenance Mech. Area) Poor housekeeping, no containment, poor base, evidence of leakage stains)
- 875: (Site 300, Paint Shop Area) No containment, poor surfaces
- 801: (Site 300 Corp Yard Area) No containment, gravel surface, no roofing
- 169: Liquid waste not placed in WAA on available skid, which had containment.
- 431: No containment
- 431: (East) Unofficial WAA, no containment
- 432: (East) Unofficial WAA
- 438: Unofficial WAA
- 442: Cracked base
- 321: Plating shop plating waste tank - no containment
- 322: No containment
- 151: No containment

2. B-322 - Hazardous Waste Containment. Lack of secondary containment and sufficient storage capacity for the tank storing 322 Plating Shop hazardous wastes has resulted in the release of wastes from the tank.

Plating solution spills and rinsewaters containing listed and characteristic hazardous wastes are released into the floor sump in the 322 Plating Shop. Solutions from this sump are pumped into a tank outside the plating shop. This tank in turn is periodically pumped by Hazardous Waste Management for shipment to off-site commercial treatment facilities. Overfilling of this tank has occurred as evidenced by stains down the sides of the tank.

Discussion with plating shop personnel indicated that such overfilling occurs periodically, usually as a result of excessive build-up of liquids in the plating shop sump which are discharged to the tank. Spillage from overfilling the tank would not be contained, since there is no secondary containment.

In most areas of the laboratory where tanks are used to store hazardous waste or wastewaters potentially containing hazardous wastes, the tanks are paired. The paired tanks may either be in below-ground sumps or, if they are above ground, they have secondary containment. When one tank is full and being sampled, the second tank is used. Requests have been made for appropriations to build a second tank and diked containment for the B-322 shop tank.

3. Hazardous/Mixed/Radioactive Waste Transportation. On-site transportation of hazardous/mixed/radioactive wastes in an open flatbed truck without side restraints increases the possibility that in the event of an accident, containers would fall from the truck, rupture, and release hazardous or radioactive constituents into the environment. Since incompatible wastes may be transported in the same load, rupturing of containers could result in the mixing of incompatible wastes.

   A 4-foot-high flatbed truck is used during the Main Site weekly waste pick-up run. Drums of waste placed on pallets are banded together and placed on the truck with a forklift. The truck proceeds from one waste accumulation area to another until it is full.

4. Laboratory Closure Procedures. Lack of laboratory-wide closure procedures for individual laboratories or facilities can result in mishandling of unknown wastes and chemicals with increased potential for inadvertent releases into the environment. Chemicals and unknown wastes often accumulate in laboratories or facilities that are no longer active because of termination of funding or completion of the project.

   Clean-up and disposal of discarded chemicals and wastes is not handled in a consistent manner throughout the laboratory. In the Chemistry Program, the health and safety technician cleans the laboratory and arranges for disposal of chemicals and wastes if the laboratory is not properly cleaned by the departing experimenters. In the Laser Program, cleanup of shutdown laboratories with accumulations of chemicals and wastes is the responsibility of the incoming experimenters who will be occupying the space. In most cases, neither the health and safety technician nor incoming experimenter will be as familiar as the former experimenter with the

nature of the wastes and chemicals in the laboratory. This can present special problems at a laboratory facility like LLNL, where the use of radioactive and toxic substances is widespread.

5. Building Sanitary Discharge Analysis-Hazardous Constituents. The lack of a building-specific sanitary effluent monitoring program could allow the discharge of hazardous wastes into the sanitary system to go undetected.

Most buildings where hazardous/radioactive wastes are generated have sinks that are directed to the sanitary system and other sinks that are directed to the retention tank system. Typically signs posted over the sink indicate whether the sink is plumbed to retention tanks or to the sanitary system (see Findings 3.3.4.4.1,2,3 and 5). LLNL does not have a program for periodic analyses of monitoring effluents from individual buildings to determine if wastes are being improperly disposed of into the sanitary system. The incentive for "unauthorized discharge" of wastes to the sanitary system may increase if a planned waste chargeback system is implemented (see Finding 4.1.2.4.6). Survey-related sampling is planned.

6. Retention Tank Access. Unlimited access to retention tanks could allow unauthorized discharging of hazardous/mixed wastes into retention tanks.

LLNL uses retention tanks to receive process and laboratory wastewaters that may contain hazardous/radioactive constituents. Each tank receives wastewaters from a particular building. Most tanks are paired so that while one full tank is being analyzed to determine treatment and disposal options (e.g., treatment of the 514 Liquid Waste Treatment Facility or an off-site commercial treatment facility, or sewer direct discharge to the sanitary system), the other tank can be filled.

Many retention tanks are directly accessible through unsecured access plates, through which hazardous/radioactive wastes could be directly poured into the tank. The analytical protocol, which is tailored for each retention tank, may not detect unauthorized discharges. In addition, unauthorized discharges could go undetected if they occur after a sample is taken.

The incentive for unauthorized discharges of wastes may increase if a planned hazardous/radioactive/mixed waste treatment/disposal cost chargeback system is adopted. Individual program areas and projects would be charged for treatment/disposal costs in an effort to encourage waste minimization at the generating source. This chargeback system is being

considered because of the dramatically increasing costs for off-site treatment of hazardous wastes and the lack of any disposal facilities for mixed wastes.

7. Hazardous Waste Training. Lack of a formal training program for generators of hazardous/mixed/radioactive waste at LLNL may lead to the mishandling and improper use or disposal of such wastes.

LLNL has many individual facilities generating hazardous waste and, consequently, many individual generators of hazardous waste. These individual generators are responsible for the initial classification, collection, and packaging of hazardous/radioactive/mixed wastes and transportation to the designated waste accumulation area.

Evidence that generators do not always handle waste properly is described below:

- Available containment is not properly used in waste accumulation areas at Building 169; solid wastes were placed on pallets with containment, while liquid waste containers were on the ground and not even located within the designated WAA.
- Overfilling of plating shop waste tank occurs at the 322 Plating Shop.
- Wastes are placed outside the designated WAA (Building 893).
- Shutdown laboratories and facilities are not always properly cleaned, and wastes are not properly disposed of by experimenters.

Training of health and safety technicians and hazardous waste management personnel appears to be adequate. Individual generators generally were aware of proper waste handling techniques for radionuclide-containing wastes, but not for hazardous wastes. LLNL does not have any training program on hazardous waste handling techniques and requirements for individual generators. Neither Operation Safety Procedures (OSPs), which are procedures for individual operations, nor Facility Safety Procedures (FSPs), which are produced for entire facilities, discuss in any detail the specific hazards or handling techniques for hazardous waste.

8. Mixed Waste Storage and Treatment Facilities. Mixed wastes containing liquids are being stored in an unpermitted, non-contained storage area in B-514, a practice which results in a

potential for release of hazardous constituents. Practices required by hazardous waste regulations, such as diking and inspections to minimize the potential for release of hazardous wastes or constituents, are not in place. These are likely to be required once California receives authorization to regulate mixed wastes.

LLNL generates a variety of mixed wastes, including reactive uranium wastes, corrosives such as acids and alkalis, EP toxic wastes containing leachable metals, EPA-listed solvents, and California oils. All these wastes contain D-38 or tritium.

The primary treatment method for mixed liquid wastes is solidification; the main solidification facilities are at the 514 Liquid Waste Treatment Facility, although small quantities of mixed wastes may be solidified using Portland cement with added sodium silicate. Acids and alkalis are adjusted to a pH range of 6 to 8 prior to solidification. Oil and solvent-based liquids are solidified with Envirostone.

Low-level plutonium-containing liquids (< 150 mg/l) are solidified at the 419 Decontamination Facility. More highly concentrated plutonium liquids are solidified in glove boxes in 332. Small quantities of tritium-contaminated oils are solidified in 331.

Approximately 3,000 cubic feet of solidified wastes are produced monthly at 514 when the solidification facilities operate. These solidified wastes were all formerly shipped to NTS. However, in early 1986, NTS stopped accepting any radioactive wastes unless the generating facility certified that the wastes did not contain any hazardous constituents. Therefore, LLNL can no longer send solidified mixed wastes to NTS unless the hazardous characteristic has been removed prior to solidification. Corrosives such as acids and alkalis neutralized prior to solidification could be shipped. Listed wastes such as oils, solvents, etc., could not be shipped even when solidified. Long-term storage will be required until mixed waste disposal facilities are available.

Materials Management oxidized depleted uranium (D-38) metal turnings in a uranium burn pan located in Building 231. Burn-pan sludge was solidified in 514 and burn-pan wastewaters treated in the 514 Liquid Wastewater Treatment Facility. Solidified sludges were sent to NTS. In early 1986 (second quarter), the burn pan was decommissioned. Since the decommissioning of the pan, 63 drums of D-38 had accumulated at 514 by November 1986, with the inventory increasing by 1 to 2 drums/week. These uranium turnings are stored under oil (itself a

California-listed hazardous waste when wasted) to prevent the reactive uranium from combusting.

4.2 Toxic and Chemical Materials

4.2.1 General Description of Pollution Sources and Controls

The Toxic Substances Control Act (TSCA) of 1976 enables EPA to develop adequate data on the effects of chemicals on health and the environment and to regulate the use of toxic chemicals to reduce unreasonable risk of injury to health or the environment. It grants EPA the authority to (1) require industry to provide information on chemicals used and manufactured; (2) require industry to test the health and environmental effects of chemicals used and manufactured; and (3) control production, distribution, use, and disposal of certain chemicals that cause unreasonable risk of injury to health and the environment.

Regulations published to date cover two major areas: reports to EPA and restrictions on the production, use, and disposal of specific substances. Under the reporting requirements, facilities must notify EPA of any chemicals exported and report their inventory of imported and manufactured chemicals. In addition, facilities must submit safety, health, and environmental data on specific substances. The restrictions on production, use, and disposal cover polychlorinated biphenyls (PCBs), asbestos, polybrominated biphenyls (PBBs), 2,3-dibromopropyl phosphate, fully halogenated chlorofluoroalkanes, and waste material containing tetrachlorodibenzo-p-dioxin (TCDD).

At LLNL, the DOE Environmental Survey covered PCBs, asbestos, fully halogenated chlorofluoroalkanes, and pesticides/herbicides. In addition, the handling of waste lithium hydride and the storage of drums of boron were also addressed.

PCB Sources

The LLNL 1985 Annual Report (Griggs and Buddemeier, 1986) identifies 12 PCB transformers and 1,985 capacitors on-site. The total weight of PCBs is 4,395 kilograms. Transformers are located in or near Buildings 151, 431, 381, 391, and 423. The capacitors are located throughout the LLNL facilities. No other PCB equipment was identified on-site. All current operating PCB equipment is labeled according to current TSCA regulations as well as security fences and access doors.

LLNL had one recent, small, PCB spill in 1985 when a transformer in the 618-619 salvage yard began to leak. The material spread over an area of approximately 1 square foot and was properly cleaned and disposed of. After removal of the stained soils, analysis showed the PCB levels to be less than 1 part per million (ppm). LLNL does not conduct effective inspection of its PCB equipment, as evidenced by the leaking equipment and combustibles found near the PCB transformers that were identified during the Survey.

Building 625 is designated as the PCB storage area for LLNL. This area is well maintained and has a 6-inch continuous dike. The HWM group is responsible for operating this area. PCB equipment that is disposed of from 625 is properly manifested and sent to off-site contractors approved by the EPA.

Asbestos Sources

Asbestos materials are present throughout the LLNL facility. The majority of asbestos has been used for insulation. Some of the buildings with active asbestos removal projects include B-131, B-222, and the old barracks area. Asbestos removal projects are conducted according to NESHAPS regulations. LLNL Industrial Hygiene personnel monitor these projects to ensure that the removal personnel are conducting the project according to regulations. After material is double-bagged and crated, it is stored at the on-site waste storage areas before shipment to a state-approved, off-site disposal area. The on-site building areas are asbestos-labeled. Amounts removed per year varied greatly. No estimates were available.

Chlorofluoroalkane Sources

Refer to Section 3.1.2 for a discussion of chemicals in this category.

Pesticide/Herbicide Sources

A total of 230 gallons and 1,028 pounds of pesticides were used on the Main Site in 1986. These include Roundup, Fore, Princep, Surflan, Lorox, Ronstar, Talon, and Orthene. These are stored in Buildings 519, 520, and 294. Records for this operation are maintained by LLNL personnel in Building 519.

At Site 300, the major pesticides used are Fumarin, Ditchacinon, Hyvar-x, Kro-var, and Amitrol. These are stored in Building 841. The mixing area in 819 is plumbed to a retention tank. Since this tank is

not analyzed for pesticides, there is no way to track a spill from this area. No restricted pesticides are used at LLNL.

All applicators are state licensed and attend training courses on a regular basis. All storage areas are secured, diked, and well maintained. The application of pesticides is conducted according to the direction given by the producers of each individual product.

At both sites, containers are triple rinsed, and washings are added to the batch being applied. Containers are then sent to HWM.

Other Toxic Material Sources

Lithium hydride waste is occasionally generated at LLNL and stored in the 612 Storage Area before ultimate disposal.

Nine drums of elemental boron are stored in the surplus equipment warehouse at Camp Parks. Two drums of elemental boron are stored in the equipment warehouse at the Sunshine Building.

4.2.2 Findings and Observations

4.2.2.1 Category I

None.

4.2.2.2 Category II

1. PCB Transformer Releases and Storage. The following PCB transformers were identified as having leaks and/or combustible materials near them:

Transformer	Location	Problem	Status
740	151	Drip pans with oil/combustibles nearby	Corrected 12/18/86
741	151	Drip pans with oil/combustibles nearby	Corrected 12/18/86
PLC0832	431	Oil and grit around valve	Awaiting analysis
104	431	Evidence of oil leak near drain valve as evidenced by discoloration of sorbent.	No action
341	381	Drip on bottom of drain valve	No action
342	381	Chronic leak since 1981; oil in drip pan and on side of transformer	No action
108	423	Combustibles stored nearby	Corrected as of 12/18/86

2. PCB Capacitor Release and Improper Storage. A leaking capacitor was identified in room 1931 (Building 231). Subsequent analysis was positive for PCBs. A bank of nine PCB capacitors was identified as being stored in the non-PCB storage area at 612. In addition, no PCB labels were in place. These capacitors were scheduled for subsequent removal. One PCB capacitor was improperly stored outside of 423. Provisions had been made to remove it, but as of December 19, 1986, the unit was not stored properly.

4.2.2.3 Category III

None

4.2.2.4 Category IV

1. Elemental Boron. Nine drums of elemental boron are being stored at Camp Parks and two drums of elemental boron are being stored at the Sunshine Building. Camp Parks and the Sunshine Building are surplus equipment warehouses and are not appropriate places to store these materials. Elemental boron is a flammable material (Sax, 1984).

2. PCB Capacitors. Several pallets of capacitors, in storage at Camp Parks, are not labeled either PCBs or non-PCBs. Records indicate that the capacitors do not contain PCBs; however, the absence of labels could create confusion during a PCB inspection or emergency situation.

3. Pesticide Spills. According to program personnel at Building 819, there is no mechanism for alerting the HC safety technician when there is a pesticide spill in the pesticide mixing area.

The mixing area has a drain plumbed to a retention tank, which is not routinely analyzed for pesticides. This could result in the release of contaminated retention tank effluent to the sanitary sewer.

4. Lithuim Hydride. A 5-gallon drum of lithium hydride (LiH) is being stored in the B-612 area in a manner that allows water to collect on it. LiH is reactive with water and could cause a fire in the mixed waste storage area. This situation was corrected December 18, 1986.

5. PCB Reports. Annual PCB reports for 1980 and 1981 show that 434 capacitors are unaccounted for. (Although not an environmental problem, this accounting error could result in a fine.)

6. PCB Leaks. PCB leaks are not being cleaned up within 48 hours. This could result in a larger PCB clean-up as well as a fine.

4.3 Radiation

4.3.1 Background Environmental Information

The LLNL radiation site setting can be described as a subset of each of the previous media settings (i.e., air, soils, hydrogeology, and surface waters). Each of these primary pathways is responsible for radionuclide transport and ultimate contamination of vegetation, food, ambient air drinking water, and soils.

Background radiation in the vicinity of LLNL is a consequence of both natural and man-made sources. These sources include cosmic radiation, natural radioactive materials in the soils and building materials, fallout from past atmospheric weapons detonations; releases of radioactive materials from nuclear power plants and other facilities handling radioactive materials worldwide; and the intake of radioactive materials in food, drinking water, and air. The most significant exposure is that to the lungs from background levels of radon. The annual average effective dose equivalent for natural background in the United States is approximately 189 millirem/year (mrem/yr) (United Nations, 1982). This dose is detailed in Table 4-9. About one-half of the dose equivalent is attributable to the inhalation of radon-222 and its decay products. Previously accepted estimates of background doses did not include the radon contribution and were set at about 100 mrem/year.

The data in Table 4-9 were derived in accordance with the approach recommended by the International Commission for Radiation Protection (ICRP) in ICRP Reports 26 and 30. This approach

TABLE 4-9

AVERAGE ANNUAL EFFECTIVE DOSE EQUIVALENT TO HUMANS FROM NATURAL BACKGROUND RADIATION LAWRENCE LIVERMORE NATIONAL LABORATORY LIVERMORE, CALIFORNIA

Organ	Annual Effective Dose Equivalent (mrem)
Gonads	24
Breast	14
Lung (Total)	100
Red Bone Marrow	13
Bone Surfaces	6
Thyroid	3
Other	29
Total(1)	189

Source: United Nations, 1982.

(1) Total represents the product of the appropriate weighting factor times the annual dose equivalent for pulmonary, trachial/bronchial, and mean doses.

allows direct comparison of the effective dose for different organs by reflecting the distribution of and organ sensitivity to various radionuclides. This is accomplished by applying "weighting factors" to the doses received by individual organs. The weighting factors are expressed as the fraction of the total risk for the entire body attributable to the organ. The sum of the dose equivalents for the individual organs provides an estimate of the total effect of the radiation on the whole body.

The EPA reports gamma radiation dose rates on a quarterly basis for select locations throughout the United States in Environmental Radiation Data (EPA, 1986). During the most recent reporting period of January - March 1986, measured dose rates equivalent to an annual dose of approximately 70 mrem ± 3.6 mrem were reported for the Berkeley, California, monitoring location. Although the Lawrence Livermore Main Site has not selected any one TLD monitoring station as a "background" station, averages of 55 Livermore Valley TLD locations indicated annual dose rates of approximately 60 mrem ± 11 mrem (Griggs and Buddemeier, 1986). Background or perimeter gamma radiation doses cannot be reported for Site 300 because there is no TLD monitoring program in place.

As required by DOE Order 5484.1, Chapter III, 4d2d1-3, LLNL conducts an annual "assessment and reporting of potential dose to the public." In 1985 DOE adopted an interim radiation protection standard for environmental activities to be implemented in calendar year 1985 (DOE, 1985c). It is DOE policy to follow the guidance of the National Council on Radiation Protection and Measurements (NCRP) to the extent practicable with respect to radiation protection standards. A comprehensive revision of previous NCRP recommendations on a basic radiation protection system is still under development. However, current NCRP guidance is available regarding protection of the public in its September 18, 1984, advice to the Environmental Protection Agency published under the title "Control of Air Emissions of Radionuclides." In this document, the NCRP endorses the recommendation of the International Commission on Radiological Protection (ICRP) to limit the continuous exposure to any member of the public from other than medical sources and natural background to 100 mrem per year whole body dose-equivalent. The previously recommended limit of 500 mrem per year is retained for non-continuous exposures. This recommendation is now adopted as an interim standard for DOE environmental activities for the sum of all exposure pathways.

Radiation exposures are received from external sources and from radionuclides taken into the body by inhalation of air and ingestion of water and foodstuffs. Radionuclides taken into the body will continuously irradiate the body until they are removed through either radioactive decay or metabolic processes. Consequently, internal dose estimates are calculated as "50-year dose commitments." These are obtained by integrating the total dose received by an individual's body

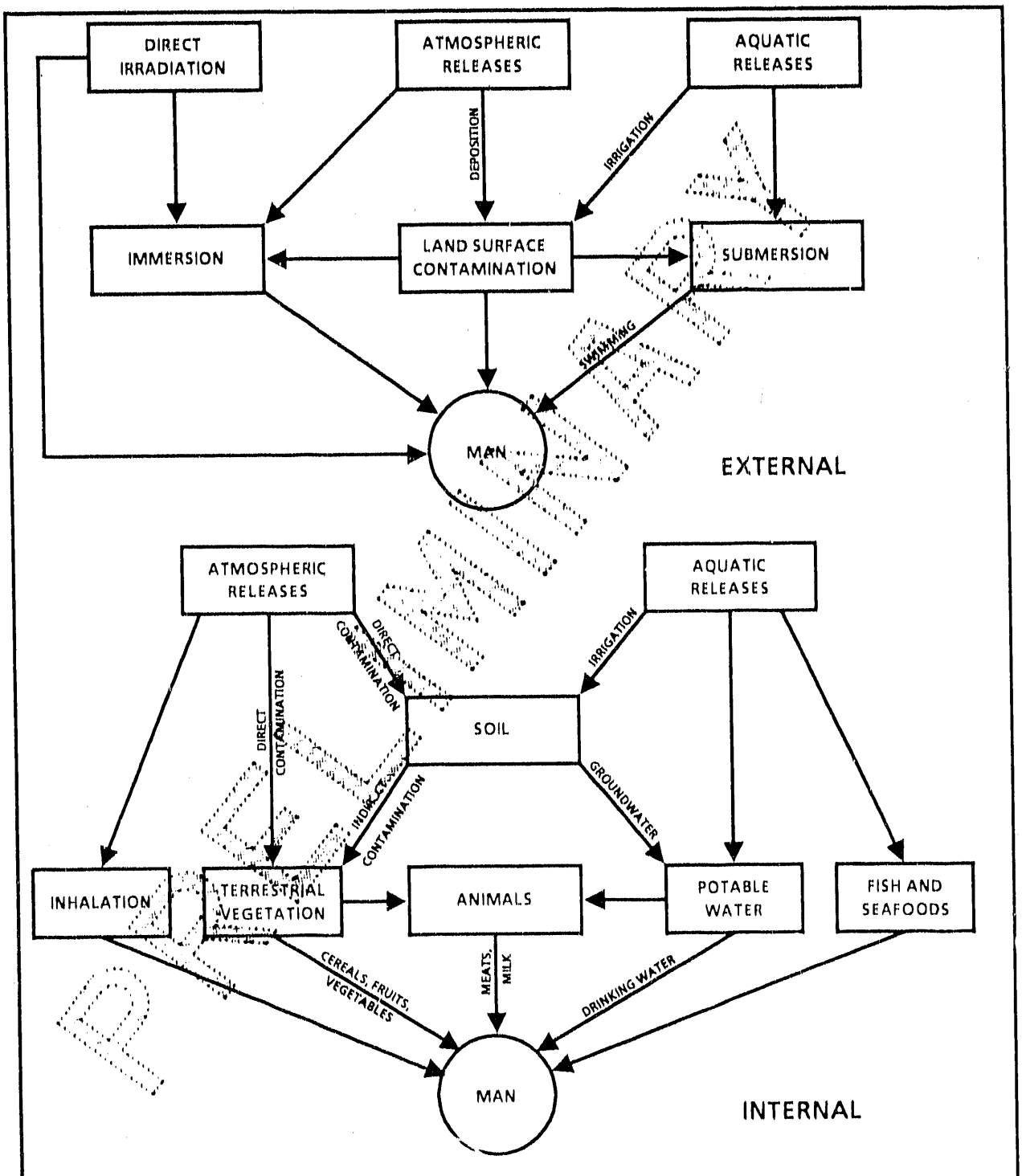
over an assumed remaining lifetime of 50 years. Principal pathways for exposure of humans from radionuclides released from LLNL are shown in Figure 4-1. The doses to the various major organs are considered for various exposure pathways. The radiation doses received by a specific organ are weighted and summed to determine the total dose.

