DOE/EH/OEV--24P

DE91 002510

U.S. Department of Energy
Washington, DC

Environment, Safety and Health
Office of Environmental Audit

Environmental Survey
Preliminary Report

Solar Energy Research Institute
Golden, Colorado

October, 1988

PREFACE TO
THE DEPARTMENT OF ENERGY
SOLAR ENERGY RESEARCH INSTITUTE
ENVIRONMENTAL SURVEY PRELIMINARY REPORT

This report contains preliminary findings based on the first phase of an Environmental Survey at the Department of Energy's (DOE) Solar Energy Research Institute (SERI), located at Golden, Colorado. The Survey is being conducted by DOE's Office of Environment, Safety and Health.

The SERI Survey is a portion of a 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 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 1989.

The preliminary findings in this report are subject to modification based on comments from the Chicago Operations Office concerning their technical accuracy. The modified preliminary findings will be incorporated into the Environmental Survey Summary Report.

September 1988
Washington, D.C.

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

TABLES

FIGURES

EXECUTIVE SUMMARY

Introduction

This report presents the preliminary findings of the first phase of the Environmental Survey of the U.S. Department of Energy's (DOE) Solar Energy Research Institute (SERI), conducted December 14 through 18, 1987.

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. The team includes outside experts supplied by private contractors. The objective of the Survey is to identify environmental problems and areas of environmental risk associated with SERI. The Survey covers all environmental media and all areas of environmental regulation. It is being performed in accordance with the DOE Environmental Survey Manual. The on-site phase of the Survey involves the review of existing site environmental data, observations of the operations carried on at SERI, and interviews with site personnel.

Site Description

SERI is located at three separate areas of Jefferson County, Colorado, near Denver. The two major facilities are the 300-acre SERI Permanent Site and three buildings in the Denver West Office Park. These facilities are approximately 1 mile apart and about 2 miles east of Golden, Colorado. The third site is the 340-acre Wind Energy Research Center (WERC), located at the DOE Rocky Flats Plant, approximately 12 miles northeast of the SERI Permanent Site. SERI is operated by the Midwest Research Institute (MRI) for DOE. It is the primary Federal facility devoted to solar energy research and conducts research in biofuels, photovoltaics, solar thermal energy, ocean thermal energy, and other areas.

No environmental concerns were raised in meetings with Federal, state, and local regulators. The regulators showed an interest in the Environmental Survey process and in their role in the review of documents produced during the Survey.

Summary of Findings

The major preliminary findings of the Environmental Survey for SERI are:

- There is a potential for the release of potentially hazardous substances to the soil and air due to inadequate liquid waste storage practices at the Permanent Site Boneyard and at WERC; and

- There is a potential for mismanagement of hazardous waste due to instances of noncompliance with RCRA regulations and improper waste management practices.

Overall Conclusions

The Survey found no environmental problems at SERI that represent an immediate threat to human life. The environmental problems identified at SERI indicate that the site is affected by relatively minor environmental problems, most of which are regulatory in nature, and are the result of current operational practices.

Transmittal and Follow-up of Findings

The preliminary findings of the Environmental Survey for SERI were shared with the DOE Chicago Operations Office and SERI at the Survey closeout briefing held on December 18, 1987. By May 17, 1988, the Chicago Operations Office had developed a draft action plan to address the Survey preliminary findings. A final action plan, addressing all the Survey findings cited herein, will be prepared by the Chicago Operations Office within 45 days after receiving this Preliminary Report. Those problems that involve extended studies and multiyear budget commitments will be the subject of the DOE-wide Environmental Survey Summary Report and DOE-wide prioritization.

Within the Office of the Assistant Secretary for Environment, Safety and Health, the Office of Environmental Guidance and Compliance has immediate responsibility for monitoring environmental compliance and the status of SERI Survey findings. The Office of Environmental Audit will continue to assess the environmental problems through a program of systematic environmental audits that will be initiated toward the conclusion of the DOE Environmental Survey in 1989.

1.0 INTRODUCTION

The purpose of this report is to present the preliminary findings developed during the Environmental Survey, December 14 through 18, 1987, at the U.S. Department of Energy's (DOE) Solar Energy Research Institute (SERI), Golden, Colorado. As a Preliminary Report, the contents are subject to revision. Revisions to the preliminary findings based on the DOE Chicago Operations Office (CH) technical accuracy review will be incorporated into the Environmental Survey Summary Report. CH and the DOE SERI Area Office manage SERI, which is operated by a subsidiary of Midwest Research Institute.

The SERI Survey is part of the larger DOE-wide Environmental Survey 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 them. 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 SERI Environmental Survey was conducted by a multidisciplinary team of technical specialists headed and managed by a Team Leader and Assistant Team Leader from DOE's Office of Environmental Audit. A complete list of the SERI Survey participants and their affiliations is provided 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 of 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 overall Survey Plan is presented in Appendix C.

Preliminary Survey findings, in the form of existing and potential environmental problems, are presented in Sections 3.0 and 4.0. Section 3.0 includes findings that pertain to a specific environmental medium (i.e., air, soil, surface water, and groundwater), whereas Section 4.0 includes those that are non-media-specific (i.e., waste management, toxic and chemical materials, radiation, quality assurance, and inactive waste sites and releases). Because the findings are highly varied in 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. A list defining the abbreviations used throughout the text is provided in Appendix D.

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

- Category I includes only findings that, based on information available to the Team Leader, involve immediate threat to human life. Findings of this category shall be conveyed immediately to the Environment, Safety and Health personnel at the scene or in control of the facility or location in question for action. Category I findings are environmental problems with the highest potential risk, the strongest confidence in the finding, based on the information available, and the most restrictive appropriate response 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 exposure, or a one-time exceedance where residual impacts pose an immediate potential for human exposure.

  - Evidence that a health-based environmental standard may be exceeded, as discussed in the preceding situation, within the time 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 environmental management practices.

- Noncompliance with significant regulatory procedures (i.e., 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 environmental problems where the risk is high but where 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, most discretion is available to the Operations Offices and Program Offices as to appropriate response; however, the need for that response is such that management should not wait for the completion of the DOE-wide Survey to respond. Unlike Category I findings, a sufficient near-term response to Category II findings by the Operations Office may include further characterization before any action is 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 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 problems. Under this category, the range of alternatives available for response and the corresponding time limits for response are the greatest. Environmental problems included within this category will typically require lengthy investigation and remediation phases, as well as multiyear budget commitments. These problems will be included in the DOE-wide prioritization to ensure that DOE's limited resources are used effectively.

In general, levels of pollutants or materials that constitute a hazard or potential for hazard are those that exceed some Federal, state, or local regulations for release of, contamination by, or exposure to such pollutants or materials. However, in some cases, the Survey may determine that the concentration of some nonregulated material is sufficient to be included as an environmental problem. Likewise, concentrations of regulated materials even though below limits established by regulatory authorities, that nevertheless 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 that are violations of regulations or requirements (e.g., improper storage of hazardous chemicals in unsafe tanks). Such conditions present a potential hazard to human health and the environment and should be identified as an environmental problem. Additionally, potentially hazardous conditions are those where 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 of management practices that are indirectly related to environmental risk but are not appropriate for inclusion in Categories I through III. Such findings can be based on 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 Offices and appropriate Program Office for 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 constitute only the first step in a multistep, iterative process to prioritize DOE's problems.

Normally, the next phase of the Survey process is the Sampling and Analysis (S&A) effort, the results of which are used to further define environmental problems and risks as identified during the Survey. However, based on the on-site portion of the SERI Survey, no S&A needs were identified.

It is clear that certain of the findings and observations contained in this report are highly varied in magnitude, risk, and characterization. Consequently, the priority, magnitude, and timeliness of near-term responses will require careful planning to ensure appropriate and effective application. The information in this Preliminary Report, albeit provisional, will assist the Chicago Operations Office and SERI Area Office in planning these near-term responses.

The Chicago Operations Office submitted a draft action plan dated May 17, 1988, in response to the preliminary findings presented at the conclusion of the on-site Survey activities and summarized in the SERI Survey Status Report dated February 5, 1988. The draft action plan for the SERI Survey has been reviewed by the Office of Environmental Guidance and Compliance (OEGC) which has immediate responsibility for monitoring the status and overseeing the adequacy of corrective actions taken by the Operations Office in response to the Survey findings.

As required in the December 2, 1987, memorandum from the Assistant Secretary for Environment, Safety and Health to the Operations Office Managers entitled, Follow-up of Environmental Survey Findings, the Chicago Operations Office will prepare and submit a final action plan to the Deputy Assistant Secretary (DAS) for Environment within 45 days after receiving this Preliminary Report. The final action plan for the SERI Survey will address all of the preliminary findings cited herein, and incorporate OEGC's comments on the draft action plan.

2.0 GENERAL SITE INFORMATION

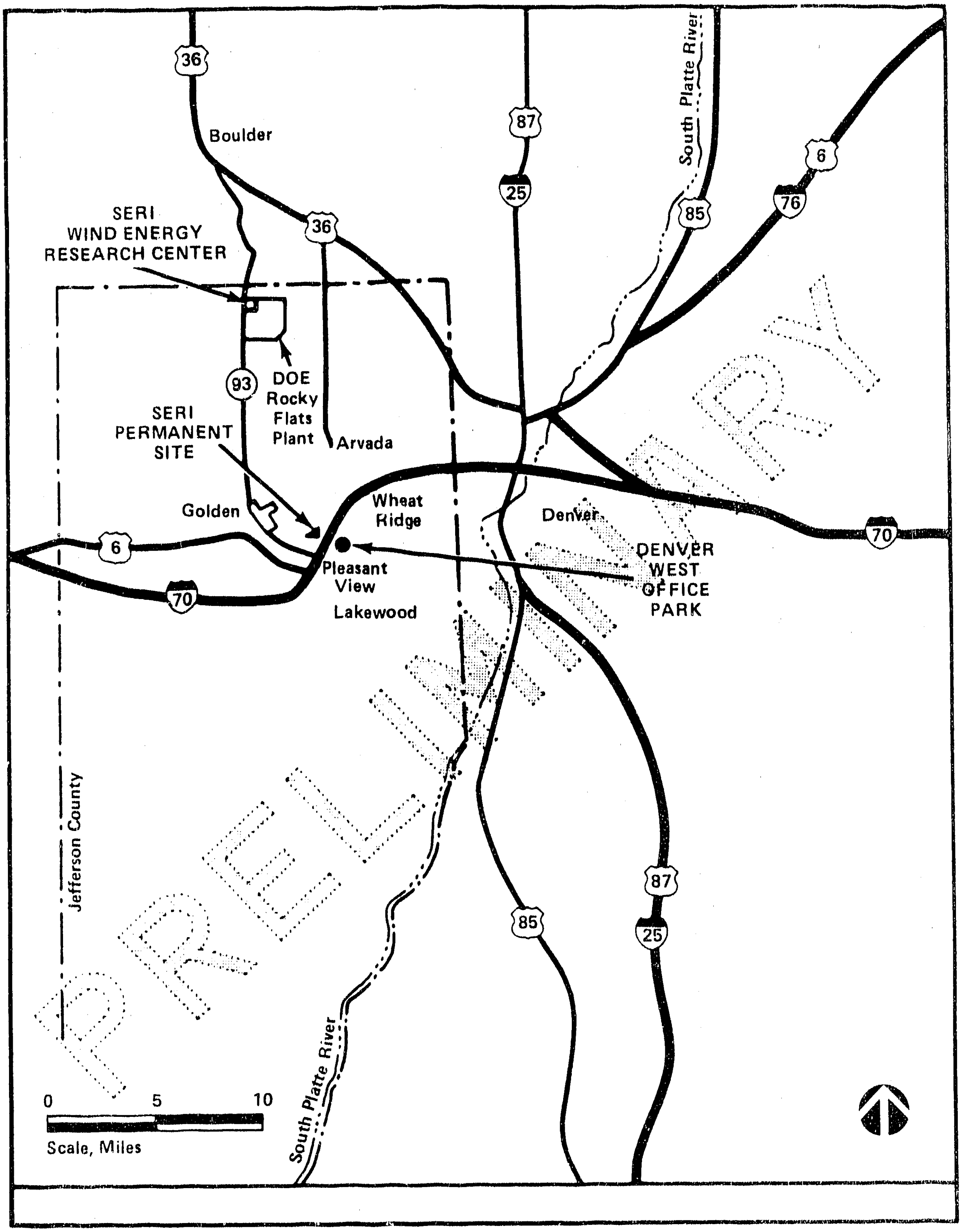
Much of the information in this section is summarized from the Site Development Plan (Higginbotham & Associates, 1986), The Solar Energy Research Institute Master Plan (SERI, 1986b) and the Solar Energy Research Institute Environmental Assessment (SERI, 1979).

2.1 Site Setting

SERI facilities occupy three separate locations in Jefferson County, Colorado, near the City of Denver. The three facilities are the Denver West Office Park (Buildings 15, 16, and 17), the Permanent Site, and the Wind Energy Research Center (WERC). The general location of the three SERI facilities is shown in Figure 2-1, with the specific building locations within each facility illustrated in Figures 2-2, 2-3, and 2-4, respectively. The Denver West Office Park and Permanent Site are approximately 2 miles east of Golden and 12 miles west of central Denver. WERC is adjacent to the DOE Rocky Flats Plant, approximately 12 miles northeast of the Permanent Site, as illustrated in Figure 2-1. The Denver West Office Park is a relatively flat, landscaped office complex occupied by a number of three-story buildings, parking lots, and common areas. The elevation of the Denver West Office Park is approximately 5,730 feet. It is surrounded by residential and commercial areas and Interstate-70.

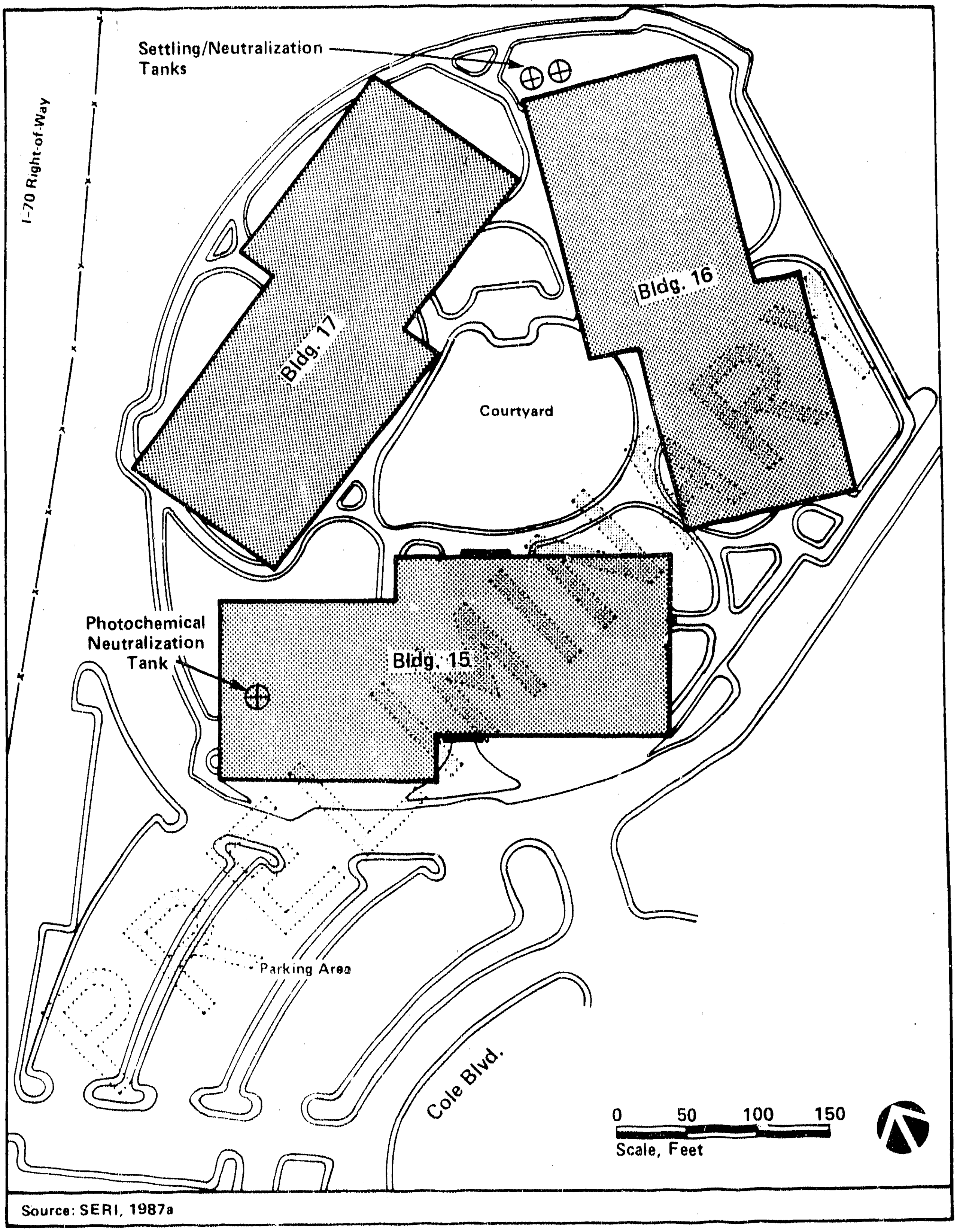
The SERI Permanent Site, located 1 mile west of the Denver West Office Park, is on a 300-acre tract donated by the State of Colorado to the Federal Government. The area occupied by the Permanent Site, located at the eastern end of South Table Mountain, was formerly part of Camp George West, a training post for the Colorado National Guard. The Permanent Site, is bordered on the south by Denver West Parkway, Camp George West, and residential areas, and on the east by a commercial development which includes the Denver West Office Park. The site is bordered on the north and west by South Table Mountain. Most of the Permanent Site is presently open, unused space. Site elevation ranges from 5,730 feet to 6,050 feet.

The WERC facility occupies a 340-acre flat area approximately 6,050 feet in elevation. Some small quarries operate in the vicinity of the facility, and an abandoned cement plant is located 4 miles away. With the exception of operations at the Rocky Flats Plant, which borders WERC to the south, as shown in Figure 2-1, the area surrounding WERC is open grazing land.



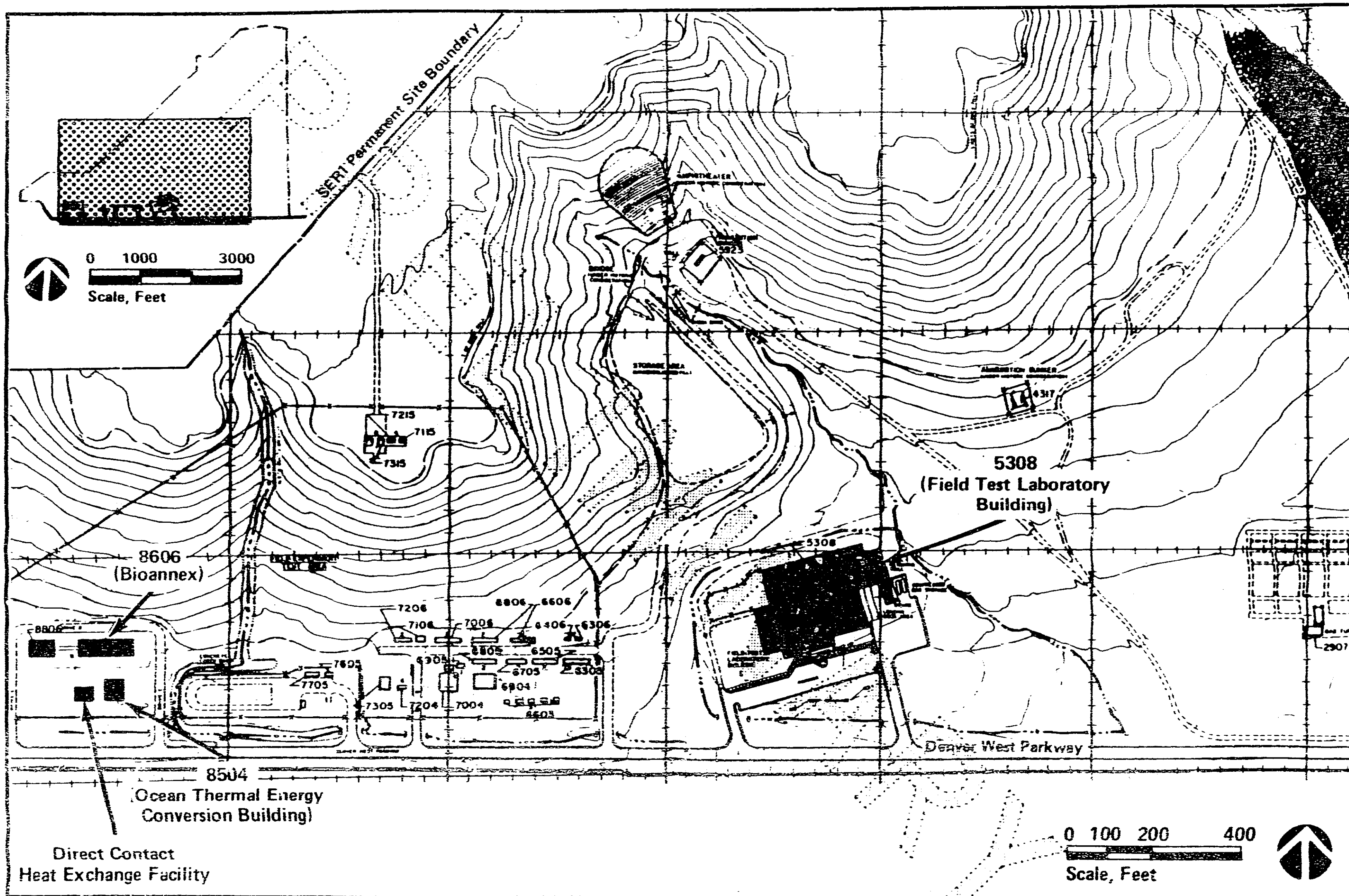
LOCATION OF SERI FACILITIES
IN THE DENVER METROPOLITAN AREA

FIGURE 2-1



SERI BUILDINGS AT THE DENVER WEST OFFICE PARK

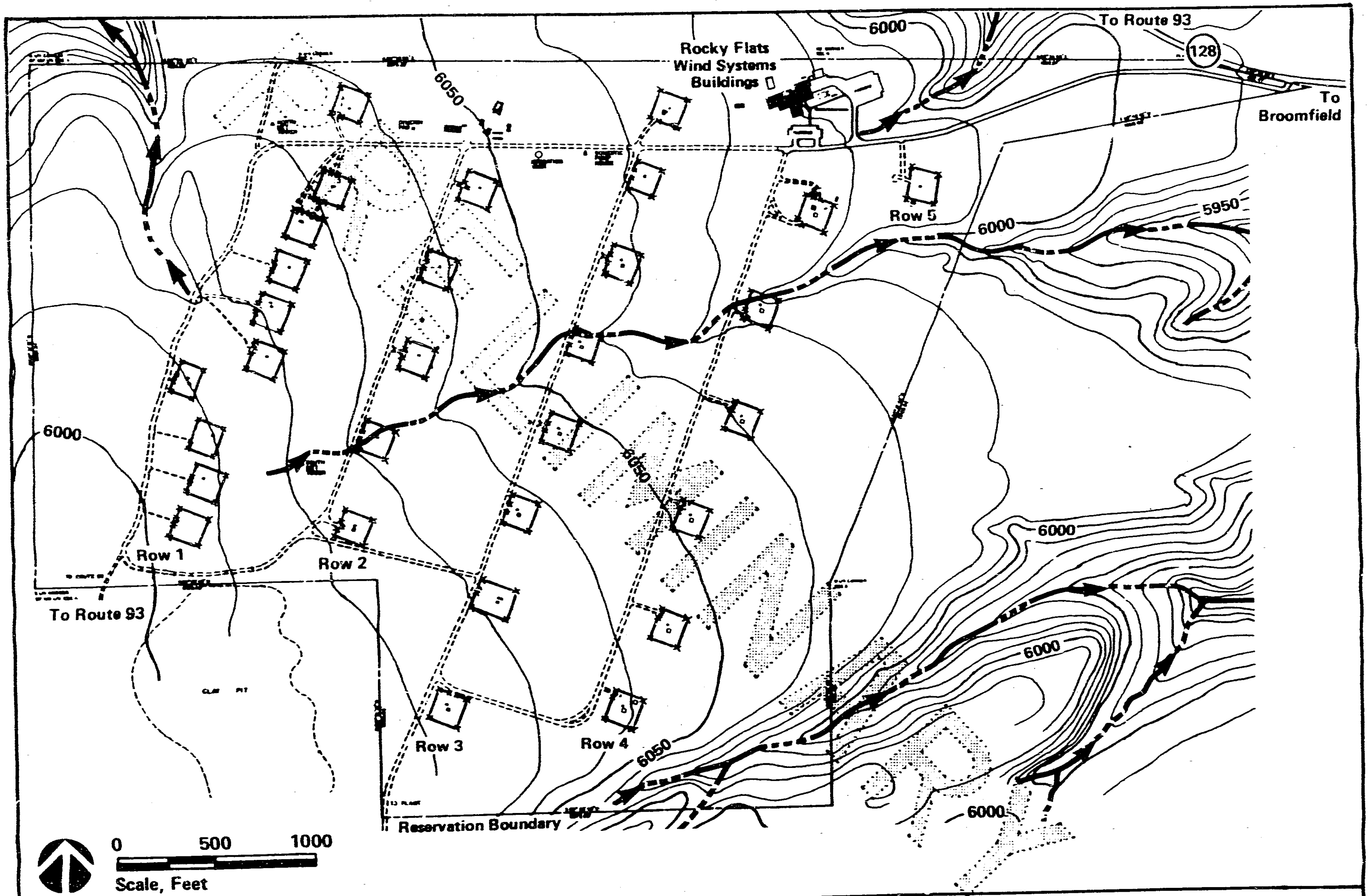
FIGURE 2-2



Source: Higginbotham & Associates, 1986

DETAIL OF THE DEVELOPED PORTION OF THE SERI PERMANENT SITE

FIGURE 2-3



Source: Higginbotham & Associates, 1986

FIGURE 2-4

WIND ENERGY RESEARCH CENTER SITE MAP

Jefferson County, in which all the SERI facilities are located, had a 1980 population of approximately 372,000 according to the 1980 census. The population of the Denver metropolitan area was 1,618,500 in 1980. The 1985 population of Jefferson County was estimated to be 435,000 and that for the Denver metropolitan area was estimated to be 1,900,000. The nearest town to SERI, Golden, had an estimated 1985 population of 14,410 (DOC, 1986). Population figures are summarized in Table 2-1.

TABLE 2-1

POPULATION GROWTH IN SELECTED AREAS NEAR SERI

City or Area	Census of Population		Percent Change	Projected Population	
	1970	1980		1990	2000
Denver	515,314	492,365	-4.5	510,200	518,500
Lakewood	92,742	113,808	+22.7	136,500	172,100
Pleasant View	4,997	5,841	+16.9	6,828	7,981
Golden	9,817	12,237	+24.7	17,200	23,700
Wheat Ridge	29,778	30,293	+1.7	33,000	37,100
Unincorporated Jefferson County	49,172	107,067	+117.7	136,935	181,221

Source: Higginbotham & Associates, 1986

Approximately 520 people worked at the SERI Denver West Office Park location in 1987, and an additional 70 employees worked at the Permanent Site. The present activity at the WERC facility is minimal and the facility has only one full-time staff person.

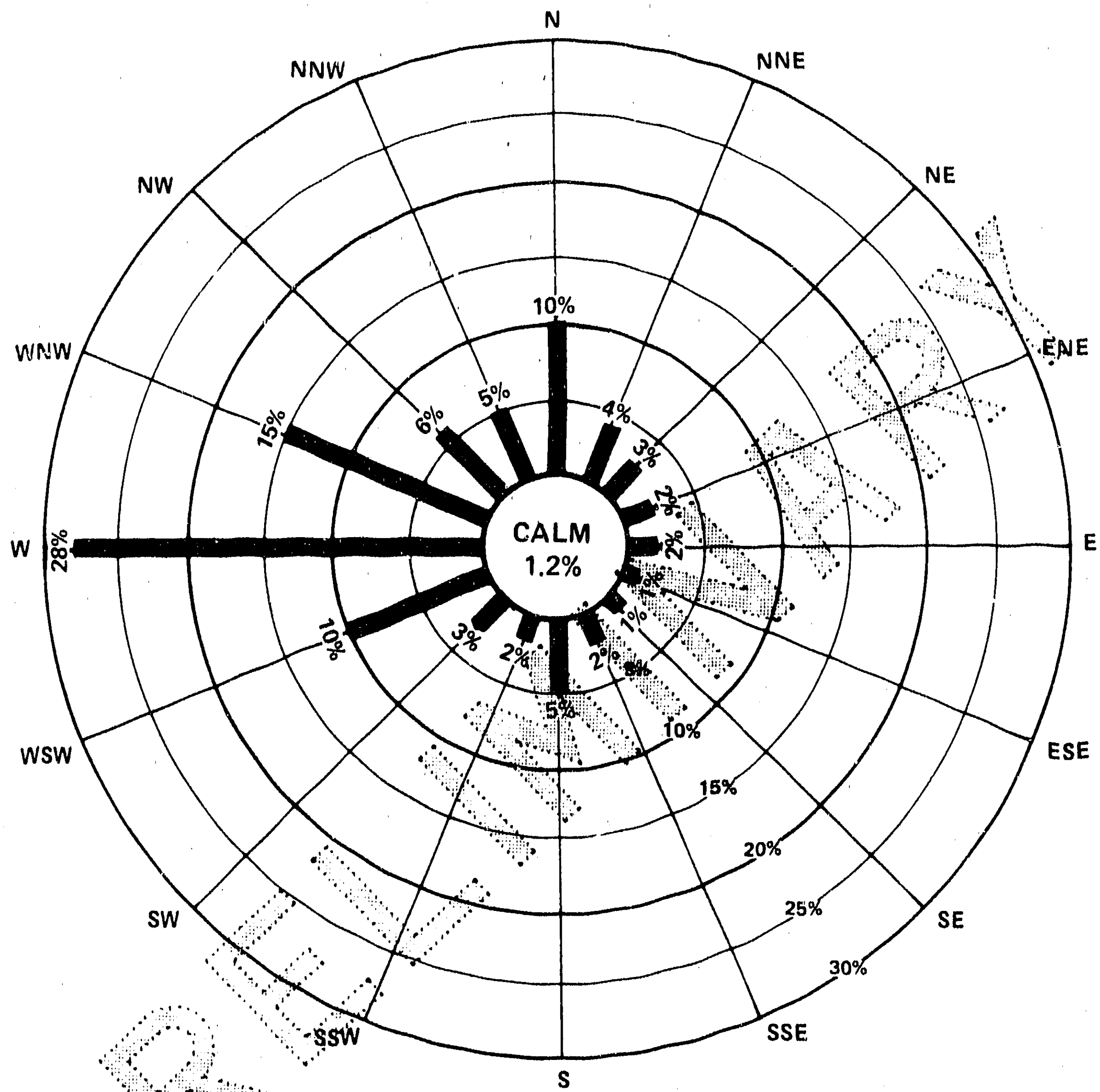
Jefferson County has a semi-arid climate, and experiences sunshine throughout the year with relatively moderate precipitation. The average annual rainfall is less than 20 inches, with a maximum of 25 inches recorded in 1969. Typically, more than 80 percent of the precipitation falls as rain with 40 percent in the spring, and 40 percent in the summer and fall. The remaining precipitation is fall, winter, and spring snowfall.

Temperatures in the region are generally moderate, but daily weather variations can be extreme. Spring temperatures range between the low 50s (°F) to low 70s in the daytime and between the mid 20s and low 40s at night. Average winter temperatures range from the mid 40s in the daytime to the mid teens at night. The wide temperature variations are characteristic of all seasons and are the result of temperature losses caused by the high elevation and sparse cloud cover of the area, and by associated changes in wind directions at night.

Wind patterns in the vicinity of the Denver West Office Complex and the Permanent Site are controlled primarily by local topography and buoyancy forces, rather than by regional forces. Varying densities of local air masses result from heating and cooling of air in contact with the ground. Where there is sloping terrain, as at the SERI Permanent Site, air masses move up or down the slope depending on the relative density of the air above. Generally the flow patterns at the Denver West Office Complex and the Permanent Site experience diurnal wind shifts due to drainage winds from higher elevations at night and upslope winds from lower elevations during the day. Westerly winds predominate during hours of darkness, shifting in the early daylight hours to predominantly northeasterly winds until sunset. Figure 2-5 is a wind rose for nighttime winds, and Figure 2-6 depicts daytime wind patterns.

Wind patterns in the vicinity of WERC are also controlled primarily by local topography. Figure 2-7 shows an annual wind rose for the Rocky Flats Plant, which is adjacent to WERC. The average wind speed is approximately 10 miles per hour (mph). Occasionally very strong gusty winds, sometimes in excess of 100 mph, are experienced, especially in the spring and fall. Unseasonably warm temperatures during late winter and early spring months are usually attributed to Chinook winds, which are warm dry winds descending from the Rocky Mountains with speeds often exceeding 70 mph.

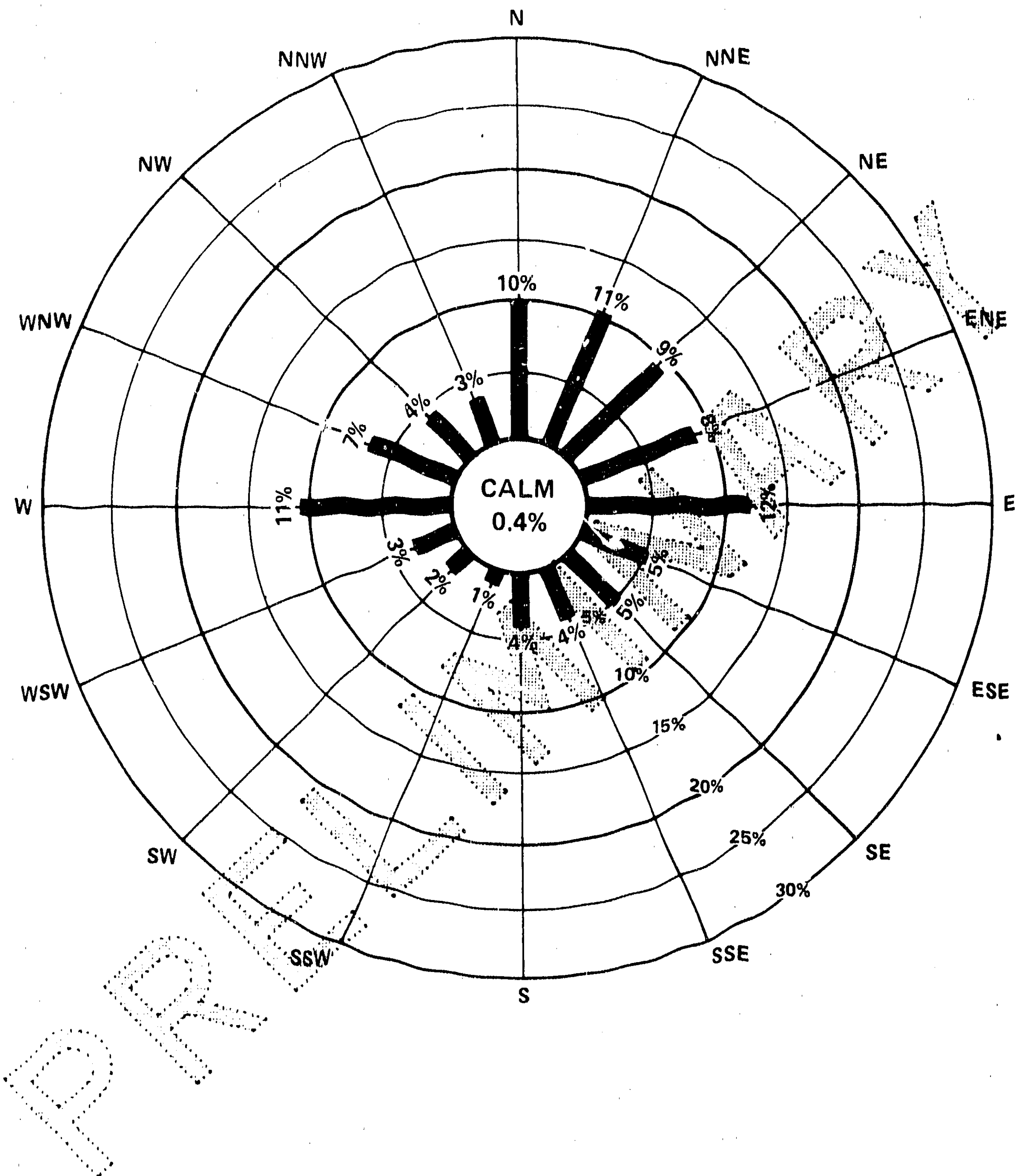
The Denver area is subject to diurnal wind shifts and seasonal temperature inversions, particularly at night and during the winter months. These inversions may be extended, lasting up to a full day, and contribute to periodic and seasonal exceedances of Federal and state regulatory standards for particulates, ozone, and carbon monoxide in the Denver area. These air quality standard exceedances do not always extend to the Golden area and SERI facilities. Large variations in local micro-meteorology, particularly wind shifts influenced by the local topography, affect the



Source: Higginbotham & Associates, 1986

ANNUAL NIGHTTIME WIND ROSE FOR THE SERI PERMANENT SITE
6 PM – 6 AM (JULY, 1981 – JUNE, 1982)

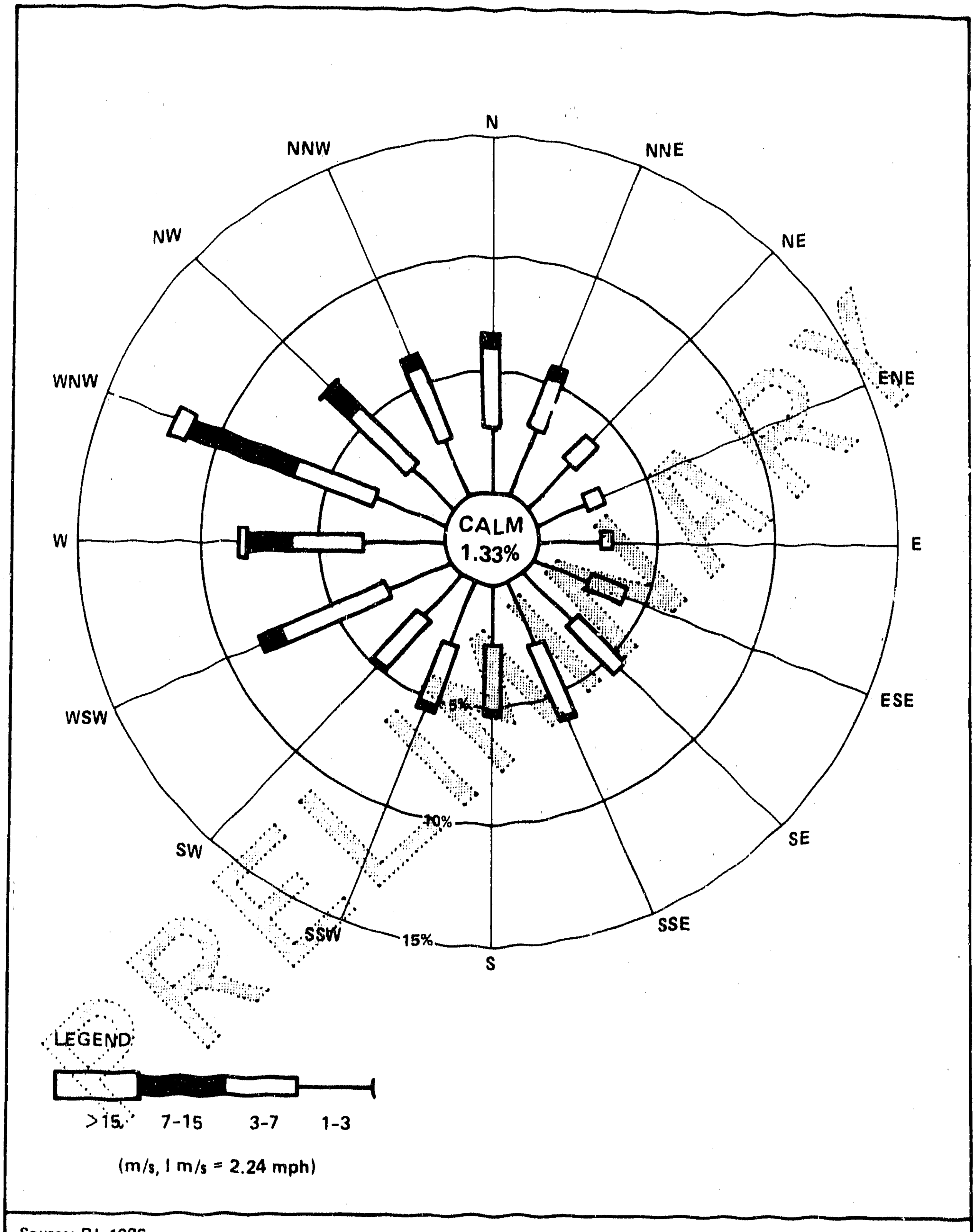
FIGURE 2-5



Source: Higginbotham & Associates, 1986

ANNUAL DAYTIME WIND ROSE FOR THE SERI PERMANENT SITE 6 AM – 6 PM (JULY, 1981 – JUNE, 1982)

FIGURE 2-6



Source: RI, 1986

1985 ANNUAL WIND ROSE
FOR THE ROCKY FLATS PLANT, ADJACENT TO WERC

FIGURE 2-7

dispersion characteristics in the vicinity of the Permanent Site and Denver West Office Park.

Jefferson County lies between the extensive grasslands of the eastern Colorado plains and the Front Range of the Rocky Mountains. Natural vegetation in this region is a mix of sparse prairie grasses and alpine meadow grasses. Various shrub communities appear in sheltered areas such as drainage channels and ravines along the slopes of South Table Mountain. Prominent shrubs are predominantly mountain-mahogany and sumac, with chokecherry and rabbit brush. Grasses include western wheatgrass, green needlegrass, and buffalo grass. The Permanent Site is approximately 60 percent grassland and 40 percent shrubland. The unused portion of the WERC facility is nearly 100 percent grassland. Most of these plants are xerophytes, which require relatively little moisture to sustain growth. However, they are delicate plants which recover slowly from a disruption of their natural habitat. The environment does not naturally support a tree population. Scattered pine and aspen trees appear in higher elevations. The hardwood, broadleaf, deciduous trees lining the streets of nearby communities were planted and cultivated by early immigrants to the area. Vegetation at the Denver West Office Park consists of cultivated grass, shrubs, and trees typical of a landscaped area.

The South Table Mountain area where the Permanent Site is located represents an island of relatively undisturbed native range habitat compared to nearby segments of urban development. The extent of wildlife species at the Permanent Site was evaluated in 1987, and is summarized in the SERI Wildlife Report (The Forum Associates, Inc., 1987). It is known that certain species of birds, such as the western meadowlark and black-billed magpie, nest in the area. Signs indicate that various ground mammals and raptors have occupied parts of the mesa and slopes. Sightings of mule deer, rabbits, and coyotes have been reported at the Permanent Site. Species of wildlife at the WERC site have not been characterized.

2.2 Overview of Major Site Operations

SERI was established by Congress in 1974 and commenced operations in 1977. SERI is operated by the Midwest Research Institute (MRI) for the DOE. The facility is the primary Federal laboratory devoted to research and development of solar energy technologies. The principal sites of SERI activities are the Permanent Site and three buildings at the Denver West Office Park. The Permanent Site is presently occupied by the Field Test Laboratory Building (FTLB), Biological Technology Research (Bioannex) Facility, Ocean Thermal Energy Conversion (OTEC) Facility, Direct Contact Heat Exchanger (DCHX) Facility, and several smaller facilities.

The Bioannex Facility consists of Buildings 8606 and 8806, which contain respectively the dilute acid digester and a wood chip storage area. The OTEC Facility is located in Building 8504, and the DCHX Facility is located on a concrete pad adjacent to the OTEC Facility. A summary of permanent and temporary buildings located at the Permanent Site is shown in Table 2-2. The locations of the Bioannex, OTEC, and DCHX facilities are shown in Figure 2-3.

Two buildings of the three-building complex at the Denver West Office Park, shown in Figure 2-2, are occupied by SERI offices (Buildings 15 and 17). Building 16 of the Office Park is presently occupied by some of the SERI research laboratories. It is planned that all SERI operations will be moved from the Denver West Office Park to facilities at the Permanent Site in the near future (SERI, 1986b). Activity at WERC, located at the DOE Rocky Flats Plant, is presently minimal.

DOE-funded research activities at SERI fall into 10 basic subcategories:

Solar Electric	-	Photovoltaic Energy
		Wind Energy
		Resource Assessment
Solar Fuels	-	Biofuels
		Solar Energy Storage
Solar Heat	-	Solar Buildings
		Building Energy Research and Development
		Solar Thermal Energy
		Ocean Energy
Information Branch	-	Solar Technical Information

TABLE 2-2
BUILDINGS AT THE SERI PERMANENT SITE

Number/Title	Function
Permanent Buildings	
2907 Gas Turbine Facility	Gas cylinder storage
4317 Storage Bunker	Historic ammunition bunker
5308 Field Test Laboratory Building (FTLB)	Laboratories, storage, offices
5923 Storage Bunker	Historic ammunition bunker, SERI storage
8504 Ocean Thermal Energy Conversion (OTEC) Facility	Research
8606 Biological Technology Research Facility (Bioannex)	Research
8806	Storage
Temporary Buildings	
6305	Test trailer for photovoltaics
6505, 6606, 6705, 6805, 6806, 7006, 7206	Control and test trailers
6603	Wood and glass test cells (five)
6804	Wood and glass test building
6905	Electrical distribution and phone relays
7004	Photobiology equipment
7106	Control and test equipment storage
7115	Daylight test facility
7204	Mid-Temperature Collector Research equipment
7215	Solar Research Laboratory equipment
7305	Mid-Temperature Collector Research
7315	Solar Research Laboratory equipment
7605	Modular Industrial Solar Retrofit storage
7705	Modular Industrial Solar Retrofit experiment control

Source: Higginbotham & Associates, 1986

SERI also conducts research on a reimbursable-funding basis for other Federal agencies in the above areas. Specific research areas of interest to the Survey are described as follows:

Photovoltaic Energy - SERI develops, designs, and fabricates prototype photovoltaic cells in several laboratories in Building 16 of the Denver West Office Park. Development studies include manufacture and treatment of semiconductor materials by metal vapor deposition, small-scale plating and etching, and chemistry and materials research. Specific studies ongoing during the Survey included the metal organic chemical vapor deposition experiments conducted in Building 16 laboratories.

Biofuels - SERI conducts a number of different studies of biomass conversion (e.g., wood, algae) to organic fuels. Specific studies ongoing during the Survey included aquatic species (algae conversion), anaerobic digestion (bacterial conversion), and biochemical and thermochemical conversion. Development studies involve growing algae colonies; operation of chemical conversion pilot plants to convert algae, wood products, etc., to liquid fuels; photosynthesis research; conversion catalyst development; and anaerobic digestion of municipal waste to produce methane. Experimental studies are conducted at the FTLB and the Bioannex Facility at the Permanent Site and several Building 16 laboratories. Specific activities include the wood fuels pyrolysis reaction in the high bay area of the FTLB, organometallic catalyst development laboratories in Building 16, and dilute acid hydrolysis digester in the Bioannex Facility.

Solar Thermal Energy - Research activities in this area involve direct conversion of solar radiation into electricity, high-temperature heat sources, or high heat-value chemical compounds. Specific experiments include the molten salt heat transfer experiments in the FTLB high bay.

Ocean Energy - Research activities in this area include the open-cycle OTEC program at the Permanent Site OTEC Facility, which involves thermodynamic, fluid dynamic, and materials and structures research related to the conversion of ocean thermal energy directly to electricity.

Solar Buildings and Building Energy Research and Development - SERI performs research in the areas of solar thermal processes and materials research. Activities in the solar thermal processes areas include solar buildings; solar thermal research technology, primarily for industrial and utility applications; and building energy research and development. Research is performed and results are integrated into prototype systems that industry can use to expand or improve its products.

The materials and supporting research performed has as its objective the identification and development of promising materials for solar thermal systems. These include materials for absorbing, transmitting, and reflecting solar radiation; materials for advanced structural support; and working fluids. Wind energy research activities at SERI are presently minimal. Resource assessment is a non-laboratory activity.

2.3 State and Federal Concerns

A meeting was held on November 4, 1987, with representatives of the EPA as well as the various state and local environmental regulatory agencies. The representatives were invited to present their concerns over existing or potential environmental problems associated with SERI operations.

The representatives raised no issues of concern. The representatives from Pleasant View Sanitation District stated that they are satisfied with the procedures used by SERI to control discharges to the public sewer system.

3.0 MEDIA-SPECIFIC SURVEY FINDINGS AND OBSERVATIONS

The discussions in this section pertain to existing or potential environmental problems in the air, soil, surface water, and groundwater media. They include a summary of the available background environmental information related to each medium, a description of the sources of pollution and their control techniques, a review of the environmental monitoring program specific to each medium, and a categorization and explanation of the environmental problems found by the Survey team related to each medium.

3.1 Air

Discussion in the following sections relates to the ambient air quality in the Denver/Golden area, air emissions sources and controls, SERI's air emissions and ambient air quality environmental monitoring program, and findings and observations related to air emissions. Area meteorology is discussed in Section 2.0. Radionuclide air emissions, storage, use, disposal, and monitoring activities are discussed in Section 4.3.

3.1.1 Background Environmental Information

The air quality in the Denver/Golden area is better than Federal air quality standards for nitrogen oxides and sulfur dioxide, and is not in attainment of Federal or state standards for carbon monoxide (CO), total suspended particulates (TSP), and ozone. The Denver area is subject to prolonged inversion conditions, especially at night and during the winter months. These inversions may be extended, lasting up to a full day, and contribute to seasonal exceedances of Federal and state standards for CO, TSP, and ozone. Although the entire Denver metropolitan area is designated non-attainment for these pollutants, the exceedances of the air quality standards do not always extend to the Golden area and SERI facilities, or other areas outside central Denver.

Federal ambient air quality standards for TSP were superseded in July 1987 by standards for PM-10 particulate (the fraction of total particulate with a diameter less than 10 micrometers). Complete PM-10 air quality data for the Denver area are not available. Elevated concentrations of CO and ozone in the Denver/Golden area are attributed primarily to emissions from mobile sources, particularly automobiles. Woodburning stoves and industrial sources also contribute to high levels of CO and ozone; several major industrial sources are located near SERI. TSP concentrations result from mobile sources, stationary combustion equipment, and fugitive dust.

Table 3-1 summarizes Federal and state ambient air quality standards for criteria pollutants. Ambient air quality data for non-attainment pollutants (CO, TSP, and ozone), are summarized in Figure 3-1 (Higginbotham & Associates, 1986) for four ambient air quality monitoring stations in proximity to SERI. The general locations of the stations are shown in Figure 2-1.

Carbon monoxide and ozone concentrations are measured at the Denver and Arvada stations; the Arvada station is closer to SERI. The 8-hour standard for CO was exceeded at the Arvada station on 5 days in 1986 and 4 days in 1985 (second highest concentration 10 ppm in both years). Carbon monoxide concentrations at the Arvada station are lower than those measured at the Denver station, as illustrated in Figure 3-1, due to the lower number of mobile sources. The ozone standard was exceeded on one day in both 1985 and 1986 (second highest concentration of 0.11 ppm in both years) (Colorado APCD, 1987). The expected number of annual violations of the ozone standard is predicted based on statistical analysis of monitored ambient ozone concentrations. Ozone concentrations at the two locations are comparable, and no recent trends are apparent from the data for either CO or ozone concentrations.

The closest TSP monitoring stations to SERI are Lakewood and Golden. The secondary 24-hour TSP standard was exceeded at both stations in 1985 and 1986. Historically, annual geometric mean TSP concentrations at the Golden and Lakewood stations have not always exceeded the standard, as illustrated in Figure 3-1, and have been lower than concentrations measured at the Denver station.

3.1.2 General Description of Pollution Sources and Controls

In general, the air emissions sources at SERI, with the exception of combustion sources, are below the minimum source size, or otherwise do not fall within state or

TABLE 3-1

SUMMARY OF AMBIENT AIR QUALITY STANDARDS (CRITERIA POLLUTANTS - NONRADIOACTIVE)

Parameter	Averaging Time	NAAQS	Colorado AAQS
Total Suspended Particulate[a]	Annual Geometric Mean Primary[b]	75 µg/m^3	75 µg/m^3
	Annual Geometric Mean Secondary[c]	60 µg/m^3	60 µg/m^3
	24-Hour Primary[b,d]	260 µg/m^3	260 µg/m^3
	24-Hour Secondary[c,d]	150 µg/m^3	150 µg/m^3
PM-10 Particulate	Annual Arithmetic Average, Primary and Secondary	50 µg/m^3	----
	24-Hour Average, Primary and Secondary[e]	150 µg/m^3	----
Sulfur Dioxide	Annual Arithmetic Mean Primary[b]	0.030 ppm	----(f)
	24-Hour Primary[b,d]	0.140 ppm	----(f)
	3-Hour Secondary[c,d]	0.500 ppm	0.267 ppm
Carbon Monoxide	1-Hour Primary[b,d]	35 ppm	35 ppm
	8-Hour Primary[b,d]	9 ppm	9 ppm
Nitrogen Oxides	Annual Arithmetic Mean Primary[b]	0.05 ppm	0.05 ppm
Ozone	1-Hour Primary[b,e]	0.12 ppm	0.082 ppm
Lead	Calendar Quarter Primary[b]	1.5 µg/m^3	1.5 µg/m^3
Hydrogen Sulfide	30-Minute Average	---	0.1 ppm

Sources: NAAQS-40 CFR 50; Colorado ; AAQS - Code of Colorado Regulations, Volume 5, Part 14

a NAAQS superseded in July 1987 by PM-10 Particulate Standards

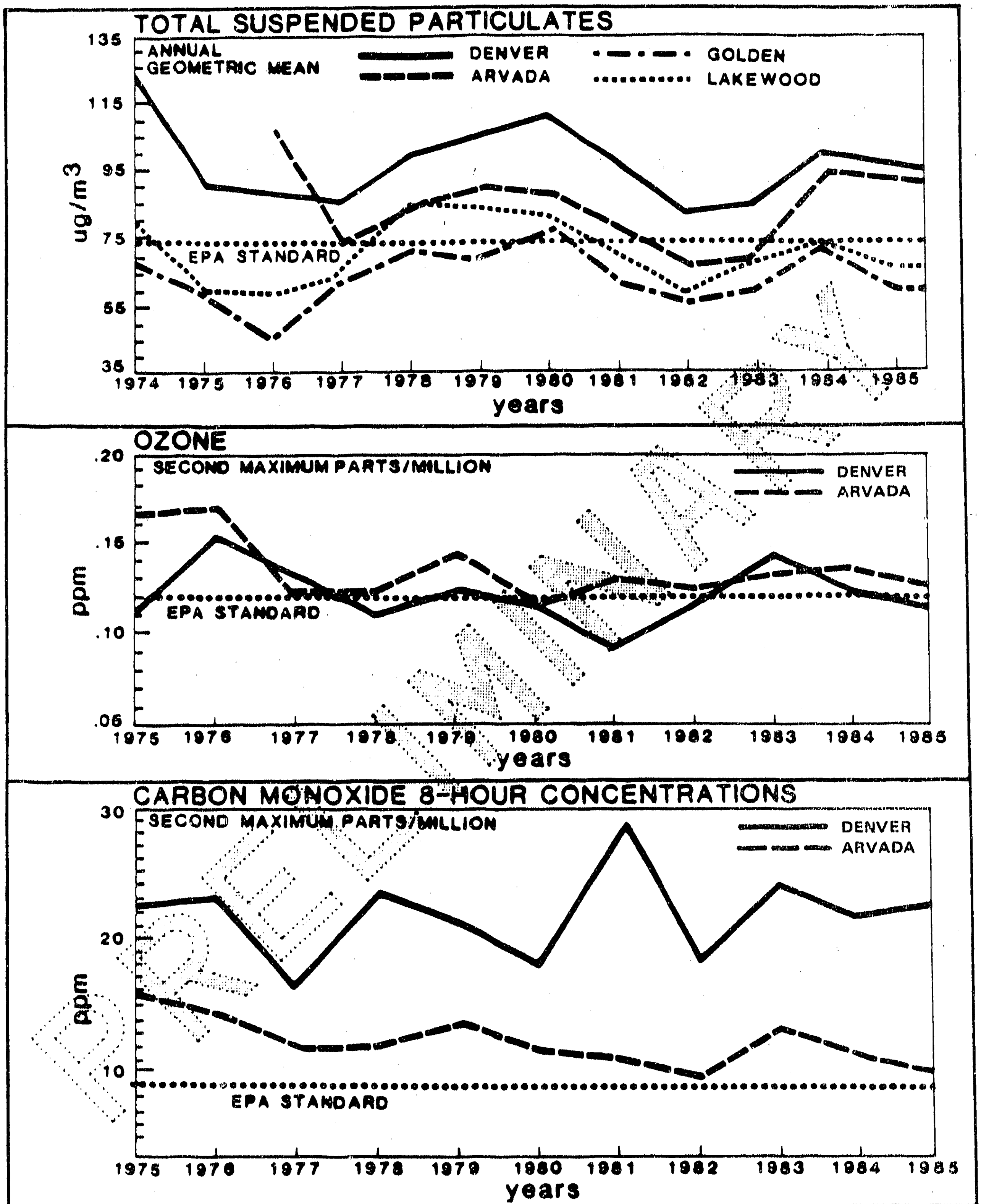
b Primary National Ambient Air Quality Standards (NAAQS) are intended to protect public health.

c Secondary NAAQS are intended to protect public welfare.

d Not to be exceeded more than once per year.

e Statistically estimated number of days with concentrations in excess of the standards is not to be more than 1.0 per year.

f Colorado State Standards are expressed as an incremental concentration above baseline, as opposed to a numerical standard.



Source: Higginbotham & Associates, 1986

ANNUAL TOTAL SUSPENDED PARTICULATES, OZONE 1-HOUR AND CARBON MONOXIDE 8-HOUR CONCENTRATIONS IN THE DENVER AREA: HISTORICAL COMPARISONS 1975 – 1985

FIGURE 3-1

Federal regulations. State of Colorado regulations provide for the exemption of some types of research operations from air emission permit requirements (Colorado Air Regulation No. 3, II.C, Air Emission Notice Requirements, Exemptions), and due to this exemption, the six gas-fired boilers and gas/fuel-oil-fired boilers located in Building 16 of the Denver West Office Park, and in the FTLB, OTEC, and DCHX Laboratories at the Permanent Site, are the only emission sources at SERI that presently require permits from the Colorado Department of Health (Colorado Air Regulation No. 1, Emission Control Regulations). There are no operations at SERI, other than the boilers, that could be considered continuous emission sources. The sources of air emissions for each of the major SERI facilities are discussed below.

3.1.2.1 <u>Denver West Office Park</u>

All sources and potential sources of air emissions at the Denver West Office Park SERI facilities are located in Building 16, with the exception of a small photographic laboratory in Building 15.

Building 16

Air emission sources in Building 16 include 8 metal organic chemical vapor deposition (MOCVD) laboratories, 38 research laboratories devoted to biology, photosynthesis, semiconductor material development, photochemistry, organometallic chemistry, and other research activities, and 2 dual-fuel (gas and No. 2 fuel oil) package boilers. These air emission sources are discussed below along with the ventilation system in Building 16.

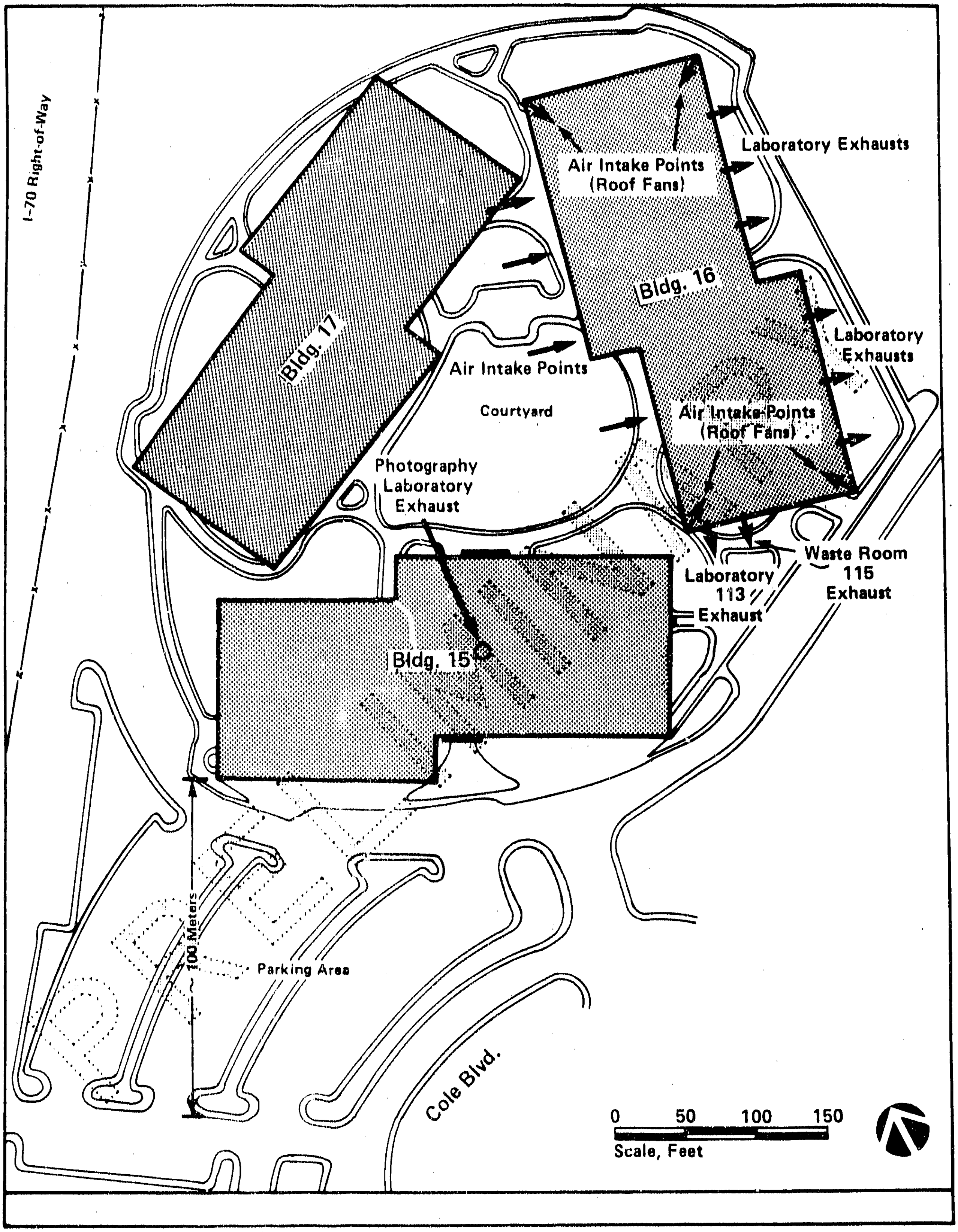
<u>Building 16 Ventilation System</u> - As previously discussed in Section 2, the Denver West Office Park buildings were originally designed to be office buildings, rather than chemical laboratories, and Building 16 was converted to a laboratory facility by SERI in cooperation with the building landlord. The conversion involved installing laboratory hoods and utility services (gas, water) and redesigning and rebuilding a substantial portion of the building ventilation system.

The original Building 16 ventilation system consisted of standard fiberglass ductwork and ventilation fans. These fans did not provide sufficient air turnover for the laboratory hoods, and roof fans with a capacity of 50,000 cubic feet per minute (cfm) were subsequently installed. The fiberglass ductwork in the building was also not air-tight, and as a result, fumes from laboratory exhaust hoods were escaping into the ceiling space of the building and entering other laboratories. The fiberglass ductwork was replaced by "megafixed" air-tight ductwork in laboratories where toxic or odorous materials are used.

Due to its original design as an office building, installation of roof vents on Building 16 was impractical, and therefore building air intakes and laboratory exhaust vents were situated in the external walls of the building. Four air supply fans are located on the roof of Building 16, which provide 50,000 cfm of makeup air. External wall air intakes and exhausts are separated, to prevent short-circuiting of the exhaust, with intakes situated on the courtyard side of the building, and exhausts on the parking area side of the building, as shown in Figure 3-2. With the exception of the Room 113 and Room 115 exhausts, which are single exhaust points, the laboratory exhausts shown in Figure 3-2 do not correspond to individual exhaust points, but represent multiple exhaust points that are situated at all three stories of Building 16. The location of the exhausts has resulted occasionally in detection of odorous constituents in the immediate vicinity of the SERI parking area. These incidents are generally related to upset laboratory experiments, and are of short duration. The location of the laboratory exhausts is of greater concern with respect to accidental release scenarios related to the storage and handling of toxic gases (e.g., arsine, phosphine) in the MOCVD laboratories.

Use of "toxic" materials is prohibited by SERI policy in non-megafixed hoods. "Toxic" materials include toxic metals, such as arsenic, and solvents such as trichloroethylene (TCE) and acetone, but not acids or "non-toxic" solvents, such as alcohols. This policy is not strictly enforced since laboratories using small amounts (on the order of a few gallons per year) of toxic materials were observed during the Survey where prohibited substances were being used in non-megafixed hoods. Laboratories using larger amounts (a few gallons per month) of prohibited substances are generally subject to written procedures concerning use of megafixed hoods. However, some laboratories were found to have outdated procedures or no procedures.

<u>Building 16 Metal Organic Chemical Vapor Deposition Laboratories</u> - The MOCVD laboratories are located in Rooms 103, 122, 190, 216, 218/220, 368, 369 and 454 of



DENVER WEST OFFICE PARK BUILDINGS 15 AND 16 INTAKES, VENTILATION, AND LABORATORY EXHAUSTS

FIGURE 3-2

Building 16, and are summarized in Table 3-2. Experiments in growing semiconductor materials for photovoltaics research are conducted in these facilities. Metal and organometallic materials are deposited on various substrates under vacuum conditions in laboratory-scale reactors. The MOCVD apparatus is enclosed in ventilated cabinets, and both the apparatus and cabinets are exhausted through megafixed ducts to the atmosphere. Various toxic, corrosive, and pyrophoric gases, including arsine, phosphine, silane, germane, hydrogen chloride, hydrogen sulfide, hydrogen selenide, silicon tetrafluoride, and diborane, are used in the metal deposition studies, as well as gram quantities of organometallic compounds such as methyl aluminum and tetramethyl tin. The gases most commonly used in the MOCVD laboratories are arsine, silane, phosphine, and hydrogen chloride. Hydrogen selenide, germane, diborane, hydrogen sulfide, and silicon tetrafluoride are used intermittently in the laboratories.

The MOCVD Analytical Laboratory in Room 222 is used to conduct analyses of MOCVD substrates. Several grams per month of chromium and arsenic compounds are used in this laboratory. Potassium cyanide and nickel plating solutions and other primarily nonvolatile solutions are also used, as well as small quantities of acrylonitrile. Toxic metal and solvent emissions from this laboratory are minimal based on the amount of materials used.

Gases are introduced to the MOCVD reactors from 30-ft^3-capacity gas cylinders through a complex valve manifold system. There are multiple valves in the system, which can be shut off manually or automatically (by turning off power to a solenoid valve) in the event a leak is detected in the system. Approximately 10 percent of the gas introduced to the reactors deposits on the substrate material, and the remainder is exhausted from the apparatus. The exhaust from apparatus not equipped with a scrubber or carbon bed is flared to convert phosphine and organometallic compounds to less toxic phosphorus pentoxide and metal oxides, and to reduce explosion hazards which would otherwise result from releasing hydrogen into the ventilation system. The conversion efficiency of the flare is not known. MOCVD systems in Room 190 are equipped with commercially procured caustic scrubbers, which remove toxic gases from the apparatus exhaust with greater than 99 percent efficiency, according to manufacturers' data. The exhaust gases are diluted to 5 percent gas/95 percent nitrogen before entering the scrubbers.