4.3.2 General Description of Pollution Sources and Controls

Aerial radiation surveys conducted in August 1975 to characterize radiation emission sources indicate major sources of gamma emissions from accelerator operations (Main Site and Site 300), waste storage areas, radiography areas, plus numerous other sources that have been decommissioned or are no longer operational. These surveys indicate the greatest off-site (outside perimeter fencing) exposure rates to be < 1.0 to 2.0 microrem/hour (μrem/hr) (~ < 9 to 18 mrem/year) above background at the Main Site and < 1.0 mrem/hour (~9 mrem/year) above background at Site 300. An updated aerial radiation survey has been conducted and should be available soon. Comparison of these updated survey results with the results from the 1975 survey will indicate or be affected both by changes due to new construction and by operations (various program activities).

The major source of penetrating radiation closest to perimeter fencing and therefore most important, from an uncontrolled public access exposure standpoint, is the insulating core transformer (ICT) rotating target in Building 212. Increased evaluations of this source relating to potential exposure were conducted as a result of the removal of shielding equipment. Table 4-10 summarizes environmental monitoring data in comparison with appropriate limits and guidelines. As can be seen from the data, even with continued exposure at the fence line for 24 hours/day, 365 days/year, the maximum calculated 1986 dose would be 28.5 percent of the DOE limit and 15.1 percent of the national average background, including radon exposure. Proposed acquisition of the East Avenue property between LLNL and Sandia National Laboratories Livermore (SNLL) would probably eliminate Building 212 as a point of concern relating to public direct radiation exposure.

Immersion, or external penetrating radiation exposure from radionuclides in air, and external penetrating radiation exposure from radionuclide land surface contamination, also known as ground-plane irradiation, are additional direct radiation issues. Environmental TLD monitoring programs, in conjunction with soil radionuclide monitoring of the Livermore Valley, demonstrate that public exposure is well below permissible limits and is essentially indistinguishable from background levels.



SOURCE: Adapted by DOE Survey team.

FIGURE 4-1

PATHWAYS FOR EXPOSURE OF MAN FROM
ATMOSPHERIC AND AQUATIC RELEASES OF RADIOACTIVE EFFLUENTS
LLNL – LIVERMORE, CALIFORNIA

TABLE 4-10

PERIMETER GAMMA AND NEUTRON EXPOSURE FROM BUILDING 212 OPERATIONS
1986
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Monitoring[1] Location	Gamma Measured Dose (mrem)	Neutron Measured Dose (mrem)	Background[2] (Gamma only in mrem)	Combined Dose Excluding Background (mrem)	Percent of DOE 100 mrem Guide	Percent of [3] U.S. Average Background
11 & 5	56	7.1	62	1.1	1.1	0.5
12 & 3	61	29.5	62	28.5	28.5	15.1

Source: Developed by DOE Survey team.

1 See Figure 4-2
2. Background measurements are considered to be the annual average of the Livermore Valley TLD results.
3. See Table 4-9

As expected, on-site soil sampling at Site 300 indicates higher ^{238}U concentrations than Livermore Valley off-site sampling results (see Soil Section, Figures 3-18, 3-19, and Tables 3-7 and 3-8); however, lack of an environmental TLD monitoring program in conjunction with off-site sampling at Site 300, prevents continuous documentation of acceptable penetrating radiation levels. Ground-plane irradiation is not a significant dose contributor at the Main Site and is not suspected to be a significant dose contributor at Site 300.

Primary sources of radionuclide usage and potential environmental concern are listed in Table 4-11. LLNL control technologies for radioactive effluents fall into three basic categories, depending on the physical state of the radionuclide and the media. Particulate emissions in air streams are primarily controlled by HEPA filtration. Gaseous and vapor air emissions (primarily tritium gas and tritiated water) are catalytically oxidized (HT or TT to HTO) followed by molecular sieve trapping. The primary control technology employed to limit emission to surface water is the use of retention tanks at facilities with the potential to generate radioactively contaminated liquid wastes. Retention tank contents are analyzed, evaluated for compliance with appropriate standards, and then either discharged to the sanitary sewer system or treated at the Hazardous Waste Treatment Facility for proper radioactive waste disposal.

4.3.3 Environmental Monitoring Program

Direct radiation is measured in several ways at the Main Site. Penetrating gamma radiation is measured using TLDs at the site perimeter (fence line) in 22 locations, including triplicate cluster locations, for precision analysis. Environmental neutron dose-rate measurements are also made at the fence line in eight locations using ^{235}U track etch detectors (see Figure 4-2) (Griggs and Buddemeier, 1986). Additionally, another 55 locations are monitored for gamma radiation in the Livermore Valley (Figure 4-3).

Mean annual measured doses for the Main Site perimeter and Livermore Valley gamma radiation (1985) were 59 mrem ± 6 mrem and 60 mrem ± 11 mrem, respectively. Both of these compare favorably with the 70 mrem ± 3.6 mrem measurements reported earlier in this section by EPA. The mean annual measured neutron dose for the 1985 Main Site perimeter was 5.2 mrem ± 1.1 mrem. This entire dose is presumably attributable to Main Site operations, since no background neutron dose information is available, and if it were, would most probably be negligible.

Site 300 perimeter and off-site penetrating radiation cannot be fully assessed because of the lack of an environmental TLD monitoring program. Gamma emissions currently are primarily produced by

TABLE 4-11

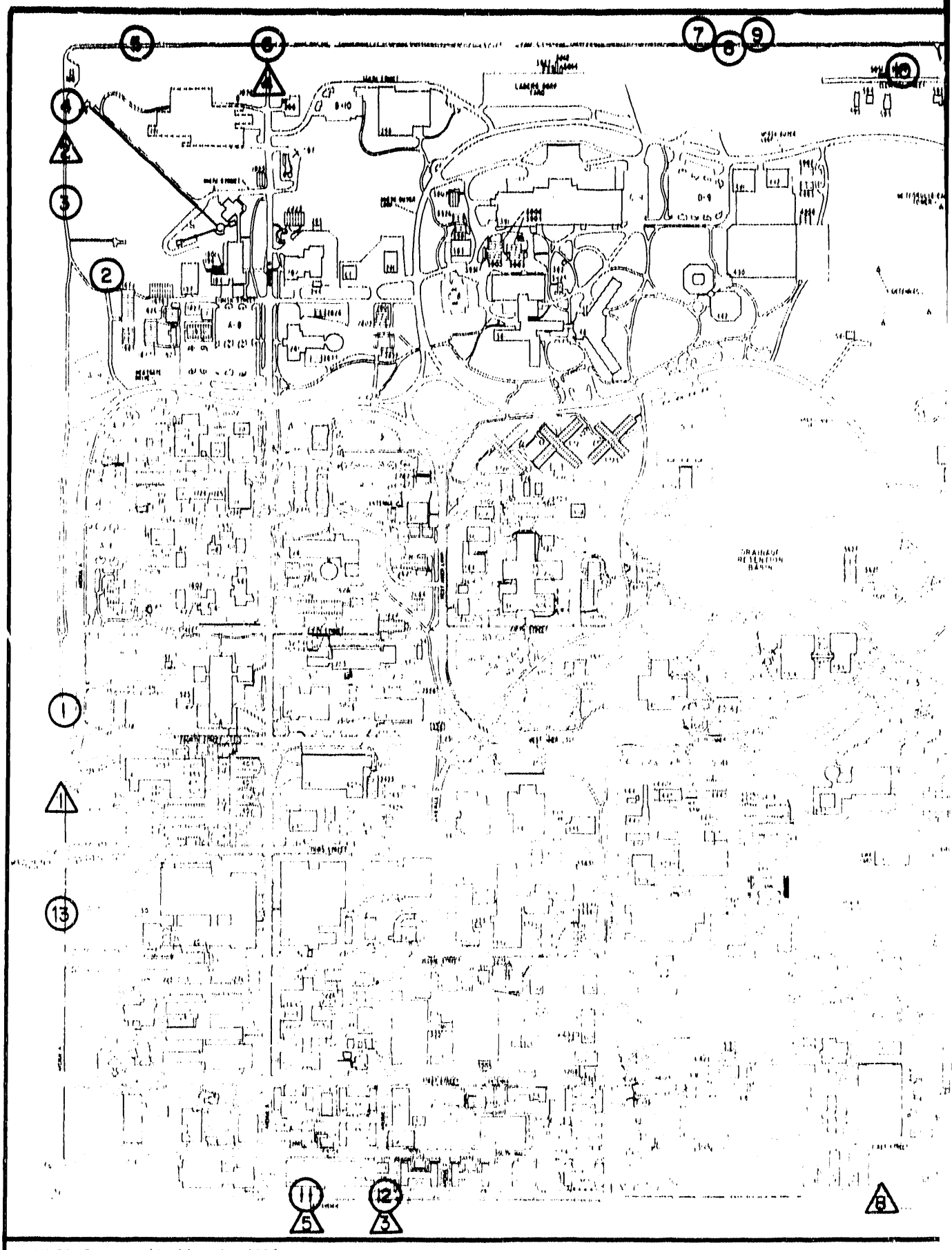
PRIMARY SOURCES OF RADIONUCLIDES
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Operation	Bldg. No.	Primary Activity	Radioactive Species of Concern	Primary Control Technology
Mass Uranium Enrichment Facility	175	Uranium isotope separation.	Uranium	HEPA Filters
Linear Accelerator	194	Accelerator experimentation	Nitrogen 13 Oxygen 15	HEPA filters and monitoring
Insulating Core Transformer	212	Rotating target experiments	Tritium	Catalytic oxidation
Controlled Material Vault	231	Receiving, shipping, and storage of isotopes.	Uranium Plutonium Other isotopes	HEPA Filters
Heavy Element Facility	251	Diagnostics for nuclear underground testing and basic research into heavy element behavior	Plutonium Uranium Curium	HEPA Filters
Rotating Target Neutron Source	292	Materials damage research.	Tritium	Partial catalytic conversion of HT to HTO followed by molecular sieves
Tritium Research Facility	331	Radioactive gas and related compound research	Tritium	Partial catalytic conversion of HT to HTO followed by molecular sieves
Plutonium Metallurgy Facility and Central Vault	332	Basic and applied research in Pu metallurgy; Pu-bearing engineering assembly testing; development of Pu fabrication techniques; storage of special nuclear materials.	Plutonium Uranium	HEPA Filters

TABLE 4-11
PRIMARY SOURCES OF RADIONUCLIDES
LLNL - LIVERMORE, CALIFORNIA
PAGE TWO

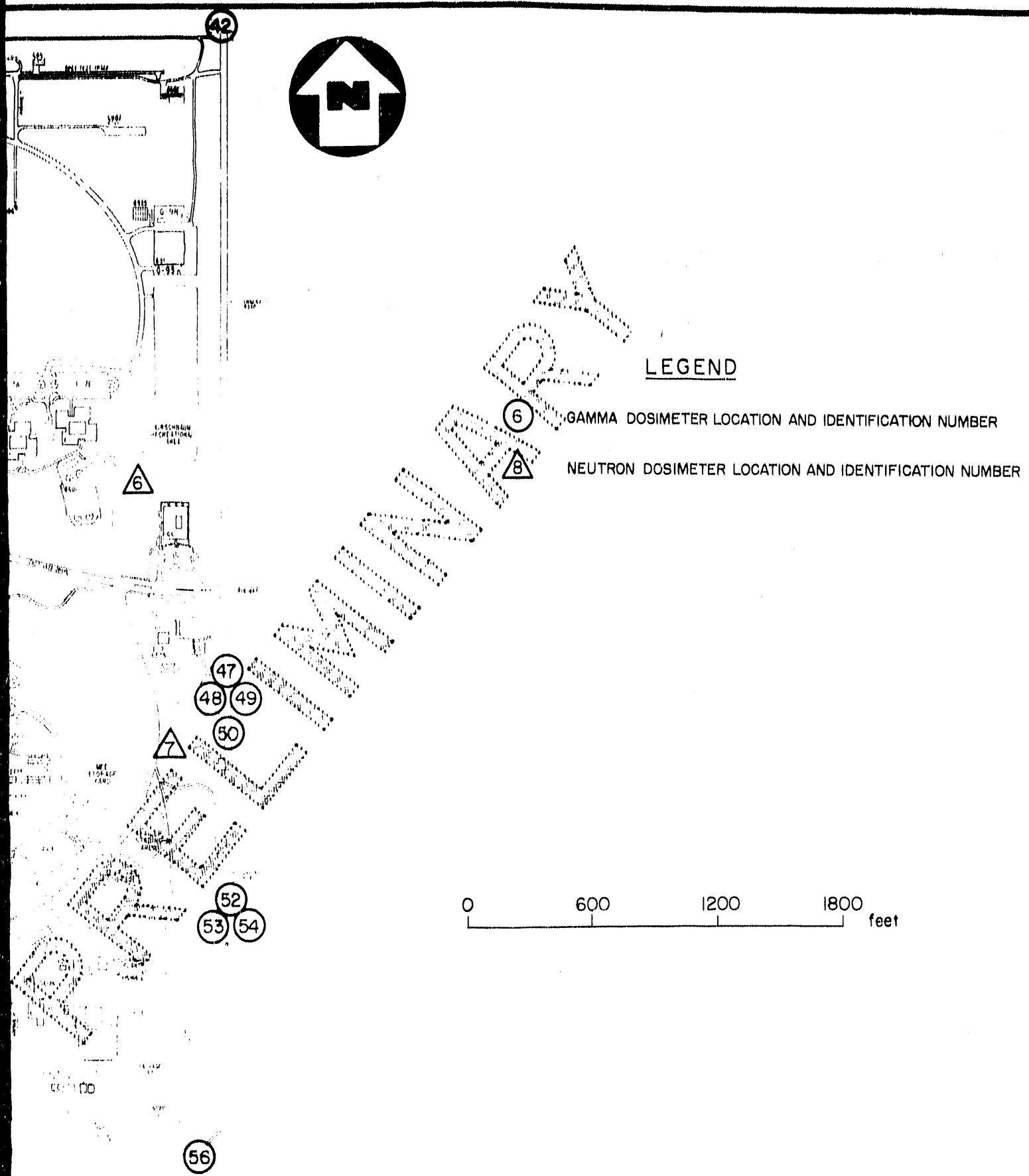
Operation	Bldg. No.	Primary Activity	Radioactive Species of Concern	Primary Control Technology
Decontamination Facility	419	Radiological decontamination of equipment using acid baths, ultrasound, and chemical treatment.	Tritium Uranium Americium Plutonium	Monitoring
Special Isotope Facility	490 Complex	Final demonstration step for laser enrichment of uranium.	Uranium	HEPA Filters
Waste Management Facility	514 612 624	Liquid solidification incineration, compaction, and packaging for off-site shipment. Liquid waste treated by chemical adjustment, precipitation, and filtration.	LLW TRU	HEPA Filters
Advanced Test Accelerator (ATA)	865	Repetitively pulsed electron beam for charged particle beam research.	Nitrogen-13 Oxygen-15	HEPA Filters and monitoring

Source: Adapted from University of California, 1986.



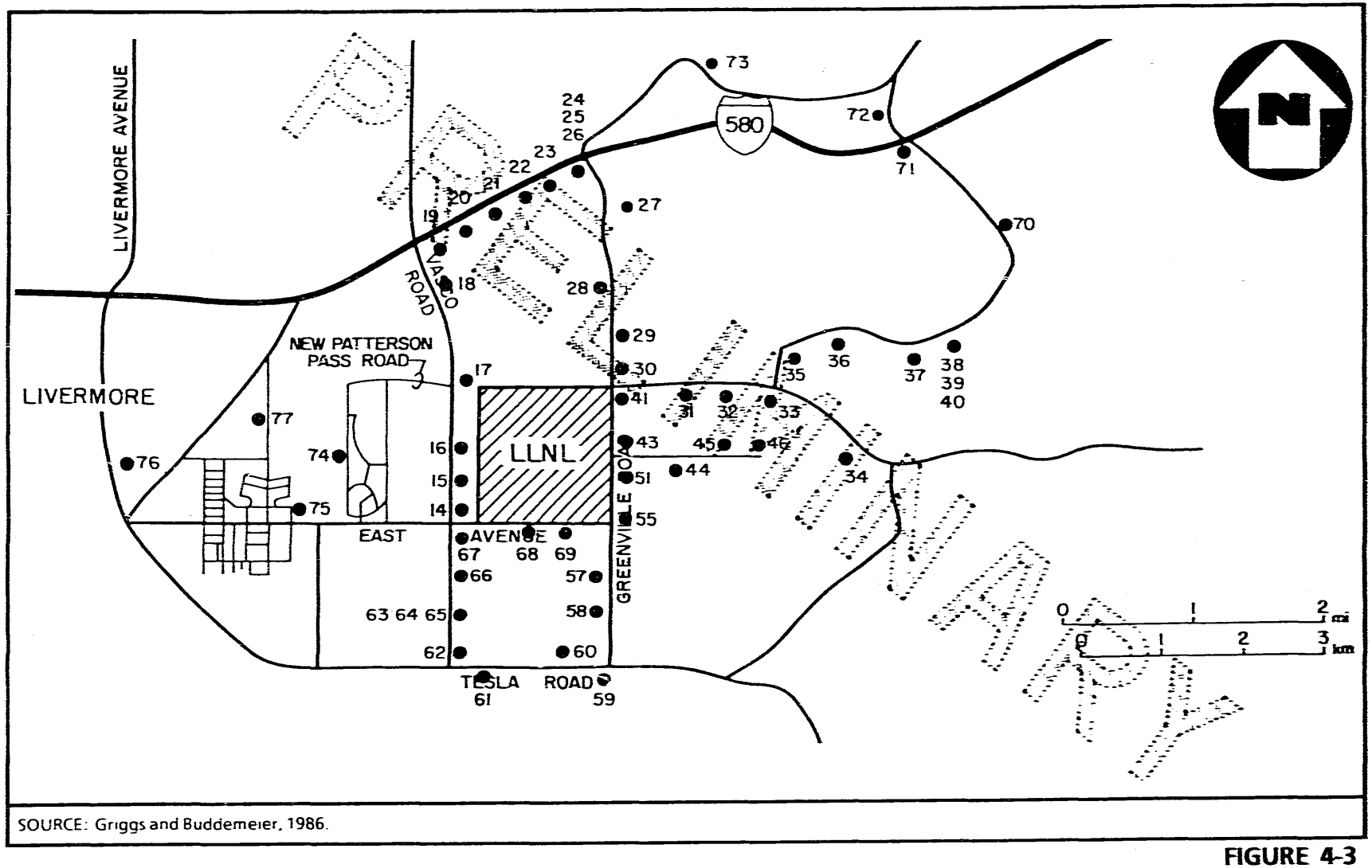
SOURCE: Griggs and Buddemeier, 1986.

GAMMA DOSIME
LLNL – LIV



ER LOCATIONS – MAIN SITE
RMORE, CALIFORNIA

FIGURE 4-2



SOURCE: Griggs and Buddemeier, 1986.

FIGURE 4-3

OFFSITE GAMMA DOSIMETER LOCATIONS – MAIN SITE
LLNL – LIVERMORE, CALIFORNIA

the ATA (Advanced Test Accelerator) in the form of short-lived ^{15}O and ^{13}N radionuclides. Although current operations are not likely to produce exposure above background, documentation of off-site penetrating radiation doses in uncontrolled public access areas would verify compliance, and would provide information regarding any past activities that could have possibly contributed to increased ground-plane irradiation.

LLNL has an extensive environmental radionuclide monitoring program, which is integrated into both the site process and environmental monitoring programs. Radionuclides are monitored or measured in

- Stack emissions.
- Ambient air at the Main Site perimeter, Livermore Valley, and Site 300.
- Retention tank wastes.
- Sewer discharges.
- Soil, potable water, and groundwater.
- Vegetation, wine, honey, and milk.

Of the numerous facilities at LLNL, only five were considered to have emissions warranting inclusion in dose assessment calculations (see Finding 4.3.4.4.3). The methodology used for calculating air pathway doses at the fence line, to the maximally exposed individual, and the population dose within an 80 kilometer radius of LLNL are summarized in Figure 4-4. Table 4-12 summarizes public dose from LLNL due to airborne effluents during 1985. As outlined in AIRDOS (EPA's approved model for calculating dispersion of radiocontaminants), distances from each of these facilities to each of the three receptors (fence line, nearest resident, and 80 kilometer radius) are calculated and entered for each of 16 compass point directions. Maximum values are then estimated using the LLNL Continuous Point Source (CPS) code Gaussian plume model for annual reporting purposes. While there is no reason to believe LLNL-developed models for air dispersion are less accurate or less conservative than AIRDOS, LLNL has not submitted its modeling strategy to EPA for approval as an alternative dose assessment methodology. Until simultaneous AIRDOS-LLNL CPS dose comparisons can be made, underestimation of public doses as the result of use of models that have not been approved by EPA is a possibility and a violation of NESHAPs requirements listed in 40 CFR 61.93. Additionally, tritium releases from the 624 Incinerator are not included in LLNL dose assessment calculations. While the quantity of tritium airborne releases is administratively controlled to no more than 50 Ci/year, calculation or environmental sampling to identify the actual quantity going up the stack and associated dose calculations is at least as likely to be a factor as the 5 Ci released from the ICT in Building 212 during 1985.