TABLE 3-2

SUMMARY OF DENVER WEST OFFICE PARK MOCVD LABORATORIES

Room Number	Number of MOCVD Units	Design	Emission Control System	Toxic Material Storage
103	One	In-House Design	Flare	Gas Cylinders
122	One	In-House Design	Flare	Gas Cylinders
190	Three	In-House Design	Two Caustic Scrubbers[a]	Gas Cylinders
216	One	In-House Design	Flare	Gas Cylinders
218/220	One	Commercially Procured Machine	Carbon Bed/ Oxidizer	Gas Cylinders
368	One	In-House Design	Flare	Gas Cylinders (H_2Se)[b], Liquid Cylinders (AsH_3, PH_3)[c]
369	One	In-House Design	Caustic Scrubber to be installed	Gas Cylinders
454	One	In-House Design	Flare	Gas Cylinders

Source: SERI, 1987d.

a Two units exhaust to one scrubber, one unit to the other
b H_2SE - Hydrogen Selenide
c AsH_3 - Arsine; PH_3 - Phosphine

The commercial MOCVD system in Room 218/220 has an oxidizer/carbon bed adsorption system, which is an experimental system designed to replace scrubber technology. Both the adsorption and scrubber systems have demonstrated greater than 99 percent efficiency in removing toxic compounds from the exhausts. New MOCVD units will be equipped with scrubber or adsorption control systems, according to SERI policy. A scrubber was being installed in Room 368 at the time of the Survey. The scrubbers and carbon bed systems only control routine gas releases from the MOCVD apparatus. Nonroutine releases to the ventilated cabinets and enclosures are not controlled.

All MOCVD apparatus exhausts, cabinet exhausts, gas storage cabinet exhausts, and laboratory ambient air are monitored for arsine, phosphine, hydrogen selenide, and diborane by remotely located toxic gas analyzers, manufactured by MDA, Inc. Silane and germane are pyrophoric and spontaneously combust in air. Fires resulting from releases of these pyrophoric compounds are detected by smoke alarms. Hydrogen sulfide, hydrogen chloride, and silicon tetrafluoride, which are used in small amounts in the laboratories, or are less acutely toxic than arsine and phosphine, are not detected by the toxic gas analyzers.

Gas samples are aspirated from the MOCVD laboratories to the analyzers by a vacuum system, and the toxic gases contact and react with a chemical tape in the analyzer. The tape changes color upon contact with the gas, and is continuously analyzed by an optical system that indicates the concentration of toxic gases in the sampled gas. The units are alarmed to indicate high concentrations of toxic gases. Audible and visual alarms are located in each MOCVD laboratory and in the MDA analyzer room. An audible alarm is located at the Building 15 security desk. Low- and high-level alarm points are included in Table 3-3. SERI has established written procedures for responding to alarm situations (Thompson, 1987).

The MDA analyzers are remotely located from the MOCVD laboratories, so that they can be safely accessed during alarm situations. This necessitates sample lines of approximately 100 feet in length in some cases. The long sample lines are expected to result in a lag of on the order of 30 seconds between the time of a release and the alarm indication. Preventive maintenance is scheduled and performed by the SERI Facilities branch. Monthly scheduled procedures include checking the sample gas

TABLE 3-3

ALARM POINTS FOR MDA TOXIC GAS ANALYZERS

	Low-Level Alarm Point	High-Level Alarm Point	TLV[a]	IDLH[b]
Arsine	0.05 ppm	0.25 ppm	0.05 ppm	6.0 ppm
Phosphine	0.10 ppm	0.90 ppm	0.30 ppm	200 ppm
Room 216	0.30 ppm	0.60 ppm	0.30 ppm	200 ppm
Diborane	0.10 ppm	0.50 ppm	0.10 ppm	40 ppm
Hydrogen Selenide	0.05 ppm	0.25 ppm	0.05 ppm	2.0 ppm

Source: Deb, 1987; Thompson, 1987

a TLV = Threshold Limit Value ("Allowable" 8-hour/day exposure) in ACGIH, 1987

b IDLH = Immediately Dangerous to Life and Health flow rates, entering alarm set points, performing electrical and optical calibrations, and replacing the chemical tapes. Although these procedures are performed on a scheduled basis, no documentation is kept as to the specific activities performed (e.g., whether the analyzers were properly functioning when calibrated, and if not, what actions were taken to correct the situation). The analyzers are not routinely calibrated with standard gases containing a known concentration of toxic gases. This procedure was last performed by the analyzer manufacturer in December 1985, and is not regularly scheduled by SERI administrative procedures.

Routine emissions of toxic gases from MOCVD apparatus are generally very low. Exhaust concentrations from systems without emission controls are routinely less than the low-level alarm point concentrations (below 50 ppb for arsine, 100 ppb or 300 ppb for phosphine), and releases from systems equipped with scrubber or no scrubber emission controls are generally not detectable. Nonroutine releases are infrequent and of short duration, based on SERI unusual occurrence reports. The concentration of nonroutine releases has generally been below the high-level alarm points shown in Table 3-3. No nonroutine release incidents in the past 2 years involved a high-level alarm situation, with the exception of an incident in 1987 in which the analyzer alarm points were set incorrectly (Thompson, 1987). Low-level alarm conditions have been experienced in the past in Rooms 216 and 218/220. Incidents in Room 216 were the result of combined procedural and design problems. Procedural deficiencies have been remedied, although the apparatus was under renovation but still active at the time of the Survey. Room 218/220 contains the single commercially procured MOCVD unit. This machine has experienced operational problems and has been modified by SERI personnel.

Accidental release scenarios have been analyzed by SERI and Midwest Research Institute (MRI), and the ambient site boundary concentrations of toxic gases resulting from various release scenarios have been estimated in an internal, unpublished report prepared in 1985 (Duncan, 1985). Release scenarios analyzed include releases of the total volume of one or more toxic-gas cylinders into a gas cylinder storage cabinet or into a laboratory room. Calculations were performed based on the old Building 16 ventilation system, in which MOCVD laboratory exhausts were located on both the north and east sides of the building. The present system has exhausts only on the east side of the building, and has a higher total exhaust rate. The increased exhaust velocity of the new system may slightly increase the distance to which the exhaust is dispersed, and the increased exhaust volume may decrease the exhaust concentrations from those calculated using the old design parameters.

Ambient concentrations were calculated at a 100-meter distance from Building 16, which is the minimum distance at which the dispersion model used in the study is considered accurate, and is also approximately the site boundary. Worst-case (F Class) stability conditions were assumed. The highest predicted concentrations for arsine, phosphine, and diborane were on the order of 1 ppm, which is above the 8-hour threshold limit value-time weighted averages (TLV-TWA) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) for three compounds, but below the immediately dangerous to life and health (IDLH) levels for the compounds. TLV-TWA and IDLH concentrations for the toxic gases used at SERI are listed in Table 3-4. Predicted concentrations of hydrogen selenide were lower than the ACGIH TLV-TWA.

The maximum concentration of hydrogen chloride resulting from an accidental release scenario was about 5 ppm, which is equivalent to the ACGIH TLV-TWA for hydrogen chloride, and that for silicon tetrafluoride was less than 1 ppm. Release durations on the order of 5 minutes were estimated for these release scenarios. The maximum concentration of germane was about 0.3 ppm, 0.1 ppm above the ACGIH TLV-TWA. No IDLH values have been published for silicon tetrafluoride and germane although SERI assumes an IDLH value of 6 ppm (the same as for arsine) for comparative purposes. The duration of the worst-case release was estimated to be about 30 minutes. Other scenarios with release durations up to 12 hours had calculated ambient concentrations an order of magnitude below the ACGIH TLV-TWA values.

The study demonstrates that under worst-case release conditions, exposure levels would be less than the corresponding IDLH levels for all toxic gases, at the site boundary. The study also shows that the total exposures are of short duration for scenarios demonstrating the highest concentrations. The dispersion model used for the analysis did not allow for the calculation of ambient concentrations of toxic gases in the immediate vicinity of the Building 16 parking area. These concentrations are expected to be somewhat higher than those calculated at 100 meters from the building and would be of approximately the same duration.

TABLE 3-4

VALUES OF AIRBORNE CONCENTRATION LEVELS FOR TOXIC GAS COMPOUNDS USED AT SERI

Compound	IDLH[a] (ppm)	TLV-TWA[b]		TLV-STEL[c]	
		ppm	mg/m^3	ppm	mg/m^3
Arsine	6	0.05	0.2	NA[d]	NA[d]
Phosphine	200	0.3	0.4	1	1
Hydrogen Selenide	2	0.05	0.2	NA	NA
Hydrogen Chloride	100	5.0	7.0	NA	NA
Diborane	40	0.1	0.1	NA	NA
Germane	NA	0.2	0.6	NA	NA
Silicon Tetrafluoride	NA	NA	NA	NA	NA

a Immediately Dangerous to Life and Health, provided by SERI.
b Threshold limit value-short-term exposure limit (8-hour exposure) in ACGIH, 1987.
c Threshold limit value-time weighted average (15-minute exposure) in ACGIH, 1987.
d NA indicates that no IDLH or TLV values are available.

Concentrations are not expected to exceed IDLH levels for significant periods even under worst-case release and meteorological conditions (Duncan, 1985).

Ambient concentrations in the immediate vicinity of Building 16 during accidental releases are expected to be investigated in 1988 (DeLaney, 1987a). No analysis of the probability of any release scenario is provided in the study. However, administrative and procedural engineering controls combined with emergency response procedures make scenarios involving total release of one or more gas cylinders unlikely.

Building 16 - Research Laboratories - Building 16 contains a total of 38 laboratories, excluding the 8 MOCVD laboratories previously discussed. These laboratories are devoted to research in photoelectrochemistry, coatings technology, photosynthesis, organometallic chemistry, and other technologies. The laboratories emit small quantities of toxic metals, acids, and solvents through the laboratory ventilation system. Emissions are neither controlled nor monitored. Laboratory operations are generally quite varied and sporadic in nature and no continuous operations are conducted. The laboratory hood exhausts vent to the east side of Building 16, except for Room 113 (glass laboratory, high-pressure laboratory), which exhausts to the north side of the building as shown in Figure 3-2.

Room 102 contains an electric diffusion furnace, which is used to prepare semiconductor materials. Semiconductor materials are placed in glass "boats" and doped with various gases. Cold hydrogen fluoride is used in an etching tank (approximately 2 ft^2 in area) to etch silicon, and some sulfuric acid and hydrogen peroxide are also used. Small quantities of TCE and acetone are used in a non-megafixed hood. Releases of small quantities of acid and solvent fumes are indicated by some corrosion of the fiberglass ductwork and occasional noticeable solvent odors in an adjacent laboratory. No operations were being conducted in this laboratory at the time of the Survey.

Small-scale plating and etching operations are conducted in a clean room in the Photodeposition/Thin Film Deposition Laboratory in Room 107/109. Solvents, acids, photoresist solutions, and small quantities of cyanide-containing plating solutions are used in the clean room. Vacuum evaporation/deposition machines located in this laboratory are used to deposit metal films on various substrates. The machines are ventilated by flexible hoses and the vacuum systems exhaust into the laboratory. Metal emissions from the vacuum systems are negligible based on sampling conducted by SERI during an industrial hygiene study. Air emissions of cyanide compounds and other plating solution components are minimal, based on their low volatility and on the amount of materials used.

Various organometallic compounds (e.g., tetramethyl tin, methyl aluminum) are used in the Room 286 Organometallic Chemistry Laboratory. These are generally handled in gram quantities and may require handling in a glove box, as some organometallic compounds are pyrophoric. High-purity acrylonitrile is prepared in 2,000-milliliter batches in a distillation apparatus in a ventilation hood. Acrylonitrile is expected to be emitted through the hood exhaust in part-per-million concentrations. Small quantities of hexane, dimethoxyethane, and other solvents are also used in this laboratory.

The High-Pressure Laboratory in Room 113 is used for testing high-pressure equipment, and for etching of silicon wafers. Glass boats for the diffusion furnace in Room 102 are fabricated in this laboratory. Silicon etching, polishing, and cutting equipment is used, and small quantities of nitric and hydrofluoric acids are emitted to the etching bench hood during etching operations. Gallon quantities of TCE, acetone, and other solvents are also used. This laboratory has a megafixed exhaust located on the north side of Building 16. No activities were being conducted in this laboratory during the Survey.

Vacuum thin film deposition machines and sputtering machines are used in the Room 384 MOCVD laboratory to apply microgram quantities of various metals to metal substrates and optical materials. Oil diffusion and cryogenic vacuum pumps are used, and surface analyses of the coated substrates are conducted. Parts-per-billion concentrations of arsenic were measured in the fiberglass ventilation ductwork when it was replaced with megafixed ductwork. Vacuum deposition machines are also located in the Room 454 MOCVD Laboratory. The oil vacuum pump exhausts into the laboratory, and no metal emissions were detected in the pump exhaust when sampled by SERI during an industrial hygiene study. The vacuum pump oil absorbs arsenic from the machine exhaust, and must be periodically disposed of as hazardous waste. Disposal of waste oil is discussed in Section 4.1.

Air- and water-sensitive organometallic catalysts are prepared and tested in the Synthesis and Catalysis laboratories in rooms 269 and 280. Bench-scale vacuum apparatus and glove boxes are used to handle the sensitive compounds, and oxygen scavenger and water scavenger columns are used to purify the gases in the apparatus. A mercury piston pump is used to quantitatively collect gases from the system for analysis. Small amounts of mercury are expected to be emitted from the vacuum exhausts to the laboratory ventilation system.

Building 16 Steam Boilers - Two natural gas-fired boilers located in Building 16 provide hot water for laboratory operations. The boilers are exempt from state permit requirements because of their small size. The boilers emit small quantities of nitrogen oxides, hydrocarbons, sulfur dioxide, and carbon monoxide.

Building 15

Building 15 Photographic Laboratory - The SERI Photographic Laboratory is located in two rooms of Building 15, and is used to process commercial photographic film. The laboratory uses quart to gallon per month quantities of sulfuric acid, dichromate and copper chloride solutions, hydroquinone, and a variety of commercial photographic chemicals. There are no chemical hoods in the Photographic Laboratory; ventilation of the laboratory is provided by ceiling fans, which exhaust out the building through a ceiling vent. Air emissions of acid and organic compounds from this laboratory are minimal based on the amounts of materials used. Some evaporation of chemicals to the ceiling vents is expected to occur during laboratory operation.

3.1.2.2 Permanent Site

Air emissions sources at the SERI Permanent Site are primarily at the FTLB, with the exception of the gas-fired boilers located at the Bioannex and OTEC facilities. No significant air emissions result from the Bioannex acid digester (Block, 1986) and DCHX (Fangrande, 1986) facilities, as both these units are closed systems which do not have continuous air emission exhausts.

FTLB

Air emission sources in the FTLB include biological and organic chemistry research laboratories, two gas/oil-fired hot water boilers, and the Biofuels Facility located in the high bay area of the building. The emissions from and the ventilation system for each of these facilities are discussed below.

FTLB Research Laboratories - The FTLB laboratories are devoted to research in fuels technology, cell biology, heat transfer, organic chemistry, and other technologies. Laboratory operations are sporadic and no continuous operations are conducted. The laboratories emit small quantities of toxic metals, acids, and solvents, including hydrochloric and hydrofluoric acids, methylene chloride, benzene, TCE, and carbon disulfide through the central and west FTLB laboratory stacks. The two FTLB laboratory exhausts were sampled for 14 organic chemicals, carbon disulfide, and ammonia during one 2-day and one 3-day period in 1986 (ASI, 1987). Eight of the 16 compounds sampled were detected in the exhausts, and data are summarized in Section 3.1.3. The data indicate that emission concentrations are generally low and variable. It is not expected that exhaust emission monitoring can adequately characterize laboratory emissions if it is not performed on a continuous basis (DeLaney, 1987a). However, the sampling data and chemical inventory data provided to the Survey team by SERI indicate that emissions from the FTLB laboratories are small. SERI submitted an air pollutant emissions notice (APEN) for the FTLB laboratory stack emissions (Duncan, 1983). The state declined to issue a permit for the emissions, based on the status of the FTLB as a research facility.

FTLB Hot Water Boilers - The FTLB has two dual-fuel boilers, which provide hot water for all FTLB operations, with the exception of the Biofuels Facility. Both boilers fire gas as a primary fuel, with oil used as a backup, and have state operating permits. The dual-fuel boilers are located in the FTLB main boiler room. A third dual-fuel boiler was being installed in the boiler room at the time of the Survey and had not yet been permitted. The total heat input of the two existing FTLB dual-fuel boilers is approximately 3 million British thermal units per hour (Btu/hr). The heat input of the new boiler is also approximately 3 million Btu/hr. The boilers are subject to criteria pollutant and capacity limitations based on fuel consumption, and emit small quantities of sulfur dioxide, nitrogen oxides, hydrocarbons, and carbon monoxide through the boiler exhaust stack.

FTLB Biofuels Facility - The Biofuels Facility is located in the high bay area of the FTLB. The reactor system converts biomass (wood) to a liquid/solid fuel product using steam, electric heat, and a solid catalyst. Wood particles enter an electrically heated cyclonic reactor with steam, which pyrolyzes the wood to a mixture of vapors, oil, and solid char. The char is collected by a cyclonic separator, which is estimated to be 95 percent efficient. The oil/vapor mixture and remaining solid char then enter a catalytic reactor, which cracks the mixture into olefinic products (e.g., ethylene). The pyrolysis products are then quenched in a cyclonic water scrubber, which absorbs some of the soluble organic constituents. The cooled gas stream then passes to a packed scrubber, which absorbs most of the remaining soluble organic constituents. Process gases exit through a natural gas-fired flare which incinerates the remaining organic constituents, and then to a dedicated stack.

The liquid organic constituents collected from the pyrolysis reactor system include tars, aromatic compounds (e.g., benzene, toluene), resin compounds, phenols, and olefins. The process gases exiting the pyrolysis reactor have been analyzed and are of the following approximate composition (Duncan, 1983):

Carbon monoxide	45 percent by volume
Hydrogen	23 percent
Methane	12 percent
Carbon dioxide	10 percent
Ethylene	5 percent
Butanes, butenes, aromatics	5 percent

These gases and scrubber liquids containing olefinic and aromatic compounds and soluble tars are incinerated by a natural gas-fired flare in the exhaust duct. The flare is maintained at 1,800°F and has a gas residence time of approximately 3 seconds. Small amounts of acetone are also incinerated by the flare when the reactors are cleaned. Sampling of the flared exhaust gases shows that the gases are primarily carbon dioxide, nitrogen, and water vapor, with small quantities of nitrogen oxide formed during combustion. The combined efficiency of the dual scrubber and flare has not been measured, but is expected to be greater than 99 percent for organic constituents based on the control system operating conditions and inlet gas composition.

The pyrolysis process has a dedicated gas fired steam boiler (400,000 Btu/hr heat input), which emits small quantities of carbon monoxide, sulfur dioxide, nitrogen oxides, and hydrocarbons through a dedicated exhaust stack. The boiler is exempt from State of Colorado permit requirements based on its small size (Colorado Air Regulation No. 3, II.C, Air Emission Notice Requirements, Exemptions). SERI filed an APEN with the state for pyrolysis process flare emissions (Duncan, 1983). The APEN included an abbreviated process description and emission calculations. The state declined to issue a permit for this process, based on the status of the pyrolysis reactor as a research facility.

Other Permanent Site Facilities

Bioannex and OTEC Boilers - Both the Bioannex and OTEC facilities have dedicated gas-fired boilers that provide steam for process operations. These boilers have state operating permits and are subject to fuel consumption and criteria pollutant emission limitations. The boilers emit small quantities of nitrogen oxides, hydrocarbons, sulfur dioxide, and carbon monoxide through separate, dedicated exhaust stacks.

3.1.2.3 Wind Energy Research Center

There are no known sources of air emissions from WERC operations.

3.1.3 Environmental Monitoring Program

With the exception of the toxic gas analyzers in the Building 16 metal vapor deposition laboratories, no continuous monitoring of toxic or criteria air pollutant exhaust gas concentrations is conducted at SERI. SERI also does not presently conduct routine monitoring of ambient air concentrations of toxic or criteria air pollutants.

However, SERI conducted continuous and periodic ambient air quality monitoring at the Permanent Site in 1986 and in the four previous years, but has discontinued the monitoring program as of 1987. SERI also conducted periodic stack sampling of the FTLB laboratory exhausts in 1986. The stack sampling program was also discontinued as of 1987 (ASI, 1987). The programs were discontinued because it is not expected that stack or air quality monitoring can adequately characterize laboratory emissions if not performed on a continuous basis (DeLaney, 1987a), and because the emissions identified were very small, as discussed below.

The FTLB central and west laboratory exhausts were sampled for 14 organic chemicals, carbon disulfide, and ammonia during one 2-day and one 3-day period in 1986 (ASI, 1987). Sampling was performed on July 28, July 30, December 8, December 9, and December 10, 1986. Eight of the 16 compounds sampled were detected in the exhausts during one or both of the sampling periods, and only carbon tetrachloride, chloroform, and toluene were detected during both periods. The data, as summarized in Table 3-5, indicate that emission rates are generally low and variable. There are no Federal or state emission standards for the pollutants. Samples were taken from the exhaust fan inlet plenum rather than the stacks, using long-duration indicator tubes. The sampling location used is a turbulent-flow area and this may have biased the sampling results to some extent. However, the overall variability of the emissions measurements is likely to be more a function of the variability of the FTLB laboratory operations, particularly considering that five of the eight measured compounds were detected during only one of the two sample periods, and only four sampled emission rates were above 1 gram/min.

Ambient monitoring was conducted at two sites near the FTLB in 1986 for the same 16 constituents for which the stack sampling was performed. The monitoring locations, shown in Figure 3-3, are situated in the two prevailing wind directions downwind of the FTLB (east and west). The location of the samplers was such that they would be adequate for detecting emissions from FTLB operations, but not likely to detect emissions from Building 16 operations, as the distance between the FTLB and Building 16 is over 1 mile, and the expected ambient air concentrations resulting from Building 16 emissions are very low. Sampling was conducted during one 2-day (July 24 and July 25, 1986) and one 3-day period (November 17, November 18, and November 19, 1986). Five charcoal adsorption tubes and one silica gel adsorption tube were used to collect samples. The six sample tubes were analyzed for the constituents listed in Table 3-6.

Samples taken on the first day of the second sampling period at the west site were invalidated by a power outage. Only three of the 16 constituents sampled for were

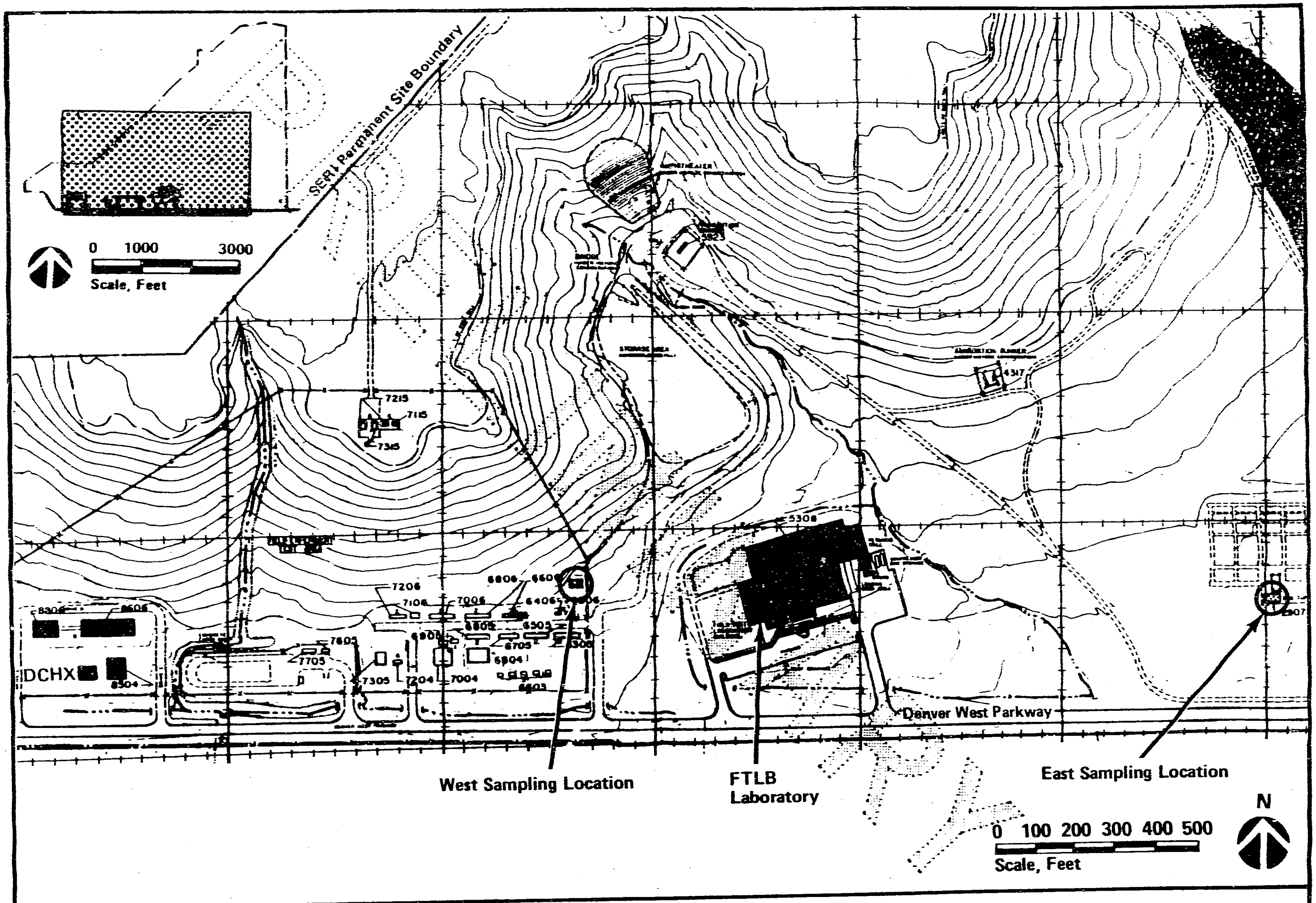
TABLE 3-5

SUMMARY OF EMISSION RATES FROM THE FTLB CENTRAL AND WEST LABORATORY STACKS, 1986

Compound	Date Detected	Stack	Emission Rate (grams/min)
Acetone	December 8, 1986	central	0.12
	December 9, 1986	central	0.14
Benzene[a]	July 28, 1986	central	0.14
Carbon tetrachloride[b]	July 28, 1986	central	6.04
	July 30, 1986	west	2.09
	December 8, 1986	central	0.34
	December 9, 1986	central	0.51
	December 10, 1986	central	0.40
	December 10, 1986	west	0.27
Chloroform[b]	July 30, 1986	central	1.06
	December 8, 1986	central	0.24
	December 9, 1986	central	0.03
	December 10, 1986	central	0.04
Methylene chloride[b]	December 8, 1986	central	0.03
	December 10, 1986	central	0.02
Toluene	July 28, 1986	central	0.10
	July 30, 1986	central	0.12
	July 30, 1986	west	0.04
	December 8, 1986	central	0.01
	December 9, 1986	central	0.005
	December 10, 1986	central	0.01
	December 10, 1986	central	0.01
Trichloroethylene[b]	July 28, 1986	central	0.36
	July 30, 1986	central	0.23
	July 30, 1986	west	0.36
Carbon disulfide	July 28, 1986	west	16.90
	July 30, 1986	central	0.16
Ethanol			ND[c]
Methanol			ND[c]
Ethyl ether			ND[c]
Acetonitrile			ND[c]
Propanol			ND[c]
Tetrahydrofuran			ND[c]
Dioxane			ND[c]
Ammonia			ND[c]

Source: ASI, 1987

a Federal National Emission Standards for Hazardous Air Pollutants (NESHAP) Pollutant
b Being considered for regulation under NESHAP
c ND = Not Detected



Source: ASI, 1987

FIGURE 3-3

AMBIENT AIR SAMPLING LOCATIONS
AT THE SERI PERMANENT SITE
1986 PROGRAM

TABLE 3-6

CONSTITUENTS SAMPLED IN AMBIENT AIR
AT THE SERI PERMANENT SITE, 1986 PROGRAM

Absorption Tube Number	Sorbant Type	Compound
1	charcoal	trichloroethylene
1	charcoal	carbon tetrachloride
1	charcoal	chloroform
1	charcoal	methylene chloride
1	charcoal	dioxane
1	charcoal	benzene
1	charcoal	toluene
1	charcoal	acetone
2	charcoal	tetrahydrofuran
3	charcoal	propanol
4	charcoal	ethanol
5	charcoal	acetonitrile
5	charcoal	carbon disulfide
6	silica gel	methanol

Source: ASI, 1987

detected during the two sampling periods and the concentrations detected were very low, as discussed below. Data are summarized in Table 3-7.

The levels of carbon tetrachloride, methanol, and toluene detected at both the east and west sampling locations during the first and second sampling periods were well below occupational exposure limits (30,000 µg/m³, 260,000 µg/m³, and 375,000 µg/m³, 8-hour TLV-TWA, respectively). Ambient air quality standards have not been established for these compounds. Only carbon tetrachloride and toluene were detected during the first sampling period, and only toluene and methanol were detected during the second sampling period. As with the FTLB stack emissions sampling, ambient sampling is not expected to adequately characterize the FTLB laboratory emissions unless it is done on a continuous basis. The sampling data and chemical inventory usage at the FTLB do suggest, however, that concentrations of organic constituents in the vicinity of the FTLB are likely to be very low.

Continuous ambient air quality monitoring for TSP and PM-10 (fraction of total particles less than 10 microns meters in diameter) was conducted from April 1984 through March 1985 at the Permanent Site, and data were compared with baseline data obtained from October 1982 through March 1984 (ASI, 1985), before startup of the FTLB. Baseline and post-operational particulate sampling locations are shown in Figure 3-4. The location of the particulate sampling station was changed in May 1984 in an effort to obtain the highest probable monitoring concentrations from the FTLB (ASI, 1987).

Table 3-8 summarizes the baseline and operational TSP and PM-10 annual and 24-hour concentrations at the Permanent Site. The annual geometric mean TSP concentration in 1984-1985 was 62 percent of the Federal and state secondary TSP standard of 60 µg/m³ and 66 percent of the 24-hour secondary standard of 150 µg/m³. The quarterly average TSP concentrations were approximately 10 percent greater than the corresponding baseline values, with the exception of the first quarter of 1985, for which the concentration was 37 percent of the corresponding baseline value. This increase is partially attributed to differences in weather conditions and construction activity between 1984 and 1985 (ASI, 1987).

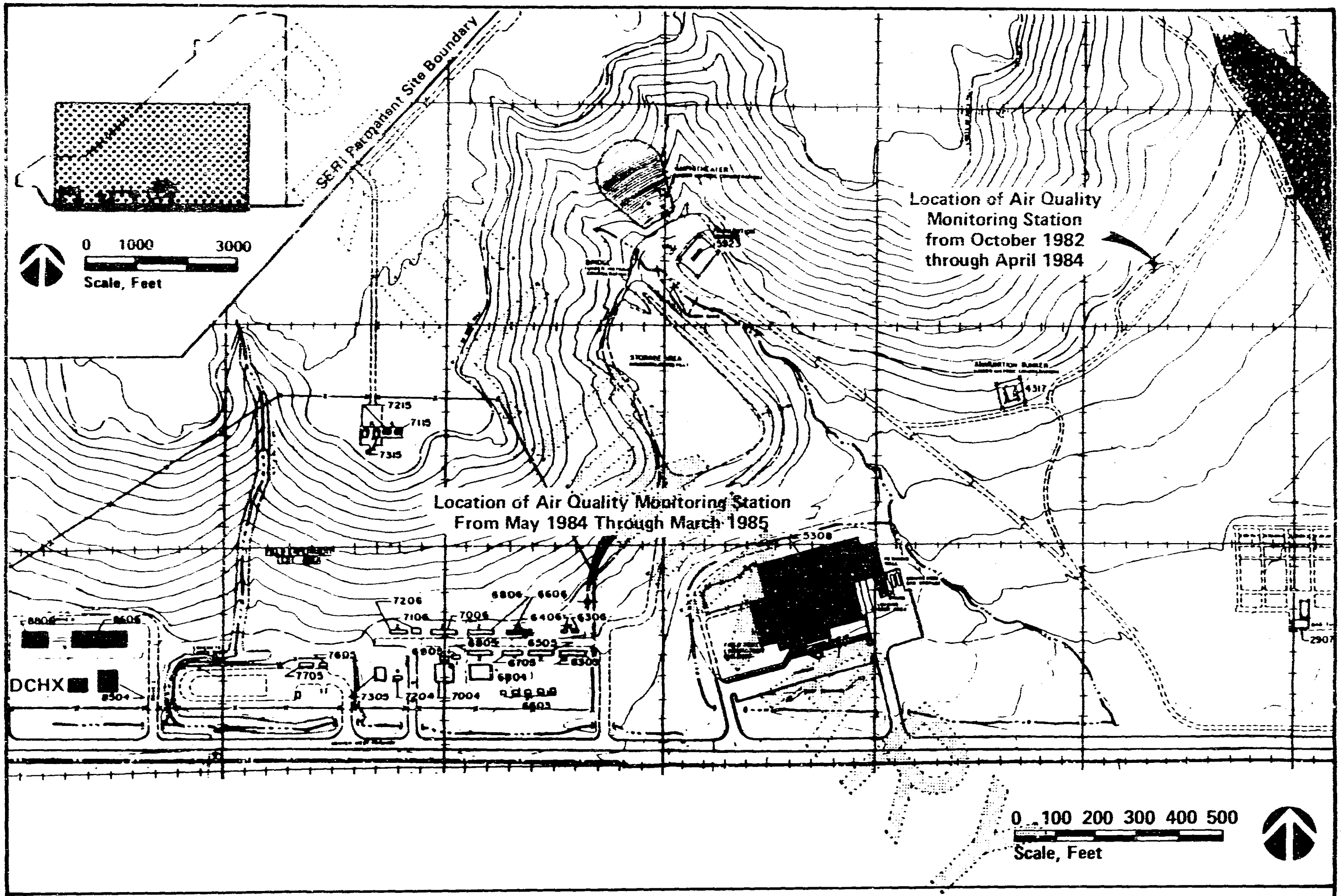
The Federal PM-10 standards were promulgated in July 1, 1987, FR Vol. 52, p. 120 and superseded the TSP standards. The Federal primary and secondary annual PM-

TABLE 3-7

SUMMARY OF DETECTED AMBIENT CONCENTRATIONS AT THE PERMANENT SITE, 1986 PROGRAM

Sampling Date	Site	Detected Concentration ($\mu g/m^3$)
Carbon tetrachloride		
July 24, 1986	east	2,041
July 25, 1986	west	1,158
Methanol		
November 17, 1986	east	335
Toluene		
July 24, 1986	east	26
July 25, 1986	west	46
November 18, 1986	east	10
November 18, 1986	west	9

Source: ASI, 1987



Source: ASI, 1985

LOCATIONS OF SERI PARTICULATE AIR MONITORING STATIONS
OCTOBER, 1982 – MARCH, 1984 AND APRIL, 1984 – MARCH, 1985 PROGRAM

FIGURE 3-4

TABLE 3-8

BASELINE AND 1984-1985 OPERATIONAL ANNUAL AMBIENT PARTICULATE DATA SUMMARY - SERI PERMANENT SITE (concentrations are µg/m³)

	TSP		PM10		PM10/TSP	
	1984-85	Baseline	1984-85	Baseline	1984-85	Baseline
Annual Arithmetic Average	40.6	36.4	23.7	24.9	0.62	0.65
Annual Geometric Mean	37.2	N/A[a]	22.1	N/A[a]	0.60	N/A[a]
Highest Concentration--24-hour	108	143	61	75	0.98	0.77
Second Highest Concentration--24-hour	91	113	53	48	0.97	0.74
Number of Valid Observations	86		85		79	
Total Number of Observations	93		93		81	

[a]N/A - Not Available

10 standard (arithmetic average) is 50 $\mu g/m^3$, and the primary and secondary 24-hour standard is 150 $\mu g/m^3$. The annual average PM-10 concentration at the Permanent Site was 53 percent less than the standard. EPA expects the PM-10/TSP ratio in most areas of the United States to range between 0.50 and 0.60. The mean PM-10/TSP ratio at the Permanent Site was slightly higher than this range at 0.62.