To calculate the "fence-line" site boundary, nearest resident, and population doses, a continuous-point-source computer code based on the Gaussian plume model was used.

$$C_{downwind} = 3.17 \times 10^{4}(\chi/Q)(Q) \quad , \tag{3}$$

where

χ/Q = diffusion parameter, sec/m^3,

Q = release rate, Ci/y,

$3.17 \times 10^4 = 1 \times 10^{12} \frac{pCi}{Ci} / 3.15 \times 10^7 \frac{sec}{y}$,

$C_{downwind}$ = concentration downwind, pCi/m^3,

$$D_{max\ individual} = U \times C_{downwind} \times D \quad , \tag{4}$$

where

U = intake rate, m^3/y = 8000 m^3/y, inhalation rate for adult maximum exposed individual,

$C_{downwind} = 3.17 \times 10^4\ (\chi/Q)(Q)$,

D = dose factor, mrem/pCi,

for ^{3}H, D = 6.23×10^{-3} mrem/pCi × 1.5 to include immersion dose = 9.35×10^{-3} mrem/pCi,

for ^{13}N, D × U = $5.22 \times 10^{-3} \frac{mrem \cdot m^3}{pCi \cdot y}$,

for ^{15}O, D × U = $5.25 \times 10^{-3} \frac{mrem \cdot m^3}{pCi \cdot y}$,

$D_{max\ individual}$ = mrem/y.

For population dose, the diffusion factors and population figures for an area within 80 km of LLNL were summed over all directions.

$$\text{Dose (person-mrem)} = 3.17 \times 10^{4} \left[\sum_{i}^{n} (\chi/Q)_i P_i \right] Q\ U\ D \quad , \tag{5}$$

where,

$\left[\sum_{i}^{n} (\chi/Q)_i P_i \right]$ = Summation of the (χ/Q) for region i times the population in region i for all regions n, $\frac{person\text{-}sec}{m^3}$

Q = release rate, Ci/y,

U = inhalation rate, average individual (adult),

D = dose factor, mrem/pCi.

SOURCE: Griggs and Buddemeier, 1986

FIGURE 4-4

DOSE ASSESSMENT METHODOLOGY - AIR
LLNL - LIVERMORE, CALIFORNIA

TABLE 4-12

ESTIMATED WHOLE-BODY RADIATION DOSE TO THE PUBLIC FROM LLNL AIRBORNE EFFLUENTS DURING 1985 LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Nuclide	Bldg. No.	Facility	Curies	Dose at Site Boundary (mrem)	Dose to Nearest Resident (mrem)	Dose Within 80-km Radius of LLNL (person-rem)
^{3}H	331	Tritium Facility	1,989	0.05[a]	0.03[a]	0.22[a]
	212	Insulating Core Accelerator	5	0.00	0.00	0.00
	292	Rotating Target Neutron Source	210	0.11	0.02	0.08
^{13}N, ^{15}O	194	Linear Accelerator	120	0.06	0.01	0.00
	865	ATA[b] (Site 300)	400	0.00	0.00	0.00
TOTAL				0.22	0.06	0.30

Source: Adapted from Griggs and Buddemeier, 1986.

a Doses are based on the 624 Ci of HTO released by LLNL. The dose due to the 1,365 Ci of HT released by LLNL does not add significantly to the total. SNLL emitted about 450 Ci of HTO, which are not included in these calculations.

b Advanced test accelerator.

Other dose pathways considered applicable to LLNL operations include tritium in potable water, vegetation, wine, honey, and milk. The calculation methodology for potable water exposure is shown in Figure 4-5. Tables 4-13 and 4-14 show calculated adult, whole-body dose measurements for the locations shown in Figures 4-6 and 4-7, assuming a person would consume 2 liters/day and assuming dose conversion factors for tritium contained in ICRP 30 from that sampling location. The highest dose is 0.05 mrem, which represents 0.03 percent of the U.S. average background radiation dose shown in Table 4-9.

In similar fashion, dose from the forage-cow-milk pathway is calculated using the methodology shown in Figure 4-5. Figures 4-8 and 4-9 show the Livermore Valley and Site 300 vegetation sampling locations, followed by Tables 4-15 and 4-16 listing calculated adult, whole-body dose measurements for these sampling locations. Most conservative vegetation pathway public dose calculations yield exposures of 0.3 mrem/year for Livermore Valley locations and 9 mrem/year for Site 300 locations. These exposure levels represent 0.15 percent and 4.8 percent of the U.S. average background radiation dose shown in Table 4-9. Table 4-17 shows measured tritium concentrations in milk obtained from farms within 5 kilometers of LLNL (Livermore Valley) and the associated adult, whole-body dose. Milk dose calculations assume intake of 30 liters/year and use the ICRP 30 tritium dose conversion factor.

Tables 4-18 and 4-19 show tritium concentrations in wine and honey, which are two locally produced agricultural products. No dose assessment calculations have been made because accurate data on consumption of these specific products would be difficult to obtain and probably not contribute significantly to public dose. Inclusion of this information is provided as another indicator of off-site impacts due to LLNL activities.

In summary, assuming maximally exposed individuals and conservative dose assessment calculations, Table 4-20 shows the summed dose consequences from all LLNL and Site 300 sources as reported in the 1985 annual monitoring report. As discussed earlier, actual milk tritium measurements indicate doses much lower than those calculated for the Livermore Valley vegetation-cow-pathway. The Site 300 maximum vegetation dose is grossly overstated because on-site vegetation was sampled even though it is not foraged by cows. Sampling of milk from a nearby dairy farm, which would provide a more realistic indication of Site 300's contribution to the off-site vegetation dose pathway, was not conducted. Based on observations of operations during the Survey, it is likely that milk tritium concentrations of farms near Site 300 would be in the same concentration range as the Livermore Valley milk results.

Annual Dose from Potable Water

Assuming that all water sampled is available as drinking water, the annual whole-body dose for tritium has been calculated using the following equation:

$$R_{\text{total body}} = C_w U_w D_w \quad . \tag{1}$$

where

C_w = concentration in pCi/liter,
U_w = intake rate, liters/y,
= 730 liters/y for maximum exposed individual,
D_w = dose factor, mrem/pCi,
= 6.23×10^{-8} mrem/pCi for the whole-body ingestion pathway for an adult, and
$R_{\text{total body}}$ = annual dose in mrem to the total body from ingestion of 730 liters of potable water with concentration C_w.

Annual Dose from Forage-Cow-Milk Pathway for Tritium in Vegetation

Assuming that all feed for the cattle was pasture grass, the annual whole-body dose per μCi/ml HTO for the maximum exposed individual has been calculated using the following equation:

$$D_{\text{total body}} = D_{\text{veg}} + D_{\text{meat}} + D_{\text{milk}} \tag{2}$$

$$D_{\text{veg}} \text{ (leafy vegetables)} = U_{\text{veg}} \times C_{\text{veg}} \times D_{\text{HTO}} \quad , \tag{2a}$$

where

U_{veg} = intake rate, kg/y, 64 kg/y for maximum exposed individual,

C_{veg} = concentration in pCi/kg = $10^9 \frac{\text{pCi/kg}}{\mu\text{Ci/ml}} \times C_{\text{veg}}$ μCi/ml (measured),

D_{HTO} = dose factor, mrem/pCi = 6.23×10^{-8} mrem/pCi for ^{3}H for the adult whole-body ingestion pathway,

D_{veg} (mrem/y) = 3.40×10^4 C_{veg} μCi/ml (measured).

$$D_{\text{meat}} = U_{\text{meat}} \times C_{\text{meat}} \times D_{\text{HTO}}, \tag{2b}$$

where

U_{meat} = 110 kg/y,

D_{HTO} = 6.23×10^{-8} mrem/pCi,

SOURCE: Griggs and Buddemeier, 1986

FIGURE 4-5A

DOSE ASSESSMENT METHODOLOGY – WATER / VEGETATION
LLNL – LIVERMORE, CALIFORNIA

$C_{meat} = (F_f)\,(Q_f)\,(C_{veg}) \exp(-\lambda_i t_s)$,

F_f = fraction of daily intake of nuclide per kg of animal/fish (pCi/kg in meat per pCi/day ingested by the animal), days/kg,

Q_f = amount of feed consumed, kg/day,

C_{veg} = same as above,

λ_i = radiological decay constant, day^{-1},

t_s = time between slaughter to consumption, days.

$$C_{meat} = \left(1.2 \times 10^{-2} \frac{day}{kg}\right)\left(50 \frac{kg}{day}\right)\left(C_{veg} \frac{\mu Ci}{ml}\right)\left(10^9 \frac{pCi/kg}{\mu Ci/ml}\right)$$

$$\times \exp[-1.5 \times 10^{-4}(20)] = 0.6 \times 10^9 \frac{pCi/kg}{\mu Ci/ml} \times C_{veg} \frac{\mu Ci}{ml} \text{(measured)} ,$$

$$D_{meat}\ (mrem/y) = 0.41 \times 10^4 \times C_{veg}\ \mu Ci/ml\ \text{(measured)} .$$

$$D_{milk} = U_{milk} \times C_{milk} \times D_{HTO} , \qquad (2c)$$

where

U_{milk} = 310 liters/y,

$D_{HTO} = 6.23 \times 10^{-8}$ mrem/pCi,

$C_{milk} = F_m\, Q_f\, C_{veg} \exp(-\lambda_i t_f)$,

F_m = fraction of daily intake of nuclide per liter of milk (pCi/liter in milk per pCi/day ingested by the animal) day/liter,

Q_f = amount of feed consumed, kg/day,

C_{veg} = same as above,

λ_i = radiological decay constant, $days^{-1}$,

t_f = transport time from the feed to milk receptor,

$$C_{milk} = \left(1.0 \times 10^{-2} \frac{day}{liter}\right)\left(50 \frac{kg}{d}\right)\left(C_{veg} \frac{\mu Ci}{ml}\right)\left(10^9 \frac{pCi/kg}{\mu Ci/ml}\right)$$

$$\times \exp[-1.5 \times 10^{-4}(2)] = 0.5 \times 10^9 \frac{pCi/liter}{\mu Ci/ml} \times C_{veg} \frac{\mu Ci}{ml} \text{(measured)} .$$

$$D_{milk}\ (mrem/y) = 0.97 \times 10^4 \times C_{veg}\ \mu Ci/ml\ \text{(measured)} .$$

$$D_{total}\ (mrem/y) = 0.40 \times 10^4\, C_{veg}\ \mu Ci/ml\ \text{(measured)} + 0.41 \times 10^4\, C_{veg}\ \mu Ci/ml\ \text{(measured)}$$
$$+ 0.97 \times 10^4\, C_{veg}\ \mu Ci/ml\ \text{(measured)} = 1.78 \times 10^4\, C_{veg}\ \mu Ci/ml\ \text{(measured)} .$$

SOURCE: Griggs and Buddemeier, 1986

FIGURE 4-5B

DOSE ASSESSMENT METHODOLOGY – WATER / VEGETATION (cont'd.)
LLNL – LIVERMORE, CALIFORNIA

TABLE 4-13

TRITIUM (HTO) IN WATER
LIVERMORE VALLEY
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Location[a]	No. of Samples	[(10^{-7} µCi/ml ± 2σ(%)]			%SDM[b]	%CG[c]	Calculated Adult Whole-Body Dose (mrem)
		Maximum	Minimum	Average			
11	4	0.8	0.4	0.6	23	3×10^{-1}	3×10^{-3}
15	4	0.8	0.5	0.7	16	3×10^{-1}	3×10^{-3}
16	4	2.3	1.3	1.8	27	9×10^{-1}	8×10^{-3}
19	4	0.7	0.5	0.6	18	3×10^{-1}	3×10^{-3}
20	10	34.5	0.7	9.9	107	5	5×10^{-2}
23	4	0.7	0.4	0.5	27	3×10^{-1}	3×10^{-3}
24	4	1.5	0.5	0.9	51	4×10^{-1}	4×10^{-3}
26	4	1.7	1.4	1.5	9	8×10^{-1}	7×10^{-3}
29	4	0.7	0.3	0.4	37	2×10^{-1}	2×10^{-3}
30	4	1.0	0.4	0.6	44	3×10^{-1}	3×10^{-3}
31	4	0.9	0.3	0.6	44	3×10^{-1}	3×10^{-3}
33	4	0.8	0.1	0.5	52	3×10^{-1}	3×10^{-3}
37	4	1.2	0.4	0.8	47	4×10^{-1}	4×10^{-3}

Source: Griggs and Buddemeier, 1986.

a. See Figure 4-6 for sample locations.
b. Standard deviation of the mean
c. CG, Concentration Guide, = 2×10^{-5} µCi/ml.

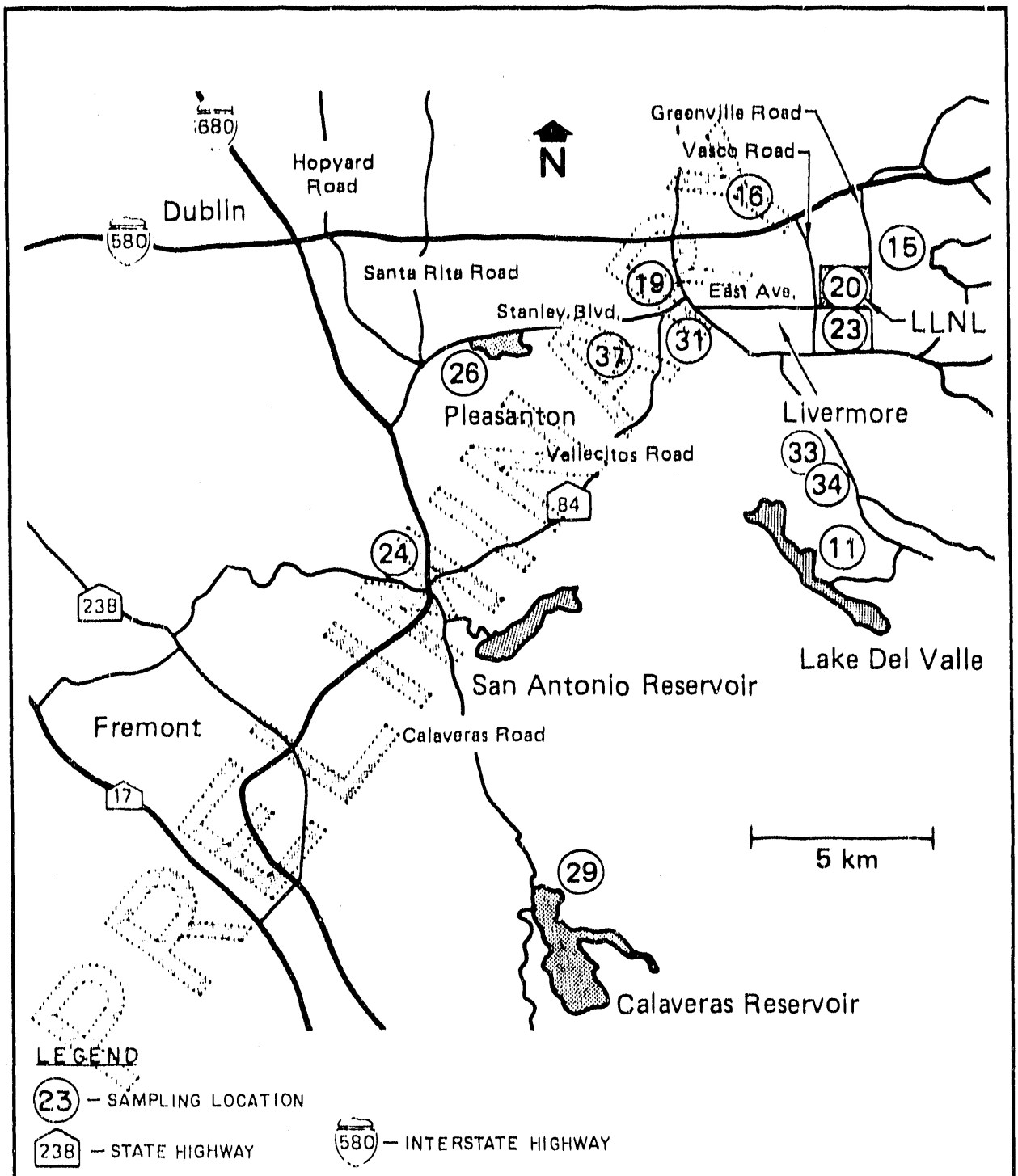
TABLE 4-14

TRITIUM (HTO) IN WATER - SITE 300
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFRONIA

Location[a]	No. of Samples	[(10^{-7} µCi/ml ± 2σ(%)]			%SDM[b]	%CG[c]	Calculated Adult Whole-Body Dose (mrem)
		Maximum	Minimum	Average			
3	4	0.3 ± 21	0.0	0.1	83	7×10^{-2}	7×10^{-4}
4	8	0.3 ± 24	0.0	0.1	65	5×10^{-2}	5×10^{-4}
5	8	0.6 ± 10	0.0	0.2	88	9×10^{-2}	9×10^{-4}
6	1	0.2 ± 23	0.2 ± 23	0.2	----	1×10^{-1}	1×10^{-3}
7	4	0.5 ± 13	0.1 ± 73	0.2	108	1×10^{-1}	1×10^{-3}
14	8	0.9 ± 8	0.5 ± 12	0.6	22	3×10^{-1}	3×10^{-3}
20	7	0.8 ± 9	0.4 ± 15	0.6	27	3×10^{-1}	3×10^{-3}
21	4	0.5 ± 12	0.2 ± 27	0.3	48	1×10^{-1}	1×10^{-3}
22	8	0.8 ± 8	0.0	0.2	135	1×10^{-1}	9×10^{-4}
23	4	0.4 ± 15	0.1 ± 44	0.2	58	1×10^{-1}	1×10^{-3}

Source: Griggs and Buddemeier, 1986.

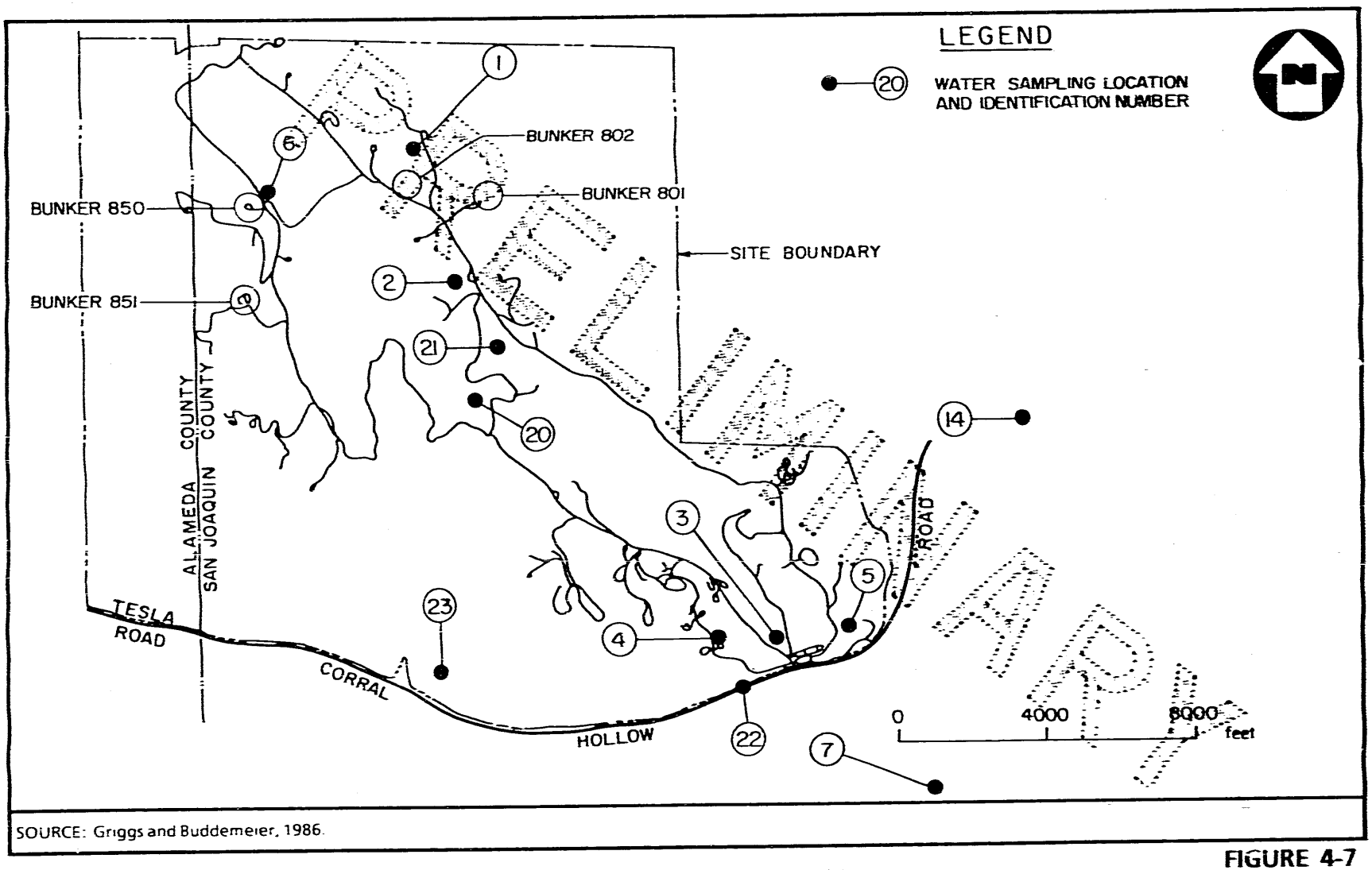
a See Figure 4-7 for sample locations
b Standard deviation of the mean
c CG, Concentration Guide, = 2×10^{-5} µCi/ml.



SOURCE: Griggs and Buddemeier, 1986

FIGURE 4-6

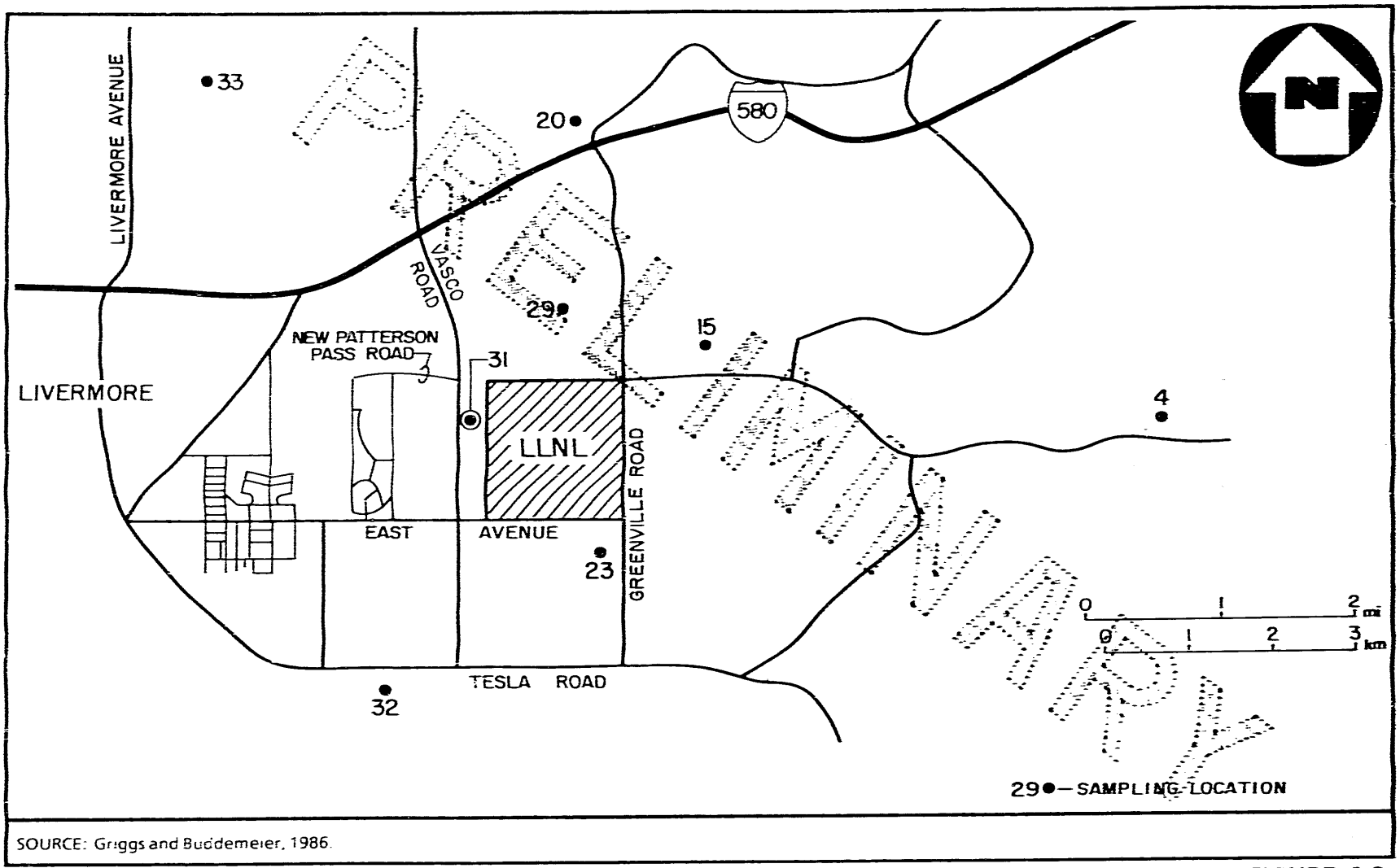
LIVERMORE VALLEY WATER SAMPLING LOCATIONS
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Griggs and Buddemeier, 1986.

FIGURE 4-7

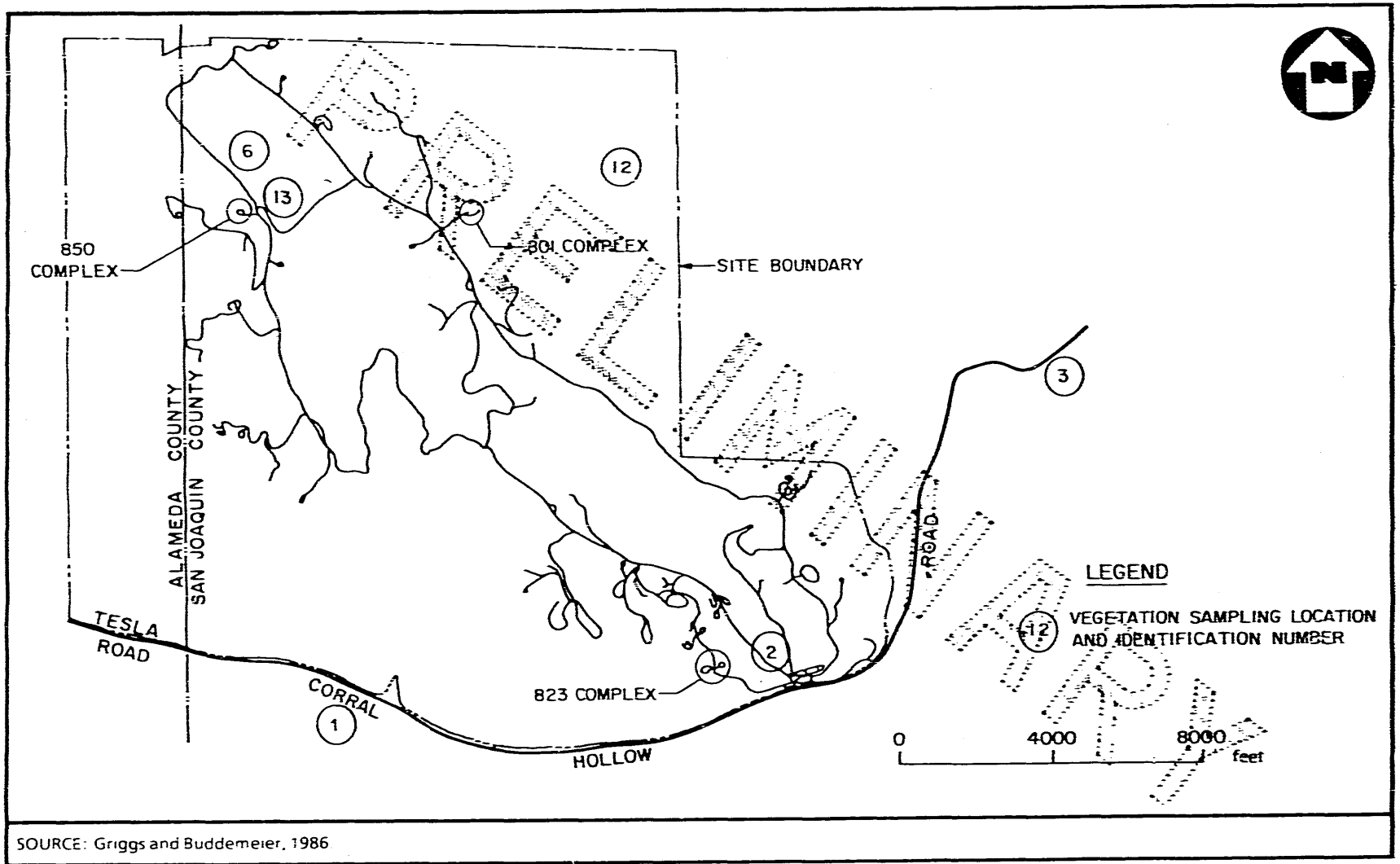
SITE 300 WATER SAMPLING LOCATIONS
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Griggs and Buddemeier, 1986.

FIGURE 4-8

LIVERMORE VALLEY VEGETATION SAMPLING LOCATIONS
LLNL – LIVERMORE, CALIFORNIA



SOURCE: Griggs and Buddemeier, 1986

FIGURE 4-9

SITE 300 VEGETATION SAMPLING LOCATIONS
LLNL – LIVERMORE, CALIFORNIA

TABLE 4-15

TRITIUM (HTO) IN VEGETATION - LIVERMORE VALLEY
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Location[a]	No. of Samples	[10^{-7} µCi/ml ± 2σ(%)] In Water Recovered			%SDM[b]	Calculated Adult Whole-Body Dose (mrem)
		Maximum	Minimum	Average		
4	4	4.2 ± 24	2.8 ± 40	3.6	17	6×10^{-3}
15	4	326.0 ± 1	8.1 ± 14	91.4	171	2×10^{-1}
20	4	17.2 ± 8	4.5 ± 24	9.9	55	2×10^{-2}
23	4	440.0 ± 1	26.4 ± 5	144.3	137	3×10^{-1}
29	4	20.7 ± 6	4.9 ± 23	11.6	58	2×10^{-2}
31	4	17.5 ± 7	5.2 ± 22	9.7	57	2×10^{-2}
32	4	14.4 ± 8	2.5 ± 44	8.8	64	2×10^{-2}
33	4	4.4 ± 23	1.0 ± 100	1.9	88	3×10^{-3}

Source: Griggs and Buddemeier, 1986.

a See Figure 4-8 for sample locations
b Standard deviation of the mean

TABLE 4-16

TRITIUM (HTO) IN VEGETATION - SITE 300
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Location[a]	No. of Samples	[10^{-7} µCi/ml ± 2σ(%)] In Water Recovered			%SDM[b]	Calculated Adult Whole-Body Dose (mrem)
		Maximum	Minimum	Average		
1	4	1.6 ± 68	1.1 ± 100	1.2	21	2×10^{-3}
2	4	1.1 ± 97	1.0 ± 100	1.1	1	2×10^{-3}
3	4	1.3 ± 85	1.1 ± 100	1.1	11	2×10^{-3}
6	4	13,600.0 ± 0.4	1.6 ± 68	4,983.6	130	9
12	4	2.2 ± 45	1.1 ± 100	1.5	36	3×10^{-3}
13	4	151.0 ± 2	2.4 ± 46	71.3	171	1×10^{-3}

Source: Griggs and Buddemeier, 1986.

a See Figure 4-9 for sample locations.
b Standard deviation of the mean.

TABLE 4-17

TRITIUM IN MILK - LIVERMORE VALLEY
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

	HTO [10^{-7} µCi/ml ± 2σ(%)]
Number of samples	29
Maximum	5.2 ± 20
Minimum	1.0 ± 100
Average	1.5
% SDM[a]	55.9
Calculated adult whole-body dose (mrem)	3×10^{-3}

Source: Griggs and Buddemeier, 1986.

[a] Standard deviation of the mean

TABLE 4-18

TRITIUM (HTO) IN VEGETATION - SITE 300
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Location	No. of Samples	[10^{-7} µCi/ml ± 2σ(%)] In Water Recovered			%SDM[a]
		Maximum	Minimum	Average	
California	2	1.8 ± 12	1.2 ± 14	1.5	27
Europe	4	13.9 ± 3	2.3 ± 10	5.5	102
Livermore	3	3.9 ± 6	3.0 ± 8	3.4	15

Source: Griggs and Buddemeier, 1986.

[a] Standard deviation of the mean

TABLE 4-19

TRITIUM (HTO) IN HONEY - LIVERMORE VALLEY
LAWRENCE LIVERMORE NATIONAL LABORATORY- LIVERMORE, CALIFORNIA

Location	No. of Samples	[10^{-7} µCi/ml ± 2σ(%)] In Water Recovered			%SDM[a]
		Maximum	Minimum	Average	
California	2	7.3 ± 4	2.6 ± 7	5.0	67
Livermore	2	4.6 ± 6	3.9 ± 6	4.2	11

Source: Griggs and Buddemeier, 1986.

[a] Standard deviation of the mean

TABLE 4-20

EFFECTIVE WHOLE-BODY DOSE EQUIVALENT[1]
LAWRENCE LIVERMORE NATIONAL LABORATORY- LIVERMORE, CALIFORNIA

Pathway	Livermore Valley Maximum Individual Dose (mrem)	Site 300 Maximum Individual Dose (mrem)
Air	0.03	0.00
Water (Potable)	0.05	0.003
Vegetation	0.30	9.0
Totals	0.38	9.003
Percent of DOE 100 mRem Guideline	0.38%	9.003%
Percent of U.S. Average Background Radiation Exposure (~189 mrem)	0.2%	4.8%

Source: Developed by DOE Survey team.

1 Excludes direct radiation doses.

4.3.4 Findings and Observations

4.3.4.1 Category I

None

4.3.4.2 Category II

None

4.3.4.3 Category III

None

4.3.4.4 Category IV

1. Direct Radiation - Perimeter and Off-Site Monitoring At Site 300. Lack of a perimeter and off-site environmental penetrating radiation monitoring program at Site 300 prevents documentation and evaluation of potential present or past environmental impacts. Discussions with LLNL personnel indicate that location of TLDs at existing air monitoring sites might be a logical first step in combination with other sampling/measurement location criteria.

2. Dose Assessment - Calculation Methodology. While there is no reason to suspect the accuracy of LLNL's CPS (Continuous Point Source) computer modeling code for estimating public dose, EPA NESHAPs requires the use of the AIRDOS computer modeling code or an equivalent approved by EPA. Since EPA has received no requests to evaluate "equivalent" codes, calculations of public dose to radionuclide effluents should be made using the approved methodology to avoid any potential underestimation of environmental risk. LLNL personnel are aware of AIRDOS requirements and are taking steps to rectify this situation.

3. Dose Assessment - 624 Incinerator. Underestimation of public radiation dose may be occurring as a result of failure to incorporate the 624 incinerator radionuclide emissions into the dose assessment calculations. While tritium releases are administratively limited to 50 Ci/yr, measurement of actual emissions and subsequent dose calculations could be incorporated into the dose assessment procedures.

4.4 Quality Assurance/Quality Control

4.4.1 General Description of Data-Handling and Sampling Procedures

At LLNL, the environmental quality assurance responsibilities are divided among the Hazard Control (HC) Laboratory, the Main Site verification monitoring program, the Site 300 verification monitoring program, and the ambient air sampling program.

The HC Laboratory analyzes environmental samples, waste samples, and retention tank samples. Analyses include metals by atomic absorption and inductively coupled plasma (ICP), solids, radiological analyses, pH, and organics by gas and liquid chromatography. The laboratory is certified by the State of California and AIH. Although a quality assurance (QA) plan is in effect, several areas are not adequately addressed, including chain-of custody, lack of a QA coordinator, calibrations, and written procedures. The Main Site verification monitoring program is basically concerned with the monitoring well program and ensuring that all aspects of dealing with outside laboratories and sampling are carried out in a correct manner. The Site 300 verification monitoring program is centered upon the monitoring well sampling project and includes proper sampling, written procedures, and chain-of-custody. The ambient air sampling program includes an evaluation of the accuracy of the measurements taken from on-site and off-site sampling stations.

4.4.2 Findings and Observations

4.4.2.1 Category I

None

4.4.2.2 Category II

None

4.4.2.3 Category III

None

4.4.2.4 Category IV

1. HC Laboratory B-253, Quality Assurance/Quality Control (QA/QC) Program. Analytical results for environmental samples may be suspect for the following reasons:

- No sample log books are in use for organic results from EPA Method 601 analysis.
- No formalized (written) procedures are present for maintenance and calibration of all analytical instrumentation.
- Laboratory procedures notebooks are not updated regularly.
- No one is formerly designated as a QA/QC coordinator.
- Chain-of-custody process stops when samples are dropped off at laboratory by sampler; samples sit unattended until analysis; no chain-of-custody is used for samples sent to the contract laboratory, Brown and Caldwell.
- There are no formal (written) procedures for identifying unsatisfactory results. Section head uses best judgment to decide when to use sample results, but there is no formal documentation on how the decision is made.
- Calibration results for metal analyses by atomic absorption and ICP are sometimes "eyeballed" versus plotted to determine linearity.
- Only blank samples are spiked to determine recovery; actual samples are not spiked. This process confirms instrument calibration but does not give a measure of interferences in the determination that could be caused by the sample matrix.
- Existing QA/QC program does not cover chain-of-custody.
- There are no formal (written) procedures for checking data transfer errors.

2. Main Site Verification Monitoring Plan, QA/QC. Analytical results for environmental samples may be suspect for the following reasons:

- The current QA/QC plan does not cover chain-of-custody adequately, especially for samples sent to the HC laboratory (B-253) and outside laboratories other than Brown and Caldwell.
- No provisions are in place to conduct internal audits of environmental samples.
- A sample tracking form showing date, time, sample identification, and number does not accompany samples from point of sampling to analysis.

3. Site 300 Verification Monitoring Plan, QA/QC. Analytical results for environmental samples may be suspect for the following reasons:

- No written procedures are available for sampling.
- No blanks or duplicates are taken during a sampling round.
- Sample bottles are not rinsed with the solution to be sampled prior to taking the sample.
- Sample refrigerator is not locked when samples are stored overnight. (In this instance, chain-of-custody procedures are not followed.)

4.5 Inactive Waste Sites and Releases

4.5.1 General Description of Pollution Sources and Controls

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 (reauthorized and amended in 1986) established (1) notification requirements, (2) liability standards, and (3) response authority for dealing with releases of hazardous substances to the environment. Also known as "Superfund," CERCLA's scope is expansive. The EPA and state agencies can undertake or order study or cleanup when there is a release or the substantial threat of a release of a hazardous substance to the environment.

Superfund was substantially expanded by the Superfund Amendments and Reauthorization Act of 1986 (SARA). In addition to significantly increasing the size of the fund to finance cleanups, SARA creates a response authority for petroleum underground storage tank releases (technically, an amendment to RCRA) and mandates community right-to-know and emergency preparedness

programs (Title III). SARA also obligates Federal facilities to comply with the same regulations and policies as other entities. Hence, except for certain limited national security waivers, Federal facility cleanup plans for sites on the National Priorities List must undergo EPA review and concurrence.

This section describes several sources and potential sources of hazardous substance releases from Lawrence Livermore National Laboratory (LLNL) facilities into the environment. The release sources from both Site 300 and the Main Site are described separately. This section focuses on specific known or suspected areas of contamination that may be responsible for these contaminated areas.

The known groundwater contamination resulting from these sources is discussed in Section 3.4. The sources are listed and described generally in this subsection (4.5.1), while more detail is provided in the Findings section (4.5.2).

4.5.1.1 Livermore Laboratory (Main Site)

There are at least four major areas of groundwater contamination (listed and discussed below) at the Main Site. The sources of contamination for three of these areas have not been identified. In addition, there are numerous other actual or potential sources of contamination. The Livermore Laboratory Main Site is one of the few DOE facilities to have been included on the EPA's National Priorities List (NPL), finalized on July 21, 1987. The December 1986 Phase I report (Lindeken et al., 1986) summarized the use of the Hazard Ranking System (HRS) to establish ranking scores for sites. Five areas at the Main Site were scored. Of these five areas, four general areas (listed in Table 4-21) scored higher than the arbitrary 28.5 Hazard Ranking System (HRS) score above which sites are proposed for the NPL. (An area of tritium contamination in the groundwater at Site 300 scored below the 28.5 cut-off score.)

Southwest and Off-site Area

The source of the organics in the groundwater at the southwest corner of the site, as described in Sections 3.4.4.3 and 4.5.2.3, is not clearly known. LLNL investigations have generally identified (1) historical Navy releases into the storm sewer system that previously discharged to the southwest corner and (2) an old Navy "continuous fuel pit" that extended from the present location of B-403 to the southwest corner.

TABLE 4-21

MAIN SITE AREAS USED FOR PROPOSED
LISTING ON NATIONAL PRIORITIES LIST,
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Laboratory Area	HRS Score
1. Southwest and Off-site Area	32.7
2. Building 403 Gasoline Leak	36.7
3. Southeast Area	32.7
4. South Central Area (includes East Traffic Circle Landfill, Taxi Strip, and Old Salvage Yard)	32.7

Source: Lindeken et al., 1986.

B-403 Gasoline Leak

The B-403 gasoline leak is one of the few clearly identifiable sources of groundwater contamination at the site. LLNL estimated that 17,000 gallons of gasoline leaked into the ground from an underground storage tank in 1979. This area was historically used by the Navy for aircraft refueling and fuel storage; hence, other fuel leaks may have occurred in this area.

Southeast Area

The source of groundwater contamination in the southeast area of the site has not been clearly identified. Several likely sources are discussed in Section 4.5.2.3.

South Central Area

The south central area at the Main Site includes at least the following three major sources of groundwater contamination:

- East Traffic Circle Landfill
- Taxi Strip Storage Area
- Old Salvage Yard

Miscellaneous Known and Suspected Areas of Contamination

According to a compilation by LLNL (Dreicer, 1985), there are at least 50 areas of known and suspected contamination at the LLNL Main Site. These areas range in size from abandoned dry wells to landfills. A list of these areas is given in Section 4.5.2.3. These areas may pose a threat to surface water or groundwater. If they remain uncharacterized, contamination might spread and could result in undetected threats and/or more expensive remedies.

4.5.1.2 Site 300 Sites

There are at least six known or suspected sources of contamination at Site 300 as well as several apparent spill or abandoned waste locations. These sources are listed and described briefly below.

TCE Release: B-834 Complex, B-830 and GSA Area

Trichloroethylene (TCE) has been released at Site 300 from the Building 834 complex, as well as Building 830 and the General Services Area (GSA) area dry wells. TCE has been found in groundwater near Building 834 at Site 300. TCE has also been found in groundwater from Spring 3 and Well 7, which are both in the GSA. More details on the groundwater quality are given in Section 3.4. In addition, the TCE contamination at Site 300 was the subject of a 1983 report (Carpenter et al., 1983), and was addressed in Part I of the Phase I report (Lindeken et al. 1986).

Site 300 Landfills

Eight landfills at Site 300 have been operated since the 1950s. Two pits (Numbers 1 and 7) are presently operating. Generally, the landfills receive shot debris and firing table gravel associated with hydrodynamic test operations at the high explosives firing bunkers. The debris and gravel is typically contaminated with uranium, beryllium, and lead. These landfills are discussed further in Sections 4.1 and 4.5.2.

High Explosives (HE) Burn Pit (Site 300)

Three pits and a steel container near Building 829 are used for burning waste HE and HE-contaminated wastes. A steel container, called an "iron horse," is used for burning HE processing sludge from classified bags. This burn pit is discussed further in Section 4.5.2.

HE Wastewater Lagoons (Site 300)

Wastewaters from HE processing in various buildings at Site 300 were discharged to lagoons near those buildings. Eight lagoons were used for disposal of wastes from HE processing and machining until a permitted surface impoundment was installed in 1985.

Firing Tables and Bunkers (Site 300)

There are several firing tables and bunkers at Site 300 where uranium, beryllium, and lead wastes have been released. Known as "hydrodynamic diagnostics complexes," these firing tables are covered with gravel to serve as a cushion for the HE shot.

GSA Dry Wells (Site 300)

Seven dry wells located in the GSA at Site 300 were used for the disposal of a variety of hazardous substances from the early 1960s until the state ordered their closure in 1980. The waste types and the approximate disposal rates for the closed GSA dry wells are described in Section 4.5.2.

Miscellaneous Spills and Abandoned Waste Areas

At Site 300, spills and abandoned wastes were observed in several areas, including

- GSA area near Well 7 (stained soil and abandoned drums).
- GSA area between B-875 and B878 on south side near Corral Hollow Road (stained soil).
- GSA area north of B-875 along embankment, and drum rack (stained soil and discolored runoff).
- B-827 C, D, and E drum rack drains and sumps (stained concrete and sediment).
- Buried drum behind B-827E drum rack.
- B-827A oil spills on pavement.
- B-8750 drain on uphill side of Building 805 (stained asphalt and sediment).