PM-10 samples collected at both locations were analyzed for fluorides and toxic metals, including arsenic, beryllium, cadmium, chromium, lead, selenium, and vanadium. Separate samples were taken for asbestos and mercury. Arsenic, beryllium, cadmium, chromium, vanadium, and selenium levels were below detection limits in both baseline and 1984-1985 samples, and lead and fluoride concentrations in the 1984-1985 samples were below or slightly above baseline concentrations (ASI, 1985). Mercury vapor concentrations measured in 1984-1985 were significantly above baseline concentrations, which were below the detection limit of the exposure badges used for sampling. However, the FTLB emits negligible quantities of mercury, and the concentrations measured are less than 1 percent of the occupational exposure limit of 100 $\mu g/m^3$ for mercury.

No particulate sampling locations were located near Building 16 during the 1982-1984 and 1984-1985 study periods and those near the FTLB were too remote from Building 16 to be expected to detect emissions from Building 16 operations.

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. Possible inaccuracy of exhaust concentration measurements. The MDA toxic gas analyzers in Building 16 are not subject to routine standard gas calibration and lack documentation of maintenance procedures, which could lead to improperly quantified atmospheric releases and pose a laboratory safety problem.

   The MDA analyzers used to measure exhaust concentrations of arsine, phosphine, diborane, and hydrogen selenide from the MOCVD apparatus, gas storage cabinets, other storage cabinets, and laboratories are presently subjected only to optical/electrical calibrations on a routine, scheduled basis. Although these procedures ensure that the analyzers themselves are functional, these procedures do not demonstrate that the measured gas concentrations correspond to the concentrations actually present at the sample points. This may result in inaccurate exhaust concentration measurements. Records provided by SERI indicate that calibration of the MDA analyzers using gas standards was last performed in December 1985, and is not a scheduled maintenance item.

   SERI also could not provide documentation of the results of routine maintenance and calibration of the analyzers performed by the maintenance department, as data output tapes upon which these results are recorded are not retained for more than 30 days. On at least one occasion in 1987, incorrect alarm points were entered into one of the analyzers. This resulted in inaccurate notification of the laboratory operator of a potential release situation. Lack of documentation of maintenance and calibration data and lack of routine standard gas calibrations may present potential safety hazards, as the laboratory operator may not be accurately informed of laboratory toxic gas levels, and a potential environmental hazard, since an accidental release may not be accurately detected.

2. Ineffective air quality characterization. The historical SERI ambient air quality monitoring program was inadequate in identifying the impact of SERI operations on local air quality.

SERI conducted continuous monitoring of ambient concentrations of total and PM-10 particulate at the Permanent Site during the period 1982 to 1985, and conducted periodic monitoring of ambient concentrations of organic compounds at the Permanent Site in 1986. The design and implementation of the program were such that the resulting data are viewed by the Survey as inadequate in characterizing the impacts of SERI operations on air quality. The location of both the particulate and organic compound samplers was such that they would not detect emissions from Building 16, where a significant portion of the SERI laboratory operations are conducted. Also, periodic sampling of ambient concentrations of organic compounds in the vicinity of the FTLB was not coordinated with the use of the compounds in the FTLB laboratories. Therefore the relationship between FTLB operations, emissions, and ambient concentrations was not determined. Although there is no indication that significant degradation of air quality has occurred or is occurring as a result of past or present SERI operations, the monitoring data are inadequate to definitively evaluate SERI air emissions. The SERI ambient air quality monitoring program was discontinued at the end of 1986.

3.2 Soil

This section describes the soils at the three SERI areas (the Permanent Site, WERC, and the Denver West Office Park) and pollution sources and controls. Findings and observations related to soils are reviewed and discussed in Section 4.1.2 (Waste Management), 4.2.2 (Toxic and Chemical Materials), and 4.5.3 (Inactive Waste Sites and Releases).

3.2.1 Background Environmental Information

The Permanent Site includes the gently to moderately sloping mesa top of South Table Mountain, the moderately steep side slopes, and moderate to gently sloping toe at the base of the mesa. The principal soil orders are classified as Mollisols and Aridisols (Price and Amen, 1975). These soils are fine- to medium-textured loamy mixed dark-colored soils, with intercalated clay layers. The loamy texture is the chief distinguishing characteristic of the soils on the mesa top. Slopes on the mesa top range from 1 to 6 percent. Stones and boulders occupy about 10 percent of the surface, with patches of higher concentration scattered throughout the area. Bedrock occurs at depths between 20 and 40 inches.

On the steep side slopes of the mesa, bedrock underlies a dark skeletal structured soil near the top that has no diagnostic horizon. This dark-colored loamy soil forms a matrix between stones and boulders that range in diameter from 10 to 36 inches. Slopes on the upper section of the mesa side range from 35 to 65 percent; lower slopes range from 20 to 40 percent. Stones and boulders comprise approximately 45 percent of the material and bedrock occurs at a depth of 20 inches or less; rock outcrops are also present.

Soils on the lower side slope consist of fine-textured and markedly montmorillonitic loose soil with a light-colored surface layer. Weathered shale occurs at depths of 20 to 40 inches. On the gently sloping (10-30 percent) toe below the mesa, soils are fine-textured montmorillonitic clay loams. These soils have dark-colored surface layers and well-developed heavy clay loam subsoils to a depth of 60 inches.

Most of the soils at the developed portion of the Permanent Site are derived from the detrital colluvium as a result of weathering of the Denver Formation and to a lesser extent, the overlying latite. The major distinguishing characteristic of these soils is a high shrink-swell tendency. The clay fraction of the soil imparts a significant contaminant attenuation capacity to the unsaturated zone at SERI. If small-scale spills of hydrocarbons and inorganic chemicals occur, they may be expected to be entrained in the upper soil horizons and not reach the deep aquifers. However, the absence of a humic layer and the presence of sandy soils mean that light organic and some anion contaminants would not be retained.

The soils at WERC are more heterogeneous than the soils at the Permanent Site. The soils are highly variable because they are derived from an alluvial fan from Coal Creek Canyon located at the foot of the Colorado Front Range. The alluvium, which forms the surficial deposits over much of the site, consists of layers of clayey, sandy silt with interbedded gravel and cobbles.

The soils at the Denver West Office Complex basically consist of fill material and disturbed soils.

3.2.2 General Description of Pollution Sources and Controls

The main pathway for potential soil contamination at SERI is an accidental surface spill during delivery, transfer, or disposal of chemicals and fuels. In addition, potential soil contamination could result from leaks developing in various catchment tanks and neutralization sumps designed to neutralize hazardous waste, and from fuel storage tanks at several buildings, including FTLB, Biotech Annex, and Building 16 (Section 4.2).

3.2.3 Environmental Monitoring Program

Soil samples have not been analyzed for hazardous constituents. There is no ongoing environmental monitoring program that includes soil as a study medium, nor is a future program planned.

3.2.4 Findings and Observations

The findings involving soil contamination are the result of current and past releases, spills, or disposal practices, and are therefore discussed within the context of other findings in Sections 4.1.2 (Waste Management), 4.2.2 (Toxic and Chemical Materials), and 4.5.2 (Inactive Waste Sites and Releases).

3.2.4.1 Category I

None

3.2.4.2 Category II

None

3.2.4.3 Category III

None

3.2.4.4 Category IV

None

3.3 Surface Water

This section deals with surface-water features in the areas surrounding SERI facilities, surface-water pollution sources and controls at SERI, surface-water and liquid waste monitoring programs at the Institute, and findings and observations related to surface water. Drinking water sources and uses are also discussed.

3.3.1 Background Environmental Information

3.3.1.1 Surface-Water Drainage

The SERI facilities are located at three separate locations--a three-building complex (Buildings 15, 16, and 17) at the Denver West Office Park, the Permanent Site, and WERC (Figure 2-1). As described in the following paragraphs, each of the areas has different drainage patterns.

There are no natural surface-water features at the Building 15, 16, and 17 complex in the Denver West Office Park. However, a man-made ornamental pond is situated in the courtyard in the middle of the three buildings (Figure 2-2). Rainfall and snowmelt within the courtyard drain into the pond, and overflow from the pond is discharged to the Office Park's stormwater management system (Section 3.3.2.2). Lena Gulch runs through another portion of the Denver West Office Park, approximately 1/4-mile southwest of Buildings 15, 16, and 17 (Figure 3-5). The flow of Lena Gulch eventually empties into the South Platte River, 20 miles northeast of the site (Figure 2-1).

Most of the Permanent Site is situated on the southern slope of South Table Mountain. Therefore, about 90 percent of the surface drainage from the site flows in a southerly direction toward Lena Gulch (Figure 3-5). Most of this flow is first either intercepted by the Welch Ditch or routed through a suburban neighborhood into a stormwater management canal. Both the Welch Irrigation Ditch and the stormwater canal then flow into Lena Gulch. The remaining 10 percent flows in a northerly direction to the Welch Ditch, which also flows from the north side of South Table Mountain to Lena Gulch.

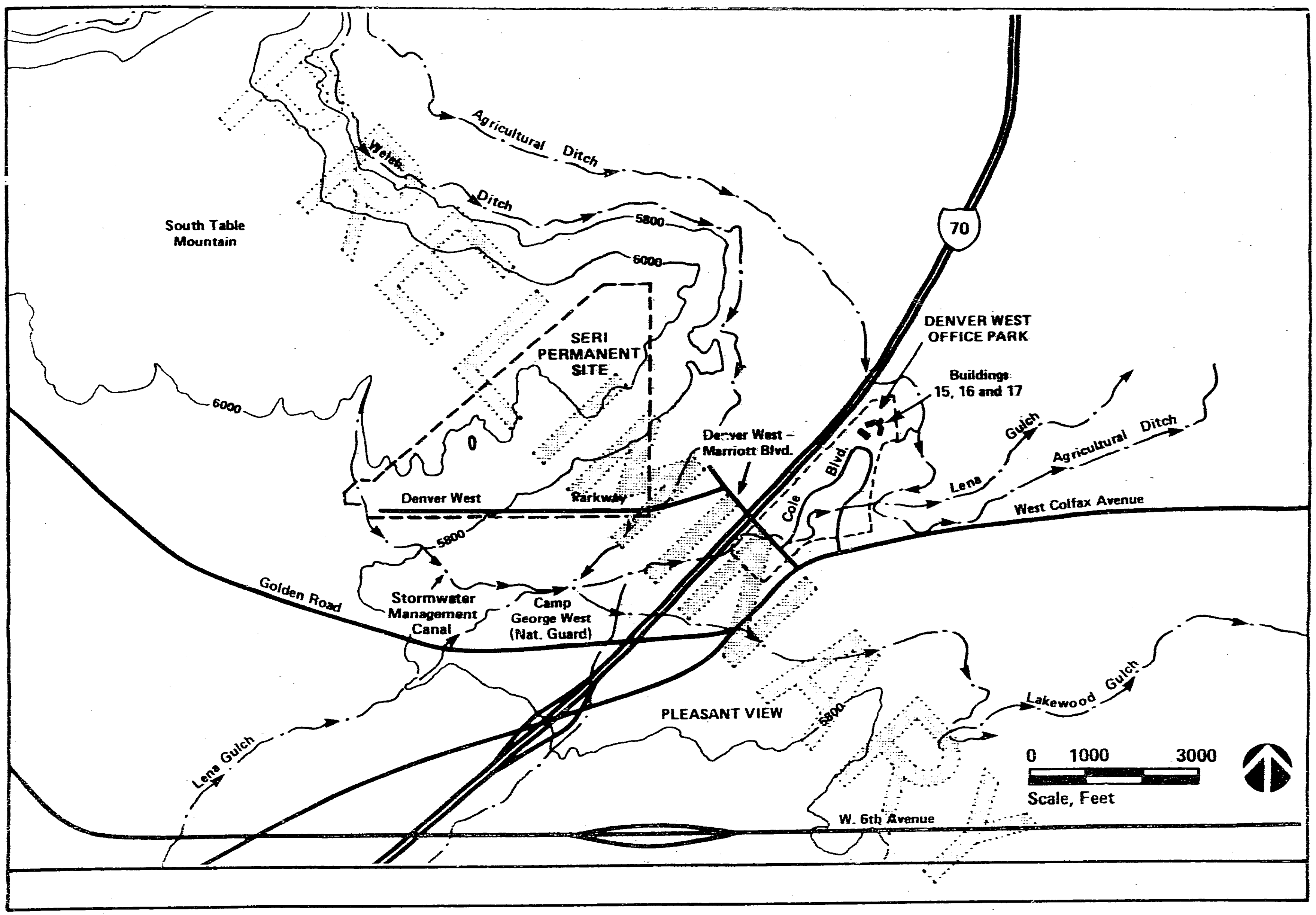


FIGURE 3-5

SURFACE WATER FEATURES IN THE VICINITY OF THE
SERI PERMANENT SITE AND THE DENVER WEST OFFICE PARK

The drainage pattern for the surface flow at the Permanent Site consists of 14 headwater sub-basins, which are described in Table 3-9 and illustrated in Figure 3-6. Because of the low annual rainfall of less than 15 inches and the small recharge area, all the streams flowing from the Permanent Site are intermittent. Although the intermittent stream channels and drainage ditches have sufficient capacity to carry most flows, there is some flooding of residential yards south of the FTLB during periods of high runoff as described in Section 3.3.2.2.

WERC occupies a generally flat, featureless plain. Drainage is generally to the east via two channels, one in the middle of the site and the other along the southern boundary (Figure 2-4). These drainages form a series of gullies to the east of WERC that are the headwater tributaries of Rock Creek. The northern portion of the site is drained by two channels that also form gullies and flow into Coal Creek, approximately 1 mile to the north. Rock Creek and Coal Creek join approximately 10 miles northeast of WERC and eventually flow into the South Platte River.

3.3.1.2 Wetlands and Flood-Prone Areas

There are no wetlands or flood-prone areas at the Denver West Office Park.

Although all drainageways at the Permanent Site and WERC may contain wet soils during portions of the year, only drainageway F (Figure 3-6) at the Permanent Site, which is partially filled with concrete rubble, is recorded to support wetlands vegetation. This area encompasses less than 1 acre, and species include spikerush, baltic rush, several sedges, bluegrass, hemlock, and field mint. In addition, a number of ephemeral pools or depressions occur on top of South Table Mountain. These localized areas are dominated by western wheatgrass and bluegrass.

The estimated 100-year floodplains for the Permanent Site are illustrated in Figure 3-7. The drainage basins with the greatest potential for flooding and off-site impacts from the Permanent Site are the combined F_1 and F_2 basins, the combined G_1 and G_2 basins, the combined H_1 and H_2 basins, and the combined I_1 and I_2 basins (Figure 3-6). Runoff from the F_1/F_2 basin flows into a storm drain inlet and then into Welch Ditch. Although this basin carries the heaviest runoff, it is easily handled because of the proximity of Welch Ditch and a retention basin. The G_1/G_2 basin carries the second-highest volume of runoff and has the least impact on adjacent

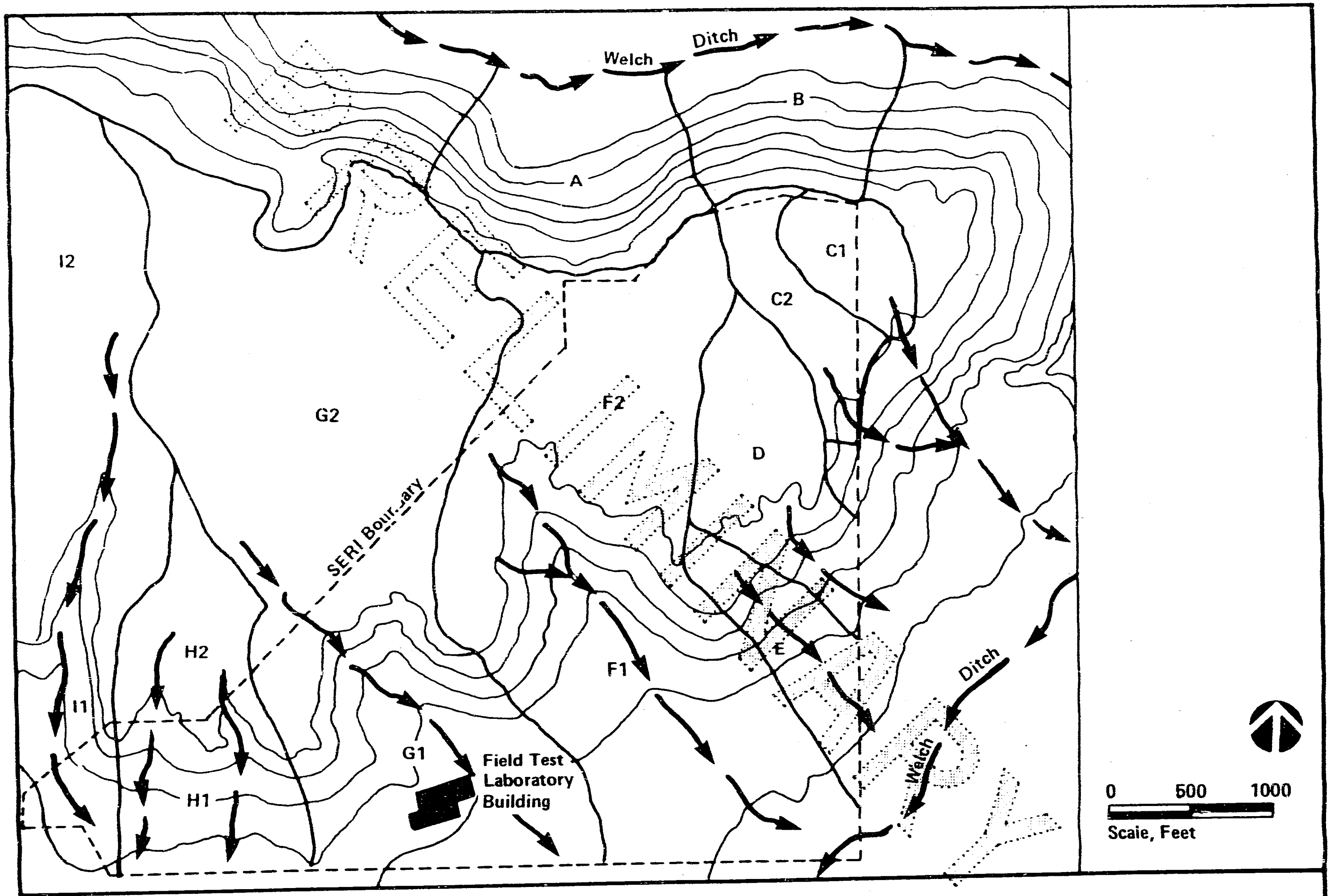
TABLE 3-9

SERI PERMANENT SITE DRAINAGE BASIN CHARACTERISTICS

Sub-basin [a]	Drainage Area (acres)	Average Slope (%)	Flow Length (ft)
A	39	25	1,200
B	31	31	1,100
C_1	12	05	900
C_2	16	03	1,200
D	29	11	2,100
E	24	19	1,700
F_1	75	10	3,300
F_2	55	04	1,500
G_1	55	11	2,100
G_2	111	02	3,000
H_1	24	14	1,300
H_2	22	02	1,200
I_1	20	06	2,500
I_2	155	05	2,300

Source: SERI, 1987b

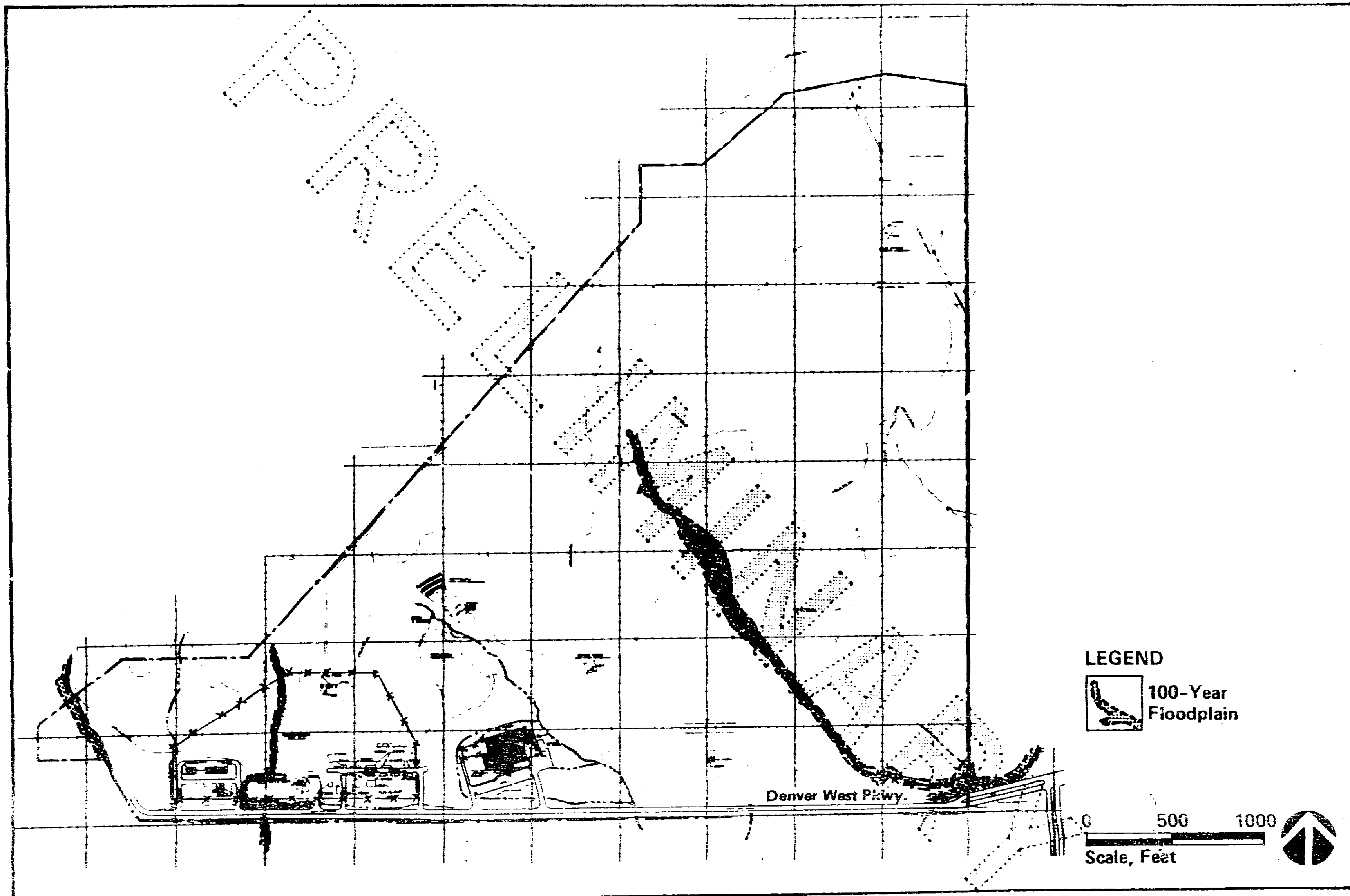
a See Figure 3-6



Source: Higginbotham & Associates, 1986

SERI PERMANENT SITE DRAINAGE BASINS

FIGURE 3-6



Source: Higginbotham and Associates, 1986

100-YEAR FLOODPLAINS AT THE SERI PERMANENT SITE

FIGURE 3-7

parcels. This is primarily due to the undeveloped nature of the Camp George West land onto which this basin discharges. The H_1/H_2 and I_1/I_2 basins discharge through the residential area south of the site, and flows from them may have caused property flooding (Section 3.3.2.2). On the Permanent Site property, the H_1/H_2 100-year floodplain is restricted to drainageways and stormwater management basins. Thus, developed areas on the Permanent Site are not likely to be flooded.

3.3.1.3 Water Supply and Uses

Water to both the Denver West Office Park and the Permanent Site is provided by the Consolidated Mutual Water District (Con Mutual), and comes from the Maple Grove Treatment Facility. The source of water to this facility is mainly reservoirs in the mountains to the west. Water is supplied to the Permanent Site through Con Mutual's pump station number 14, located about 50 feet east of SERI's east boundary, in the Denver West Parkway right-of-way. Water is pumped from the pump station to the Permanent Site facilities through a 12-inch main under Denver West Parkway.

During 1987, a 2-million-gallon water storage tank was constructed on top of South Table Mountain, immediately north of the Permanent Site. The tank is connected to and filled by pump station number 14 via the 12-inch main under the Denver West Parkway and a line in an easement along the western side of the Permanent Site. Thus, water to the Permanent Site can be supplied either from the pump station or the tank.

Water at the WERC site is provided by a 500-foot-deep well located at the domestic pump house in the north-central portion of the site (Figure 2-4). The water is pumped into a 5,000-gallon holding tank where it is chlorinated. Other treatment includes softening and iron removal. The water is then distributed to the Wind System Building via an underground 4-inch polyvinyl chloride (PVC) pipe. A 10,000-gallon holding tank, located adjacent to the Wind System Building and used as a fire protection reservoir, also receives water from the on-site well.

3.3.2 General Description of Pollution Sources and Controls

Three types of wastewater are generated as a result of SERI operations -- sanitary wastewater, industrial wastewater, and stormwater. The sources of these wastewaters and the treatment and disposal methods used are discussed in the following subsections.

3.3.2.1 Sources of Liquid Waste

Sanitary Wastewater

Sanitary wastewater is generated from the three buildings at the Denver West Office Park; the FTLB, Bioannex, and several trailers at the Permanent Site; and the Wind System Building and Carpenter's Shop at WERC. The major sources at all of these buildings are drains from lavatory sinks and toilets and drinking water fountains.

At the Denver West Office Park, each building has its own sanitary drain system that discharges to the Office Park sewer piping system and then to the municipal Pleasant View Sanitation District (PVSD) conveyance system.

At the Permanent Site, sanitary wastewater from the building sanitary systems in the FTLB and the trailers flow out through underground 6-inch PVC pipes. These flow into a PVC line that increases from 6 to 8 inches in diameter as it runs east under Denver West Parkway. Near the eastern site boundary, the line becomes 12 inches in diameter. It then turns south and connects with PVSD's 15-inch main line near Interstate 70. Sewage from the Bioannex and OTEC facilities flows out the west side of the site through an 8-inch underground PVC line. This line connects to a PVSD collector in the adjoining residential area.

At WERC, the piping system from the Wind System Building to three 2,000-gallon septic tanks consists of a 6-inch cast iron line. Unspecified piping conveys sewage from the Carpenter's Shop to a fourth 2,000-gallon septic tank.

Industrial Wastewater

At SERI, most industrial wastewater is the result of research activities, as described in Section 2.2. Specifically, the major sources are laboratory sink drains in Building 16 and the FTLB, process water from experiments at the Bioannex, and, to a minor extent, the photography laboratory discharge in Building 15. Liquid hazardous wastes, which are generated in small quantities in laboratory and research areas throughout SERI, are generally managed pursuant to the Resource Conservation and Recovery Act, as described in Section 4.1. However, small amounts may be discharged into laboratory sink drains and may include acids and bases, halogenated and non-halogenated organics, and aqueous heavy metals. At the Bioannex, the liquid process waste consists of water (80 percent), wood residues (10 percent), calcium carbonate (5 percent), and calcium sulfate (5 percent), and has a pH of between 11 and 12. The photography laboratory discharge includes unknown concentrations of silver.

At both Building 16 and the FTLB, wastewater that flows into the laboratory sink drains is conveyed through acid-resistant glass piping, which is independent of the sanitary system, to settling/neutralization tanks, as described in Section 3.3.2.2. At the Bioannex, process wastewater is treated and temporarily stored in a sump, as described in Section 3.3.2.2. After treatment or storage, the laboratory and process flows from all facilities are combined with the sanitary flow. The combined effluent from the Denver West Office Park and the Permanent Site totals approximately 20,000 gallons per day (gpd) (SERI, 1987b). Individual flow contributions from the sanitary and industrial systems have not been reported.

There are no industrial wastewater flows at WERC.

Stormwater

Stormwater is generated by rainfall and snowmelt runoff from paved areas (parking lots, roads) and rooftops at all three SERI facilities and from undeveloped areas such as the top and flanks of South Table Mountain at the Permanent Site and most of the WERC site. Stormwater most likely incorporates oils, grease, lead, and other metals from paved areas as it flows across the site. In addition, it may suspend soil particulates as it flows across the undeveloped areas.

3.3.2.2 Wastewater Treatment and Disposal

Sanitary Wastewater

Sanitary wastewater from the Denver West Office Park and the Permanent Site is conveyed through the local PVSD trunk line (Section 3.3.2.1) to the Metropolitan Denver Sewage Disposal District (MDSDD) treatment facility. This facility has a secondary treatment capacity of 185 million gallons per day (mgd) and is presently treating 155 mgd.

At WERC, sewage from the Wind System Building is disposed of through a series of three 2,000-gallon-capacity septic tanks located underground near the southeast corner of that building. A single 2,000-gallon tank is located underground near the Carpenter's Shop and serves that building exclusively. The sewage held in these tanks is periodically pumped out and disposed of at the neighboring DOE Rocky Flats Plant sewage treatment facility.

Industrial Wastewater

Discharges containing silver from the photography laboratory in Building 15 first pass through a neutralization tank before merging with the sanitary wastewater flow. The in-ground, polypropylene neutralization tank within Building 15 is filled with limestone and has an estimated capacity of 160 gallons. The photo-processor, which is used infrequently and has a small effluent volume, has no silver recovery unit.

The laboratory drain flow from Building 16, which may contain small quantities of organic and inorganic hazardous materials, is routed through two 1,200-gallon in-ground tanks located outside the northwest corner of Building 16 (Figure 2-2). The first in the series is an unlined concrete settling tank, while the second is a plastic-lined concrete neutralization tank containing limestone. Downstream of these tanks, the laboratory wastewater combines with the sanitary wastewater from the building and flows to the sanitary sewer and eventually, to the MDSDD treatment facility.

Similarly, the laboratory drain effluent in the FTLB, which also may contain small quantities of organic and inorganic hazardous materials, flows through two 350-gallon fiberglass-reinforced plastic tanks in a crawl space under the building. The first tank is for settling, while the second contains limestone for neutralization. Immediately downstream, the sanitary and laboratory wastewaters combine and flow to the sanitary sewer and, eventually, to the MDSDD treatment facility.

At the Bioannex, liquid waste, containing water, wood residue, calcium carbonate, and calcium sulfate, and having a pH of between 11 and 12, is produced in batches after experiments are run. The batch is first transferred to a 1,000-gallon holding/settling tank in the building where it is neutralized to a pH of between 6 and 7. It is then transferred to a 5,000-gallon in-ground concrete sump immediately north of the building. When the sump level reaches 4,000 gallons, the contents are released in batch to the sanitary sewer and, eventually, to the MDSDD treatment facility. The frequency of release varies depending on the extent of experimentation but, on the average, occurs every 2 months.

At present, SERI is not required by PVSD to have a wastewater discharge permit for Building 16 or the FTLB, since they have a solvent management program which presumably results in low concentrations of chemicals in the discharge. However, discharge limitations at the MDSDD treatment facility for mercury may be changed from the present 2.0 ounces per day to 0.4 ounce per day. As a result, users such as SERI may, in the future, be required to have permits that include discharge limits on mercury. SERI is required to have a permit for the batch discharge of the Bioannex sump. SERI has this permit with the condition that 24-hour advance notice be given before a discharge occurs and that a record of the contents of the sump be provided. SERI is conforming to these conditions.

Although wastewater effluent sampling at SERI is not required for permitting purposes, samples of wastewater from Building 16, the FTLB, and the Bioannex sump have been taken. This program is described in Section 3.3.3.

Stormwater

Stormwater is not treated for quality at any of the SERI facilities. However, there are stormwater management systems and structures at the Denver West Office Park and the Permanent Site to control runoff quantity. At Buildings 15, 16, and 17 in the Denver West Office Park, the ornamental pond in the courtyard receives runoff from within the courtyard. The pond has an unspecified holding capacity and overflow is routed through a pipe to the parking lot between Buildings 16 and 17 (Figure 2-2). Runoff from the parking lots outside Buildings 16 and 17 flows to a detention area to the east of Building 16. The detention area consists of the lower portion of the parking lot and an adjacent grassy area. Stormwater from this area is then routed through underground piping to Lena Gulch. Runoff from the parking lot outside Building 15 flows overland to gutters along Cole Boulevard. It is then collected in stormwater sewers and routed to Lena Gulch.

At the Permanent Site, stormwater drainage facilities include natural open-channel drainageways (Sections 3.3.1.1 and 3.3.1.2), an interceptor/detention channel along the north side of the western portion of Denver West Parkway, and modifications to open-channel drainageways to intercept, divert, and convey runoff around existing facilities. Stormwater structures on the Permanent Site include 13 roadway cross-culverts and 5 detention ponds. These detention ponds and their outlet control structures have been constructed to control runoff quantity. The structures were designed to retain the difference in runoff between the 100-year future (post-development) and 100-year existing (pre-development) storm event, in accordance with local regulations. But provisions of the regulations do not require design for more frequent storm events.

Neighboring residents south of the FTLB have expressed concerns to SERI personnel that runoff quantities from the developed portion of the Permanent Site, as a result of the more common, smaller storm, may be causing flooding of their properties. Partially in response to these concerns, SERI is in the process of modifying existing storm drainage facilities at the Permanent Site, including enlarging detention basins and altering outlet structures, to reduce the impacts of peak flows from such storm events on the surrounding residential community.

Stormwater at WERC is conveyed along the natural drainage pattern, which includes four natural drainageways (Figure 2-4). It is channeled to Coal Creek or Rock Creek and eventually the South Platte River, as described in Section 3.3.1.1.

3.3.3 Environmental Monitoring Program

SERI currently has no environmental monitoring program for surface water. One sample of snowmelt was taken from the top of South Table Mountain at the Permanent Site in 1979 (Table 3-10). Turbidity, suspended solids, Kjeldahl nitrogen, and phosphate were measured above levels expected for unpolluted streams.

Wastewater discharges have been sampled and analyzed at SERI on three occasions -- March 1986, July 1986, and December 1986. Although the locations for all three sampling periods were the same (Building 16 and the FTLB discharges and the Bioannex sump), the March sampling and analysis effort differed from the July and December efforts in the sampling methods used, the personnel and laboratories used, and the parameters analyzed.

In March, grab samples were taken and analyzed by MDSDD for six metals, one organic, and four physicochemical parameters. MDSDD's sampling and analytical protocols were not analyzed during the Survey The samples from Building 16 and the FTLB included the combined laboratory/sanitary flow, and were taken downstream of the neutralization/settling tanks, while the sample from the Bioannex was taken directly from the sump. The results are presented in Table 3-11 along with applicable publicly-owned treatment works (POTW) user discharge limitations. Metals and pH were within discharge limits. Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) levels at Building 16 and the FTLB, and total suspended solids (TSS) values at all three facilities were lower than average sanitary wastewater concentrations (Benefield and Randall, 1980). BOD and COD values at the Bioannex, while much higher than those for Building 16 and the FTLB, are normal for industrial wastewater (Benefield and Randall, 1980). Additionally, the Bioannex sump does not receive sanitary wastewater to dilute the process flow.

During July and again in December 1986, 24-hour composite samples were taken at the same locations as in March and were analyzed for 4 metals, 29 organics, cyanide, gross beta radioactivity, and 4 physicochemical parameters. These samples were taken and analyzed by an outside contractor. Their sampling efforts were not observed by the Survey team, and certain sampling protocols such as field quality control procedures, field measurements, and chain of custody were not reported.

TABLE 3-10

SERI PERMANENT SITE SURFACE-WATER QUALITY*

Parameter	Results
Turbidity	27 units
Total Dissolved Solids	80 mg/L
Suspended Solids	12 mg/L
Kjeldahl Nitrogen	0.7 mg/L
Phosphate	0.3 mg/L
Lead	Less than 0.01 mg/L
Mercury	Less than 0.001 mg/L

Source: SERI, 1979

*Collected 3/12/79 from snowmelt at top of South Table Mountain

TABLE 3-11

SERI WASTEWATER DISCHARGE ANALYTICAL RESULTS, MARCH 1986[a]

Parameter	Building 16[b]	FTLB[b]	Bioannex[c]	POTW User Discharge Limits[d]
Biochemical Oxygen Demand (mg/L)	16	36	982	N/A[e]
Chemical Oxygen Demand (mg/L)	41	38	1,690	NA[e]
Total Suspended Solids (mg/L)	16	90	58	N/A[e]
pH (units)	8.4	8.2	6.1	>5.0
Phenol (mg/L)	<0.03	0.04	2.4	N/A[e]
Cadmium (mg/L)	<0.005	<0.005	<0.005	1.2
Chromium (mg/L)	≤0.01	≤0.01	0.17	7.5
Copper (mg/L)	0.04	0.06	0.10	4.5
Lead (mg/L)	≤0.01	≤0.01	≤0.01	15.0
Nickel (mg/L)	≤0.01	≤0.01	0.17	15.0
Zinc (mg/L)	0.04	0.10	0.52	15.0

Source: MDSDD, 1986

a Grab samples
b Sample taken from manholes downstream of junction of sanitary and laboratory drain systems and the settling/neutralization tanks.
c Sample taken from Bioannex sump.
d 24-hour average and instantaneous
e N/A = Not applicable

Protocols and quality assurance/quality control for the laboratory analyses are discussed in Section 4.4. The results are presented in Table 3-12; one parameter that is not presented but which was found at a high concentration in the sample collected at the Bioannex in December was acetone (14,000 µg/L). None of the parameters measured has any corresponding POTW user discharge limits, with the exception of pH (greater than 5.0) and cadmium (1.2 mg/L). Both pH and cadmium were within POTW user discharge limits.

The values for BOD and TSS in July and December are similar to those in March, as discussed above, although TSS was considerably lower in the Bioannex sump in December. Analysis for volatile organics resulted in undetectable concentrations of all parameters except chloroform and methylene chloride. Metal concentrations were below detectable limits for the three facilities, with the exception of mercury in the December 1986 sample from Building 16. Although no POTW user discharge limits presently exist for mercury, one may be established within the next 1 to 2 years.

Although no wastewater samples were taken in 1987, a wastewater discharge sampling and analysis program was being designed at the time of the on-site portion of the Survey (December 1987). The program was to include monthly 24-hour composite sampling at the point where the Building 15, 16, and 17 and FTLB discharges connect with the PVSD system and subsequent analysis for a variety of inorganics, and quarterly grab sampling just downstream of the neutralization tanks at Building 16 and the FTLB and subsequent analysis for organics.

3.3.4 Findings and Observations

3.3.4.1 Category I

None

3.3.4.2 Category II

None

TABLE 3-12

SERI WASTEWATER DISCHARGE ANALYTICAL RESULTS, JULY AND DECEMBER 1986[a]

Parameter	Unit	Location		
		Bldg. 16[b]	FTLB[b]	Bioannex[c]
<u>July 1986</u>				
pH	@25°C	6.97	7.16	6.88
Total Suspended Solids (TSS)	mg/L	27.0	36.0	2520.0
Biochemical Oxygen Demand (BOD)	mg/L	11.0	6.0	340.0
Purgeable Compounds (Volatile Organics)	µg/L	--[d]	ND[e]	ND[e]
Flammability - Lower Explosive Limit (LEL)	°F	>150.0	>150.0	>150.0
Phenol	mg/L	<0.05	≤0.05	0.24
Arsenic[f]	mg/L	≤0.01	≤0.01	≤0.01
Cadmium[f]	mg/L	≤0.01	NA[g]	NA[g]
Total Cyanides	mg/L	<0.05	<0.05	<0.05
Mercury	µg/L	≤0.3	<0.03	≤0.3
Selenium[f]	mg/L	≤0.01	≤0.01	≤0.01
Gross Beta	pCi/L	9.3 ± 7.4	9.7 ± 8.0	38 ± 30
<u>December 1986</u>				
pH	@25°C	7.55	7.10	6.78
Total Suspended Solids (TSS)	mg/L	10.0	27.0	14.0
Biochemical Oxygen Demand (BOD)	mg/L	32.0	66.0	1290.0
Purgeable Compounds (Volatile Organics)	µg/L	--[h]	--[h]	ND[e]
Flammability - Lower Explosive Limit (LEL)	°F	>150.0	>150.0	>150.0
Phenol	mg/L	<0.05	<0.05	<0.37
Arsenic[f]	mg/L	≤0.01	≤0.01	≤0.01
Cadmium[f]	mg/L	≤0.01	≤0.01	≤0.01
Total Cyanides	mg/L	<0.05	<0.05	<0.05
Mercury	µg/L	5.9	≤0.3	≤0.3
Selenium[f]	mg/L	≤0.01	≤0.01	≤0.01
Gross Beta	pCi/L	9.2 ± 7.5	16 ± 8.0	24 ± 21

Source: Greystone Development Consultants, Inc., 1987; SERI, 1987a

a 24-hour composite sample; applicable POTW user discharge limitations included on Table 3-11.
b Samples taken from manholes downstream of junction of sanitary and laboratory drain systems and the settling/neutralization tanks.
c Samples taken from Bioannex sump.
d Of the 28 parameters tested, only chloroform (20 µg/L) and methylene chloride (221 µg/L) were detected.
e Not Detected.
f These parameters are from Building 16 only.
g Not Analyzed.
h Of the 28 parameters tested, only chloroform (5 µg/L) and methylene chloride (20 µg/L) were detected.

3.3.4.3 Category III

None

3.3.4.4 Category IV

1. Lack of surface-water characterization. The lack of characterization of surface water at the SERI facilities precludes an assessment of ambient impacts of past and present SERI operations on surface waters.

There is presently no surface-water quality monitoring at any of the SERI facilities. Surface-water features at these facilities include an ornamental pond at the Denver West Office Park and intermittent streams at the Permanent Site and WERC. Although there is no indication that significant degradation of surface-water quality has occurred as a result of past and present SERI operations, there are no data to support or refute this assumption. Potential sources of surface-water contamination are potentially hazardous unidentified wastes stored at the Permanent Site Boneyard and at Building A-60 at WERC (Section 4.1.2.2, Finding 1), and any hazardous wastes disposed of at potential inactive waste sites (Section 4.5.2.3, Finding 1).

SERI does not have any direct surface-water point discharges and therefore, does not require a National Pollutant Discharge Elimination System (NPDES) discharge permit. As a result, there is no monitoring requirement for NPDES permit compliance purposes. SERI is required to have, and does have, a permit for the batch discharge of the Bioannex sump. Although no monitoring is required in this permit, SERI is monitoring wastewater discharges from Buildings 15, 16, and 17 (combined discharge) and the FTLB, and has monitored wastewater discharges from the Bioannex sump, Building 16, and the FTLB in the past.

3.4 Hydrogeology

This section discusses regional geologic conditions, groundwater characteristics, pollution sources and specific controls, environmental monitoring programs, and the effect SERI operations have on the subsurface environment. Much of the background information is summarized from SERI (1979).

3.4.1 Background Environmental Information

3.4.1.1 Regional Geology

SERI is located at three geographically separate facilities, as described in Section 2.0. All are situated on the eastern flank of the Colorado Front Range of the Rocky Mountains. Underlying the Denver area is a thick sequence of sedimentary rocks consisting of the Denver, Arapahoe, Laramie, and Fox Hills Sandstone Formations. In the Denver basin, these strata extend to a depth of about 12,000 feet, where crystalline Precambrian rocks are encountered, and are the deep aquifers that supply groundwater to the Denver area. To the west, these formations gradually rise until west of SERI the Front Range uplift has folded and faulted them. As a result, the sedimentary strata rise sharply and outcrop sporadically as near-vertical "hogbacks" in a narrow northwest-trending ridge zone bordering the foothills.

The Permanent Site is directly south of the South Table Mountain plateau, a mesa formed by weakly consolidated sedimentary rocks of the Denver Formation protected by a resistant lava layer around which similar but unprotected rocks have been eroded. The mesa stands approximately 500 feet above the rolling topography that gently slopes several miles eastward to the South Platte River. The indurated lava on the mesa top is approximately 30 feet thick, and is classified as a latite, an extrusive trach andesite of Paleocene age. The latite is fractured and prominently displays columnar jointing with numerous secondary vertical and horizontal fractures.

The area surrounding the mesa where the Permanent Site is located is subject to rockfalls and small landslides. The cliffs along the perimeter of the mesa top are the primary source areas for loose rock. Dislodged boulders generally fall to the lower slopes and move slowly to the toe by soil creep. Other colluvium is added by preferential erosion of the Denver Formation. No recent significant landslide activity has been noted.

The Denver West Office Park is located approximately 1 mile east of the Permanent Site. Subsurface conditions at Denver West are not expected to vary significantly from those at the Permanent Site.

The closest major fault to the Denver West Office Park and Permanent Site is the Golden Fault, about 2 miles west of the Permanent Site, which is presently inactive. Historic earthquake activity is low, with most moderate-intensity and low-intensity earthquakes occurring in the mountains to the west. There are no mineral deposits at SERI that would represent a viable economic resource, although historically aggregate and clay have been mined in the area.

The geology of the WERC site is very similar to conditions at the Permanent Site and the Denver West complex. However, the latite is absent and fluvial outwash covers most of the area. This forms a heterogeneous unconsolidated mantle called the Rocky Flats Alluvium, colluvium, and valley fill alluvium.

The Denver Formation, which contains the principal regional aquifer, underlies the lava caprock at the Permanent Site and alluvium at Denver West Office Park and WERC, and consists of interbedded claystone, siltstone, sandstone, and conglomerate sequences. It is 430 feet thick and is considered to be of upper Cretaceous age (Figure 3-8).

3.4.1.2 Hydrogeology

Two sandstone units within the sequence of sedimentary strata described in Section 3.4.1.1 -- the Arapahoe and the Laramie (Figure 3-8) -- are also important aquifers in this sequence, in addition to the Denver Formation, described above. The Arapahoe Formation consists of a claystone with interbedded sandstone lenses near its base. It is approximately 450 feet thick; however, the permeable zone (aquifer) is thin and occurs as interconnected sandstone lenses about 600 feet below SERI. This unit is underlain by the Laramie Formation, which is up to 600 feet thick. The upper part of the Laramie Formation is nearly impermeable and consists of several hundred feet of shale with low transmissivity. It is considered an aquiclude since it

AGE	LITHOLOGY	FORMATION	APPROXIMATE THICKNESS (Ft.)	DEPTH From Top of South Table Mtn.
Paleocene		Latite (Lava Flow)	30	30
		Denver Formation *	430	460
Upper Cretaceous		Arapahoe Formation *	450	910
		Laramie Formation *	600	1,510
		Fox Hills Sandstone *	100	1,600
		Pierre Shale	7,200	8,810
		Niobrara Formation	350	9,160

* Aquifers

BEDROCK STRATIGRAPHIC SECTION AT THE SERI PERMANENT SITE

FIGURE 3-8

effectively prevents vertical migration of groundwater between the Arapahoe Formation and the Laramie-Fox Hills aquifer. The lower part of the Laramie consists of interbedded sandstone and kaolinite claystone. This unit and the underlying Fox Hills sandstone are collectively referred to as the Laramie-Fox Hills aquifer, which lies more than 1,300 feet below SERI and is approximately 100 feet thick.

Groundwater also occurs in a shallow perched flow system in the colluvium and the upper strata of the Denver Formation at the Office Park and Permanent Site. This shallow aquifer underlying SERI is responsive to surface runoff and rapid infiltration. Since it is recharged by infiltration of incident precipitation, perched groundwater levels are highly variable, ranging from the ground surface during precipitation events to nearly dry conditions in the summer. This aquifer is confined by a siltstone/shale aquiclude approximately 100 feet below the surface. As a result of the Denver Formation's low vertical permeability and heterogeneous lithology, the general infiltration rate and horizontal flow rate are relatively slow, whereas localized rates in highly fractured areas are rapid.

Most private wells in proximity to the Permanent Site and Denver West Office Park terminate in the shallow perched aquifer. The perched aquifer was used by residents prior to 1960 as a potable water source, but since 1960 when the area was converted to municipal supply, the shallow wells have been relegated to landscape irrigation and other non-potable uses. A few shallow wells sporadically run dry during summer months and a number of dug wells have collapsed.

At the Permanent Site and the Denver West Office Park, shallow groundwater movement is initially away from the top of South Table Mountain, as it follows local surface-water drainage channels (Section 3.3) and then trends northeast. Shallow groundwater conditions at the Office Park may be affected by the extensive fill placement and surface restructuring as a result of the site's construction activities. Deep groundwater flow is also to the northeast toward the zone of regional discharge along the South Platte River (Figure 2-1).

At the WERC site, groundwater is found primarily in the Laramie-Fox Hills aquifer and flows to the east. However, shallow groundwater is found in the Rocky Flats Alluvium, colluvium, and valley fill alluvium, which flows towards the South Platte River (Figure 2-4).

There is one production water well located at WERC in a pumphouse; its reported depth is 500 feet and effective yield is approximately 30 gallons per minute (gpm). This well supplies all process water to WERC. Commercial bottled water is used by WERC personnel as the principal potable drinking water source.

3.4.2 General Description of Pollution Sources and Controls

3.4.2.1 <u>Sources of Groundwater Pollution</u>

Although no subsurface contamination is known to exist at SERI, shallow groundwater is subject to potential contamination by past and present activities at SERI. The shallow perched aquifer at the Permanent Site is the most susceptible to degradation from spills or releases since this area is a recharge point and has rapid flow conditions. Potential sources of shallow groundwater contamination at SERI may include:

- the Boneyard northwest of the FTLB at the Permanent Site (Section 4.1);
- the fill in the drainage channel northeast of the FTLB (Section 4.5);
- the fuel oil and heat transfer fluid storage tanks at the FTLB (Section 4.2.1.5);
- the gasoline storage tanks at WERC;
- catchment tanks and neutralization tanks at Building 16 in the Denver West Office Park, and the Bioannex and FTLB at the Permanent Site (Section 4.2.1.5);
- mishandling of hazardous materials at Building 16 and the FTLB (Section 4.1); and
- sewage holding tanks at WERC (Section 4.2.1.5).

3.4.2.2 Controls of Groundwater Pollution

Pollution controls at SERI include such administrative and physical methods as careful handling of chemicals and the use of polyethylene liners in concrete holding tanks. Fuel storage tanks are monitored by extrapolating usage figures from known delivered volume.

Surface-water flow is diverted by drainage canals at the Permanent Site and stormwater sewers at the Denver West Office Complex (Section 3.3). Waste chemicals are packaged and shipped off-site for processing and disposal (Section 4.1). Hazardous waste and chemical storage/transfer areas are contained and have catchment and neutralization tanks to retain spills and leaks (Section 3.3).

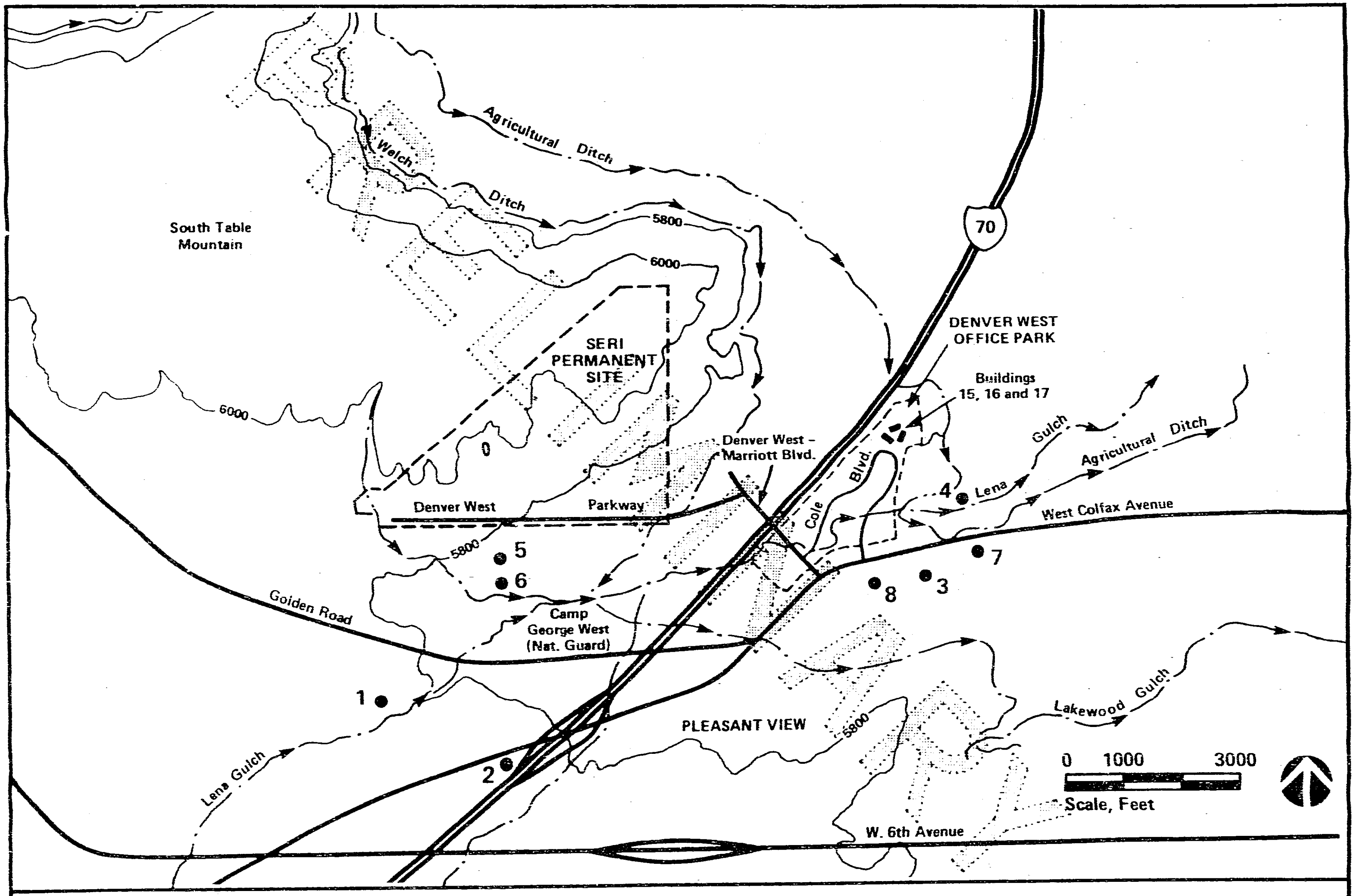
3.4.3 Environmental Monitoring Program

3.4.3.1 Introduction

The groundwater monitoring network consists of eight residential wells located within 1 mile of the Permanent Site as described below and depicted in Figure 3-9. The wells were chosen from 50 wells in the area to obtain a representative sample of groundwater in the area around SERI. The first five wells listed are the monitoring sites selected in 1982. Well number 8 was selected in 1983 to replace well number 2, which is no longer in use. Wells number 6 and 7 are alternate sampling points.

Well number 1. 16610 W. 9th Avenue
Depth: Approximately 100 feet
Use: Irrigation
Age: Unknown
Sample Record: 1982 to present

Well number 2. 795 McIntyre Street
Depth: Approximately 85 feet
Use: Domestic Supply - Abandoned
Age: Unknown
Sample Record: 1982-1983



Source: Geystone Development Consultants, Inc., 1987

WELL SAMPLING LOCATIONS IN THE VICINITY OF THE SERI PERMANENT SITE AND THE DENVER WEST OFFICE PARK **FIGURE 3-9**

Well number 3. 1245 Meadow Sweet Road
Depth: Approximately 35 feet
Use: Irrigation
Age: Unknown
Sample Record: 1982 to present

Well number 4. 1541 Alkire Court
Depth: 40 feet
Use: Irrigation
Age: 3/30/61
Sample Record: 1982 to present

Well number 5. 1490 Nile Street
Depth: Approximately 110 feet
Use: Irrigation
Age: Prior to 1950
Sample Record: 1982 to present

Well number 6. 1290 Nile Street
Depth: Approximately 140 feet
Use: Domestic Supply
Age: Unknown
Sample Record: None, alternate

Well number 7. 1280 Orchard Road
Depth: Approximately 28 feet
Use: Irrigation
Age: Unknown
Sample Record: None, alternate

Well number 8. 1390 Hawthorne Road
Depth: Approximately 30 feet
Use: Irrigation
Age: Prior to 1956
Sample Record: 1983 to present

All the wells are privately owned and, except for well number 4, construction details and date of installation are unknown. No well logs are available for the monitoring wells and all current use is for local irrigation only. Sampling and analysis is performed by outside contractor laboratories. The contractors did not have written protocols on quality assurance (QA) and quality control (QC) and did not report the results of routine checks that may have been used.

Sampling was not observed during the Survey, and the description of sampling methods in the reports submitted to SERI gives only a cursory account of procedures. The wells are reported to be purged prior to sampling, samples are retained in bottles pre-filled with preservatives supplied by the laboratory, chilled, and delivered the same day to the laboratory. No field blank samples are run and no field tests such as pH, conductivity, and temperature are performed at the point of collection.

3.4.3.2 Monitoring Parameters

Starting in 1982, semi-annual and quarterly sampling was performed on the above wells with analysis for 26 parameters and 13 parameters, respectively. Since then, the number of parameters has changed, and sampling in July 1986 included analysis of 12 inorganic parameters used as indicators of contamination and 8 parameters in December 1986, which included selected volatile organic compounds (VOCs) (Table 3-13). No environmental samples are collected at WERC.

3.4.3.3 Monitoring Data

There is currently no evidence that groundwater is contaminated off-site since shallow wells in the Denver Formation within a 1-mile radius of the Permanent Site show either background levels of various potential contaminants or no detectable concentrations (Greystone Development Consultants, Inc., 1987). The local shallow groundwater is slightly alkaline and is similar to the regional groundwater found along the entire Front Range with respect to dissolved constituents. No anomalous values were indicated by the analytical results. However, this does not preclude the possible contamination of the local shallow groundwater system directly under the

TABLE 3-13

SERI GROUNDWATER SAMPLING PARAMETERS

Parameter	July 1986	December 1986
Total Dissolved Solids (TDS)	*	--
Mercury	*	--
Nitrate	*	*
Selenium	*	--
Chloride	*	--
Fluoride	*	--
Sulfate	*	--
Turbidity	*	*
pH	*	*
Radium-226	*	*
Gross alpha	*	*
Gross beta	*	*
Total Suspended Solids (TSS)	*	*
Purgeable Compounds (volatile organics)	--	*

Source: SERI, 1987a.

* Analyzed
-- Not Analyzed

Permanent Site, since the wells used during the monitoring program are distant from the site and may not reflect local groundwater quality or conditions.

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

None

3.4.4.4 Category IV

1. Ineffective groundwater monitoring program. The current groundwater monitoring program is ineffective in identifying the Permanent Site's impacts on groundwater quality.

   Groundwater data currently collected by SERI are reported in the Annual Site Environmental Report. As stated in the 1986 Annual Site Environmental Report (SERI, 1987a), the current monitoring well network was designed to include representative upgradient and downgradient wells for monitoring. But the well network is remote from the sites that it was designed to monitor (Figure 3-9). The water quality of the wells may be compromised by local events unrelated to the SERI complex, since all the wells are shallow and are responsive to localized recharge and potential off-site pollution sources. None of the monitoring wells could be expected to intercept a credible spill or chronic leak from the SERI complex since their remote location and shallow construction could allow a contaminant to circumvent the well point or become diluted before the plume front reached the well point. Additionally, no well logs are available for the monitoring wells and specific construction details and dates of completion are not known, making it difficult to interpret results of analysis on water quality or physical characteristics such as site-specific flow direction and rate.

Contrary to what is indicated in the environmental monitoring report, no upgradient wells are sampled since shallow, local groundwater flow at SERI originates from South Table Mountain and no wells are located in this area. Shallow upgradient wells would need to be located on the mesa slope to reflect background conditions at the Permanent Site.

Additionally, wells have been sampled sporadically by various contractors using different sampling methodologies and possibly different laboratory procedures, making data correlation difficult. There were no written QA/QC procedures for sampling and analysis of groundwater and chain of custody was not documented prior to 1987, thereby compromising the validity of data obtained prior to that time. During sampling, parameters such as temperature, pH, and conductivity, which may provide information indicating possible anomalies if subsequent laboratory measurements are significantly different from field parameters, were not measured. Since 1987, groundwater-related QA/QC information has been specified by SERI in contracts in a cursory fashion. However, contractor deliverables to SERI have not included QA/QC information, making an accurate interpretation of the data quality difficult.

Despite the ineffectiveness of the current groundwater monitoring program, the collective monitoring network is historically indicative of shallow water quality over a large area and therefore establishes background shallow groundwater quality on a regional basis only.

SERI currently possesses a U.S. Environmental Protection Agency (EPA) small-quantity generator (SQG) identification number giving the address of the Denver West Office Park.

All hazardous waste generated at SERI is handled by the Environmental, Safety, and Health (ES&H) Group. However, no documentation exists at SERI completely describing the procedures by which hazardous waste, once generated, is stored and prepared for off-site shipment. Some hazardous waste handling procedures have been documented in Section VII-B of the SERI Environmental Safety and Health Manual. However, these procedures have not been updated since June 1, 1981, and Federal regulations addressing this subject have evolved considerably since that date. The following four topics are among those addressed in the manual and are discussed below with regard to their implementation as observed by the Survey team: waste classification, waste containers, removal of chemical waste containers from the laboratory, and waste disposal.

Waste Classification

The waste classification procedure at SERI is intended to help identify and classify hazardous waste into a few general categories. The procedure states that chemical wastes are to be segregated into collectable and noncollectable materials. The noncollectable chemical wastes, which are to be disposed of down the laboratory drains at the points of generation, are identified by the following eight broad categories :

- Organic Acids
- Alcohols
- Glycols
- Esters
- Ketones
- Caustics
- Most Aqueous Solutions
- Dilute Mineral Acids

SERI currently possesses a U.S. Environmental Protection Agency (EPA) small-quantity generator (SQG) identification number giving the address of the Denver West Office Park.

All hazardous waste generated at SERI is handled by the Environmental, Safety, and Health (ES&H) Group. However, no documentation exists at SERI completely describing the procedures by which hazardous waste, once generated, is stored and prepared for off-site shipment. Some hazardous waste handling procedures have been documented in Section VII-B of the SERI Environmental Safety and Health Manual. However, these procedures have not been updated since June 1, 1981, and Federal regulations addressing this subject have evolved considerably since that date. The following four topics are among those addressed in the manual and are discussed below with regard to their implementation as observed by the Survey team: waste classification, waste containers, removal of chemical waste containers from the laboratory, and waste disposal.

Waste Classification

The waste classification procedure at SERI is intended to help identify and classify hazardous waste into a few general categories. The procedure states that chemical wastes are to be segregated into collectable and noncollectable materials. The noncollectable chemical wastes, which are to be disposed of down the laboratory drains at the points of generation, are identified by the following eight broad categories:

- Organic Acids
- Alcohols
- Glycols
- Esters
- Ketones
- Caustics
- Most Aqueous Solutions
- Dilute Mineral Acids

The given list of collectable wastes, though only a partial list, is more specific but overlaps substantially the list of broad categories identified as noncollectable (Table 4-1).

The laboratories typically have Safe Operating Procedures (SOPs) that do not address waste disposal except to mention that hazardous waste is to be placed in the available waste containers. SOPs typically do not address waste classification or identification. In other cases, laboratories are operating without approved SOPs. Nearly all laboratories in Building 16 at the Denver West Office Park and in the FTLB at the Permanent Site are currently using solid and liquid chemicals which, when disposed of, would be a hazardous waste. Laboratories 103, 190, 216, 218, 368, 369, and 454 in Building 16 perform research involving the use of toxic gases, including arsine, diborane, germanium tetrahydride, phosphine, and silane. Pump oil used in operating the gas containment systems for these gases becomes contaminated and may be a hazardous waste. A partial listing of these laboratories and the chemicals they use is presented in Table 4-2. WERC and the remainder of the buildings at the Denver West Office Park and the Permanent Site use chemical substances in only extremely small quantities and are not currently generating hazardous wastes.

In laboratories where liquid hazardous waste is generated, two hazardous waste satellite accumulation containers are typically used for the collectable wastes. The accumulation containers are marked either "AQUEOUS WASTE" or "ORGANIC WASTE" and are marked with the laboratory number where they are kept. In some cases, a plastic container is used to accumulate organic waste and no distinction is made between halogenated and nonhalogenated organic solvents. Other hazardous wastes, including other hazardous liquid wastes and hazardous waste soilds, that are generated in the laboratories may be collected separately from the aqueous and organic waste; however, this separation is decided by the Laboratory Supervisor without specific written guidance, and the ES&H Group is involved in this decision only when so requested by the Laboratory Supervisor.