Diesel tankers near GSA (Well 7) and B-811

Four diesel tank trailers were parked at the GSA area near Well 2 and near B-811. These tankers appear to have been abandoned, and no LLNL personnel contacted were knowledgable about the contents of these tanks, if any.

Overflow Basin for Sewage Lagoon

An "overflow" basin located southeast of the sewage lagoon near the GSA of Site 300 may be the source of soil or groundwater contamination. The overflow basin is usually dry, but has been used in the past. The bottom of the basin is devoid of vegetation and appears to be discolored.

4.5.2 Findings and Observations

4.5.2.1 Category I

None

4.5.2.2 Category II

None

4.5.2.3 Category III

1. Southwest and Off-site Area. There are several historical sources of groundwater contamination in the southwest portion of the site. A plume of contaminated groundwater has moved more than 4,000 feet off-site from the southwest corner of the Main Site. The exact sources of the widespread groundwater contamination in the southwest area on and off the Main Site are not known. Some reasonable speculation is possible by both LLNL and the Survey team, however, because of the identity of the contaminants and information gathered from an extensive ongoing records search and interviewing project. The known and suspected major sources in the southwest area are reviewed briefly here. More detailed information is available in the following documents, further details on which are provided in the reference section.

   - Dreicer, M., May 1985. Preliminary Report on the Past and Present Uses, Storage and Disposal of Hazardous Materials and Wastes on the LLNL, UCID-20442.

   - Dresen, M. D. and F. Hoffman, July 1986. Volatile Organic Compounds in Groundwater West of LLNL, UCRL-53740.

   - McConachie, W. A. and F. Hoffman, July 1986. Reconnaissance of Groundwater Quality in the Southwest Corner of Lawrence Livermore National Laboratory, UCAR 10164.

   - Lindeken, C. L., J. A. Loftis, and R. C. Ragaini. June 1986. Draft DOE CERCLA Program Phase I Installation Assessment Part II: The Livermore Site.

   The largest sources of groundwater contamination are believed to be between First Street and East Avenue near West Perimeter Drive. Dozens of other sources may have contributed, however. The contaminant found by LLNL at the highest concentration in the monitoring wells in this area (MW-116) is perchloroethylene (PCE). Other volatile organic compounds, such as trichloroethylene (TCE) and 1,1,1-trichloroethane, have also been found in this area as well as off-site for about 4,000 feet. The source of the PCE is believed to be degreasers and solvents used by LLNL and the former site tenants (the U.S. Navy). A procedures manual found

in a records search of Navy archives indicated that the Navy used more than 20 pounds of TCE or PCE for degreasing each aircraft engine (Lindeken, 1986). PCE was also used by the Navy for a large dry cleaning operation. TCE was also used, among other purposes, in Arroyo Seco for reducing the foaming and sudsing near the outfall which resulted from detergent discharges into the sewers. Blueprints of the storm sewer and sanitary sewer system show that both sewers previously led to an outfall in the Arroyo Seco south of the present Building 111 in the southeast corner of LLNL. Solvents released into sewers or onto the pavement from the entire southern half of the site, where the Navy and the early laboratory buildings were located were discharged through this outfall. There is no available information on the total quantity of contaminants released. Failure to quantify the contaminants in the groundwater could result in significant uncertainty in any groundwater remediation attempts because of the inability to perform a basic mass balance analysis.

Another source of groundwater contamination in the southwest area of the site was the former Navy gasoline storage and refueling facilities. Large gasoline storage tanks were located east of Building 403, the site of the recent gasoline leak discussed in the next finding. Naval aircraft were refueled from the "continuous fuel pit," which extended from the current location of Building 321 to north of Building 418. A pipeline ran through this long pit from the fuel storage tanks. Constant pressure was maintained in the fuel line so that aircraft could park near any of the dozens of dispensing hoses located along the line. Leaks from this fuel line may have migrated along the trench to the southwest part of the site.

Groundwater contamination in the southwest area has been extensively characterized. The remedial action to mitigate the spread of groundwater contamination is now being planned. Three to five wells are expected to be used for extraction pumping of contaminated groundwater followed by air stripping. Early testing of the air stripping system (on-site pilot scale) has achieved up to a 99 percent removal efficiency. Consequently, the TCE and PCE concentrations have decreased from 7.9 and 100 ppb, respectively, to below detectable limits (0.5 ppb).

2. Building 403 Gasoline Leak. About 17,000 gallons of gasoline leaked into the ground in 1979 from an underground storage tank east of Building 403 and have contaminated the groundwater. This leak has also been extensively studied, and is detailed in the 1986 Phase I report (Lindeken et al., 1986) and in Dresen et al., 1986a.

The planned air-stripping remedial activities discussed above for the southwest area are also expected to be applied to the B-403 gasoline leak.

Although the B-403 gas leak is believed to be the primary source of groundwater contamination in this area, other sources are thought to have contributed. These include the former Navy fuel storage and automobile maintenance facility and a former drum and storage area. Groundwater contamination near B-403 is discussed in Section 3.4.4.3.1.

3. Southeast Area. The following known or potential sources are believed to have contributed to groundwater contamination in the southeast area:

- Drum leaks around Building 518.
- Drum racks at Buildings 513, 514, 518, and 519.
- Navy activities in Buildings 412 and 514.
- Oil tank spillage contaminated with solvents and polychlorinated biphenyls (PCBs) in the new salvage yard.

The groundwater in the southeast corner of the site has been contaminated by several known sources, and possibly other unknown sources. A variety of known and potential sources of groundwater contamination have been aggregated as the "southeast section" for the purpose of HRS scoring and groundwater investigations.

There is no precise information available on the actual type or quantity of waste disposed of in this area. The quantity of wastes disposed of in this area was assumed by LLNL to be about one to two drums of TCE, but the actual amount may have been much higher Aircraft maintenance requiring the use of more than 20 pounds of TCE or PCE per engine occurred in this area at Building 514. Although a significant amount of waste TCE and PCE was discharged to the Arroyo Seco in the southwest area via the sewers, a considerable amount is also believed to have been washed off the pads onto the ground. Also, hazardous substances other than TCE and PCE have apparently been released to the ground in this area. For

example, spills of methyl ethyl ketone (MEK), acetone, etc., from drum racks and spills in the waste handling and treatment area near Buildings 514 and 612 have been reported by LLNL.

4. East Traffic Circle Landfill. An abandoned landfill located underneath the East Traffic Circle and used from the mid-1950s to 1970 has contaminated groundwater, and possible contamination of subsurface soil may remain. About 4.77 acres were used for a landfill under what is now the East Traffic Circle, extending to underneath Building 514. Originally used primarily for nonhazardous garbage, the landfill was largely exhumed and transported off-site between July 1984 and late 1985. Details of the removal are given primarily in McConachie et al., 1986. This section reviews the major features of this old landfill and the general extent of residual contamination.

Seven areas of the landfill were found to contain hazardous substances. The material included 160 PCB capacitors, rusted crushed drums (fewer than 100), broken laboratory bottles, metal shavings, and used automobile air and oil filters. During the East Traffic Circle Landfill exumation, several areas of visibly discolored soil were observed in layers up to a few feet thick.

The amount of soil removed depended on the analyte considered. Virtually all measurable (less than 0.050 mg/kg), PCB-contaminated soil was removed. Heavy-metal-contaminated soil piles were removed to below California Total Threshold Limit Concentration (TTLC) guidelines. The heavy metal concentration remaining in the landfill pit was believed to be within the ability of the sorptive capacity of the soil to immobilize the contaminants. No goal appears to have been established for the removal of volatile organics from the old landfill. Soil samples from below empty drums indicated the presence of 11 mg/kg of TCE and 50 mg/kg of PCE. Residual TCE and PCE concentrations are unclear from available information. A monitoring well located near the old landfill (MW-142) has shown 410 µg/l TCE as well as a variety of other chlorinated organics.

The adequacy of the source removal at the East Traffic Circle Landfill is unclear because of the lack of analytical data on organic contaminant concentration during and after the cleanup. The cleanup appears to have been focused primarily on radionuclides and PCB, not organic solvents. In only a few cases were any sampling and analysis performed for organic solvents. Several soils samples revealed TCE. This sampling and analysis was initiated by visual evidence of contamination such as drums, bottles or carboys, and discolored soil. The lack of routine

monitoring may have resulted in residual contamination's going undetected. There is no information on the type and amount of residual contamination.

5. Taxi Strip. Spills and surface impoundments ("evaporation trays") located on a former Navy taxi strip caused groundwater contamination. From 1953 until an excavation operation in 1983, hazardous waste was stored on an area south of the East Traffic Circle, known as the Taxi Strip. It was named for the Navy taxi strip previously on the site. The 1983 excavation project removed most of the contaminated soil pursuant to California State guidelines. Groundwater contamination is known to have occurred, however, because of the following historical activities on the taxi strips:

   - Storage of thousands of carboys containing acids and caustics (90 percent) and organic solvents (1-2 percent).
   - "Solar Evaporators" (also referred to as "evaporation ponds") approximately 10 feet by 20 feet by 1 foot (essentially small, unlined surface impoundments) were used to evaporate liquid wastes.
   - Storage and transfer of used oils and solvents (south of Building 431).

   In 1983, about 4,000 cubic yards of contaminated soil were removed from the taxi strip area to a maximum depth of about 35 feet. A monitoring well near the taxi strip has shown TCE contamination of up to 740 µg/l.

6. Old Salvage Yard. Spills and discharges of hazardous substances on the old salvage yard may have contaminated groundwater. An old salvage yard was located on the present site of the electrical power distribution center south of the former taxi strip. The old salvage yard served essentially the same role as the current yard relocated to the southeast in 1979, except that hazardous substances were stored and spilled there. There is no information available on the type or quantity of waste at this site.

7. Inadequate Spill Identification, Characterization, and Cleanup. Inadequate identification and characterization of spills may result in continued or future groundwater contamination. According to a published compilation (Dreicer, 1985), there are approximately 50 known or suspected areas of contamination. A total of 52 areas are aggregated and listed in Table 4-22. Of these, 14 sites are known to be contaminated and 34 other areas were suspected of being

contaminated. In addition, 4 areas (e.g., carcass burial) were believed to be of "little concern." The areas considered to be "suspect" include several areas where some contamination can be visually observed on the surface (e.g., No. 24-plating shop spills).

Of these 52 areas, the Survey team reviewed the available analytical data for 41 of these sites in some detail. Approximately half (22) of the sites evaluated have not been directly sampled. In several cases, groundwater monitoring downgradient of the sites indicated that the sites were not sources of groundwater contamination. Soil samples have not been taken at the sites to confirm whether subsurface contamination has occurred (i.e., a potential source of groundwater contamination). This lack of information may result in contaminated areas remaining in place. These contaminated areas may create leachate slowly or more rapidly in the future because of a change in drainage patterns or removal of a temporary cap, such as a trailer or an asphalt pad. Also, failure to identify contaminated soil areas could result in the inadvertent removal of that soil to an unsafe location such as a landfill or an on-site "clean" fill area on a construction site or a recreational field. Windborne soil may also present an inhalation or dermal contact risk.

The ongoing groundwater investigation at LLNL is being coordinated with the identification, characterization, and cleanup of contaminated areas. In cases where significant groundwater contamination has been found, such as the Old Taxi Strip, the Building 403 gasoline leak and the East Traffic Circle Landfill, source characterization and cleanup have been performed or are being planned. The remainder of the list of 52 known or potential sources of contamination appears to be relatively smaller sources. These sources have the potential to contaminate groundwater or other environmental media. The planned groundwater pump-and-treat operation can only serve as a temporary plume stabilization process until the ultimate sources of the groundwater contamination are found and mitigated through removal or treatment.

8. Landfills (Site 300). The inactive landfills (2, 3, 4, 5, and 8) at Site 300 appear to be causing groundwater contamination. The active landfills (1 and 7) may also be sources of groundwater contamination but are discussed in this report in Section 4.1. These landfills are occasionally referred to as "pits."

TABLE 4-22

KNOWN AND SUSPECTED CONTAMINATION AREAS
APRIL 1985
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

1. Oil drums drained
2. Fire training area spills
3. Old reactor retention tanks
4. Dip tank spills
5. Solvents used
6. Garbage pits
7. Swamp
8. Fire training area spills
9. Buried cows and goats
10. Pu garden
11. Garbage pits
12. East Traffic Circle landfill
13. Radioactive material storage
14. Radioactive spill
15. Plating shop sumps
16. Old garbage dump
17. Barrel storage spills
18. B-231 sump (N)
19. B-231 sump (S)
20. Solvent spills
21. Old B-331 dry well
22. TCE spills
23. B-222 retention tanks
24. Plating shop spills
25. Acid dissolver
26. Navy gas tanks
27. Barrel storage rack
28. TCE spills
29. Xylene and toluene spills
30. Hg reclaimer
31. Machine shop spills
32. Plating shop sump
33. Navy continuous fuel pit
34. Navy gas pits
35. Navy gas and oil tanks
36. Old drum and cylinder storage
37. Oil and chemical spills
38. Taxi strip
39. Oil and chemical spills
40. Bunkers and storage yard
41a. Present road oil stored (W)
41b. Present road oil stored (E)
42. Past road oil stains
43. Waste evaporation
44. TCE and diesel fuel spills
45. Radioactive waste operation
46. Pipe shop dip tank
47. Solar evaporation pit
48. Salvage yard
49a. Solvent and oil spills (N)
49b. Solvent and oil spills (S)
50. Temporary barrel storage
51. Fuel tankers stored
52. Old salvage yard

Source: Dreicer, 1985.

The eight landfills at Site 300 are listed in Table 4-23 with the waste received and period of use. Landfills 1 and 7 are presently open and receiving hazardous waste as interim status facilities. Landfill 6 (Pistol range landfill) received primarily uncontaminated garbage, except for 2,000 PCB capacitors. PCBs are very insoluble and generally immobile in groundwater.

The landfills are discussed in more detail in the Phase I report (Lindeken et al., 1986) and a special study report on groundwater (Buddemeier et al., 1985). Generally, the landfills received shot debris and firing-table gravel associated with hydrodynamic test operations at the high explosives firing bunkers containing uranium, beryllium, and lead.

Landfills 3, 4, and 5 are grouped together on the western edge of Site 300, straddling the border between Alameda County and San Joaquin County. These landfills received firing-table debris contaminated with tritium. The precise amount of tritium in these landfills is unknown. More than 200,000 pCi/l of tritium activity was found in the vadose zone and groundwater near these landfills. Although details of the high explosives experiments involving some form of tritium are still classified, unclassified shipping records indicate that about 22,670 Ci of tritium were sent to Site 300 between 1963 and 1978. About 20,900 Ci were expended during testing, of which approximately 90 percent was expended at Bunker 850. Wastes from Bunker 850 were sent to Landfills 3, 4, and 5. According to Buddemeier et al. (1985), Pit 3 is most clearly a tritium source. Pit 4 appears to be a relatively negligible source of tritium. Active Pit 7 does not appear to be a tritium source because it opened in 1978 following cessation of the tritium tests. The relatively low contribution from Pit 5 is unclear because information is not available on types and quantities of disposed wastes. Details on the distribution of tritium in the groundwater are given in Section 3.4.4.3.2. Investigation on the extent of contamination and possible remedial activities are continuing. It is possible that the tritium will decay to below drinking water standards before it migrates over the facility boundary.

9. Landfill Caps at Site 300 are Inadequate and are Eroding and Failing. Loss of integrity of the caps on Landfills 2, 3, 4, and 5 at Site 300 may result in continued or future groundwater contamination because of infiltration of rainfall or surface water and subsequent leachate generation. The caps at Landfills 2, 3, 4, and 5 have been compromised by rodent burrowing and erosion. The Survey team observed dozens of ground squirrel burrows in the landfills. In addition, a drainage ditch appears to have migrated and expanded into landfill Pit 2. No

TABLE 4-23

SITE 300 LANDFILLS
LAWRENCE LIVERMORE NATIONAL LABORATORY -
LIVERMORE, CALIFORNIA

Landfill	Waste Received	Period of Use
1	Firing table debris	1961 - Present
2	Firing table debris	1956 - 1960
3[a]	Firing table debris	1958 - 1967
4[a]	Firing table debris	1968 - 1979
5[a]	Firing table debris	1968 - 1978
6	Decontaminated furnaces, filters, glove boxes, damaged pallets, PCB capacitors, drums (mostly empty)	1964 - 1973
7	Firing table debris	1978 - Present
8	Firing table debris	???? - 1962

Source: Lindeken et al., 1986.

[a] Received tritium wastes from Bunker 850; about 22,670 Ci of tritium were shipped to Site 300 for high explosive tests from 1961-1978. About 95% of tritium was used at B-850.

debris was observed to be exposed from the bank of the widening ditch, but the gravels may have been from a shot table. There were no markers at Pit 2 to identify precisely where the landfill was located and, thus, which area was a cap whose integrity needed to be protected from erosion.

Landfills 2 and 8 also received firing-table debris similar to that deposited in Pits 3, 4, and 5, except that relatively insignificant quantities of tritium were believed to have been disposed of in these pits, according to LLNL (Buddemeier et al., 1985). Because all are located on the northeastern side of Site 300, these pits were grouped together for HRS scoring. The HRS score of 17.0 appears to be in error because of the assignment of an observed release score of zero, despite the detection of tritium and uranium in the groundwater. The observed release should have automatically merited 45 points in the raw calculations. This change could have had a significant effect on the HRS score.

10. TCE Contamination Near B-834 (Site 300): Trichloroethylene (TCE) has been released at Site 300 from the Building 834 complex, as well as Building 830 and near the General Services Area (GSA) area dry wells. The source of the TCE release at the B-834 Complex has been determined by LLNL, and is described below. The exact source of the TCE contamination at B-830 and the GSA is not clearly known. TCE has also been found in groundwater from Spring 3 and Well 7, which are both in the GSA. More details on the groundwater quality are given in Section 3.4.4.3. In addition, the TCE contamination at Site 300 was the subject of a 1983 report (Carpenter et al., 1983), and was addressed in Part I of the Phase I report (Lindeken et al., 1986).

TCE was used at the B-834 test complex as a heat transfer fluid. Built in 1959, the B-834 Complex consists of several buildings and test cells used for thermal treatment and testing of weapons components. TCE releases occurred probably from Buildings C and D as a result of deterioration of pump seals, valve gaskets, and pipe threads, as well as direct discharges to floor drains or dry wells. Several hundred cubic yards of contaminated soil were removed from around B-834, but no soil cleanup goals were specified and no post-cleanup testing was performed; hence, there may be residual contaminants.

B-834 is believed to be the largest source of TCE at Site 300, but some TCE has been found in two other areas. The TCE found in water from Spring 3 is believed to be a result of TCE use at B-830, but this connection has not yet been established through groundwater monitoring. The TCE contamination in Well 7 (0.9 to 52 µg/l, with most samples between 1 and 5 µg/l from

1982 to 1983) is believed to be a result of activity in the GSA, but no TCE was found in water from three boreholes near Well 7. Soil and rock samples near Well 2, however, did indicate the presence of TCE. The Survey team observed extremely sloppy housekeeping activities around Well 7. Dried paint sludge and oil-stained and old drums were found within 30 yards of Well 7.

11. Miscellaneous Spills and Abandoned Waste. Miscellaneous spills and abandoned waste areas at Site 300 may be sources of soil and groundwater contamination. The Survey team observed the following spills or abandoned wastes:

- GSA area near Well 7 (stained soil and abandoned drums).
- GSA area between B-875 and B878 on south side near Corral Hollow Road (stained soil).
- GSA area north of B-875 along embankment, and drum rack (stained soil and discolored runoff).
- B-827 C, D, and E drum rack drains and sumps (stained concrete and sediment).
- Buried drum behind B-827E drum rack.
- B-827A oil spills on pavement.
- B-8750 drain on uphill side of Building 805 (stained asphalt and sediment).

This list does not necessarily represent a comprehensive compilation of spills or abandoned waste areas at Site 300. These areas indicate the presence of relatively small actual or potential sources of groundwater contaminaton that, in sum, may equal or exceed the threat posed by larger sources, such as the B-834 Complex TCE leak.

12. Inadequate Cleanup ("Closure") of HE Process Wastewater Lagoons. The lack of completed cleanups ("closures") of HE wastewater lagoons at Site 300 may result in groundwater contamination. The HE lagoons are now being reviewed for "closure" under RCRA (40 CFR, Section 264), which is administered by the State of California Regional Water Quality Control Board - Central Valley Region. A "closure" (cleanup) under RCRA does not necessarily involve exuming the waste, but may simply require monitoring and capping, based on state requirements.

Wastewaters from HE processing in various buildings at Site 300 were discharged to lagoons near those buildings. Eight lagoons were used for disposal of wastes from HE processing until a permitted surface impoundment was installed in 1985. Table 4-24 shows the flow and composition of HE wastewaters to the lagoons. The HE lagoons were constructed between

the late 1950s and mid-1960s (e.g., B-805 was built in 1957; B-806C was built in 1966). According to on-site interviews by the Survey team, however, the weir and clarifier systems were built approximately 2 to 5 years after the buildings. Presumably, the buildings were used for HE processing during this period, prior to the construction of the weir and clarifier systems. Therefore, for an uncertain number of years, raw HE processing wastewater was discharged to the lagoons. Recent analytical data (Raber, 1983) from water sampled downstream of the weir/clarifier system and the nucleopore filter is of limited relevance to understanding the nature of the wastes discharged into the lagoons because it excludes the undissolved HE which had been discharged into the lagoons prior to the construction of the weir/clarifier system. The highest volume of HE-processing wastewater was apparently discharged to B-806 lagoon, which was constructed in 1966 and presumably had a clarifier installed before operation, unlike the pre-1960 lagoons. The lagoons at B-827C and B-827D do not have a clarifier.

Qualitatively, the HE processing wastes have included the following compounds:

- Xylene
- Acetone
- Ethyl acetate binder
- Propellants
- Baratol
- Ammonium perchlorate
- HMX (1,3,5,7-tetrahitro-1,3,5,7-tetraazacyclooctane)
- RDX (1,3,5-trinitro-1,3,5-triazacycl nexane)
- TNT (trinitrotoluene)
- PETN (pentaerythritol tetranitrate)
- TATB (triaminotrinitrobenzene)

Quantifying the presence of these compounds in soil and groundwater samples is difficult in some cases. For example, TATB has a very low solubility in water (less than 1 part per million), and no analytical procedures have been developed for its determination at low concentrations. The detection limit for PETN using high-performance liquid chromatography (HPLC) was 300 ppm (Raber, 1983).