Waste Containers

The Safety Policy/Procedure for waste disposal requires that three separate, standardized containers be used for the satellite accumulation of hazardous wastes at each point of generation. The three containers are to be clearly labeled (black

TABLE 4-1

COLLECTABLE CHEMICAL WASTES AT SERI ACCORDING TO SAFETY POLICY/PROCEDURE VII-B

Waste Type	Waste Description
General classes of collectable chemical waste	Flammable liquids Carcinogenic substances Concentrated mineral acids (i.e., concentrated nitric and sulfuric acid) Aqueous solutions containing heavy metals Heavy metals (i.e., mercury) Any radioactive material Stable isotopes
Specific classes of collectable chemicals	Aromatic hydrocarbons Aliphatic hydrocarbons Cyclic hydrocarbons Substituted hydrocarbons Halogenated hydrocarbons Hydrofluoric acid Concentrated mineral acids Aqueous solutions of heavy metals Aldehydes
Noncollectable chemicals which cannot be disposed of through the building drainage system	Perchlorates Solutions to media containing pathological or mutant bacteria Peroxidizable chemicals

Source: SERI, 1984

TABLE 4-2

INVENTORY OF SELECTED SOLVENTS IN FTLB AND BUILDING 16 LABORATORIES[a]

Solvent	FTLB Laboratories															Building 16 Laboratories																
	119	120	131	139	140	141	142	151	158	204	206	207	215	216	MSL[b]	102	103	106	107	109	110	113	118	119	122	155	156	158	159	173	189	190
Acetone	X	X	X		X	X	X	X	X		X	X_a	X	X	X			X	X		X_2	X	X	X			X	X	X	X	X	X
Acetonitrile							X	X			X	X	X																X		X	
Benzene																																
Carbon Tetrachloride											X																	X	X			X_2
Chlorobenzene																																
Chloroform						X_2		X		X_2	X	X	X						X	X		X_2						X	X			
Dichloroethane																																
Diethyl Ether																													X			
Dimethyl Formamide											X					X											X_2	X	X			
Methylene Chloride																													X			
Methyl Ethyl Ketone	X								X_2						X							X							X			X_2
Methyl Isobutyl Ketone					X																											
Pyridine					X_2			X_2			X																		X_2			
Tert Butyl Methyl Ether							X																									
Tetrachloroethane																																
Tetrachloroethylene																																
Tetrahydrofuran							X																					X	X			
Toluene			X	X	X				X		X	X					X_2	X									X	X	X		X	
Trichloroethane																						X			X_2							X
Trichloroethylene	X								X							X	X	X	X	X		X				X	X		X	X		X
Xylene	X	X				X		X									X	X											X			

TABLE 4-2

INVENTORY OF SELECTED SOLVENTS IN FTLB AND BUILDING 16 LABORATORIESa (Continued)

Solvent	Building 16 Laboratories (Continued)																											
	191	192	202	204	206	207	214	216	217	218	221	267	268	269	282	283	285	286	287	363	369	370	371	383	384	387	388	454
Acetone			X			X	X_2	X		X	X	X	X	X	X	X		X	X	X	X		X	X	X			X
Acetonitrile										X	X	X		X	X	X		X	X				X			X_2		
Benzene												X_2		X			X	X	X_2				X					
Carbon Tetrachloride											X		X				X	X	X		X		X			X		
Chlorobenzene																	X	X						X		X		
Chloroform				X	X	X			X_2	X		X			X	X	X	X	X		X		X			X		
Dichloroethane															X_2			X										
Diethyl Ether															X	X		X				X						
Dimethyl Formamide					X						X							X	X				X	X_2		X_2		
Methylene Chloride		X										X				X		X			X	X	X	X		X		
Methyl Ethyl Ketone											X					X_2				X_2	X		X	X	X	X		
Methyl Isobutyl Ketone																			X									
Pyridine											X_2				X_2				X				X_2			X_2		
Tert Butyl Methyl Ether																												
Tetrachloroethane																		X										
Tetrachloroethylene																										X		
Tetrahydrofuran											X_2		X						X				X			X		
Toluene	X_2					X							X		X	X_2		X	X		X	X	X	X	X	X		X
Trichloroethane																										X		
Trichloroethylene							X	X			X	X			X			X		X	X	X		X		X	X	X
Xylene	X_2										X					X_2		X				X	X			X		

Source: SERI, 1987c

a X = 1 liter or more of this solvent stored in laboratory; X_2 = 500 mL to 1 liter of this solvent stored in laboratory

b MSL = Molten Salt Laboratory

lettering on a yellow field) "HALOGENATED ORGANIC SOLVENT WASTE," "NONHALOGENATED ORGANIC SOLVENT WASTE," and "AQUEOUS WASTE." In addition, special waste chemicals that cannot be placed in one of the above three containers are to be handled on a case-by-case basis. Finally, waste oil from the pumps and motors used in the laboratories is to be placed in the original container and is to be recycled. No distinction is mentioned between nonhazardous waste oil and hazardous (i.e., contaminated with heavy metals) waste oil.

The procedure also specifies that the two solvent waste containers are to be constructed of metal and the aqueous waste container is to be constructed of polypropylene plastic.

Furthermore, each container is required to have a logsheet that is to be completed each time waste is placed in the container, stating the date, the individual using the container, the name of the waste, and its physical description, pH, and volume. Each logsheet is to be identified by laboratory room number and is to state whether the corresponding container is for organic or aqueous waste.

In practice, only two containers are used, one for "organic waste" and one for "aqueous waste." The containers are frequently but not consistently accompanied by a logsheet rolled up and placed under the container handle, and the logsheet is often not marked with the laboratory number or the waste container type to which it belongs. In some cases, logsheets are located in arbitrary locations elsewhere in the laboratory, separate from their corresponding containers. Logsheets for aqueous waste containers, when kept rolled up under the container handle for several months, have in some laboratories begun to deteriorate from acid exposure such that they crumble when they are unrolled.

Most laboratory logsheets and waste containers identify very small amounts of collectable chemical waste despite the fact that they are storing substantial quantities of some chemicals typically associated with hazardous waste generation, including liter-sized or larger bottles of organic solvents such as benzene, toluene, methylene chloride, dichloroethane (DCEA), and trichloroethylene (TCE). For example, Laboratory 387 in Building 16 had not placed any hazardous waste in either the aqueous or the organic waste containers at the time of the Survey despite the presence of several gallons of solvents. The presence of these solvents (a solvent inventory is shown in Table 4-2) suggests that they would be used and that at least some measurable quantity of organic waste would be generated. In some cases, the quantity of waste inventoried on the container logsheet does not correspond to the quantity of waste visible in the container. For example, the organic waste container in Laboratory 369 in Building 16 contained 1 to 2 liters of waste, but the corresponding container logsheet was blank.

Since the periods of accumulation between waste collection events are variable and may extend for several months or longer, actual waste generation rates can only be grossly approximated. Over several months or years, an average rate may be calculated from waste shipment manifests; however, it is not possible to document that the monthly hazardous waste generation rates consistently fall below the RCRA small-quantity generator limit of 1,000 kg. The level of research activity fluctuates considerably over time, and consequently the actual waste generation rate is expected to vary as well.

Removal of Chemical Waste Containers from the Laboratory

The waste removal procedure states that the satellite accumulation waste containers in the laboratories are to be collected once each week by the Facilities Management Branch and transported to the SERI chemical waste processing area. The contents of all the accumulation containers belonging in the three standardized groups are then to be transferred to one of three corresponding 55-gallon drums. The procedure specifies what protective equipment is to be worn and that at least two staff members are to be present when the waste is transferred between the laboratory waste accumulation containers and the drums.

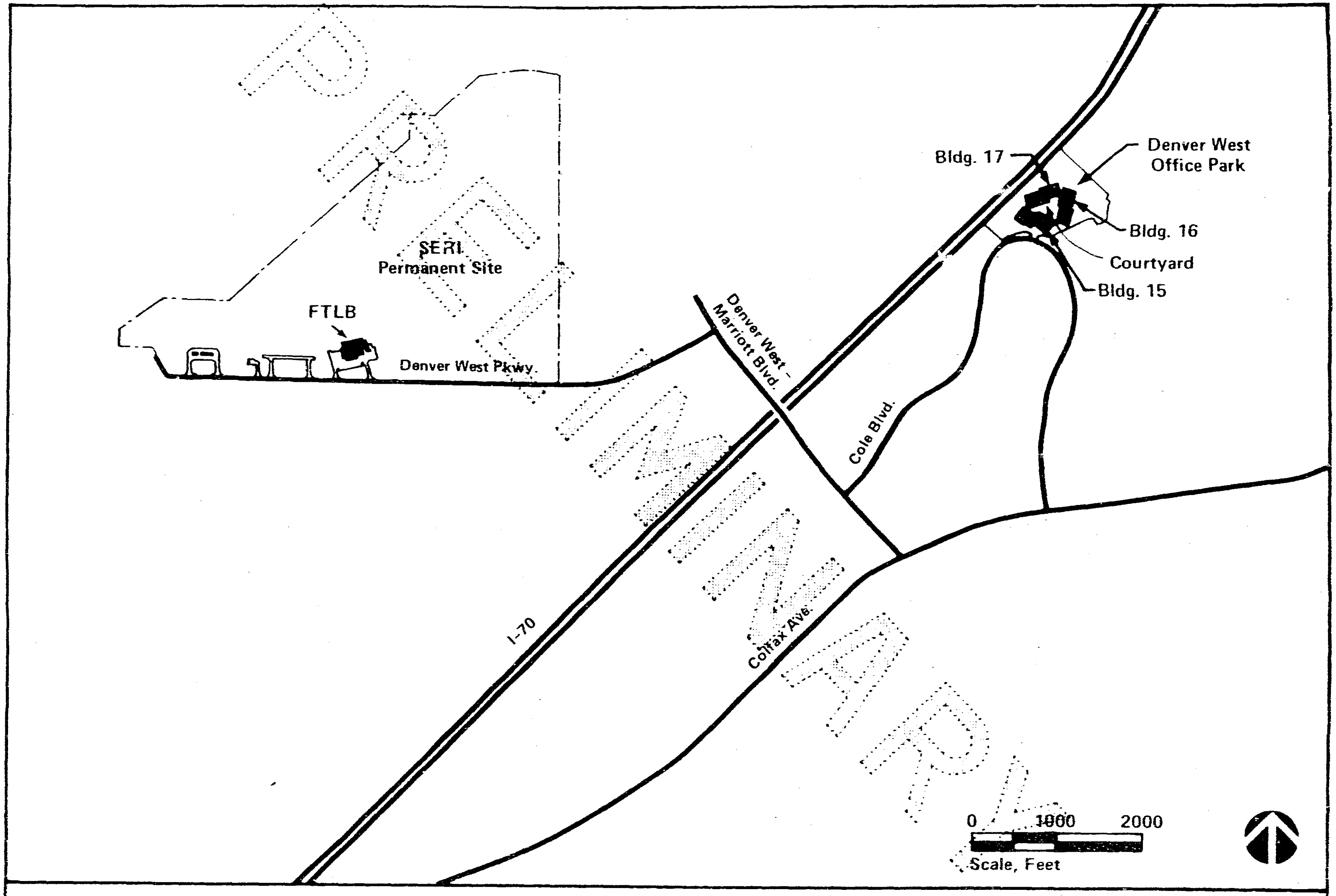
In practice, the waste accumulation containers are not collected weekly but at infrequent intervals, usually at the request of the Laboratory Supervisor. The waste accumulation containers in these laboratories, usually 3 to 5 gallons, typically contain only small amounts of waste, usually 1 liter or less, which has been collected over periods ranging from less than 1 month to nearly 2 years.

Four factors, including (1) the general lack of control by the Laboratory Supervisors and the ES&H Group over waste identification and handling, (2) the apparent discrepancy between the quantity of chemicals used and quantity of collectable waste generated, (3) SOPs that do not address specific waste identification and handling procedures to be used in individual laboratories, and (4) the Safety Policy/Procedure guidance allowing disposal of hazardous waste down the laboratory drains, are evidence that an unmeasurable quantity of potentially hazardous waste is being disposed of in the laboratory drains. Organic and metals analyses performed on the wastewater effluent from SERI facilities (Section 3.3) indicated that permissible maximum disposal concentrations stated in 40 CFR Part 261.3(a)(iv)(E) of RCRA were not being exceeded. However, no analyses were performed in 1987.

When the waste accumulation containers in Building 16 are collected by the ES&H Group, they are transported from the generation points to Room 115 in that building, which is currently being used as a 180/270-day hazardous waste accumulation area. In some instances, the wastes are instead transported to and stored at the Permanent Site in Room 104 in the FTLB. For hazardous waste generated at the Permanent Site, the waste containers are transported by truck or van over public roads by the ES&H staff to Building 16. The normal route taken for this trip uses Denver West Parkway, Denver West-Marriott Boulevard, and Cole Boulevard and is shown in Figure 4-1. Wastes typically are not generated at WERC.

While the waste accumulation containers are being transported to Room 115 and emptied, no extra waste accumulation containers are kept in the laboratories for hazardous waste collection until the original waste accumulation containers are returned. The turnaround time to have an accumulation container emptied and returned to the laboratory is approximately 1 week, during which no means for waste accumulation is available in the laboratories.

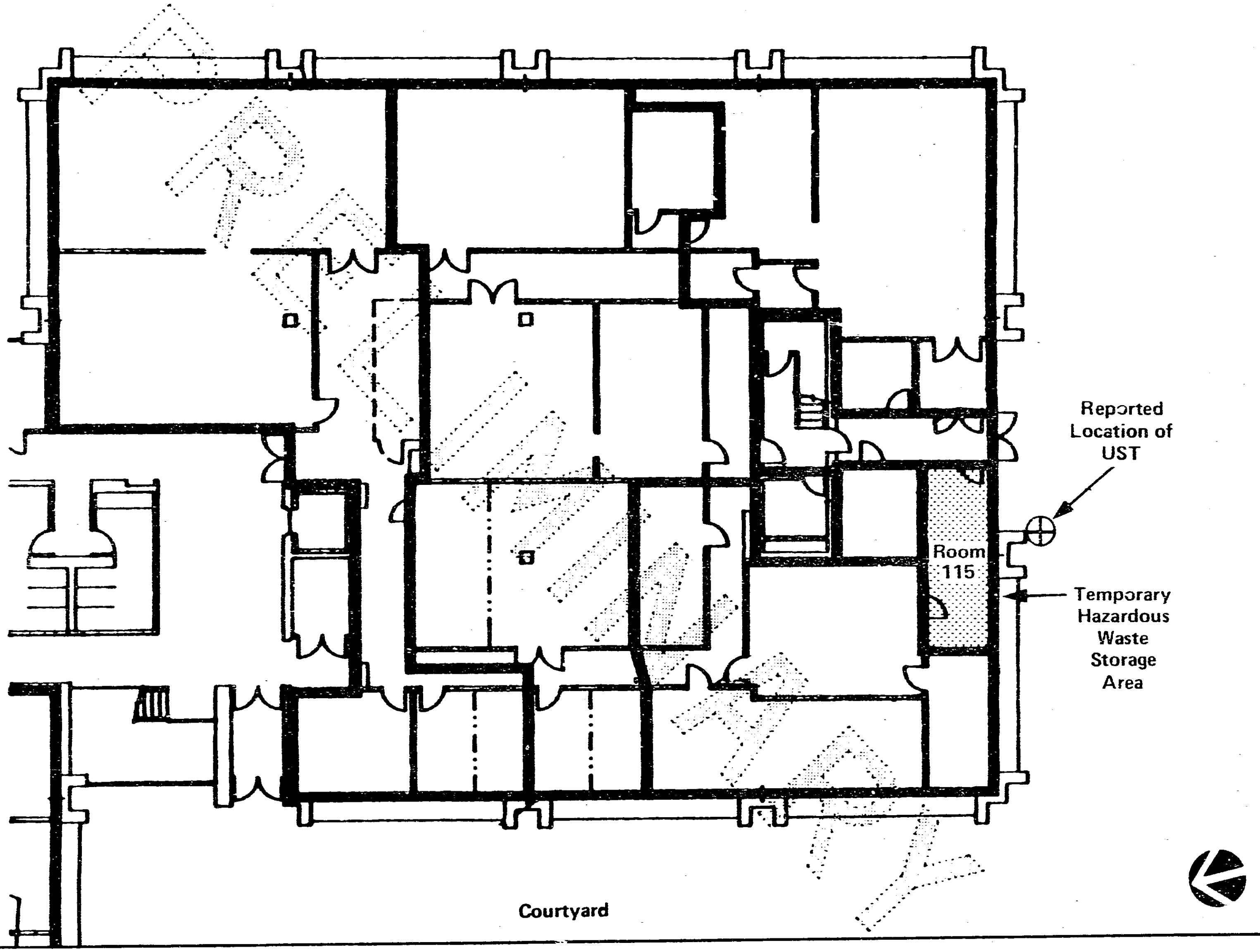
Room 115 is a small room at one end of the first floor of Building 16 (Figure 4-2). Its approximate dimensions are 8 feet by 20 feet. The room contains a cabinet that has an internal drain to control spills and contains two 55-gallon drums. The cabinet drain empties to a 100-gallon polyethylene underground storage tank (UST), reportedly located adjacent to the building (Figure 4-2). The room also contains two other drums, a table with a pumping apparatus to transfer waste from accumulation containers to drums, several bags of absorbent material for spills, a laboratory countertop and sink, a single water-filled fire extinguisher, a steel shelving unit, and several dozen waste containers of varying sizes and



Source: Higginbotham & Associates, 1986

ROADS USED FOR HAZARDOUS WASTE TRANSPORTATION BETWEEN THE SERI PERMANENT SITE AND THE DENVER WEST OFFICE PARK

FIGURE 4-1



Source: SERI, 1987d

LOCATION OF THE TEMPORARY HAZARDOUS WASTE STORAGE AREA AT BUILDING 16 OF THE DENVER WEST OFFICE PARK

FIGURE 4-2

configurations. Full containers are mixed with empty containers. Containers may or may not be marked to identify their contents, and the means of identifying containers varies. Some containers have removable labels, others have their contents handwritten or stenciled directly on the container, and still others are identified by virtue of being product containers into which their original contents, now a waste, have been placed. These containers are stored on the floor around the perimeter of the room or on the steel shelving unit. A complete, formal inventory of all the wastes being stored in the room is not maintained. The room has no telephone, no emergency action information posted, no emergency internal alarm, and no floor drain or curbing to control major spills.

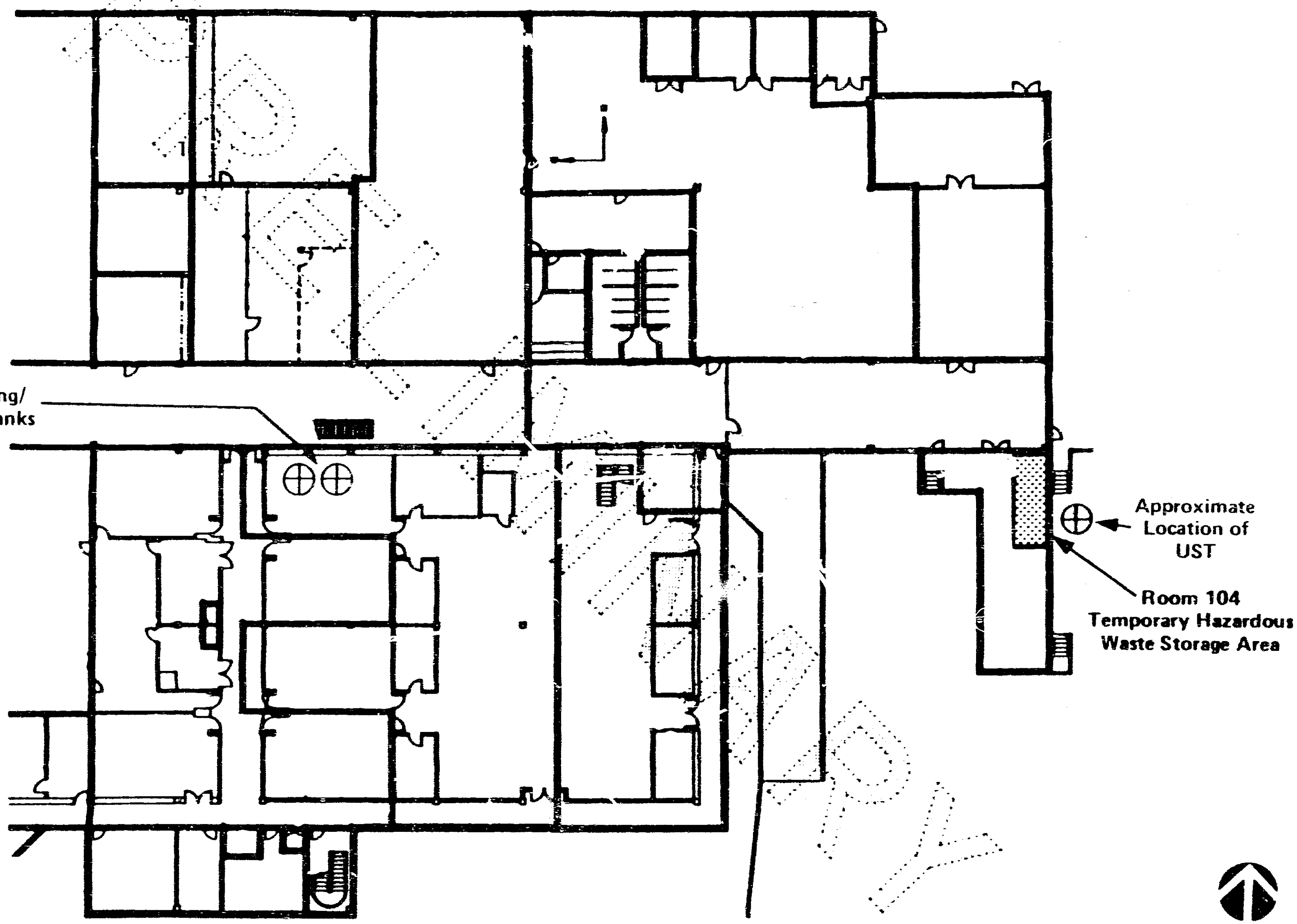
Once the waste accumulation containers are received in the 180/270-day accumulation area in Building 16 from either the off-site Permanent Site or elsewhere in the Denver West Office Park, the contents of the aqueous and organic waste accumulation containers are pumped into 2 corresponding 55-gallon drums of aqueous and organic waste. At that time, the logsheets for the accumulation containers are clipped to the cabinet in which the two drums are staged. Only a single person is typically present during the waste transfer. After the accumulation containers have been emptied, they are rinsed in a laboratory sink in the accumulation area, then stored in the facility until they can be returned to the laboratory from which they originated.

In addition to the accumulation containers of aqueous and organic wastes, other waste containers may be collected and transported to the 180/270-day accumulation area. This also is usually done at the request of the Laboratory Supervisor. These containers include, but are not limited to, waste oil contaminated with heavy metals such that it is hazardous (EP toxic), other uncontaminated (nonhazardous) waste oils, hydrofluoric acid, ethers, mercury, and unidentified wastes. Two separate drums for waste oils and hydrofluoric acid, located outside the containment cabinet, are maintained in the 180/270-day accumulation area. When these wastes are received in the facility, they are transferred to the appropriate drum. Each of the fou different drums in the facility (aqueous waste, organic waste, waste oil, and hydrofluoric acid) are typically stored until they are filled, regardless of how long the drum contents accumulate, even if the accumulation periods exceed 180 or 270 days, which are the maximum allowable time periods that a small-quantity generator can accumulate hazardous waste according to the RCRA regulations found in 40 CFR Part 262.34. Other identified wastes are stored in the containers in which they were received.

Both hazardous and nonhazardous waste pump oil is received by this facility. However, only one 55-gallon drum is maintained for centralized storage of waste oil. This drum is marked "WASTE OIL," but it is not clear whether the drum is intended for the storage of hazardous or nonhazardous waste oil or a mixture of both (which would then be hazardous by virtue of its hazardous component).

Unidentified wastes are also stored in a variety of containers in the 180/270-day accumulation area. The unidentified wastes include at least two 5-gallon aqueous and organic waste accumulation containers that were received by the facility without accompanying logsheets, other wastes in various containers of 1 liter or less that were never identified at their generation points, and sample bottles (250 mL or smaller) of hazardous waste already shipped off-site. The unidentified wastes are kept in their original containers and are stored in arbitrary locations at the storage facility, either on the floor, on shelves above the laboratory sink in the storage facility, or on the steel shelving unit by the wall opposite the laboratory sink. The unidentified waste containers typically are not labeled as such. The unidentified wastes have been stored for an indefinite period, and no records are kept concerning their past or present disposition. Since any unidentified wastes must be analyzed and identified to allow proper disposal, and no analysis is scheduled to be performed in the future, the containers are expected to remain indefinitely in the storage facility. Chemical analyses of unidentified wastes are performed occasionally to allow the wastes to be removed from SERI.

Besides Room 115 in Building 16, hazardous waste is also accumulated in a second SERI location in Room 104 at the southeast corner of the FTLB at the Permanent Site (Figure 4-3). This room is an outdoor, covered storage area similar to a loading dock. This facility receives waste from Building 16 and the FTLB. Convenience generally dictates where the waste will be stored. Factors such as waste type, waste quantity, type of container, whether the waste is identified, potential reclamation of the waste, whether the waste will be recontainerized, and available storage space, are considered in determining where the waste will be taken.



Source: SERI, 1987d

LOCATION OF THE TEMPORARY HAZARDOUS WASTE STORAGE AREA AT THE FTLB OF THE SERI PERMANENT SITE

FIGURE 4-3

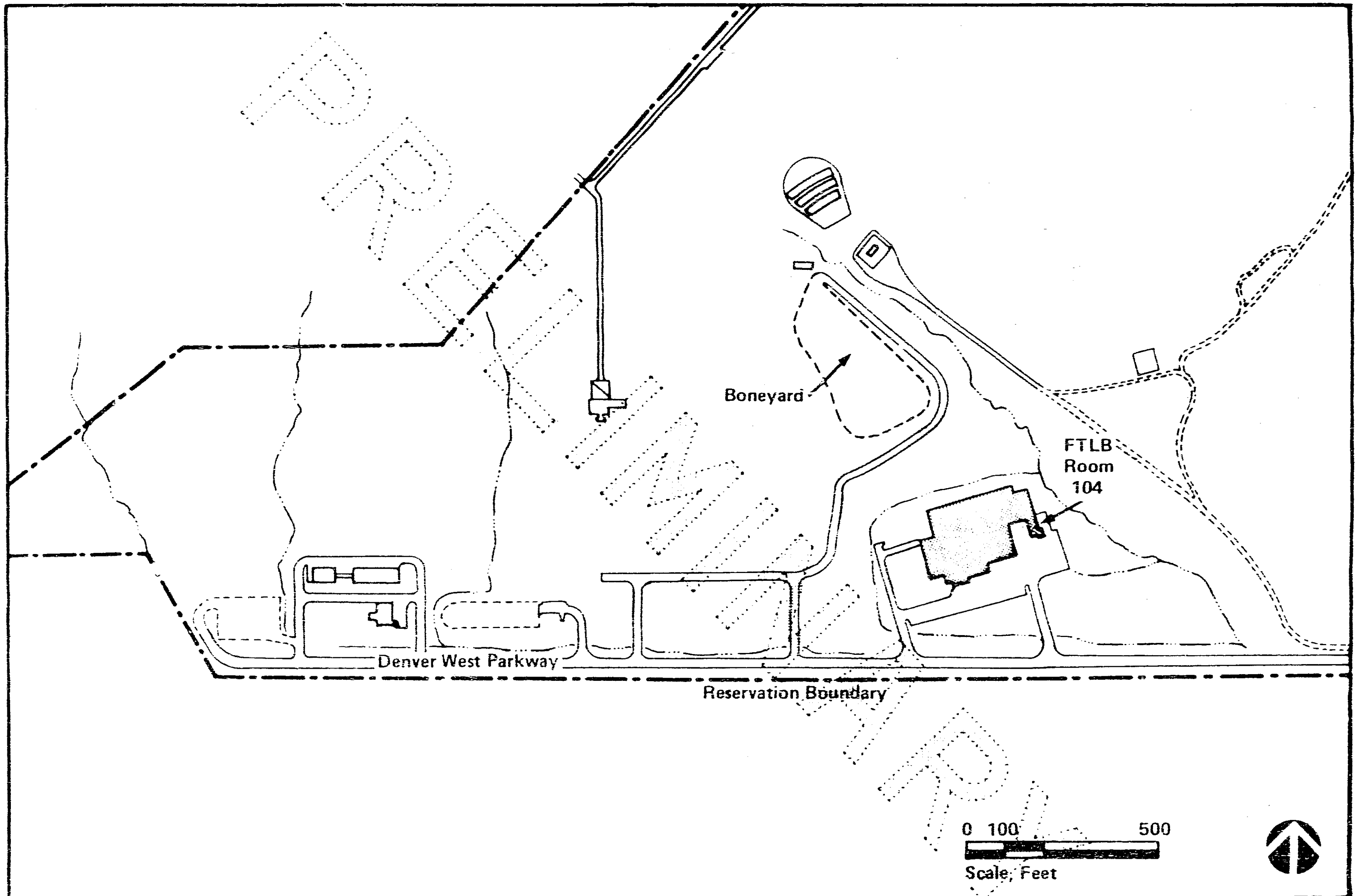
The management of this facility is similar to that of the facility in Building 16. Containers are placed at random locations in the facility, and most containers are marked in a variety of ways to identify their contents. Some containers are not marked to identify their contents, and empty containers are interspersed among full or partially full containers. Mixed among the waste containers in the facility are a variety of nonwaste materials, including empty compressed-gas cylinders, a can of gasoline used for fire prevention demonstrations, and approximately 550 pounds of Freon 12 and Freon 22 product. A complete, formal inventory of all the wastes being stored in the room is not maintained.

The FTLB hazardous waste accumulation area in Room 104 differs from the one in Building 16 in that it has a floor drain and a circumferential spill containment curb, although the curb is interrupted to allow dollies and other wheeled vehicles into the facility. The facility also is equipped with a telephone, fire extinguisher, and dry-chemical sprinkler system. The floor drain for the facility leads to a 500-gallon concrete UST located behind the east wall of the facility (Figure 4-3).

The transfer of waste between accumulation containers and drums, if necessary, is not normally performed at the FTLB facility. Instead, waste accumulation containers are usually transported to the Building 16 facility for such transfers. The procedures followed for such transportation have not been documented, and no records are kept on this activity.

In addition to the above-mentioned two primary waste accumulation areas at the Permanent Site and the Denver West Office Park, three other areas are being used for storage of potentially hazardous wastes.

At the Permanent Site, an outside, uncovered boneyard is located on a filled-in, graded area on the steep, southern side of South Table Mountain (Figure 4-4). A wide variety of materials left over from research activities are stored here for indefinite periods. Potentially hazardous waste materials include approximately 10 unlabeled, unidentified containers of liquids varying in size from 1 to 55 gallons, and approximately 20 unlabeled drums reported to contain calcium carbonate and sodium nitrate salts, some of which are empty. Other materials are primarily excessed government property and include scrap wood, metal, building materials,



Source: Higginbotham & Associates, 1986

WASTE STORAGE AREAS AT THE SERI PERMANENT SITE

FIGURE 4-4

and electrical equipment; process equipment including pumps, blowers, piping, and tanks; and a junked car.

The two other areas being used for storage of potentially hazardous waste are at WERC (Figure 4-5). At Area 3.1, 24 lead-acid batteries are being stored outside on pallets, and at Building A-60, a drum labeled "COLD LIQUID WASTE" is being stored outside on a pallet outside on the south side of the building. In both cases, there are no provisions for secondary containment, and the length of time the wastes have been stored is unknown.

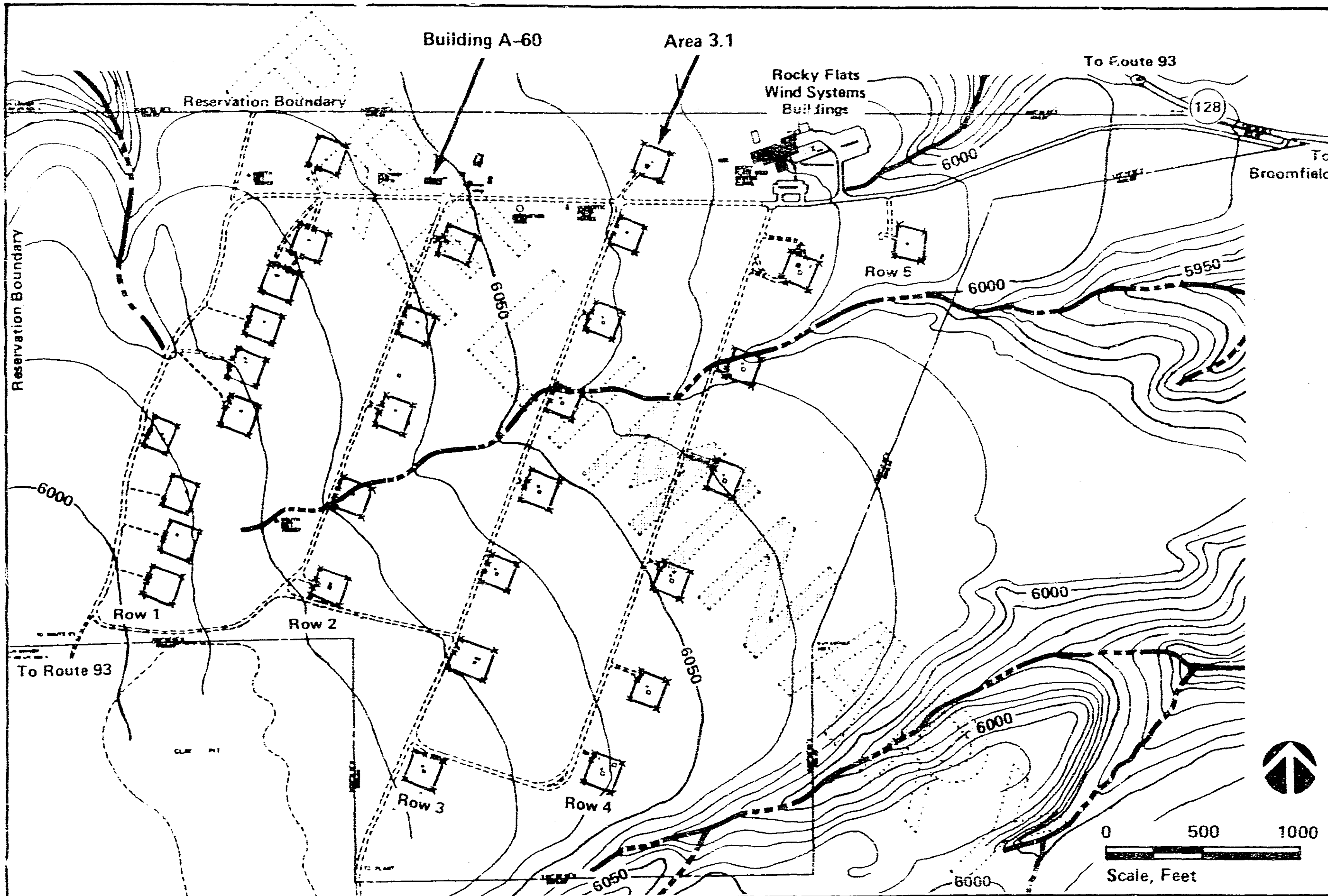
Waste Disposal

The Environmental Safety and Health Manual requires that the ES&H staff be responsible for final disposal of all chemical waste generated at SERI and that the maximum quantity of chemical waste stored at SERI at any one time should not exceed 1,000 gallons (SERI, 1984).

Hazardous waste stored at the Building 16 and FTLB 180/270-day accumulation areas is removed from SERI for off-site disposal by two separate contractors. In 1985 and 1986, the quantities of hazardous waste generated at SERI and disposed of by these two contractors were 7,717 kg and 1,142 kg respectively (SERI, 1986a; 1987a).

The primary contractor used for off-site hazardous waste transportation and disposal is Rollins Environmental Services, Inc., which disposes of the vast majority of hazardous waste generated at Building 16 and the FTLB. Shipments of hazardous waste are disposed of by Rollins at an approximate frequency of twice per year (SERI, 1987b). The timing of visits by Rollins to pick up a shipment of hazardous waste is determined by factors external to SERI. Visits are scheduled in accordance with those of other small-quantity generators in the Golden, Colorado, area in order to share waste shipping costs. Since the timing of the visits is beyond the control of SERI and a complete, accurate inventory of wastes is not maintained, SERI cannot easily determine whether either its own 1,000-gallon maximum storage limit or the RCRA small-quantity generator 6,000-kg maximum limit has been exceeded.

The ES&H Group does not perform most of the activities associated with preparing the waste for shipment. SERI employees inventory the wastes on the EPA hazardous



Source: Higginbotham and Associates, 1986

WASTE STORAGE AREAS AT WERC

FIGURE 4-5

waste manifests that accompany the shipments; however, Rollins personnel perform the container labeling, sorting, and labpacking or other recontainerization. Rollins removes hazardous waste from both the Building 16, Room 115, and the FTLB, Room 104, 180/270-day accumulation areas.

Wastes shipped by Rollins are disposed of or treated in one of two Rollins RCRA-permitted treatment, storage, and disposal (TSD) facilities, both of which are over 200 miles from SERI. The segregation of wastes between the two facilities is performed at SERI by Rollins personnel. The majority of wastes are disposed of at a landfill in Baton Rouge, Louisiana; incinerable wastes are treated in an incinerator in Deer Park, Texas. The combined volumes of these shipments have averaged approximately 40 drums per year.

The second contractor relied on for hazardous waste disposal is the Oil and Solvent Process Company (OSCO). SERI disposes of waste oils with OSCO. OSCO operates a RCRA-licensed storage and treatment facility located in Henderson, Colorado, approximately 20 miles northeast of SERI. Since the facility is located within 200 miles of SERI, only a 180-day accumulation period is allowed for the wastes disposed of through OSCO. SERI personnel perform the manifesting and any recontainerization of waste associated with these shipments. However, SERI has no documented procedures describing what activities are to be performed by SERI personnel in connection with these shipments. After leaving SERI, the waste is first received by the RCRA-permitted OSCO TSD facility. Only after OSCO receives the waste is it determined how the waste will ultimately be managed. Some of the waste, once cleaned, is acceptable for sale as supplementary boiler fuel. The remainder is disposed of in one of two RCRA-permitted hazardous waste disposal landfills in West Covina, California, and Kettlemen Hills, California.

Noncollectable Chemical Wastes

As stated earlier, an unmeasured volume of potentially hazardous waste is disposed of in the laboratory drains at Building 16 and the FTLB. In addition, a photographic laboratory located on the first floor of Building 15 is known to be disposing of chemical substances down the drain. In all three buildings, the flow from the laboratory drains eventually enters the public sanitary sewer system. However, all three buildings process the waste through either neutralization or neutralization/settling systems before allowing it to enter the sewer (Figures 2-2 and 4-3).

Building 16 and the FTLB both have systems similar to each other. Each system receives discharges from the laboratory drains only, which travel in corrosion-resistant glass piping to a settling tank. The overflow from the settling tank passes through a limestone-filled neutralization tank. Fist-sized cobbles of limestone are used in the tanks. Overflow from this tank enters the sanitary sewer. The two tanks adjacent to Building 16 are underground (i.e., they are USTs) and were installed in June 1978, have a capacity of 1,200 gallons, are covered, are constructed of concrete, and the neutralization tank is reportedly lined with a polyethylene-type material. Those in the FTLB are in the basement above the floor (i.e., they are not USTs) and were installed in 1983, have a capacity of 350 gallons, are covered, and are constructed of a fiberglass-reinforced plastic-type material. Since neither system has any control over the type, volume, or flow rate of waste passing through it, the degree of settling and neutralization to which the waste is subjected is not controlled. SERI has no procedures for controlling, maintaining, or measuring the performance of these two treatment systems, so it cannot be determined whether the waste entering these systems is effectively treated before entering the sanitary sewer.

The neutralization tanks at Building 16 and the FTLB were recharged with fresh limestone in 1987. The contents of the settling tanks have never been removed. The waste limestone in the neutralization tanks was removed by an outside contractor, Newsome Construction Company of Golden, Colorado. The waste was not chemically analyzed to determine its hazardous characteristics, but was mixed with soil in a 6:1 (soil to waste) ratio and disposed of by the contractor as a nonhazardous solid waste in the Jefferson County Solid Waste Landfill.

The system in Building 15 is located in the first floor stairwell closet on the east side of the building (Figure 2-2). It was identified to the Survey as consisting of a single 160-gallon polyethylene neutralization tank filled with fist-sized limestone cobbles (Figure 2-2). This system receives waste from only the floor and sink drains in the two-room photo laboratory in Building 15. As with the other treatment systems, no control is exerted over the volume or flowrate of waste passing through the system, so the degree to which the waste is neutralized is not controlled; however, the wastes are limited to photo developers, fixers, activators, and various chemicals associated with photoprocessing. These chemicals are very dilute and may not be hazardous when disposed of down the drain; however, the dilution and volume of waste entering the system are not measured.

The primary hazardous component of the waste is ionized silver, which may precipitate and settle in the tank. Also of concern is ionized chromium, which also may precipitate and settle in the tank; however, the quantity of chromium used in the laboratory, though unmeasured, is substantially less than the quantity of silver. Such a mixture of precipitates would fall under the definition of a characteristic toxic hazardous waste if either the silver or the chromium concentration is greater than 5.0 mg/L using the EP toxicity test.

SERI has no procedure for controlling, maintaining, or measuring the performance of the treatment system in Building 15, so it cannot be determined whether the waste entering this system is effectively treated before entering the sanitary sewer. The limestone contents of the Building 15 tank have been removed twice on unspecified dates since it was installed in 1979 by an off-site contractor hired by Denver West Management, the company that manages the office complex. It is not known whether the waste limestone was analyzed by the contractor and properly disposed of if it was determined to be hazardous.

In addition to the laboratory drains, noncollectable potentially hazardous waste from spills may also enter the floor drains in the FTLB. However, flow from the floor drains does not pass through the settling/neutralization system in the FTLB and is routed along with any dilution directly to the sanitary sewer. Except for the Building 15 photo laboratory, there are no other floor drains in Buildings 15 and 16.

Another source of noncollectable chemical waste is in Laboratory 131, a high bay in the FTLB. This laboratory does research in liquid fuels distillation from wood pulp. One of the by-products of this research is a heavy oil which coats the inside of one of the process vessels. At irregular intervals (every 1 to 4 months), the reactor vessel is rinsed out with acetone, generating a variable quantity, generally 5 to 12 gallons, of a potentially hazardous waste liquid containing acetone and the polycyclic aromatic hydrocarbons (e.g., anthracene, chrysene, fluorene) that are expected to be found in the heavy oil. This liquid is disposed of by incineration in a flare in the high bay.

This flare also has several uses in the research project for testing the combustion properties of various fuels. The flare has controls on its feed, combustion air, and temperature, but it has no pollution control device on its effluent; however, the flare effluent is analyzed for its composition. This disposal technique may or may not be considered open burning of hazardous waste depending on various interpretations of RCRA regulations. However, no clear violation of RCRA regulations has been identified by the Survey in connection with the flare.

In general, documentation relating to many of the activities surrounding the handling of hazardous waste at SERI either is not available or does not exist. This documentation includes descriptive information and procedures in the following areas:

- the transport of hazardous waste off-site between the Permanent Site and the Denver West Office Park;
- the handling of hazardous waste in laboratories when accumulation containers are not present;
- the segregation of hazardous and nonhazardous waste pump oils;
- the management of unidentified hazardous wastes;
- the storage of hazardous waste in any of the 180/270-day accumulation areas;
- the specifications of Room 115 in Building 16, Room 104 in the FTLB, and the Solvent Waste Storage Room in Building 8806 as 180/270-day hazardous waste accumulation areas; and
- the preparation of hazardous waste for off-site shipment.

4.1.1.2 Mixed Radioactive and Hazardous Waste

SERI does not currently generate, store, treat, or dispose of any mixed radioactive and hazardous waste. Its past activities also have not dealt with this waste type. No formal procedures exist at SERI to identify or manage this type of waste.

4.1.1.3 Radioactive Waste

Radioactive waste is generated at SERI in minute quantities. Only one shipment of radioactive waste has ever been shipped from SERI. This shipment occurred in March 1987 and contained 0.1975 microcurie of solid and liquid radioactive materials in a volume of 23.5 cubic feet. The disposal was handled by RAMP Industries, Inc., a licensed radioactive waste transporter, and final disposal was at the commercial low-level radioactive waste burial facility in Beatty, Nevada (SERI, 1987b). RAMP also volume-reduces and solidifies the liquid radioactive wastes at its licensed processing facility in Colorado prior to disposal. Wastes for this shipment were accumulated in the hazardous waste accumulation area in Room 115 in Building 16.

Since that shipment, only minute quantities of radioactive waste have been generated at SERI. The two laboratories currently handling radioactive materials and therefore generating radioactive waste are Laboratory 288 in Building 16 at the Denver West Office Park and Laboratory 206 in the FTLB at the Permanent Site. In Laboratory 288 in Building 16, unspecified wastes contaminated with 0.4 microcuries of tritium and sulfur-35 are stored individually in two dated, 2-gallon sealed containers in a cabinet beneath a sink. The containers were dated 1985. In Laboratory 206 in the FTLB, unspecified waste contaminated with carbon-14 is stored in a covered 2-gallon bucket on the floor next to the hood in the southeast corner. It is not known why the radioactive waste dated 1985 in Laboratory 288 was not disposed of in the March 1987 off-site shipment of radioactive waste. Information identifying the materials stored in Laboratory 206 as either waste or nonwaste was not available to the Survey team.

Laboratory 206 also has a refrigerator used for storage of radioactive materials. The refrigerator contained several dozen variously sized vials, some of which were labeled as radioactive. Not all containers had specific isotopes identified on their labels. A two-page inventory sheet on the refrigerator door is dated 1983 and 1984.

Isotopes listed on the inventory sheet include microcurie quantities of tritium, carbon-14, phosphorus-32, and sulfur-35. The radioactive materials in the refrigerator are not positively identified as either waste or nonwaste materials. However, since the half-lives of phosphorus-32 and sulfur-35 are relatively short (14.3 and 88 days, respectively) compared to the time for which they have been stored (longer than 3 years), it is possible that the materials are no longer useful and are actually waste. Among the materials stored here are liquid scintillation solutions containing carbon-14 and sulfur-35 generated at a scintillation counter located in Laboratory 217 in the FTLB. SERI currently uses and has used since 1981 only nonhazardous biodegradable scintillation solutions. The ethanol-based solutions contain varying concentrations of sodium acetate, hydrochloric acid, and pseudocumene. SERI reported that hazardous-solvent-based scintillation solutions (e.g., toluene, xylene) have never been used.

Historically, in 1985 SERI used the following five isotopes in its research activities: tritium, carbon-14, phosphorus-32, sulfur-35, and iodine-131 (SERI, 1986a). In 1986, only tritium, carbon-14, phosphorus-32, and sulfur-35 were used at SERI (SERI, 1987a). In both cases, only microcurie quantities of isotopes were used.

In the two above-mentioned laboratories, wastes are stored at their points of generation until the ES&H Group collects them at the request of the Laboratory Supervisor. The laboratory SOPs do not address the time and quantity limits for storage of radioactive waste in the laboratories or any details associated with the handling of radioactive waste (e.g., containerization, labeling).

SERI has documented its procedures for the management of radioactive wastes in Section XIV of the Environmental Safety and Health Manual.

4.1.1.4 Nonhazardous Waste

The nonhazardous wastes at the Permanent Site, the Denver West Office Complex, and WERC include office waste (e.g., paper and cardboard) and wastes generated in the laboratories. The laboratory wastes include waste paper, plastic, rubber, glassware, and laboratory equipment, some of which may be contaminated with nonhazardous and hazardous chemicals in trace concentrations.

Also, at the Bioannex (Building 8606) at the Permanent Site, several cubic yards of nonhazardous acid-digested aspen wood chips are generated at irregular, infrequent intervals as part of a biomass research project.

Various nonhazardous biological wastes also are generated at SERI. These wastes are generated in various laboratories, but research involving biological waste generating activities is generally confined to the second floor of Building 16 and the first floor of the FTLB. These wastes are characterized and managed on a case-by-case basis in each laboratory. The wastes are disposed of in an autoclave on the first floor of the FTLB, and the resulting residue is disposed of down the drain.

SERI has not attempted to characterize its nonhazardous waste either qualitatively or quantitatively, and no formal documentation exists describing the general or specific characteristics of its nonhazardous wastes. Nor are any procedures documented for the identification, segregation, and handling of nonhazardous solid waste at SERI.

At the Permanent Site, the waste is collected in a variety of accumulation containers or is bagged at its point of generation. The waste is then transferred to one of four 2-cubic-yard containers located at the Permanent Site. These containers are emptied by an outside contractor, U.S. Disposal Systems, Inc., and is disposed of off-site at a private landfill in Jefferson County operated by JeffCo Reclamations (Higginbotham & Associates, 1986).

Nonhazardous waste at Buildings 15, 16, and 17 and at WERC is handled in a similar fashion. The central waste collection containers at these facilities are emptied by outside contractors. At Buildings 15, 16, and 17, the containers are leased from and emptied by a contractor for the property manager, Denver West Management, and at WERC the containers are emptied by Rockwell International Corporation, with whom the facility is shared. Rockwell operates the adjacent Rocky Flats DOE facility. In both cases, SERI personnel are not involved in the disposal of waste.

Although the sanitary waste at the Denver West Office Complex and the Permanent Site are channeled directly into the Metropolitan Denver Sewage Disposal District (MDSDD) collection and treatment system, the sanitary waste from WERC is instead disposed of through four on-site underground septic tanks, as discussed in Section 3.3.2.2.

4.1.2 Findings and Observations

4.1.2.1 Category I

None

4.1.2.2 Category II

1. Improper storage of potentially hazardous unidentified wastes. Potentially hazardous unidentified wastes are being stored at the Permanent Site Boneyard and at Building A-60 at WERC in a manner such that they may release hazardous constituents to the soil and atmosphere.

   At the Permanent Site Boneyard, the following wastes of concern have been stored for an indefinite time: three full unlabeled 1-gallon paint cans; two full 5-gallon metal cans, one unlabeled and the other labeled "gear lubricant"; two full unlabeled white polyethylene 5-gallon jugs, one open and containing a dark oily liquid; four unlabeled red plastic drums containing sodium nitrate, one of which is open; and approximately 12 drums of calcium carbonate. These wastes are being stored directly on the ground without spill containment in a manner which can potentially release hazardous substances to the soil and atmosphere.

   At the WERC Facility outside Building A-60, a drum labeled "COLD LIQUID WASTE" is being stored outdoors without spill containment on a pallet resting on soil. The drum has been stored at this location for an indefinite time. The drum labeling indicates that the contents are nonradioactive; however, the contents are not specifically identified. The drum is believed to have originated from the adjacent Rocky Flats Plant. The drum contents are potentially hazardous, and the present condition in which the drum is stored may cause the drum to fail, releasing its contents to the soil and atmosphere.

Access to the waste drum is uncontrolled, creating a potential health risk to any SERI employees who may unintentionally mishandle the wastes.

4.1.2.3 Category III

None

4.1.2.4 Category IV

1. Improper storage of hazardous waste. Twenty-four industrial batteries are being stored at Area 3.1 of WERC in a manner such that they may release lead to the soil.

   At the WERC Facility, Area 3.1, 24 drained batteries are being stored outdoors without spill containment on pallets which are resting on soil. The batteries have been stored at that location for an indefinite time. Several of the battery cases have cracked, allowing any liquid effluent, potentially containing lead, to leak out to the surrounding soil and exposing the lead plates within the battery to the environment. The cracked batteries are uncovered and are exposed to precipitation and climatological temperature extremes, which can result in lead dissolution and soil contamination.

2. Possible disposal of hazardous wastes into a sanitary landfill. SERI is allowing disposal of potentially hazardous wastes from neutralization tanks at Buildings 15 and 16 and the FTLB into a sanitary landfill in violation of RCRA regulations.

   The Building 15 limestone-filled neutralization tank receives all materials disposed of in the first floor photo laboratory floor and sink drains. These materials have not been characterized quantitatively but are known to include acidic and caustic developer and fixer, some containing dissolved silver and chromium salts, which may potentially precipitate in the tank creating a sludge that may be classified as characteristic toxic hazardous wastes D011 or D007, respectively, according to 40 CFR Part 261.24. The tank is reported to be 3 feet by 3 feet by 30 inches in size and was filled with 4.5 tons of limestone. The tank has been emptied of and refilled with limestone by a contractor twice since 1979 at indefinite times, and the resulting waste limestone and any sludge coating on it were disposed of by the contractor. It is not known whether the wastes were characterized before they were disposed of in a municipal solid waste landfill.

The laboratory drains in the FTLB discharge to a treatment system consisting of two 350-gallon tanks operated in series. The first tank is used for settling and the second tank, which discharges directly to the sanitary sewer, is limestone-filled and is used for pH neutralization. The types, quantities, and concentrations of wastes disposed of in the laboratory drains are not adequately controlled or characterized and may be hazardous.

Building 16 laboratory drains discharge potentially hazardous wastes to a similar waste system consisting of two 1,200-gallon tanks, and these discharges have likewise not been characterized.

The solids collected in the FTLB and Building 16 settling tanks have never been removed and may be hazardous due to the nature of the waste materials processed by the systems. The limestone with any attached sludge was removed from the FTLB neutralization tank in September 1987, and that from the Building 16 neutralization tank was removed in October 1987. The solids removed from these tanks totaled a reported 11.5 tons and were mixed with soil and disposed of as nonhazardous waste in a sanitary landfill. However, no waste determination was performed in accordance with 40 CFR Part 262.11 to determine whether these solids were hazardous. The solids were potentially hazardous and could contaminate the soil of the sanitary landfill where they were ultimately disposed of.

3. Inadequate hazardous waste management practices. Hazardous waste management practices at Building 16, Room 115 and the FTLB, Room 104 do not meet RCRA requirements for hazardous waste 180/270-day accumulation areas operated by a small-quantity generator, resulting in potential release of hazardous waste to the soil, groundwater, and surface water. RCRA noncompliances which were identified by the Survey team are listed for each waste storage area in Table 4-3.

TABLE 4-3

RGRA NONCOMPLIANCES AT SERI HAZARDOUS WASTE 180/270-DAY ACCUMULATION AREAS

Noncompliance	40 CFR Regulation	Accumulation Areas	
		Bldg. 16 Room 115	FTLB Room 104
Waste have not been identified and labelled	262.34 (a) (3)	X	X
Accumulation times not marked on containers	262.34 (a) (2)	X	X
Wastes have remained over 270 days	262.34 (e)	X	
Emergency information is not posted next to telephone	262.34 (d)(4)(ii)	X	X
No telephone or external communications device	265.32	X	
Inadequate aisle space	265.35	X	X
Inadequate separation of incompatibles (hydrofluoric acid)	265.177	X	X

With regard to inadequate container identification and labeling, in Building 16, Room 115, approximately 55 small glass and plastic bottles (less than 250 mL) and two larger polyethylene bottles (3 to 5 gallons) were not identified or labeled and a 55-gallon drum of waste oil was not clearly marked as either hazardous or nonhazardous waste, and in the FTLB, two 55-gallon drums of a hazardous scrubber solution were not marked as such. Inadequately identified and labeled hazardous wastes are likely to be misidentified and mismanaged as nonhazardous solid wastes.

Additionally, the Survey found that accumulation times were not being marked on containers and that accumulation times exceeded the 180/270-day RCRA small-quantity generator limits. At Building 16, Room 115, the 55 small bottles were accumulated from between 1982 and 1985, and most were not marked with accumulation start dates; a 55-gallon hydrofluoric acid drum was not marked with an accumulation start date; and a bottle of ether (approximately 1 liter) had been stored for an indefinite period exceeding 270 days and did not have an accumulation start date. At the FTLB, Room 104, no wastes were labeled with accumulation start dates, including containers of spent sodium hydroxide scrubber solution, hydrofluoric acid, ethylene acetate, and triethylene glycol.

Four other RCRA noncompliances were identified by the Survey team. At Building 16, Room 115, no telephone or other communications device is located in the immediate vicinity (40 CFR Part 265.32). No emergency action information is posted in the vicinity of Building 16, Room 115 or the FTLB, Room 104 (40 CFR Part 262.34). Neither area has adequate aisle space such that all waste containers may be freely accessed (40 CFR Part 265.35). Both areas are storing waste hydrofluoric acid without providing secondary containment from other wastes (40 CFR Part 265.177).

4. Insufficient management of hazardous waste at satellite accumulation areas. Hazardous wastes at SERI satellite accumulation areas are not sufficiently identified, inventoried, segregated, stored, or labeled to be in full compliance with RCRA regulations. These practices may result in the mismanagement of hazardous wastes.

Hazardous wastes that are not properly identified, inventoried, segregated, stored, and labeled may be improperly managed by waste generators or ES&H personnel. Improper hazardous waste management practices may release hazardous constituents into the soil and surface waters from discharges to the wastewater sewer system, to the air from inadequate thermal treatment and venting from open waste containers, or to the soil or groundwater by unacceptable off-site disposal methods.

The Safety Policy/Procedure for waste disposal dated June 1, 1981, is inadequate to ensure that hazardous wastes are properly identified, inventoried, segregated, stored, or labeled in accordance with RCRA. The policy/procedure places major responsibility on the individual researchers and generators to make critical decisions on what is hazardous and what is acceptable for discharge to the municipal sewage treatment plant through the laboratory drains. When approved SOPs are available in a laboratory, they are often derived from the Safety Policy/Procedure, which does not contain provisions to fully ensure the safe management of hazardous wastes.

The following examples represent problems found associated with identifying, inventorying, segregating, storing, and labeling hazardous wastes:

<u>Identification</u>

Identification of hazardous wastes is a problem that can be found throughout SERI. The Safety Policy/Procedure only provides minimal guidance to the researchers who generate waste on identifying potential hazardous waste. The Safety Policy/Procedure states that waste is to be identified and subsequently segregated into three categories, aqueous wastes, nonhalogenated organic wastes, and halogenated organic wastes. However, the only two general types of hazardous waste identified in the laboratories are "organic wastes," which for the most part are solvents, and "aqueous wastes," which are mostly acids. RCRA-listed wastes and toxic wastes are not given special recognition as hazardous wastes. Lack of proper identification may contribute to potentially hazardous wastes being poured into the laboratory sinks by researchers and generators.

Inventorying

The primary method of inventorying hazardous wastes generated in the laboratories is by using a Waste Container Logsheet. The logsheets frequently do not correspond quantitatively to the container contents. Waste disposal entries on a logsheet occasionally do not clearly identify the wastes. Waste containers are located in some laboratories without accompanying logsheets. Also, some logsheets are posted in laboratories with no corresponding waste accumulation containers, and some inventory logsheets are not numbered to connect them to a specific waste disposal container.

In Building 16, Laboratory 383, no inventory logsheet could be found with the organic waste container; Laboratory 384 had not used the waste containers or recorded any information on the inventory logsheets since December 1985; in Laboratory 369 the inventory logsheet is unmarked so it cannot be determined if it is for aqueous waste or organic wastes; in Laboratory 286 the aqueous waste container contained approximately 2 gallons of waste, but only 500 mL of waste had been recorded on the inventory logsheet; in the same laboratory, the organic container contained approximately 5 gallons of waste yet only 1 liter was recorded on the inventory logsheet; in Laboratory 216 waste was in the aqueous waste container but nothing was recorded on the inventory logsheet.

Inadequate inventorying of hazardous waste can lead to potential mixing of incompatible substances in a waste container, which could subsequently lead to an uncontrolled release (e.g., fire or explosion) of hazardous substances to the environment. In addition, inadequate inventorying can lead to an unrecognized exceedance of the small-quantity generator monthly waste generation limit of 1,000 kg.

Segregation

Most laboratories have two hazardous waste containers, one for all aqueous waste and one for organic waste. Some of these laboratories handle chemicals from which the generated waste may not be compatible with wastes already in the aqueous or organic waste containers, especially since the wastes within these containers are not specifically identified on the logsheets. Reactive wastes, which are given little recognition as a hazardous waste problem, could be inadvertently deposited in the aqueous waste container. Laboratories do not consistently have SOPs that address the special procedures necessary to dispose of these wastes other than the general guidance for aqueous and organic wastes in the waste disposal Safety/Policy Procedure. Segregation of hazardous wastes is a potential problem that can be found throughout SERI, primarily because hazardous wastes are not being adequately identified. Improper waste segregation can lead to the mixing of incompatible substances in a waste container, which could potentially produce an uncontrolled release of hazardous substances to the laboratory, subsequently resulting in an atmospheric release through the building ventilation system or a release to the sanitary sewer.

Storage

Some organic solvent waste is stored in plastic containers in violation of the SERI Safety Policy/Procedures Manual, which calls for metal containers. In Laboratories 269 and 369 at Building 16, organic wastes were stored in plastic containers. In addition, organic and aqueous hazardous waste containers are not kept closed at all times as required by 40 CFR Part 265.173. Open waste containers were found in Building 16, Laboratory 103, in the FTLB, and Laboratories 140, 142, and 151.

Labeling

Some waste containers do not have labels correctly identifying their contents as hazardous waste in accordance with 40 CFR Part 262.34(c)(1)(ii). Some containers labeled as hazardous waste are used as nonhazardous solid waste containers. The contents of these containers are disposed of in a nonhazardous solid waste landfill. The presence of a hazardous waste label on such a container increases the possibility that hazardous wastes will be placed in that container, and that these hazardous wastes will eventually be released to the environment by subsequent disposal in a sanitary landfill. Some hazardous waste containers are not labeled adequately so that the proper inventory logsheet can be matched with the waste container. Inadequate hazardous waste container labeling can lead to possible misidentification of the container contents, potentially resulting in waste mishandling.

In Building 15, an unlabeled waste container was found in the Stat Camera and Production Storage Room. Unlabeled waste containers also were found in Building 16, Laboratories 102 and 371. In Laboratory 109 of Building 16, a container labeled as a hazardous waste container was being used as a nonhazardous solid waste disposal container.

5. <u>Treatment of hazardous waste by detonation without a RCRA permit</u>. Hazardous waste petroleum ether is being treated using a "shoot and burn" procedure at the Permanent Site without a RCRA permit.

   Hazardous wastes have been generated in small quantities in SERI laboratory facilities. On one occasion, less than 1 gallon of petroleum ether waste was treated by a "shoot and burn" detonation process at an unspecified location at the Permanent Site. Treatment of hazardous waste by detonation is a RCRA-regulated thermal treatment process identified in 40 CFR Part 265.382. This process requires the submission of a Part A EPA permit application as described in 40 CFR Part 270. A small quantity (approximately 1 liter) of waste anhydrous ether is currently being stored in Building 16, Room 115, and is awaiting "shoot and burn" treatment. Anhydrous ether waste is classified a reactive waste in 40 CFR Part 261.23(a)(6).

6. <u>Lack of proper approvals for transporting hazardous waste</u>. SERI lacks proper RCRA approvals and identification numbers for transporting and receiving hazardous waste at the Permanent Site and the Denver West Office Park.

   The hazardous waste generator's number issued to SERI only applies to the Denver West Office Park (Buildings 15, 16, and 17). The Permanent Site is geographically separate from the Denver West Office Park and therefore is not considered "on-site" as defined in 40 CFR Part 260.10. Wastes are generated at the Permanent Site that are or may be hazardous. Wastes generated at both the Denver West Office Park and the Permanent Site are transported by SERI personnel between the two facilities over public highways without an EPA manifest or transporter identification number as required by 40 CFR Part

262.12 and Part 263 Subpart B of RCRA. The hazardous waste storage facilities at Building 16 and the Permanent Site do not have RCRA storage permits or identification numbers allowing them to receive manifested hazardous waste from off-site locations.

4.2 Toxic and Chemical Materials

This section discusses the usage, storage, disposal, and management of toxic chemicals, herbicides/pesticides, asbestos, and polychlorinated biphenyls (PCBs), and the possible environmental contamination resulting from release of these substances from the SERI site into the environment.

4.2.1 General Description of Pollution Sources and Controls

4.2.1.1 Polychlorinated Biphenyls

Since the SERI complex is relatively new, no equipment containing PCBs has been used since its inception. Consequently no provisions for storage, handling, or disposal of PCBs are necessary at SERI.

4.2.1.2 Asbestos

No asbestos is used, handled, or stored at SERI, precluding the need for formalized specific handling, storage, or disposal protocols. However, a ceramic-fiber material is used extensively in high-temperature applications in place of asbestos. This material has properties similar to asbestos but is made from acicular aluminum silicate instead of magnesium silicate. The commercial name is Cerablanket, and it is available in sheets or in clumps of loose fiber. It degrades at temperatures above 1,000°C, and the silica recrystallizes into cristobalite, which is hazardous and may be classified as a carcinogen (Manville Sales Corp., 1988). At SERI the material is used exclusively on experimental test equipment, particularly in the molten salt experiments in the FTLB. Since there are no regulations currently applied to this substance, SERI personnel treat ceramic-fiber insulation as innocuous material.

4.2.1.3 Pesticides (Herbicides, Insecticides, Rodenticides, Algicides)

No pesticides are stored at SERI and only limited use is made of rodenticides in the form of enclosed bait boxes placed inside buildings. Herbicides and algicides are not used at SERI and insecticide application is handled by off-site contractors. Pesticides are used at SERI to control insects. To date FICAM W and FICAM PLUS have been the only insecticides used. The pesticides are applied by off-site contractors on an as-needed basis under the direction of the Safety and Health section at SERI. All mixing of pesticides is done off-site by the contractor and quantities used are reported, as required by SERI procedures, to SERI Health and Safety personnel.

4.2.1.4 Toxic and Process Chemicals Procurement and Inventory Control

SERI uses a wide variety of toxic chemicals in small quantities, primarily in wet chemistry research and development activities. Bulk-quantity chemicals are used in some pilot-scale experiments but use is transitory in nature, because usually the actual test duration is short, with some experiments lasting only a few months. SERI is a research facility so there are no large-quantity, continuous-use process chemicals used. The SERI chemical purchasing procedure and the chemical receiving, distribution, and storage practices are discussed below.

Chemical Purchasing

Chemical purchases at SERI are made by the laboratory managers. Requisitions are submitted to the Procurement and Supply Department, which maintains bulk-chemical distribution and storage areas, known as Central Stores, which includes Rooms 106 and 107 in the high bay section of the FTLB as well as area 104 of the FTLB. The requisitions specify the chemical needed, quantity required, order number, date, laboratory room number, signature of requisitioner, and building name. Procurement maintains a list of all purchases. Copies of purchase orders are retained by the Safety and Health Section. Individuals are permitted to purchase small-quantity chemicals directly but must submit information to the Procurement Office concerning the chemical name, quantity, and particular hazards associated with that chemical.

Purchase orders are issued and, upon receipt of shipment, the chemicals are listed in a computer-managed comprehensive inventory containing the chemical name, account number, Chemical Abstracts Service (CAS) number, specific laboratory, quantity, name of requisitioner, expiration date, and special hazards associated with a particular chemical. Material Safety Data Sheets (MSDSs) are maintained at chemical storage areas and in the Safety and Health section.

Receiving, Distribution, and Storage

In the Central Stores in the FTLB high bay, Room 106 is used for flammable liquid bulk storage and Room 107 is used for bulk storage of oxidizers and corrosives. Both rooms are locked, vented, and marked as to contents and hazards, and have a concrete curbing for spill containment. Area 104 is a partially enclosed outside bay at the FTLB which is used to store non-toxic compressed gas cylinders and some acids. A portion of the area is used to store hazardous waste in drums, carboys, and lab-packs. This area has a concrete curbing and a drain to a 500-gallon holding tank but is not placarded (Section 4.1.1). Distribution is from Central Stores at the FTLB directly to the requestor. Each laboratory maintains small quantities of chemicals, reagents, and gas cylinders at each point of use and storage in cabinets and lockers in or near the user's work area.

Toxic gas cylinders for SERI are stored at the Permanent Site in a separate building (Number 2907), which is located in an open field approximately 150 yards from the FTLB. The room containing the cylinders is locked and properly marked but is not cooled and is vented directly outside. Access to this building is by a poorly maintained dirt road. Delivery and distribution are made more dangerous by the condition of this road.

An abandoned ammunition bunker at SERI is used to store nineteen 55-gallon drums of pentane. Spill containment is channeled in the bunker to an underground concrete tank with an estimated capacity of 400 gallons. The partially underground bunker is marked, locked, and kept cool using natural insulation. No evidence of recent spills or leakage was observed in any of the storage areas. Many storage cabinets contained acids and solvents, and vents on the cabinets were purposely sealed in response to a requirement of the local fire marshal. Consequently, slow evaporative accumulation of fumes from partially sealed containers stored in the cabinets was noticed when the cabinets were opened.