TABLE 4-24

FLOW AND COMPOSITION OF HE* WASTEWATERS TO LAGOONS
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Building	Estimated Flow, Gallons/Day	Contaminants
825	5	Xylene, acetone, ethyl acetate binder, propellants, explosive compounds HMX, RDX, TATB, TNT, Baratol, and ammonium perchlorate
826	5**	Xylene, acetone, ethyl acetate binder, propellants, explosive compounds HMX, RDX, TATB, TNT, Baratol, and ammonium perchlorate
827C	50	Xylene, acetone, ethyl acetate binder, propellants, explosive compounds HMX, RDX, TATB, TNT, Baratol, and ammonium perchlorate
827D	80	Xylene, acetone, ethyl acetate binder, propellants, explosive compounds HMX, RDX, TATB, TNT, Baratol, and ammonium perchlorate
827E	150	Xylene, acetone, ethyl acetate binder, propellants, explosive compounds HMX, RDX, TATB, TNT, Baratol, and ammonium perchlorate
828C	500	Xylene, acetone, ethyl acetate binder, propellants, explosive compounds HMX, RDX, TATB, TNT, Baratol, and ammonium perchlorate
806A, 806B	6,000	HMX, RDX, TATB, TNT, 807
817A	100	Xylene, acetone, ethyl acetate binder, propellants, explosive compounds HMX, RDX, TATB, TNT, Baratol, and ammonium perchlorate

Source: Raber, 1983.
* High explosives
** 100 Gallons from cooling tower

A 1983 LLNL study (Raber, 1983) reported residual RDX and TNT among other contaminants in the highly filtered wastewater (i.e., the concentrations exceeded Safe Drinking Water Act Maximum Contaminant Levels (MCLs) for the few compounds having MCLs, and exceeded National Academy of Sciences, National Research Council (NRC) guidelines). The sensitivity of the analtyical technique used, however, was too crude to detect parts per billion (ppb) concentrations. Therefore, many compounds may have been undetected, despite their presence.

Significant concentrations of HMX, RDX, and TNT were found in lagoon water and sediment samples (following weir and filtration), but not in well water or springs. The upper limit recommended by the National Research Council for RDX and TNT (0.050 mg/l) was exceeded in the wastewater of lagoons 806/807 (0.5 mg/l RDX; 1.03 mg/l TNT) and 817 (2.1 mg/l RDX). No detectable (greater than 0.03 mg/l) RDX or TNT was found in the other lagoon wastewater. Significant HMX (up to 4.4 mg/l) was found in lagoon water samples. Barium (75 mg/l) and selenium (0.7 mg/l) concentrations were above RCRA groundwater protection standards (40 CFR 264.94).

The estimated discharge rate among the lagoons varied from 5 gallons per day (gpd) to 6,000 gpd. The average flow rate was about 860 gpd. The duration of use also varied from 21 to 28 years with an average of about 25 years of use. Hence, the lagoons may have received about 62.8 million gallons of wastewater over the lifetime of the lagoons (860 gpd [average rate flow] x 8 lagoons x 365.25 days/year x 25 years). Because these lagoons may have been used intermittently, the estimate probably serves as an upper bound.

LLNL is currently conducting the initial investigation stage of a planned lagoon closure program. Soil cores are being taken of each lagoon. Future closure activities will depend on the results of this investigation.

13. Overflow Basin for Sewage Lagoon. An "overflow" basin located southeast of the sewage lagoon near the GSA of Site 300 may be the source of soil or groundwater contamination. The overflow basin is usually dry, but has been used in the past. The bottom of the basin is devoid of vegetation and appears to be discolored. No information is available on whether or not hazardous substances were released into the basin. If oil or other hydrophobic supernatants were released to the sewage lagoon, then these substances would be preferentially released to the overflow basin because the overflow pipe for the sewage lagoon is located near the

surface of the lagoon. Floating compounds such as oils would therefore have been skimmed off the surface. Survey-related sampling is planned.

14. Dry Well Closure at Site 300 GSA. At the GSA of Site 300, disposal of solvents and other waste into dry wells, as well as inadequate closure of dry wells, may result in continuing or future groundwater contamination. Seven dry wells located in the GSA at Site 300 were used for the disposal of a variety of hazardous substances from the early 1960s until the State ordered their closure in 1980. The waste types and the approximate disposal rates for the closed GSA dry wells are given in Table 4-25.

In 1980, the California Regional Water Quality Control Board (CRWQCB) ordered (Order Number 80-183) LLNL to cease use of, and close, five dry wells (874N, 872S, 875S2, 873E, 879ESE) at the GSA. In late 1983, LLNL closed seven dry wells (875S1 and 873S, in addition to those listed in CRWQCB Order 80-183) by removing the casings and 1 foot of soil from around the wells. Most of the old dry-well locations were then covered with asphalt of the same thickness as the surrounding parking area. During the December 1986 survey, these old dry well locations looked like filled-in pot holes, because the asphalt patches covering them were the only remaining markers visible.

The potential for groundwater contamination stems from the potential for residual-contaminated soil remaining under and around the old dry wells after the closure. No soil sampling was performed following the exhumation, however, to determine whether the remaining soil was contaminated. The amount of soil removed was a constant 1 foot around each dry well, regardless of the amount of wastes discharged to the well. Therefore, it is unclear whether or not all of the contaminated soil was removed because the amount of soil removed was not related to the amount of contaminated soil. For example, 874N photolab rinsewater dry well apparently received relatively little waste, but 873S paint shop dry well received significantly more waste (150 gallons/month). Both, however, had 1 foot of soil removed from around the old dry well. Since contaminated soil may remain in the area of these "closed" dry wells, continued or future groundwater contamination may result.

TABLE 4-25

GSA DRY WELL SUMMARY
LAWRENCE LIVERMORE NATIONAL LABORATORY - LIVERMORE, CALIFORNIA

Dry Well	Waste Type	Disposal Rate
874-N	Photolab rinsewater (MEK, toluene, Freon)	Not available
879-ESE	Auto steam cleaning (xylene, toluene, MEK)	< 10 gallons/day
872-S	Acrylic/latex paints, oil paints, acetone, MEK paint thinner, MEK, alkaline soap	30 gallons/day 350 gallons/day
875-S1	Machine shop washdown, steam cleaning	50 gallons/month
875-S2	Acid dip rinsewater	50 gallons/month
873-E	Acid dip rinsewater	50 gallons/month
873-S	Water-based paint	150 gallons/month

Source: Ragaini, 1984

Some dry wells located outside the GSA in the process and firing areas were included in the March 19, 1985, RCRA dry well list submitted to the USEPA, but were not located, characterized, or cleaned up.

Groundwater contamination, if any, resulting from the dry wells is probably low because the wells did not receive large quantities of concentrated waste. Most of the highly soluble contaminants have already dispersed, and filterable contaminants such as sludges and heavy metals have likely adsorbed to the soil matrix and were removed with the exhumed soil. But, because of the lack of data, the actual contaminant distribution is unknown. Also, the asphalt paving over the old dry well locations serves as a cap which prevents or retards infiltration and leachate formation. Some leachate may be formed, however, from the relatively shallow local water table rising up to contaminated soil.

The solvent contamination in the groundwater at the GSA area has also not yet been completely characterized or addressed. There are several potential sources in the GSA area that may be contributing to the contamination. First, seven former dry wells in the GSA area, described above, were exhumed but no sampling and analysis was performed to confirm that the cleanup was adequately completed. In addition, TCE contamination from the B-834 Complex (north of the GSA) is known to exist, but the extent of that contamination is uncertain (Lindeken et al., 1986). Survey-related sampling is planned.

15. Diesel Fuel Tankers at Site 300. Residual fuel oil in four diesel tankers at Site 300 may present a fire and explosion hazard, as well as a soil and groundwater contamination threat.

Two diesel tank trailers are parked across from Building 811, and another two are parked between Well 7 and the sewage pond east of the GSA. These tankers were all originally parked along with several others across from B-811. Initially filled with diesel fuel oil for supplemental storage during the 1979 oil crisis, these tankers have not been used for several years. No "gas free" certification was available, however, to indicate that they had been completely emptied. Personnel interviewed on-site by the survey team indicated that there was probably several inches of residual oil in each tanker that could not be readily pumped out. The two tankers east of the GSA were parked in tall, dry grass that could present a fire hazard.

4.5.2.4 Category IV

1. Inadequate Reporting and Cleanup of Ongoing Spills and Reportable Quantity Releases. The failure of LLNL personnel to promptly report and clean up spills of hazardous substances may result in groundwater contamination, as well as possible surface-water contamination and fugitive hazardous dust emissions.

The Survey team observed numerous visible spills of hazardous substances that had neither been reported to LLNL's Hazards Control Department (HCD) or environmental agencies, nor been cleaned up. The following list identifies the hazarous substance spill locations, as well as known or suspected substances spilled, as observed by the Survey team:

- Main Site
  - Drum rack south of B-231 – solvents.
  - Retention tank overflow at B-322 Plating Shop – solvents, acids, heavy metals.
  - Drum rack south of B-321A (near First Street) – solvents.

- Site 300
  - GSA area near Well 7 – solvents, oil.
  - GSA area between B875 and B878 on south side near Corral Hollow Road – solvents, oil.
  - GSA area north of B875 along embankment, and drum rack – solvents.
  - B827 C, D, and E drum rack drains and sumps – solvents.
  - Buried drum behind B827E drum rack – unknown.
  - B827A oil spills on pavement.
  - B805 drain on uphill side of Building 805 – unknown.

This list does not necessarily provide an exhaustive catalog of spill locations. Other spills that have neither been reported to HCD nor cleaned up may exist. Many other spills have been reported and cleaned up. This list is intended to show that some areas have not been reported to HCD or cleaned up. According to a representative of the Guidance and Monitoring Section of LLNL's Environmental Protection Program (DeGrange, 1986), spills should be reported to the Hazards Control Department (HCD) technician and to the HCD team leader. Personnel within the HCD-Guidance and Monitoring group seemed to be cognizant of CERCLA's reportable quantity regulations (40 CFR 302), but spills do not appear to be routinely reported to HCD for their evaluation.

Interviews by the Survey team of several LLNL employees indicated that spill reporting training was inadequate. When program staff, who actually handle hazardous substances, were interviewed, they seemed unsure of who should be told about spills and said they only reported spills that were large. Guidance and Monitoring analysts and hazard control technicians seemed very well informed about spill reporting. However, these personnel do not usually directly handle hazardous substances. Hence, spills of hazardous substances at or above a reportable quantity may occur without an evaluation by HCD staff to determine whether it is reportable. In addition, spills of hazardous substances in amounts below a reportable quantity may present a threat to human health and the environment due to accumulated impacts.

2. Inadequate System for Preventing Inadvertent Excavation of Contaminated Soils. The lack of an adequate system to avoid digging into contaminated areas at the Main Site and Site 300 may result in groundwater contamination, off-site emissions of fugitive dusts, and inappropriate disposal.

The Main Site has a considerable number of areas contaminated with hazardous substances. Because of the high level of construction activity, there is a significant probability that these areas will be penetrated during excavation of building foundations or utility trenches. Failure to identify and characterize contaminated soil prior to excavation could result in (1) disposal of contaminated soil off-site at an inappropriate facility (i.e., Subtitle D facility or a recreational field), (2) exposure of contaminated soil to rain and subsequent enhancement of leachate production; (3) movement of contaminated equipment off-site or to unprotected areas, and (4) off-site dispersion of air emissions from fugitive dust.

3. Off-site Disposal. Hazardous waste may have been shipped off-site to disposal facilities that are, or may be, sources of groundwater contamination or other environmental releases of hazardous substances.

The Survey team reviewed documentation of off-site disposal. Records for disposal occurring after 1980 were believed to be adequate. Manifests were generally completed for each shipment and contained information regarding the amount and type of wastes being disposed of and the off-site disposal facility. For disposal prior to 1980 the off-site disposal location was usually not noted; only the transporter was indicated. Purchase orders rather than manifests were often used from 1978 to 1980.

In most cases documented hazardous waste shipments showed that, until recently, the waste was transported to sites that are now prohibited from receiving further waste shipments from EPA Superfund cleanups or San Francisco Operations Office facilities (e.g., IT Corporation-Martinez, IT Corporation-Benecia, and Chemical Waste Management, Inc.-Kettleman Hills) because of significant RCRA noncompliance at these facilities. If any site where LLNL waste has been sent becomes a Superfund site on the EPA's National Priorities List, then DOE may assume a CERCLA-generator liability for the cleanup costs and natural resource damages.

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APPENDIX A

SURVEY PARTICIPANTS

APPENDIX A

SURVEY PARTICIPANTS

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* NUS Coordinator

APPENDIX B

SITE-SPECIFIC SURVEY ACTIVITIES

APPENDIX B

SUMMARY OF SURVEY ACTIVITIES

B.1 Pre-Survey Preparation

The Department of Energy (DOE) Office of Environmental Audit, Assistant Secretary of Environment, Safety and Health, selected a Survey team for the Lawrence Livermore National Laboratory in June 1986. Mr. Lawrence A. Weiner was designated the DOE Team Leader, with Ms. Susan Barisas serving as the Assistant Team Leader. Mr. Gerald Katz was the point of contact during the on-site Survey in all Survey efforts for the San Francisco Operations Office. The remainder of the team was composed of contractor specialists from the NUS Corporation and its subcontractor, ICF Corporation. These individuals and their areas of expertise are listed below.

Speciality	Name
Air	Joseph Crist*
Surface Waters	Joseph Boros
Waste Management	Ralph Basinski
Inactive Waste Sites	James Werner (ICF)
Hydrogeology	Amy Hubbard
Radiation	Mark Francis
QA/Toxics	Arthur Olszewski

* NUS Coordinator

Survey team members began reviewing LLNL general environmental documents and reports in July 1986. Messrs. Weiner, Basinski, Crist, Burd, (Health and Safety Representative), and Ms. Barisas conducted a pre-Survey site visit on October 20-22, 1986, to gain familiarity with key DOE and site personnel. They toured the facility and completed a cursory review of the data generated in response to an information request of September 26, 1986. The request listed environmental information of interest to the Survey team for Survey planning purposes.

Ten representatives from state and local environmental agencies attended a meeting at the San Francisco Operations Office. Agencies represented included the Bay Area Air Quality Management District, the Regional Water Control Board-San Francisco Region, the Alameda County Environmental Health Department, the Zone 7 Water Agency, the California Department of Health Services, the City of Livermore, and the City of Tracy. The Environmental Protection Agency was not able to send a representative. Meeting attendees are listed in Table B-1. The questions from the attendees were general in nature and no major issues were raised, environmental or otherwise. The attendees expressed interest in receiving a copy of the Environmental Survey Manual and Interim Survey Report, and there were a few questions about the prioritization system and the money available for corrective action. Although the state expressed interest in the sampling aspects of the survey, there were no inquiries regarding the opportunity to split samples or participate in the survey in any other way. The meeting lasted approximately 45 minutes.

The Survey team intensively reviewed the information generated during the pre-Survey visit and prepared a Survey Plan for the LLNL site. This plan described the specific approach to the Survey for each of the technical disciplines and included a proposed schedule for the on-site activities.

B.2 On-Site Activities

The on-site portion of the Survey was conducted during the period of December 1-19, 1986. The opening meeting was held on December 1, 1986, at the site, and was attended by representatives from DOE Headquarters, the San Francisco Operations Office, LLNL, NUS Corporation, and ICF Corporation. Discussions during this meeting centered on the purpose of the Survey, logistics at LLNL, and an introduction of the key personnel involved.

During the Survey, team members reviewed file materials, permits and applications, background studies, engineering drawings, accident reports, and operating logbooks. The production process was thoroughly analyzed to identify existing and potential pollutants. Site operations and monitoring procedures were observed. Extensive interviews were conducted with plant personnel regarding environmental controls, operations, monitoring and analysis, past operations, regulatory permits, and waste management.

Periodic meetings of the Survey team members were held to report observations and compare findings. The DOE Team Leader, the Assistant Team Leader, the NUS Coordinator, and Survey

TABLE B-1

DOE ENVIRONMENTAL SURVEY MEETING WITH AGENCIES
OCTOBER 22, 1986

Name	Organization
Gerald Katz	DOE/San Francisco
Joseph. G. Crist	NUS Corporation
Larry Weiner	DOE/Headquarters
Susan Barisas	DOE/Argonne National Laboratories
Richard Ragaini	Lawrence Livermore National Laboratories
Perry K. Lovell	Sandia National Laboratories Livermore
Ronald L. Peterson	DOE/Albuquerque
John Cochran	DOE/Albuquerque
Jim Davis	DOE/San Francisco
Theresa Rumjahn	Regional Water Quality Control Board - San Francisco Region
Chris Smith	City of Livermore
Thomas K. Devlin	Sandia National Laboratories Livermore
Fred Hoffman	Lawrence Livermore National Laboratories
Irene Nishimura	City of Tracy, Community Development Department
Joe Slamovich	Bay Area Air Quality Management District (AQMD)
Susan Brechbill	DOE/San Francisco
Jack Bean	Bay Area AQMD
R. Roth	Bay Area AQMD
Gerald H. Winn	Alameda County Environmental Health
J. Killingstad	Zone 7 Water Agency
Denise Tsuji	Department of Health Services
Rafat A. Shahid	Alameda County Environmental Health
Roger Ferenbaugh	Los Alamos National Laboratory

team members met daily to discuss findings and progress, and to arrange for specific site personnel and facilities to be available, as needed, on the following day.

The Survey team members identified further sampling and analysis requirements necessary to complete the Survey effort. The sampling and analysis requirements were discussed with Oak Ridge National Laboratory (ORNL) representatives on December 15-18, 1986. ORNL had been designated by DOE to provide the sampling team for the LLNL site and to perform the laboratory analytical services.

A site close-out briefing was held on December 19, 1986, where the DOE Team Leader presented the preliminary observations of the Survey team. These observations were classified as preliminary, because additional research and, in some cases, additional field sampling were required to positively confirm the observations.

B.3 Sampling and Analysis

ORNL will perform the sampling and analysis portion of the Survey. ORNL evaluated the Sampling and Analysis Requests made by the Survey team and determined sampling and analysis logistics, costs, and schedules. The Sampling and Analysis Plan prepared by ORNL includes a quality assurance plan and a health and safety plan. The Sampling and Analysis team is expected to begin work at the site during August 1987.

B.4 Report Preparation

A Survey Preliminary Report for the LLNL site will be prepared for DOE review. Comments from this review and the results of the sampling and analysis efforts will be incorporated, and the report will be reissued as an Interim Report. The timing of the Interim Report is dependent upon the completion of the sampling and the reporting of the analytical results to the Survey team.

APPENDIX C

SURVEY PLAN

ENVIRONMENTAL SURVEY PLAN

LAWRENCE LIVERMORE NATIONAL LABORATORIES

DECEMBER 1 - 19, 1986

LIVERMORE, CALIFORNIA

1.0 INTRODUCTION

The Lawrence Livermore National Laboratory (LLNL) survey is part of the larger Department of Energy (DOE)-wide Environmental Survey effort announced by Secretary John S. Herrington on September 18, 1985. The purpose of this effort is to identify, via "no fault" baseline surveys, existing environmental problems and areas of environmental risk at DOE facilities, and to rank them on a DOE-wide basis. This ranking will enable DOE to more effectively establish priorities for addressing environmental problems and allocate the resources necessary to correct these problems. Because the survey is "no fault" and is not an "audit," it is not designed to identify specific isolated incidents of noncompliance, or to analyze environmental management practices. Such incidents and/or management practices will, however, be used in the survey as a means of identifying existing and potential environmental problems.

The LLNL survey will be conducted in accordance with the protocols and procedures contained in the May 16, 1986, draft Environmental Survey Manual.

2.0 SURVEY IMPLEMENTATION

The Environmental Survey of Lawrence Livermore National Laboratories (LLNL) will be managed by the Team Leader, Larry Weiner and the Assistant Team Leader, Susan Barisas. Gerald Katz will serve as the San Francisco Operations Office (SAN) representative on the Environmental Survey team. Technical support is provided by NUS Corporation personnel as follows:

Joseph G. Crist	NUS Coordinator/Air
Joseph Boros	Surface Water/Underground Tanks
Arthur Olszewski	QA/TSCA (Toxic Materials)
Mark Francis	Radiation
Ralph Basinski	RCRA (Solid, Hazardous, and Radioactive Wastes)
James Werner	CERCLA (Inactive Sites)
Amy Hubbard	Hydrogeology/Soil
Elmer Burd	Air/Radiation/TSCA (Toxic Materials)

2.1 Pre-Survey Activities

Pre-Survey activities began in early September, 1986, when Survey team members began reviewing LLNL environmental documents that were available at the DOE office of Environmental Audit & Compliance (OAC). This review was followed by a September 26, 1986 memorandum from Lawrence A. Weiner (OAC) to James T. Davis (SAN) and LLNL (via SAN), announcing the pre-survey site visit and requesting additional survey-related information.

The pre-survey site visit, October 21-23, 1986, was conducted by Mr. Weiner, Ms. Barisas, Mr. Crist, Mr. Basinski, Mr. Burd (NUS Health and Safety Advisor) and Mr. Katz. The purpose of the visit was to become familiar with the site, identify potential areas of concern for purposes of the survey, collect the documents requested in the September 26 memorandum, and coordinate plans for the upcoming survey with SAN and LLNL personnel. Mr. Ken Moor, Idaho National Engineering Laboratory (INEL) and Ms. Sandy Wagner, United Nuclear Corporation (UNC), Grand Junction Project Office (GJPO) who will manage the sampling and analysis program also attended the pre-survey site visit. During this pre-survey visit, the team met with representatives of SAN and LLNL, and officials of the various state, regional, county, and city environmental agencies. Team representatives toured the facility and collected the documents assembled by site personnel in response to the information request memorandum. These documents were transferred to NUS Pittsburgh offices in November for use by

team members during the planning stage of the survey. Additional information was requested during the pre-survey site visit and has been received. This survey plan is based upon the information received by the survey team as of November 12, 1986.

2.2 On-Site Activities and Survey Reports

The Environmental Survey will be conducted from December 1, 1986 through December 19, 1986. The survey will include the Livermore site and the Site 300. A tentative agenda is as shown in Table 1. It is expected that modifications to the agenda will be made as appropriate to minimize disruption of site activities, and to enhance survey efficiency and effectiveness. All modifications to the agenda will be coordinated with the site officials designated as survey contacts.

The on-site activities of the survey team will consist of discussions with, among others, environmental, safety, operations, waste management, purchasing, and warehousing personnel; a review of files and documents (including classified documents) unavailable prior to the on-site portion of the survey; and process-specific and area-specific tours of the facility.

A closeout briefing will be conducted on Friday, December 19, to describe the preliminary findings of the survey team. A draft report of the LLNL survey will be prepared within 4 to 6 weeks from the conclusion of the survey. The draft report will be sent to SAN and LLNL for review and comment.

Within 4 to 6 weeks of the completion of the sampling and analyses (S & A) portion of the survey (discussed below) an interim report will be prepared by the survey team. The interim report will incorporate comments to the draft report and the data from the S&A results. The interim report will be made available to the public upon request.

Upon completion of the Environmental Survey effort a final report will be prepared and will contain a DOE-wide list of environmental problems. The report will be used as an information base for the ranking of DOE's environmental problems.

2.3 Sampling and Analysis

Based on available site environmental information and the results of the on-site survey activities, the LLNL survey team will identify survey-related sampling needs. Implementation of the S&A phase of the LLNL survey will begin approximately 12 weeks after the completion of the on-site survey activities. This effort is expected to have a 2-4 week duration and will be conducted by INEL. Mr. Ken Moor will be the INEL Team Leader for the S&A phase of the LLNL survey. The INEL sampling team will draft a sampling plan based upon the

sampling needs identified by the survey team. The Assistant Team Leader (Ms. Barisas) will coordinate the review of this sampling plan with SAN, LLNL, and EPA's Environmental Monitoring Systems Laboratory (EMSL) in Las Vegas. EMSL has quality assurance and data validation responsibility for the S&A phase of the Environmental Survey.

Analysis of survey-related samples will be performed by INEL following the protocols specified in the May 16, 1986, draft Environmental Survey Manual and the LLNL Sampling Plan. Results of the sampling and analysis will be transmitted to the survey team leader for incorporation into the interim report.

3.0 QUALITY ASSURANCE

3.1 Issue Identification

The quality assurance (QA) area of the survey will focus on evaluating current sampling and analysis procedures performed at LLNL or at any off-site laboratories conducting environmental analyses on samples from LLNL. The intent will be to review the quality assurance procedures for collecting process effluent and environmental samples, for performing the laboratory analytical work to identify and to quantify pollutants, and for evaluating and reporting the data. Aspects of the quality assurance program relating to environmental management of LLNL which will be examined, if available, include: analyst training; equipment/instrument calibration and maintenance; sample collection, handling and chain-of-custody procedures; blank, replicate and spiked sample results; data reduction and reporting; and data documentation, including logbook and calculation reviews and archival data storage.

Sampling and analysis procedures will be reviewed to ensure that they conform to accepted requirements and are being appropriately implemented by LLNL. An overall survey of the LLNL environmental monitoring quality assurance program will be performed.

Primary contacts at LLNL are expected to be personnel from the analytical facilities in the Hazards Control Department.

3.2 Records Required

Files will be reviewed as part of the survey, including documents not yet reviewed or received (e.g., classified documents, individual files, documents not yet identified). Specific documents and files to be reviewed as part of the survey include, but will not be limited to, the following:

- QA plans for LLNL and any supporting analytical laboratories.
- LLNL environmental sampling and analysis procedures manuals.
- QA audits of environmental sampling and analysis at LLNL (1981-present).
- Periodic or annual QA summary reports for LLNL.
- Summaries of results of QA sample analyses of external performance evaluation samples (e.g., from DOE's Environmental Measurements Laboratory and from the EPA).
- Training records for sample collection personnel and LLNL laboratory staff.
- Laboratory notebooks, standard data reporting forms and sampling logbooks.

- Instrument maintenance, repair and calibration records for laboratory and field equipment.
- Results of internal precision and accuracy studies of environmental analyses.
- Results of interlaboratory analyses of standard samples, if any (e.g., studies between LLNL and SNLL).

4.0 SURFACE WATER/DRINKING WATER

4.1 Issue Identification

The focus of the surface water/drinking water portion of the survey will be on the possible release of polluted or contaminated wastewaters to surface waters, the Livermore Water Reclamation Plant or groundwater aquifers underlying LLNL. Potential pathways for off-site migration of pollutants include:

- Spills or leaks into permeable soil areas
- Releases to the sanitary sewers or to storm drains without retention, chemical or radiological analysis, or treatment
- Use of dry wells for disposal of liquid wastes at Site 300

A review of available information indicates that considerable attention has been paid to control of radiological releases and elimination of toxic metal pollutants. However, less documentation exists on the fate of trace levels of toxic organics in wastewaters. The survey will assess the potential for organic contamination of wastewaters, as well as review present conditions of wastewater control, collection and treatment. Liquid waste treatment, collection and handling equipment will be examined and records of operation will be reviewed.

The survey will include identification of potential discharges to surface waters, or the local sanitary authority, which may not be addressed in operating permits or other documents from LLNL. The Livermore Site and Site 300 will be investigated for evidence of possible breaks or obstructions in the sewer systems which could result in releases of wastewater to the environment. The survey will also address the possibility of cross-contamination of the potable water piping system by either the sanitary or storm drainage systems. Measures taken at LLNL to prevent back-flow of process wastewater or sanitary sewer flows into the drinking water piping systems will be reviewed, along with LLNL's self-monitoring reports (required under primary drinking water regulations). Copies of standard operating procedures (SOPs), operating logbooks, and maintenance records will be reviewed with respect to wastewater monitoring and treatment systems. LLNL field practices will be observed to determine how closely SOP's are being followed. Interviews with managers and operators of monitoring equipment and treatment systems will be conducted in order to understand modifications or significant deviations, if any, from written SOP's.

A walk-through of selected buildings will be made to observe normal routines, including maintenance activities which generate wastewaters. Various discharge and monitoring points will be reviewed, and actual sampling and analytical procedures will be observed. Emphasis will be placed on the major contributors to wastewater generation, for example plating operations in

Buildings 322 and 321, low conductivity water systems in Buildings 291 and 325, printed circuit board production in Building 141 and, for Site 300, the LINAC Radiography complex at area 823. Some minor sources (in terms of total volume) will also be examined because of the nature of the contaminants and commensurate potential environmental impacts, e.g., radiological activities in wastewaters from Buildings 151 (Nuclear Chemistry) and 419 (Decontamination). In addition to the decontamination procedures at Building 419, other toxic waste control operations in Buildings 513, 514, and 612 will be observed in some detail. The wastewater collection, holding and treatment system will be evaluated under normal operating conditions, as will the final effluent monitoring and sampling station at location 196. Site surface drainage characteristics, such as culverts, arroyos and ravines will also be examined, along with the man-made efforts to control surface run-on and run-off. The impact of changes resulting from construction of new wastewater treatment facilities will also be evaluated.

4.2 Records Required

Files will be reviewed as part of the survey, including documents not yet reviewed or received (e.g., classified documents, individual files, documents not yet identified). Specific documents and files to be reviewed as part of the survey include, but will not be limited to, the following:

- Recent analytical data on wastewater releases to the local POTW.
- Notices of violations relating to wastewater releases.
- Operators logbooks and treatment plant reports from EPD.
- Standard operating procedures for wastewater collection, holding and treatment.
- Sampling protocols and logbooks.
- Wastewater lab tracking reports.
- Treatment plant and monitoring equipment maintenance records.
- Detailed drawings of the domestic water supply, storage and distribution system.
- Records of drinking water quality.
- SPCC plan, or its equivalent.
- Progress report on proposed new wastewater treatment facility, the DWTF system.
- Internal memos or correspondence relating to surface water/drinking water problems, e.g., back-flow prevention measures.
- Memos and correspondence relating to minimizing infiltration of rainwater/groundwater into sanitary sewers during wet seasons, and exfiltration of sanitary wastewaters into soil or groundwater during dry seasons. Include data on comparison of flow monitoring with precipitation readings.
- Any information on water quality/sludge characteristics for the LLNL drainage retention basin.
- Other records as determined on-site.

5.0 AIR

5.1 Issue Identification

The air-related survey activities will involve an assessment of the air emissions at the site, the administrative and emission controls applied to the sources, and the ambient air monitoring systems. The emphasis of the survey will be on operational and procedural practices associated with the emission sources and the emission control equipment, fugitive emission sources, both within and outside the buildings, and mitigative procedures applied to fugitive emission sources. Close liaison will be maintained with the radiation team member because of the importance of air-rad issues. Facility visits will be coordinated through the Environmental Protection Department.

The general approach to the survey will include a review of existing air permits, pending applications, and standard operating procedures. Processes and control equipment will be inspected for compliance with DOE ALARA requirements for radionuclide emissions. The survey will also review the nonradiological air contaminants from the different buildings at the site, evaluate any existing controls applied to the air emissions, and assess the need for additional monitoring or emission controls to characterize or reduce the environmental consequences of the emissions.

The ambient air monitoring system will be evaluated to assess the adequacy of the existing monitoring program to characterize environmental impacts of the air emissions from the facility. The activities involved in this part of the survey will include the inspection of the ambient air quality samplers, a review of documentation applicable to the ambient air data acquisition, and an evaluation of the processing procedures used to assure the accuracy of the data.

Areas of particular interest will include emissions of the criteria pollutants (e.g., sulfur oxides, nitrogen oxides, hydrocarbons, carbon monoxide and lead) as well as regulated hazardous air pollutants (e.g., radioactive-bearing particulates, beryllium, and asbestos). Although not currently listed as hazardous air pollutants, fluorides, and freons will be included in this review.

In addition, the use of organic solvents will be assessed as a potential or actual source of emissions to determine if they are adequately characterized, monitored, and controlled. The organic emissions assessment will focus on those substances that the EPA intends to list as hazardous or toxic air pollutants.

Fugitive emissions from the resuspension of contaminated soils will be evaluated as a potential means of the airborne release of radionuclides and hazardous materials from the facility. Consideration will be given to historical and current operations to determine the potential for soil contamination and windborne releases.

Several areas of specific interest have been identified during a review of available documentation:

- o Completeness of permitting for degreasers and use of environmentally acceptable solvents. LLNL has at least 20 degreasers ranging in size from 2-to-750 gallons/year (several of the smaller degreasers are exempt from the permitting requirements).
- o Control and monitoring of beryllium, radionuclides, freon and fluoride emissions.
- o Emission potential of fugitive dust sources such as roads, and landfill activities.
- o Potential for asbestos emissions during building decontamination or demolition.
- o Effluent sampling and monitoring operations.

Throughout the survey, emphasis will be placed on assessing the available data to characterize the overall environmental impact of plant operations.

5.2 Records Required

Files will be reviewed as part of the survey, including documents not yet reviewed of received (e.g. classified documents, individual files, documents not yet identified). Specific documents and files to be reviewed as part of the survey include but will not be limited to, the following:

- o PSD ledger
- o Air effluent sampling and QA procedures
- o Ambient air sampling and QA procedures
- o Contractor stack test results
- o Effluent beryllium sampling results
- o Laboratory records on TSP and fluoride analyses (ambient)
- o Any other documents pertinent to air emissions from LLNL buildings.

6.0 RADIATION

6.1 Issue Identification

Radiological issues to be addressed during the environmental survey will center around the air, soil, surface water, and groundwater media. Each of the above mentioned media will be evaluated for radiation concerns by collecting background information and data (including ambient data), identifying existing and decommissioned radiation pollution sources and associated controls, and finally by reviewing environmental monitoring programs designed to gather data on identified pollution sources.

The survey will also evaluate rad-waste management practices, direct radiation exposure issues, dose assessment methodologies, and radiochemistry quality assurance programs for environmental monitoring data. Review of rad-waste programs including management practices for low-level, transuranic, rad-hazardous (mixed), and adherence to LLNL procedures will be a major focus of the radiation portion of the survey. A more detailed discussion of this subject is provided in section 8.0 of the work plan. The radiological evaluations will be closely coordinated with the other specialists on the survey team.

Due to the complexity of the site and the large number of buildings and operations, radiological survey issues will be organized by evaluating each of the twelve program areas. Facility visits will be coordinated through the Environmental Protection Department. To accomplish this, the assistance of persons knowledgeable in prioritizing radiation related issues (possibly the health physics representative for each safety team) invaluable for accomplishing survey objectives. Each program area will be assessed based upon observations of processes, operations, effluent sources, controls and monitoring equipment. Discussions with operating and supervisory personnel will also be utilized to provide needed information critical for complete evaluation. Reports, records, and other data associated with continuous, intermittent and any accidental or unscheduled releases should be readily accessible for review.

6.2 Records Required

Files will be reviewed as part of the survey, including documents not yet reviewed or received (e.g., classified documents, individual files, documents not yet identified). Specific documents and files to be reviewed as part of the survey include, but will not be limited to, the following:

- Radiation-related ambient air quality information.
- Background radiation data for soil, surface water, and groundwater.
- Inventories of air, soil, surface water, and groundwater radionuclide release points and quantities.
- Vegetation radionuclide monitoring data.
- Unscheduled or accidental release reports.
- Radioanalytical quality assurance programs and procedures.
- Dose assessment methodologies, including assumptions, calculations, reporting, etc.
- Building plot plans with process and equipment locations.
- Description of radiation monitoring equipment practices and procedures (e.g., calibration, maintenance, etc.).
- Reports or recommendations for upgrading radiation monitoring systems.
- Reports prioritizing new radiation monitoring installations.
- Off-site and on-site radionuclide sampling point criteria.
- Rad-waste management practices, policies, procedures, and communication mechanisms
- NESHAPS/DOE Subpart H 61.90-61.98 reports.
- Information regarding employee radiation exposure data.

7.0 TOXIC/HAZARDOUS SUBSTANCES

7.1 Issue Identification

The toxic substances survey will address raw materials and process-related chemicals used at LLNL as well as the usage, handling, storage and disposal of polychlorinated biphenyls (PCBs), asbestos, pesticides (including herbicides and biocides) and other hazardous substances. The condition and environmental monitoring of underground storage tanks used for storage of substances other than wastes will also be examined. Through interviews with key LLNL personnel and tours of plant facilities, the tracking, control and management of toxic/hazardous substances will be reviewed. This information and records of usage, will be evaluated to determine the potential for environmental contamination.

The survey will address inventory control of PCB-containing and PCB-contaminated electrical equipment, hydraulic equipment and heat transfer equipment. The condition of equipment containing PCBs and the potential for environmental contamination will also be assessed by examining a subset of this equipment. Obsolete, stored or used PCB equipment will be checked for proper containment and protection. Plant storage records for PCBs will be reviewed. Disposal practices for non-radioactive PCB materials will also be addressed.

LLNL projects involving the demolition/disposal of asbestos and asbestos-containing materials will be reviewed to identify pathways of contamination. Asbestos removal and disposal practices will be evaluated, and asbestos disposal areas will be visited.

Pesticide purchase, usage, and application records will be reviewed. The applicator training program will be reviewed. Pesticide storage areas and disposal practices will be examined to assess risk for environmental contamination.

Toxic and hazardous materials purchase and usage records will be reviewed. Areas where these materials are stored and used will be visited and handling procedures will be evaluated.

Management, inventory, and control of chlorofluorocarbons ("freons") will be examined.

Discussions will be held with those individuals knowledgeable of toxic/hazardous substances practices in order to develop an understanding of current and past practices. Discussions will be held with personnel from at least the following groups:

- Environmental Protection Department
  - Guidance and Monitoring Section
  - Investigation and Correction Section
  - Hazardous Waste Management Section

- Hazardous Control Department
  - Health and Safety Team Personnel

7.2 Records Required

Files will be reviewed as part of the survey, including documents not yet reviewed or received (e.g., classified documents, individual files, documents not yet identified). Specific documents and files to be reviewed as part of the survey include, but will not be limited to, the following:

- Toxic/hazardous substances inventory and chemical purchase records.
- Toxic substances labeling and tracking system overview.
- Procedures for purchasing, handling, storing, using and disposing of toxic substances.
- PCB transformer/capacitor inspection records (1981-present).
- Storage and inspection records for PCB contaminated equipment (1981-present) including radioactivity contaminated and non-radioactive items.
- Disposal records for non-radioactive PCB items (1981-present).
- Procedures for storage, handling, and disposal of PCB fluids.
- Correspondence with LLNL Fire Department regarding PCB electrical equipment, especially any records of fires involving PCB equipment.
- Locations of all LLNL buildings and areas containing asbestos.
- Procedures for asbestos removal, handling, and disposal as well as environmental monitoring information.
- Records of asbestos use in plant equipment and support facilities.
- Identification of active and inactive asbestos disposal areas at LLNL.
- Pesticide/herbicide training, handling, storage, and disposal records and standard operating procedures.
- Pesticide annual reports (1981-1985).
- Special procedures involving handling, storage, use and disposal of chlorofluoroalkanes (e.g., freons).
- Inventory and environmental monitoring reports and procedures for underground storage tanks (1981-present).
- Other records as determined on site.

8.0 SOLID/HAZARDOUS/RADIOACTIVE WASTE

8.1 Issue Identification

The solid/hazardous/radioactive waste survey will be carried out by reviewing and evaluating all activities generating solid wastes, and the treatment, storage, recycling and disposal practices involved in the handling of solid wastes including handling of wastes by commercial off-site facilities.

Management of all solid waste streams including mixed wastes, hazardous wastes, radioactive wastes and non-hazardous wastes will be reviewed. The review will generally consist of several activities. 1) Physical facilities where wastes are generated, accumulated, stored, treated, recycled or disposed will be inspected; 2) Personnel involved in these activities will be interviewed; 3) Files will be reviewed; 4) The potential for contamination of environmental media as defined by waste regulations will be evaluated.

At both the Livermore Site and Site 300, large numbers of sources (approximately 100-150 buildings) generate a wide variety of wastes, usually in small volumes, and generally containing toxic, radioactive and/or hazardous constituents. Many waste generating activities may be short term or sporadic since many program activities are short term or intermittent. Therefore, existing records may not accurately reflect the waste streams currently being generated.

Consequently, increased emphasis be placed on reviewing general waste characterization management practices and training practices and inspecting facilities which can potentially generate solid wastes. Off-site commercial facilities receiving wastes from LLNL will be evaluated, since some of them have been subject to compliance actions. The purpose is to evaluate potential problems at the off-site facilities which might affect LLNL wastes.

Initial emphasis will be placed on those LLNL facilities shown by past records to have generated significant quantities of waste and those facilities for which Facility Safety Procedures (FSP) have been prepared. Emphasis will also be placed on potential mixed wastes, including classified wastes which may not have been adequately characterized due to the regulatory uncertainties regarding mixed wastes.

Waste handling practices that will be reviewed include the following:

- Waste minimization and recycling.
- Waste characterization, segregation and manifesting.
- Treatment and decontamination.
- Waste accumulation, packaging, and storage procedures.
- Waste management practices, including training, inventory control, record keeping, inspection protocols, and contingency planning.

Operations and practices will be compared with existing descriptions and written procedures. Information gathered on waste generation points and waste streams will be used to find any sources of waste not previously identified or properly characterized, which may have potential to affect the environment.

Discussions will be held with those individuals knowledgeable of waste management practices in order to develop an understanding of past and existing waste management practices. Discussion will be held with personnel from at least the following groups:

- o Environmental Protection Department
  - Guidance and Monitoring Section
  - Investigation and Correction Section
  - Hazardous Waste Management Section
- o Hazards Control Department
  - Health and Safety Team Personnel
- o Plant Engineering
- o Materials Management
- o Supply and Distribution Operations
- o Off-site Vendors Handling LLNL Wastes

The review of solid/hazardous/radioactive waste practices will be co-ordinated with the CERCLA and hydrogeologic surveys to identify past and present releases that may pose a threat to the environment; the radiological survey to define problems with wastes containing radioactive constituents; and the surface water/drinking water survey since all aqueous process wastes are handled as solid wastes at LLNL.

8.2 Records Required

Files will be reviewed as part of the survey, including documents not yet reviewed or received (e.g., classified documents, individual files, documents not yet identified). Specific documents and files to be reviewed as part of the survey include, but will not be limited to, the following:

- o Part B Permit Application.
- o 3016 Inventory.
- o Underground tank storage notification & associated records.
- o Inspection records (state, local and federal).
- o Groundwater monitoring, sampling, and analytical documentation.
- o Release notification or occurrence records.

- Waste inventory documentation.
- Enforcement action documents.
- Internal facility inspection documentation.
- Correspondence with regulatory agencies on solid waste.
- Records dealing with the reuse/recycling of wastes.
- Training records

9.0 INACTIVE WASTE SITES/RELEASES (CERCLA)

9.1 Issue Identification

The survey will attempt to identify environmental problems and potential risks associated with the historical handling, storage and disposal of hazardous substances at LLNL. This aspect of the survey will be coordinated with the RCRA and hydrogeology team members. The survey will focus on current and future risks related to the following:

- Past land disposal practices (on and off-site);
- Past spills/releases from tanks, ponds, pipes, pits, trenches;
- Potential for future spills/releases; and
- On-going remedial action program.

Facilities that have handled or are currently handling hazardous, mixed and low-level radioactive substances at the Livermore Site and Site 300 will be evaluated.

At the Livermore site, relevant facilities in the following four areas identified as CERCLA ("5480.14") sites by the Phase I Installation Assessment will be evaluated:

- Southwest and off-site areas;
- Southeast section;
- South central section; and
- Northwest section

The status of activities undertaken pursuant to the proposed listing of the Livermore site on the National Priorities List will be assessed. Any available material on Phase II Confirmation Reports and Phase III Engineering Assessments will be reviewed. In addition to those areas identified in the Phase I report, several other areas at the Livermore site will be evaluated. The areas include fire training areas, dip tank spills, and garbage pits.

At Site 300, the following five sites identified as CERCLA ("5480.14") sites by the Phase I Installation Assessment will be evaluated:

- Building 834 TCE leak;
- Landfill complex 3, 4, and 5;
- High explosives process water lagoons;
- Landfill 6 (pistol range); and
- Landfills 2 and 8.

The status of the remedial actions at these sites will be assessed. In addition, several other areas at Site 300 will be evaluated. These areas include Pits 1 and 7, Advanced Test Accelerator site and the sewage treatment pond. Finally, records of off-site disposal from the Livermore site and Site 300 will be reviewed.

Sites that have undergone or are undergoing remediation will be addressed. Records and analytical data in support of the site cleanup will be reviewed. Also, inactive tanks or containers that may have held hazardous substances will be identified and their status assessed. Former storage areas and staging locations will be included in this effort.

The survey team will want to review additional material pertaining to the Phase I Installation Assessment report (i.e., map locations of all burial, spill, and release sites, aerial and surface photographs, personnel interview files, reconnaissance field data pertaining to HRS/mHRS evaluations, and the HRS/mHRS ranking procedures used for the Phase I Installation Assessment report). Drafts and preparatory material for the Phase II and III reports will also be reviewed.

The team will also want to review the environmental records pertaining to the past management, disposal (on-site and off-site), clean-up, and regulatory compliance.

Contacts for this portion of the survey will include personnel from the Environmental Protection Department.

9.2 Records Required

Files will be reviewed as part of the survey, including documents not yet reviewed or received (e.g., classified documents, individual files, documents not yet identified). Specific documents and files to be reviewed as part of the survey include, but will not be limited to, the following:

- Past waste management plans
- SOPs regarding management of hazardous substances, disposal areas and storage areas
- Hazardous substances inventories
- Listing of areas used for hazardous substances storage, receiving and shipping, and disposal
- Historical files on past operations and processes, substances used, and methods of handling and disposal
- Files on past off-site waste handling and disposal
- Records of facility expansion and building rubble disposal
- Descriptions and Notifications of inactive waste sites and potential areas of contamination
- Description of all waste management facilities, including buried tanks and structures (existing and removed)
- Historical aerial and surface photographs of the facility
- "Interview files" for the draft Phase I Installation Assessment report
- Files pertaining to any radiometric surveys of the site grounds
- Documents pertaining to past, current, and proposed remedial actions at LLNL

- Environmental records pertaining to past facility responses to hazardous substance spills and releases
- Draft Phase II and III materials, including working copies, internal memoranda, correspondence, and calculation sheets

10.0 HYDROGEOLOGY

10.1 Issue Identification

One of the major environmental issues at the facility is the release of contaminants to the groundwater. Radiological parameters appear to be well-controlled, but toxic organics have been found in the subsurface, mostly as a result of past practices.

The survey effort will involve the evaluation of recent studies of site hydrogeology, determination of the status of on-going studies, and the review of plans for further investigations and remedial actions. Each potential or known source of groundwater contamination will be visited, and drilling and sampling activities will be observed. Many of these visits to sources will be conducted jointly with the RCRA, CERCLA, and/or surface water personnel. Personnel at these various facilities will be interviewed to determine past and present waste-handling practices. Well construction will be reviewed both on "as built" diagrams, and in the field. Potential groundwater recharge and discharge areas will be investigated.

Known or suspected areas of soil contamination will also be visited. Observations of soil staining, surface drainage pathways, and nearby monitoring wells will be made. Soil sampling activities will also be observed.

Several areas of specific interest have been identified through review of the data received thus far. These include:

- Southeastern corner of the Livermore site, where there are a number of identified or suspected sources of volatile organic releases, including a gasoline spill, solvent storage, salvage yards, an abandoned landfill, a taxi strip, and various dip tanks and areas of spillage.
- Southwestern corner of the Livermore site, including materials storage areas, dumps, sumps, and spills.
- Identified (isolated) spill areas, garbage pits, and storage tanks on the northern half of the site.
- Arroyo Seco area west of the Livermore site where a trichloroethylene plume has been observed moving toward a residentual development.
- Site 300 area landfills, disposal pits, unlined evaporation lagoons, spills, and springs will be of interest in assessing potential and known groundwater contamination. Contaminants include both solvents and constituents of explosives such as nitrate.

- Areas near spills, landfills, etc., where soils have been investigated and/or regularly sampled.

Discussion will be held with personnel from at least the following groups:

- Environmental Protection Department
  - Guidance and Montoring Section
  - Investigation and Correction Section
  - Hazardous Waste Management Section

10.2 Records Required

Files will be reviewed as part of the survey including documents not yet reviewed or received. (e.g., classified documents, individual files, documents not yet identified) Specific documents and files to be reviewed as part of the survey include, but will not be limited to, the following:

- Sampling procedures and analytical protocol
- Seismic records
- Recent monthly progress reports of LLNL groundwater project
- Well construction (as-built) diagrams and current well locations
- Chemical analytical data for soils, groundwater, and/or springs
- Additional geologic and/or hydrogeologic investigations, as available
- Groundwater and soil monitoring program plan

LLNL QA/TSCA SCHEDULE - A. OLSZEWSKI

MONDAY, DEC. 1	TUESDAY, DEC. 2	WEDNESDAY, DEC. 3	THURSDAY, DEC. 4	FRIDAY, DEC. 5
Introductory Briefings	Tour Hazard Control Analytical Facilities At 253,254,255,301, 324 & 362	Review QA/QC Programs For Environmental Monitoring Bldg. 365	Observe Environmental Sampling Round And Off-Site Shipment Of Samples	Inspect PCB Storage Areas in BLDGS. 612 & 625 And Salvage Yard Visit BLDGS. 431,432 & 611
MONDAY, DEC. 8	**TUESDAY, DEC. 9**	**WEDNESDAY, DEC. 10**	**THURSDAY, DEC. 11**	**FRIDAY, DEC. 12**
Inspect Operation of TWC Facilities at Bldgs. 419,514,612 & 518 with emphasis on toxic chemical handling with J. Crist	Continue Monday's Schedule Review QA/QC Programs for Site 300	Inspect TCE Storage Areas in BLDGS. 834 & 854 Inspect HE Storage Areas & Waste Storage Facility At Site 300	Discuss Pesticide/ Herbicide Practices Visit Storage Area (520), Mixing Area (515), BLDGS. 814 & 819	Review Asbestos Monitoring & Removal Program And Inspect Disposal Areas At Site 300 & LLNL
MONDAY, DEC. 15	**TUESDAY, DEC. 16**	**WEDNESDAY, DEC. 17**	**THURSDAY, DEC. 18**	**FRIDAY, DEC. 19**
Site 300 Records and Procedures Review	Observe Dye Waste Handling At BLDGS. 175,177,121 Complete QA/QC Review	Continue Tuesday's Schedule Catch-Up Day Coordinate S&A Program	Debriefings With DOE Team Leaders And Team Members 1:00 PM Informal Close-out with EPD	Close-Out Debriefing With LLNL & SAN Personnel

SURFACE WATER/DRINKING WATER/UNDERGROUND TANKS - J. A. BOROS

MONDAY, DEC. 1	TUESDAY, DEC. 2	WEDNESDAY, DEC. 3	THURSDAY, DEC. 4	FRIDAY, DEC. 5
LLNL Introductory Briefings	Tour HAZ. Control Fac. Bldg. 253 Tour TWC Fac. BLDGS. 419, 513, 514 & 612 Tour Gas Chem. Proc. Bldg. 331 & 332 & 335	Tour LCW Stations BLDGS. 291 & 325 Tour Pool & BLDG. 318 Tour Central Steam PLT BLDG. 401 Tour Paint & Craft Shops BLDGS. 418 &511 Tour Electronics Engng BLDG. 131 (SSD) BLDG. 141 (EF & PPR)	Tour Site 300, Selected Areas Incl: BLDGS. 801, 806 A&B, 807,809,815, 817,819,823,825,826, 827(All Areas), 828, 841,851,865,872,873, 874 & 879.	Tour Special Projects: BLDG. 261 Catch-Up On Unfinished Items For This Week's Schedule First Week Debriefing
MONDAY, DEC. 8	**TUESDAY, DEC. 9**	**WEDNESDAY, DEC. 10**	**THURSDAY, DEC. 11**	**FRIDAY, DEC. 12**
Tour Bldg. 321 Plastics & Painting OPS. BLDG. 231 Tour Refractory Metals BLDG-241 Interview Staff Responsible For Potable Water Systems	Tour Laser Facilities BLDGS. 161,167,175, 177,179,298,383,391 & 482 Visit Monitoring Station at H C Station 196. Review Monitoring Data & Observe Sample Collection and Analysis Procedures	Tour Biomedical Facilities BLDGS. 361, 362,365,376,377 & 412 Tour Physics Facilities BLDGS. 194,212 & 292 Tour MFE Facilities BLDGS. 431,435 & 438	Tour Mech. Engng. Fac. BLDG. 131 Tour Plating Shop BLDG. 322 Tour Defense Systems BLDGS. 151,251,281, 341 & 345	Work On Underground Storage Tank Inventory And Status, Assist RCRA Specialists On His Tasks Second Week Debriefing
MONDAY, DEC. 15	**TUESDAY, DEC. 16**	**WEDNESDAY, DEC. 17**	**THURSDAY, DEC. 18**	**FRIDAY, DEC. 19**
Catch Up On Unfinished Items From Second Week Interview Treatment Operations Staff Assist RCRA Specialist	Define Requirements for Additional Sampling Review Sampling and Analytical Procedures And Protocols Assist RCRA Specialist	Coordinate S&A Program Needs With INEL & Assistant Team Leader Review Files Assist RCRA Specialist	Debriefings With DOE Team Leaders and Team Members 1:00 PM Informal Close-out with EPD	Close-Out Debriefing with LLNL & SAN Personnel

AIR/NUS TEAM COORDINATOR - J. G. CRIST

MONDAY, DEC. 1	TUESDAY, DEC. 2	WEDNESDAY, DEC. 3	THURSDAY, DEC. 4	FRIDAY, DEC. 5
Introductory Briefings	Air-Rad Survey With M. Francis (Inertial Confinement Fusion) and (Laser Isotope Separation)	Air-Rad Survey With M. Francis (Chemistry)	Air-Rad Survey with M. Francis	PCB Inspections Transformers And Storage Areas With A. J. Olszewski
MONDAY, DEC. 8	**TUESDAY, DEC. 9**	**WEDNESDAY, DEC. 10**	**THURSDAY, DEC. 11**	**FRIDAY, DEC. 12**
TWC Facilities with A. Olszewski	CERCLA Survey With J. Werner (Site 300)	Air Quality Monitors	Hydrogeology Survey With A. Hubbard	Air Non-Rad Survey BLDGS. 328, 691 & 292
MONDAY, DEC. 15	**TUESDAY, DEC. 16**	**WEDNESDAY, DEC. 17**	**THURSDAY, DEC. 18**	**FRIDAY, DEC. 19**
Air Non-Rad Survey Incinerator (624) BLDGS. 418, 419 & 212	Air Non-Rad Survey BLDGS. 141,241,151 & 251	Air Quality Monitors Review Of Air Emissions Records Coordinate S&A Program	Debriefings With DOE Team Leaders And Team Members 1:00 PM Informal Close-out with EPD	Close-Out Debriefing With LLNL & SAN Personnel

RADIATION - M. FRANCIS

MONDAY, DEC. 1	TUESDAY, DEC. 2	WEDNESDAY, DEC. 3	THURSDAY, DEC. 4	FRIDAY, DEC. 5
Introductory Briefings	Inertial Confinement Fusion (ICF) 298 Fusion Target Dev 381 Laser Fusion Lab 383 Laser Mach. Shop 391 High Energy Laser Laser Isotope Separation (LIS) 171-179 Laser Research 482,490 Isotope Sep. 161,167, 191	223 Chem. Engr. 231 Dev. & Assemb. 241 Refract. Mat'ls. 331 Gaseous Chem. 332 Metallurgical Chem. 335 L.I.S.F. 239 Radiography	Resources 241 Refract. Mat'ls. 243 410 Special Res. STPA #2 Magnetic Fusion 435 MFE Research	Building 261 Nuclear Design 341 Physics Res. 345 Detonator Res. Nuclear Testing 121 Exptl. Physics 255 Calibration & STDS Nuclear Chemistry 151 Nuc. Chem. 251 Diagn. Chem. Debriefing
MONDAY, DEC. 8	**TUESDAY, DEC. 9**	**WEDNESDAY, DEC. 10**	**THURSDAY, DEC. 11**	**FRIDAY, DEC. 12**
321 Mat'ls Fab Shops 343 High Pressure Computations Radiation Lab Environmental Analyses & QA	361 Biomedical 362 Biomedical 363 Animal House 365 Biomed Exp. Fac. 366 Health Effects Lab 377 MC 378 Atmospheric Res 379 Biomed Counting 412 Biomedical Lab	182 "O" Group 194 Electr Pos. Accel. 212 Accelerators 292 RTNS Fac.	419 Decontamination 514 Waste Disposal 612 Dry Waste 619 Salvage & Reclam. 324 Hazards Control 253 " " 254 Toxicology	Site 300 Review of Rad Documents, Activities (Past & Present), Practices, Policies & Procedures. Debriefing
MONDAY, DEC. 15	**TUESDAY, DEC. 16**	**WEDNESDAY, DEC. 17**	**THURSDAY, DEC. 18**	**FRIDAY, DEC. 19**
Spec. Proj. Radiation Environmental Monitoring Programs Review Air (RAD) Soil (RAD) Surface Water (RAD) Ground Water (RAD)	Review of Direct Radiation Sources & Potential Env. Exposures Review TLD Program including: - Sampling Site Selection - Calculations/Analysis - Calibration/Maintenance - Reporting	Review Dose Assessment Activities incl: - Inputs/Data - Biological Pathways - Target Organ Effects - Calculations - Reporting Coordinate S & A Program	Debriefings with DOE Team Leaders & Team Members 1:00 P.M. - Informal Close-Out With EPD	Close-out Debriefing with LLNL & SAN Personnel

CERCLA - J. WERNER

MONDAY, DEC. 1	TUESDAY, DEC. 2	WEDNESDAY, DEC. 3	THURSDAY, DEC. 4	FRIDAY, DEC. 5
Introductory Briefings	Livermore S.W. And Off-Site Areas: Landfill Building 141 Building 212	Livermore S.W. And Off-Site Areas: Building 222 Building 231 Building 331 & 332	Livermore S.E. Section: Building 131 Building 321 Complex Building 403 Building 419 Building 514 Building 510 Building 513 Review Files	Livermore S.E. Section (Con't.) Building 519 Building 518 Salvage Yard Building 511 (Soils) Building 519 (Soils)
MONDAY, DEC. 8	**TUESDAY, DEC. 9**	**WEDNESDAY, DEC. 10**	**THURSDAY, DEC. 11**	**FRIDAY, DEC. 12**
Livermore South Central Section: --East Traffic Circle Landfill And Drum Pits --Old Fuel Storage South Of Landfill --Chemical Spill Sites Review Waste Management Files	Site 300 --Pit 6 Near Pistol Range --Diesel Tankers --Pit 1& 7	Site 300 --A T Accelerator --Disposal Area Off Corral Hollow Drive --Sewage Trmt. Pond --Tour Complexes	N.S. Section: --Oil Drum Drainage Area --Fire Training Area Spills --Old Reactor Retention Tank --Dip Tank Spills	Follow-Up File Review Airport Bldg. 002
MONDAY, DEC. 15	**TUESDAY, DEC. 16**	**WEDNESDAY, DEC. 17**	**THURSDAY, DEC. 18**	**FRIDAY, DEC. 19**
Livermore Northeast Section: --Garbage Pits --Swamps --Construction Support Area W. Of B161 --Oil Shale Storage And Crusher File Review	Site 300 Building 834 Landfill 3, 4 & 5 HE Process Lagoons Landfills 2 & 8	Coordinate Sampling And Analysis Plan Preparation	Debriefings with DOE Team Leaders and Team Members 1:00 P.M. Informal Close-Out With EPD	Close-out Debriefing with LLNL and SAN personnel

RCRA - R. BASINSKI

MONDAY, DEC. 1	TUESDAY, DEC. 2	WEDNESDAY, DEC. 3	THURSDAY, DEC. 4	FRIDAY, DEC. 5
Introductory Briefings	Tour 119 Chemistry Complex Tour 225 HE Tech. Operations Bldg. Tour 241 Complex Material Dvlpmnt Tour 331 Tritium Fac. Tour 332 Plutonium Fac. & Bldg. 335	Tour Biomedical Fac. 361, 362, 365, 376, 377 & 412 Tour 292, 293 & 294 RTNS Fac.	Tour 194, 195, 196 Accelerator Fac. Tour 131 Electronics & Mech. Eng. Dept. Tour 141 Electrical Engineering Tour 151 Nuclear Chem. Tour 321 Materials Fabrication	Tour 327, 239 Non-Destructive Testing Tour 341 High Energy Research Tour 253 Hazards Control Operations
MONDAY, DEC. 8	**TUESDAY, DEC. 9**	**WEDNESDAY, DEC. 10**	**THURSDAY, DEC. 11**	**FRIDAY, DEC. 12**
Tour 251 Bioassay Tour 255 Calibration Tour 318 Complex Tour 365 Carcinogen Fac. Tour 231 Material Dvlpmnt Complex	Tour 419 Decon. Fac. Tour 514 Waste Treat Fac. Tour 612 Storage Tour 624 Incinerator	File Review Disc. with Env. Protect. Personnel Catch-up	Site 300 Waste Disposal Areas Waste Acc. Areas File review Bldgs. 801, 806, 807, 809, 815, 817, 819, 823, 825	Site 300 Bldgs. 826, 827, 828, 841, 851, 865, 872, 873, 874, 879
MONDAY, DEC. 15	**TUESDAY, DEC. 16**	**WEDNESDAY, DEC. 17**	**THURSDAY, DEC. 18**	**FRIDAY, DEC. 19**
Visit off-site Disposal Facility	Visit off-site Disposal Fac. Livermore Airport Waste Acc. Areas	Tour 261 Special Projects Catch-up on Tours of Bldgs not visited. Coordinate with Sampling Team	Debriefings with DOE Team Leaders and Team Members 1:00 P.M. Informal Close-Out With EPD	Close-out debriefing with LLNL & SAN personnel

HYDROGEOLOGY/SOILS - A. HUBBARD

MONDAY, DEC. 1	TUESDAY, DEC. 2	WEDNESDAY, DEC. 3	THURSDAY, DEC. 4	FRIDAY, DEC. 5
Introductory Briefings	Meet With Fred Hoffman Observe Quarterly Well Sampling	Visit Southeastern Corner -BLDG. 403 Gasoline Spill -BLDG. 518 VOCs -Taxi Strip/Old Salvage Yard/East Traffic Circle Landfill VOCs -Salvage Yard -BLDG. 513 Spills	File Review Groundwater And Soil Sampling	File eview
MONDAY, DEC. 8	**TUESDAY, DEC. 9**	**WEDNE . , DEC. 10**	**THURSDAY, DEC. 11**	**FRIDAY, DEC. 12**
Site 300 -General Service Area/ 834/830/851/854/855, Etc. -Wells -Springs -Pits -Lagoons	Site 300 Observe Drilling Rig At H E Lagoon And/Or Burn Pit (806 area) With CERCLA And Team Leader Visit 801,812 Complexes -Wells -Pits -Springs Etc.	File Review	Visit Southwestern Corner And Potential Source Areas (Spills, Etc.) Visit Western Area (Offsite) With TCE Plume	Revisits/Assist CERCLA/RCRA/Etc.
MONDAY, DEC. 15	**TUESDAY, DEC. 16**	**WEDNESDAY, DEC. 17**	**THURSDAY, DEC. 18**	**FRIDAY, DEC. 19**
File Review Assist CERCLA/RCRA/ Etc.	File Review Assist CERCLA/RCRA Etc.	Coordinate & Prepare Sampling And Analysis Plan	Debriefings With DOE Team Leaders And Team Members 1:00 P.M. Informal Close-Out With EPD	Close-Out Debriefing With LLNL & SAN Personnel

APPENDIX D

ABBREVIATIONS, ACRONYMS, AND SYMBOLS

AFGWC	Air Force Global Weather Center
ATA	Advanced Test Accelerator
ARAC	Atmospheric Release Advisory Capability
BAAQCD	Bay Area Air Quality Control District
BOD	Biochemical Oxygen Demand
CAD	California Administrative Code
CAL	California
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CG	Concentration Guideline
cm	Centimeter(s)
CPS	Continuous Point Source
CRWQCB	California Regional Water Quality Control Board
Cs	Cesium
°C	Degrees Celsius (or centigrade)
°F	Degrees Fahrenheit
D-38	Uranium containing higher concentrations of ^{238}U than found in nature (99.3%)
DWTF	Decontamination and Waste Treatment Facility
DOE	Department of Energy
$	Dollar(s)
e.g.	(exempli gratia) for example
EP	Extraction Procedure
EPA	Environmental Protection Agency
ESE	East-Southeast
et al.	(et alii; et alias; or et alis) and others
FAA	Federal Aviation Administration
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FY	Fiscal Year

GPD	Gallons per day
GSA	General Services Area
HC	Hazards Control
HE	High Explosives
HEPA	High Efficiency Particulate Air
HF	Hydrofluoric acid
HMX	1,3,5,7-tetranitro-1,3,5,7-tetraazocyclooctane
HNO_3	Nitric acid
HRS	Hazard Ranking System
HTO	Tritiated Water
HWM	Hazardous Waste Management
I	Interstate
ICRP	International Commission on Radiological Protection
in	Inch(es)
km	Kilometer(s)
lb	Pound(s)
LCW	Low Conductivity Water
LLNL	Lawrence Livermore National Laboratory
LWRP	Livermore Water Reclamation Plant
MEK	Methyl ethyl ketone
µCi/ml	Microcuries per milliliter
mg/l	Milligrams per milliliter
mi	Mile(s)
m^3	Cubic meter(s)
MM	Materials Management
mm	Millimeters
mrem	Millirem
NaOH	Sodium Hydroxide
NCRP	National Council on Radiation Protection and Measurement
NH_4OH	Ammonium Hydroxide
No.	Number(s)
NPDES	National Pollutant Discharge Elimination System
NTS	Nevada Test Site

NPL	National Priorities List
%	Percent
PCB	Polychlorinated biphenyls
PCE	1,1,2,2-tetrachloroethylene (perchloroethylene)
PETN	Pentaerythritol tetranitrate
pH	Negative logarithm of the hydrogen ion concentration
POTW	Publicly Owned Treatment Works
PPHM	Parts per hundred million
PPM	Parts per million
Pu	Plutonium
RCRA	Resource Conservation and Recovery Act
RDX	1,3,5-trinitro-1,3,5-triazocyclohexane
RTNS	Rotating Target Neutron Source
SARA	Superfund Amendments and Reauthorization Act
SDM	Standard Deviation of the Mean
SJCAPCD	San Joaquin County Air Pollution Control Department
SNLL	Sandia National Laboratories Livermore
TATB	Triaminotrinitrobenzene
TCA	1,1,1-Trichloroethane
TCE	Trichloroethylene
TCLP	Toxic Concentration Leaching Procedure
TDS	Total Dissolved Solids
TEOS	Tetraethyl orthosilicate
TICH	Total Identifiable Chlorinated Hydrocarbons
TNT	Trinitrotoluene
TOC	Total Organic Hydrocarbons
TOX	Total Organic Halogens or Halides
TRU	Transuranic
TSS	Total Suspended Solids
TTLC	Toxic Threshold Limit Concentrations
TWC	Toxic Waste Control
USEPA	United States Environmental Protection Agency

» U.S. GOVERNMENT PRINTING OFFICE: 1988-0-199-004

VOC	Volatile Organic Compound
WAA	Waste Accumulation Areas
WIPP	Waste Isolation Pilot Plant
yr	Year(s)

-END-

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HYDROGEOLOGY/SOILS - A. HUBBARD

MONDAY, DEC. 1	TUESDAY, DEC. 2	WE
Introductory Briefings	Meet With Fred Hoffman Observe Quarterly Well Sampling	Vi C -B S -B -T -S T L -S -B
MONDAY, DEC. 8	**TUESDAY, DEC. 9**	**WE**
Site 300 -General Service Area/ 834/830/851/854/855, Etc.	Site 300 Observe Drilling Rig At H E Lagoon And/Or Burn Pit (806 area)	Fi