In laboratories such as Rooms 103 and 191 in Building 16, the photo laboratory in Building 15, and in other laboratories at the FTLB, bottles were observed with efflorescences around the cap, with some showing signs of advanced corrosion. Chemicals not used are returned to the FTLB for storage and redistribution or are taken to one of the 180/270-day hazardous waste storage areas from which they are shipped off-site.

4.2.1.5 Petroleum Product and Hazardous Substance Storage Tanks

This section discusses the aboveground and underground storage tanks at SERI, which are used to store petroleum products, chemicals, and sewage. Characteristics such as tank size, construction, containment, content, and monitoring are also discussed for each tank, in addition to their respective impact on the environment in the event of a spill or leakage.

Aboveground Storage Tanks

Seven aboveground tanks are used at SERI. Five store diesel fuel, gasoline, or turbine oil and are of steel construction. There are two 500-gallon steel tanks at the OTEC facility that contain Chevron Turbine Oil No. 32, a heat exchange fluid. The OTEC facility tanks are situated on racks over a concrete-bermed basin. At WERC, there are three tanks -- a 400-gallon tank used to store unleaded gasoline, a 200-gallon tank for leaded gasoline, and a 200-gallon tank for diesel fuel. An earthen and gravel berm surrounds three sides of the three aboveground storage tanks; the fourth side is open to the surrounding environment and the bottom is unlined.

Additionally, there are two 350-gallon fiberglass-reinforced plastic tanks in series in the crawl space under the FTLB. The first tank receives discharges from laboratory drains and is used for settling. The overflow from the settling tank passes through the second limestone-filled neutralization tank before it discharges to the municipal sewer system.

There is no formal tank integrity testing at SERI, although periodic visual tank inspections are performed on aboveground storage tanks. Information on spill prevention, control, and countermeasures planning at SERI is contained in several documents such as the Emergency Response Plan and Safe Operating Procedures.

Underground Storage Tanks

There are seven underground catchment tanks or sumps and one 10,000-gallon polyethylene fuel oil storage tank at SERI. There are also four 2,000-gallon septic holding tanks at WERC, as described in Section 3.3.2.2.

On the northwest corner of Building 16 are two 1,200-gallon concrete tanks (Figure 2-2); one is a polyethylene-lined neutralization tank filled with limestone, and the other is a settling tank. The laboratory sink effluent from Building 16 in the Denver West Office Park passes through these tanks prior to discharging to the municipal system. In addition, the hazardous waste storage room (115) has a 100-gallon polyethylene catchment tank, which is normally empty.

The FTLB has two 500-gallon polyethylene catch tanks, one serving the flammable and corrosive liquid storage rooms and one serving the hazardous waste storage facility; both are normally empty. The flammable and explosive materials bunker has a partially underground 400-gallon concrete catchment tank that is normally empty.

The Bioannex has a 5,000-gallon concrete holding tank used for temporary storage of liquid wastes from experiments prior to discharge into the domestic sewer system.

All the underground storage tanks at SERI are less than 15 years old. None have secondary protection, although some that are constructed of concrete have polyethylene liners. There is no periodic tank monitoring conducted by SERI, nor is there a leak testing program in place. Flow-through settling and neutralization tanks such as those northwest of Building 16 and at the Bioannex are not regulated as underground storage tanks.

4.2.2 Findings and Observations

4.2.2.1 Category I

None

4.2.2.2 Category II

None

4.2.2.3 Category III

None

4.2.2.4 Category IV

1. Inadequate spill prevention, control, and countermeasures (SPCC) planning. Inadequate spill prevention, control, and countermeasures planning at SERI may result in unnecessary safety hazards and potential soil and surface-water contamination.

   Several examples of inadequate SPCC planning were identified at SERI. These include the following:

   - Insufficient SPCC documentation - SERI has developed several documents which include information on spill control planning, such as an Emergency Response Plan, Safe Operating Procedures for individual programs and projects, and a memo on Institutional Responsibilities. However, there is no single document specifically oriented to spills that includes such information as inventories of equipment, materials, and supplies for coping with spills and procedures for their use; locations of potential spill incidents; requirements for SPCC engineering; emergency contacts; spill incidents reporting procedures; and health and safety procedures. A single document would enable more effective planning and a safer and more effective spill response.

   - Inadequate containment around aboveground product storage tanks - The three aboveground petroleum product storage tanks at WERC and the aboveground hot and cold tanks west of the OTEC Building have inadequate containment, as is discussed in finding 2 of this section.

- Inadequate spill control measures in buildings - Laboratories 107 and 141 in the FTLB contain hydrogen fluoride in gallon quantities but have no neutralization capabilities immediately on-hand in the event of a spill. However, a medical/spill response team, located in the FTLB, is on call. The Hazardous Waste Storage Room (Room 115) in Building 16 has no containment/curbing at the door. The door to this room is next to the exterior door of the building. Spills from drums in the room could therefore flow outside the building. Additional information on the operation of Room 115 is contained in Section 4.1. In some laboratories, spill control devices were noted but there were no instructions on their use.

If a spill were to occur to the outside, with insufficient controls, soils would become contaminated. Spills near drainageways could contaminate water and sediment. Uncontrolled spills indoors, including those potentially resulting from the inadequacies described above, could pose a safety and health hazard to laboratory workers.

2. <u>Inadequate containment around aboveground product storage tanks.</u> Inadequate containment of three aboveground tanks at WERC and two aboveground tanks at the OTEC area may result in soil and surface water contamination, if a spill were to occur.

An earthen and gravel berm surrounds three sides of the three aboveground petroleum product storage tanks (200 gallons leaded gasoline, 200 gallons diesel, 400 gallons unleaded gasoline). The fourth side is open to the surrounding environment and the bottom is unlined. The aboveground hot and cold tanks (each approximately 500 gallons) west of the OTEC Building, which contain Chevron Turbine Oil No. 32, are situated over a concrete-bermed basin. However, the edges of the tank are approximately 6 inches from the curbing. If the sides of the tank are breached, product may spill outside the containment basin.

4.3 Radiation

SERI uses small quantities of radioactively labeled sugar, protein, and enzyme compounds in several laboratories in Building 16 of the Denver West Office Park and in several laboratories in the FTLB at the Permanent Site. Primary radionuclides used consist of tritium, sulfur-35, carbon-14, and phosphorus-32. Experiments involving iodine-125 are expected to be conducted in Building 16 laboratories in 1988. Microcurie to millicurie quantities of various compounds are stored in laboratory refrigerators, and only small amounts of labeled compounds are handled by researchers at any one time. The total inventory of radioactive materials at SERI is on the order of 50 millicuries.

4.3.1 Background Environmental Information

Background radiation in the vicinity of SERI is a consequence of both natural and man-made radiation sources. Natural background radiation in the Denver area is somewhat higher than in many other regions in the United States because of the elevation and the relatively high concentrations of naturally occurring radioactive materials such as uranium, thorium, and members of their decay chains. Locations at high elevations will have a higher background than areas at lower elevations (e.g., sea level) because at the higher elevations there is a thinner layer of atmosphere to absorb cosmic radiation. The EPA reports gamma radiation dose rates for locations throughout the United States on a quarterly basis. During January-March 1986, EPA reported measured dose rates equivalent to annual doses of between 164 ± 47 mrem in Denver, Colorado, and 62 ± 56 mrem in Harrisburg, Pennsylvania (EPA, 1986).

Because of the random nature of radioactive decay and the numerous contributors to background radiation levels, it is not possible to predict the exact background radiation in an area or to accurately differentiate the relative contributions from background and man-made sources. It is possible, however, to estimate typical background levels and also estimate background due to natural sources. For SERI, radiation levels at Denver, Colorado, can be considered to be background. The major components of background radiation exposure are natural sources.

Table 4-4 provides an estimate of the average annual natural background radiation dose for the Denver Metropolitan Area (including the DOE Rocky Flats Plant) (RI, 1986). Of the four sources listed, the primordial nuclides (internal) source does not contribute to the external or direct radiation dose; however, it is the major contributor to the total background radiation dose to members of the public. Since the total radionuclide inventory at SERI is very small (Section 4.3.2), there is no expected measurable increase of ambient radiation levels above background at or in the vicinity of the Permanent Site or Denver West Office Park. 40 CFR 61.93 states that dose equivalents to members of the general public shall be calculated using EPA models AIRDOS-EPA and RADRISK, or other procedures, including those based on environmental measurements, that EPA has determined to be suitable. SERI has based dose calculations on limited environmental monitoring data. The data are discussed in Section 4.3.3.

4.3.2 General Description of Pollution Sources and Controls

Radioactively labeled organic compounds are used or may be used on a non-routine basis in several Building 16 and FTLB laboratories; these are listed in Table 4-5. The Photosynthesis Laboratory in Building 16, Room 288, is the only laboratory within the SERI Denver West Office Complex that uses radionuclide tracers. The laboratory presently uses mostly carbon-14-labeled cell cultures, sugars, and other compounds for photosynthesis and anaerobics research, although tritium and sulfur-35-labeled compounds have been used in past experiments. Approximately 0.4 microcurie of tritium and sulfur-35 radioactive waste is stored in a cabinet under the laboratory sink, and labeled compounds are stored in the laboratory refrigerator. The waste was generated in 1985, according to the dated labels, and some of the radioactive materials in the refrigerator have been stored for more than 2 years, based on inventory records. The distinction between radionuclide inventory samples and waste is not well defined, as some of the stored materials are for experiments which have been discontinued or have exceeded their radioactive life.

The Bioresearch Laboratory in Room 283 of Building 16 was not being used for research with labeled compounds at the time of the Survey; experiments involving iodine-125 labeled proteins are proposed for 1988. The Bioresearch Laboratory is not presently designed for research involving radionuclides, and new laboratory equipment and procedures will be put into place before any labeled compounds are

TABLE 4-4

ESTIMATED AVERAGE ANNUAL NATURAL BACKGROUND RADIATION DOSE FOR DENVER METROPOLITAN AREA

Source	Effective Dose Equivalent (rem)
Cosmic Radiation	0.050
Cosmogenic Nuclides	0.0015
Primordial Nuclides-External	0.072
Primordial Nuclides-Internal	0.1326
Total for One Year (Rounded)	0.26

Source: RI, 1986

TABLE 4-5

LABORATORIES AT SERI THAT USE OR STORE RADIONUCLIDES

Building 16 Denver West Office Complex	Laboratory	Radionuclides Used and/or Stored in Laboratory
283	Bioresearch Laboratory	I-125 (proposed use in 1988)
288	Photosynthesis Laboratory	H-3, S-35, C-14 samples stored in laboratory refrigerator; S-35 and H-3 waste stored in laboratory cabinet; I-125 (proposed use in 1988)
FTLB SERI Permanent Site		
204	Cell Biology/Recombinant DNA	S-35 cell cultures stored in laboratory refrigerator
206/207	Enzyme Laboratory	H-3,S-35,C-14,P-32 stored in laboratory refrigerator; C-14 used in laboratory
217	Cell Biology/Recombinant DNA	S-35, C-14 used in scintillation counter

Source: SERI, 1987c

introduced to the laboratory (DeLaney, 1987b; Hulstrom, 1987). Work will take place under laboratory hoods, and worker training will be provided to SERI personnel by personnel from the DOE Rocky Flats Plant. The total amount of iodine-125 expected to be used in the laboratory is approximately 0.01 mCi, which is the maximum amount allowed at any one time by the safe operating procedure for the laboratory. Waste disposal procedures are not documented.

No radionuclide emission controls are applied to exhaust hoods in the Bioresearch and Photosynthesis Laboratories in Building 16. Small quantities of carbon-14, iodine-125, and other radionuclides are expected to be emitted through the Building 16 ventilation system from the evaporation of solutions containing labeled compounds. These emissions most likely do not or will not have a measurable effect on ambient radiation levels, based on the amount of radioactive materials used in the building. The total amount of such compounds used in Building 16 laboratories is controlled by administrative procedures and is on the order of 10 microcuries.

Radioactively labeled enzymes, sugars, cell cultures, and proteins are used in the Enzyme Laboratories (Room 206/207) and Cell Biology Research Laboratories (Rooms 204 and 217) in the FTLB. Radioactive compounds used in all FTLB laboratories that handle radionuclides are stored primarily in the Room 206 Laboratory refrigerator.

Approximately 1 millicurie of carbon-14-labeled sugars and enzymes were in use in the Room 206/207 Laboratory in a designated hood at the time of the Survey. The Rooms 204 and 217 Cell Biology Laboratories have prepared cell cultures using proteins and other compounds labeled with millicurie quantities of sulfur-35, phosphorus-32, and tritium in designated hoods, but were not using radionuclides at the time of the Survey. The designated hoods discharge to the FTLB radioactive isotope discharge stack. The hood in Room 207 has a particulate filter, which has been in place since FTLB operations commenced. Use of radioactive compounds in the FTLB laboratories is subject to administrative procedures which limit the amount of labeled compounds handled in the laboratories at any one time.

The concentrations of gross alpha- and beta-emitting radionuclides in particulate emissions from the FTLB radioactive isotope stack discharge were determined during the 1986 stack sampling program (ASI, 1987). Samples were taken during one 2-day and one 3-day period in 1986. Radionuclides were detected only during the second phase of the program at concentrations several orders of magnitude below DOE Derived Concentration Guides (DCGs). Data are discussed in Section 4.3.3. Radionuclide sampling was discontinued as of 1987.

Small quantities of radioactively contaminated samples, glassware, and other solid and liquid radioactive wastes are generated in the Enzyme and Cell Biology Laboratories in the FTLB and the Photosynthesis and Bioresearch Laboratories in Building 16. As laboratory operations using radionuclides are limited to a few laboratories, only small volumes of low-level wastes are generated. Aqueous carbon-14 and sulfur-35 scintillation wastes are generated from use of the scintillation counter in Room 217. These wastes are currently stored in the Room 206 and 288 laboratories and have been stored in the waste storage area in Room 115 of Building 16 before shipment. Radioactive wastes are shipped by RAMP Industries for disposal. Only one shipment of radioactive waste has been made from SERI, in March 1987, involving 23.5 cubic feet of waste containing a total of 0.1975 mCi of radioactivity. Waste collection is not performed uniformly throughout the laboratories, as some wastes stored in the laboratories predate the most recent waste shipment.

4.3.3 Environmental Monitoring Program

Baseline gross alpha and beta radiation levels were measured at the SERI Permanent Site between October 1982 and March 1984 (ASI, 1985). Measurements were taken by analyzing the PM-10 fraction (the fraction of total particles less than 10 microns in diameter) of the total particulate samples collected at the Permanent Site, and by placement of thermoluminescent dosimetry (TLD) monitors which measure beta radiation. Two TLDs were placed at the Permanent Site approximately 460 feet west of the FTLB, and one at a location remote from the Permanent Site (the office of the sampling contractor). The locations of the particulate samplers are shown in Figure 3-4 in Section 3.1.3. The average baseline concentration of gross alpha-emitting radionuclides determined from particulate analyses was 0.0042 pCi/m^3, and the average baseline concentration of gross beta-emitting radionuclides was 0.014 pCi/m^3. Gross alpha concentrations were close to counting detection limits (ASI, 1985).

The PM-10 fraction of total particulate measured at the Permanent Site averages about 60 percent, and ranges up to 98 percent. Baseline particulate radiation data were negatively biased to an unknown extent because only the PM-10 fraction of the particulate sample was analyzed. Baseline TLD monitoring performed between October 1982 and October 1983 at the location remote from the Permanent Site showed radiation dose levels of about 108 ± 6 mrem/year. These are consistent with baseline TLD monitoring at the Permanent Site of 109 ± 6 mrem/yr (ASI, 1985) and with natural background radiation levels in the Denver area of 164 ± 47 mrem/yr (EPA, 1986).

Gross alpha and beta radiation levels were measured at the SERI Permanent Site between April 1984 and March 1985 (ASI, 1985). Radioactive substances were used intermittently at the FTLB during this period. Measurements were taken by analyzing the PM-10 fraction of the total particulate samples collected at the Permanent Site and by placing TLD monitors which measure beta radiation. Particulate sampling locations are shown in Figure 3-4 in Section 3.1.3. Two TLD monitors were located approximately 460 feet west of the FTLB and one at a location remote from the Permanent Site. The average 1984 to 1985 concentration of gross alpha-emitting radionuclides from particulate analysis was 0.0040 pCi/m^3 with a standard deviation of 0.0040 pCi/m^3; and the average concentration of gross beta-emitting radionuclides was 0.020 pCi/m^3 with a standard deviation of 0.010 pCi/m^3. Gross alpha and beta concentrations were comparable to the respective 1982 to 1984 baseline levels of 0.0042 pCi/m^3 and 0.014 pCi/m^3 described above. Gross alpha concentrations were close to counting detection limits (ASI, 1985). Gross beta counts were more reliable, as they were away from sensitivity limitations of the instruments.

The particulate radiation data collected during the 1984 to 1985 period of SERI operations were also negatively biased to an unknown extent because only the PM-10 fraction of the particulate sample was analyzed, as discussed above, and because the major portion of the radionuclides used at SERI are in soluble or volatile form and are not efficiently collected by particulate filters. Ambient radiation data therefore cannot be considered representative of SERI operations. However, air emissions of radionuclides from SERI operations are small and probably do not significantly affect ambient radiation levels. TLD monitoring at the Permanent Site and at the remote location in 1984 and 1985 showed radiation dose levels on the order of 105 mrem/year. These are consistent with 1982 to 1984 baseline TLD monitoring (ASI, 1985). SERI conducts no ambient or stack monitoring of radiation at the Denver West Office Park or WERC.

The concentrations of gross alpha- and beta-emitting radionuclides in the FTLB radioactive isotope stack discharge were determined during the 1986 stack sampling program (ASI, 1987). The exhaust was sampled on July 28, July 30, December 8, December 9, and December 10, 1986, for 8 hours each day, and radiation was detected above background levels only during the second sampling period. Data are summarized in Table 4-6. Samples were taken by drawing an air sample from the stack duct upstream of the exhaust fan through a 37-mm polyvinyl chloride (PVC) particulate filter cartridge. Data from the second day of the 3-day sampling period were invalidated by experimental difficulties. The data results are negatively biased to an unknown extent, as radionuclides in volatile form will not be efficiently collected by the filter. The nature of the radionuclides used at SERI (labeled organic compounds) indicates that a significant portion of the total radionuclide emissions escaped undetected, as the compounds are generally in soluble or volatile form. Also, samples were taken from the exhaust fan inlet plenum rather than from the stack itself. The sampling location used is a turbulent flow area, and this may also have biased the results to some extent.

No alpha emitters are used at SERI, and the measured concentrations of gross alpha-emitting radionuclides in the FTLB stack are approximately background. The measured concentration of gross beta-emitting radionuclides in the FTLB stack is at least one order of magnitude below the DOE DCG for phosphorus-32, which has the lowest DCG of all beta emitters used at SERI. Although the data are negatively biased to such an extent that results cannot be considered representative of SERI operations, the total inventory of radionuclides at SERI is small and probably does not significantly affect ambient radiation levels.

4.3.4 Findings and Observations

4.3.4.1 Category I

None

TABLE 4-6

RADIOACTIVITY LEVEL IN FTLB RADIOACTIVE ISOTOPE DISCHARGE STACK

Date	Total Volume (m^3)	Concentration[a]		DOE DCG
		Gross Alpha[b] (pCi/m^3)	Gross Beta (pCi/m^3)	P-32[c] (pCi/m^3)
7/28/86	5.08	<0.02	<0.08	0.9
7/30/86	4.55	<0.04	<0.08	0.9
12/8/86	8.28	0.06 ± 0.4	0.08 ± 0.5	0.9
12/9/86	d	d	d	0.9
12/10/86	8.35	0.07 ± 0.4	0.06 ± 0.5	0.9

Source: ASI, 1987

a Concentration plus or minus 2 sigma counting error.
b No alpha emitters are used at SERI; because of detection limits and counting errors, these values are equivalent to background.
c P-32 has the lowest Derived Concentration Guide (DCG) of all beta emitters used at SERI.
d Samples invalidated by experimental difficulty.

4.3.4.2 Category II

None

4.3.4.3 Category III

None

4.3.4.4 Category IV

None

4.4 Quality Assurance

This section discusses the quality assurance/quality control (QA/QC) aspects of environmental monitoring at SERI and the sampling analysis and data management protocols associated with periodic sampling of air, surface water, groundwater, and wastewater at the site. Subcontractual analytical and sampling protocols are also discussed.

4.4.1 Environmental Sampling

Air samples were collected over a 5-year period at two Permanent Site stations near the FTLB, from a distant background site, and from an isotope discharge stack at the FTLB for various organic, inorganic, and radiometric measurements as discussed in Sections 3.1.3 and 4.3.3. Groundwater samples have been collected from 1982 to the present from a total of five off-site wells for various organic and inorganic constituents and for some radiometric measurements, as discussed in Section 3.4.3. Wastewater samples were also collected during 1986 from Building 16 at the Denver West Office Complex, and from the FTLB and the Bioannex at the Permanent Site for selected physiochemical parameters, as discussed in Section 3.3.3.

A review of the Annual Site Environmental Reports (SERI, 1985; 1986a; 1987a) and of contracts with sampling contractors indicated that no formal chain of custody existed prior to 1987 and samples were acquired without tracking logs or field parameter measurements. A more recent sampling contract, which is presently in effect, resolves most of these deficiencies but the laboratory does not report the QA/QC data to SERI as required by the contract.

4.4.2 Analysis and Data Management

SERI presently contracts with Air Sciences, Inc., to perform their environmental sampling and analysis program. Air Sciences, Inc., in turn, subcontracts the analyses on air, groundwater, and wastewater samples with Greystone Development Consultants and three specialist laboratories; Core Laboratories handles the water samples, Wilson Laboratories handles the air samples, and Acculabs handles the radiation analyses. From 1982 to 1986 the analysis of environmental samples was performed by Air Sciences, Inc., the Rocky Mountain Analytical Laboratory, and En Con Environs Control Services.

The presently used analytical laboratories follow methods outlined by EPA publications. Based on a review of data and reports, it appears that the laboratories maintain good internal chain-of-custody protocols, as samples were logged with date/time sampled, date/time received, date/time analyzed, and the initials of the analyst. A job number and a sample I.D. number were also assigned to each sample received. However, there was no indication that sample blanks, spikes, or duplicate analyses are performed and no evidence that routine instrument calibration checks are made or that standards are used on a daily basis. The laboratories may have an internal QA/QC program but specific data are not reported to SERI. Based on the Survey's review of contracts for laboratory analysis and environmental data generated prior to 1987, no requirements for QA/QC were specified or received.

Most of the pertinent data acquired by the contractors is presented in summarized form in the Annual Site Environmental Report.

4.4.3 Findings and Observations

4.4.3.1 Category I

None

4.4.3.2 Category II

None

4.4.3.3 Category III

None

4.4.3.4 Category IV

1. No formal QA/QC procedures on past environmental monitoring programs. The environmental analytical program at SERI prior to 1987 lacked formal

QA/QC procedures, which may have resulted in baseline data acquired prior to 1987 being of uncertain validity.

Prior to 1987, contracts for environmental monitoring and analysis did not require the contractor to provide specific information related to the quality of the generated data. The contracts did not address tracking logs, field parameters, duplicates, blanks, or spikes, or the use of routine calibration standards and the results of other QA/QC procedures. Additionally, review of the data indicated the analytical contractors did not perform the following QA/QC procedures:

- chain of custody was not documented by subcontractor laboratories;
- tracking logs did not accompany samples from the field through the laboratory;
- parameters, such as temperature, pH, or conductivity, which may provide information indicating possible anomalies if subsequent laboratory measurements are significantly different from field parameters, were not measured in the field during groundwater sampling;
- duplicates, blanks, or spikes were not run on baseline and annual groundwater monitoring samples acquired between 1982 and 1986;
- QC results were not provided in the monitoring and analysis reports;
- the laboratories' use of routine calibration standards was not indicated in data supplied to SERI;
- an environmental QA/QC program, required under Chapter 3 of DOE Order 5484.1 of February 24,1981, was not provided.

2. <u>Quality control cannot be verified on the present environmental monitoring program</u>. The contracted analytical segment of the environmental monitoring program presently in place at SERI does not have comprehensive QA/QC requirements, which may result in data of uncertain validity.

For environmental monitoring program contracts presently in place at SERI, the following QA/QC procedures are not specified:

- field parameters, such as temperature, pH, or conductivity, are not measured on groundwater and surface water samples. These parameters, if consistently and reliably measured, could indicate that possible anomalies in the field sampling results are protocol-related if subsequent laboratory measurements are significantly different from those obtained during field sampling;

- QA/QC results are not contractually required to be provided with the analytical data in the deliverables supplied to SERI by the contractor;

- SERI is not able to verify that QC procedures, such as duplicates, blanks, or spikes are used or that routine instrument calibration checks are made and that traceable standards are used on a daily basis; and

- quality assurance/quality control requirements as delineated in contracts with analytical laboratories are minimal and do not specify chain-of-custody protocols or verification in the form of sign-out forms or daily log copies.

4.5 Inactive Waste Sites and Releases

This section deals with the inactive waste sites that may be present, and spills and other types of releases that may have occurred at SERI. The pollution sources described below are based on site observations; review of historical photographs, unusual occurrence, site planning, and site characteristics reports; and interviews with SERI and neighboring Camp George West personnel.

4.5.1 General Description of Pollution Sources and Controls

Before being transferred by the State of Colorado to the Federal Government for the construction of SERI, the Permanent Site was part of Camp George West, a Colorado National Guard camp. The camp had been formed in 1906 as a state rifle range and was renamed Camp George West in 1934. It received extensive use during World Wars I and II, and during the early to mid-1930s was used to house 250 to 500 homeless men. However, for most of the time between the two wars, Camp George West was used only 2 weeks per year during summer training camp. After World War II, there was a drastic reduction in activity at the camp, although it has remained as a main supply base for the Colorado National Guard.

In the middle 1970s, 300 acres of the camp were turned over to the Federal Government to be used as SERI's Permanent Site. This parcel was largely undeveloped grassland and had been used mainly as a small arms firing range. The developed and highly utilized portion of Camp George West south of the Permanent Site has remained as State of Colorado property. WERC was also undeveloped grassland, used occasionally for livestock grazing, before being transferred from the DOE Rocky Flats Plant to SERI in the mid-1970s. SERI has leased the office space at the Denver West Office Park also since the mid-1970s, at a time when the Office Park was first being developed.

Based on the literature review and observations made during the Survey, few inactive pollution sources are expected, since (1) the Denver West Office Park, the Permanent Site, and WERC were constructed on generally undeveloped grassland; (2) SERI was developed at a time when most environmental and waste management regulations had been implemented; and (3) only small amounts of hazardous wastes are generated at the SERI facilities. As a result, the most likely inactive pollution sources would result from spills, releases, and past activities at Camp George West. A review of unusual occurrence reports and other documentation indicates that no significant spills have occurred to the outside environment at SERI. However, there are no documents specifically detailing inactive waste sites and releases at SERI.

Five inactive sites at SERI that may have received various types of wastes were noted during and in follow-up after the Survey. All are located at the Permanent Site (Figure 4-6) and little information was available regarding the types and quantities of materials disposed of, whether any materials were hazardous, dates of use, and sizes.

<u>Site 1</u> - An area to the northwest of the FTLB had been excavated and partially filled with soil and debris, as depicted in 1982 photographs. However, with the subsequent construction of the FTLB and installation of trailers, the site is not now apparent.

<u>Site 2</u> - Large amounts of concrete debris from Camp George West, an abandoned car, wood debris, and tires are in a northwest-to-southeast-running drainageway near the center of the Permanent Site.

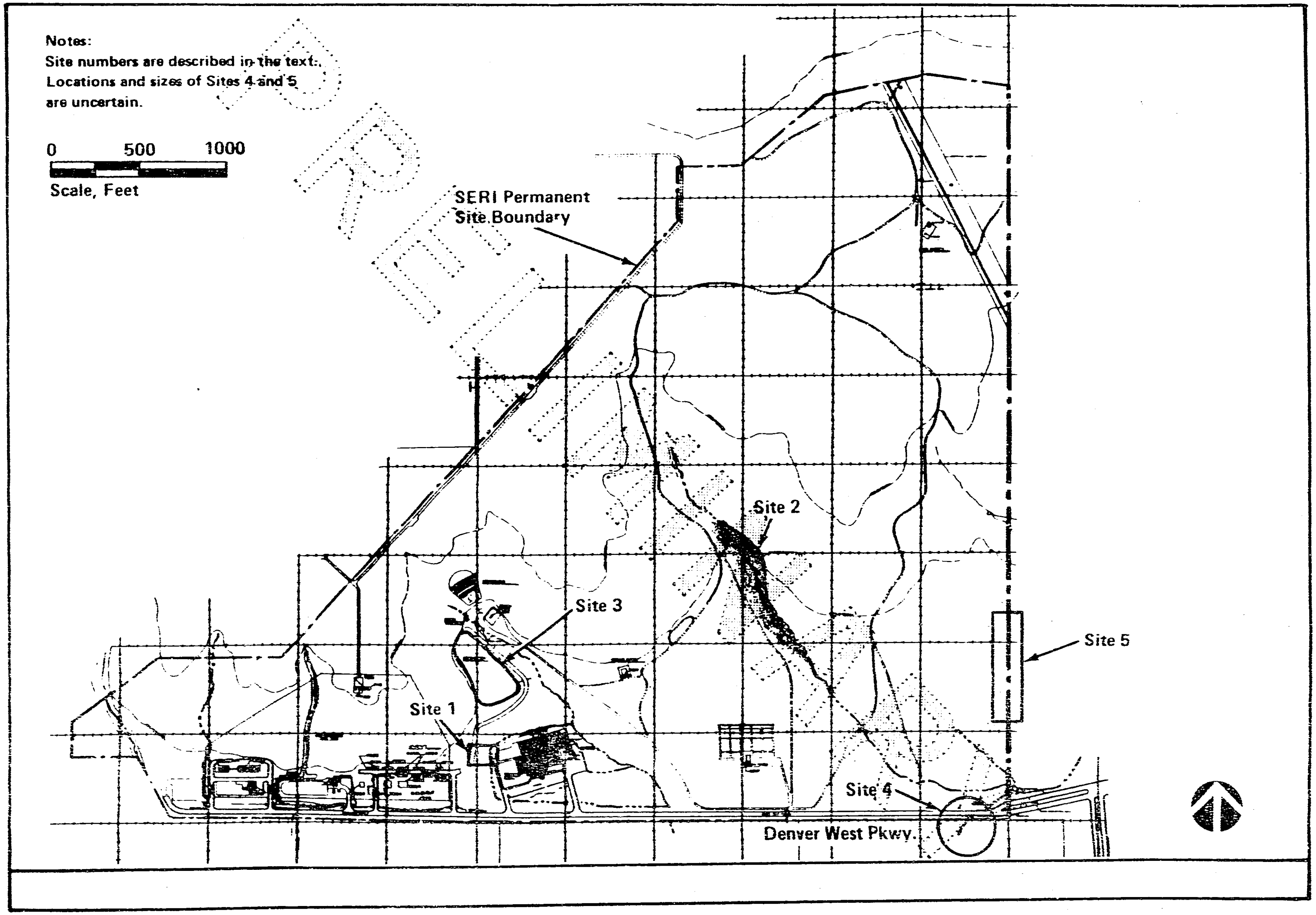
<u>Site 3</u> - Site maps indicate that materials beneath the Storage Area (Boneyard) at the Permanent Site consist of "unconsolidated fill." It is believed that this material is soil excavated during FTLB construction.

<u>Sites 4 and 5</u> - Camp George West personnel indicated that garbage and trash from the camp may have been disposed of at the following two sites in the vicinity of the SERI Permanent Site: a dump near the southeast corner (Site 4) and a dump and burn pit in a flat area near the east side of the site (Site 5) (Hightower, 1987; Conway, 1988). The existence and locations of these sites are highly speculative.

4.5.2 Findings and Observations

4.5.2.1 <u>Category I</u>

None



LOCATIONS OF POTENTIAL INACTIVE WASTE SITES AT SERI

FIGURE 4-6

4.5.2.2 Category II

None

4.5.2.3 Category III

None

4.5.2.4 Category IV

1. Inadequate characterization of inactive waste sites. Inactive hazardous waste sites and releases have not been thoroughly identified and investigated at SERI as required by DOE CERCLA Order 5480.14.

DOE Order 5480.14 of April 26, 1985, requires that each DOE facility submit a Phase I Installation Assessment (IA) report. The purpose of an IA is to evaluate site history and records in order to identify inactive hazardous waste sites that may pose an environmental risk. During the Survey, information obtained through a review of photographs and site records, visual inspection, and personnel interviews indicates the presence of five potential inactive waste sites and releases that could be addressed in an IA. These sites, as described in Section 4.5.1, are:

- soil and debris disposal area northwest of the FTLB at the Permanent Site;
- debris disposal area in a drainageway near the center of the Permanent Site;
- unconsolidated fill beneath the Storage Area at the Permanent Site;
- landfill near the southeast corner of the Permanent Site; and
- landfill and burn pit near the east side of the Permanent Site.

There is presently no evidence that hazardous materials were disposed of at these sites. However, they have not been thoroughly investigated and an IA report has not been prepared. If hazardous materials were disposed of in them, releases from these sites could result directly in soil contamination and potentially surface water and groundwater contamination.

REFERENCES

ACGIH (American Conference of Governmental Industrial Hygienists), 1987. Threshold Limit Values and Biological Exposure Indices for 1987-1988, ACGIH, Cincinnati, Ohio.

ASI (Air Sciences, Inc.), 1985. South Table Mountain Air Particulate Sampling Data Summarization, Monitoring Period April 1984 - March 1985, Final Report, Lakewood, Colorado.

ASI (Air Sciences Inc.), 1987. Air Quality Monitoring-1986, SERI Laboratory Facilities, Golden, Colorado, Final Report, Lakewood, Colorado.

Benefield, L.D., and C.W. Randall, 1980. Biological Process Design for Wastewater Treatment, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Block, S., 1986. Safe Operating Procedure for Continuous Organosolv Pulping System at FTLB140, SOP Number 190008610, SERI, Golden, Colorado.

Colorado APCD (Air Pollution Control Division), 1987. Colorado Air Quality Report to the Public, Colorado APCD, October.

Conway, M., 1988. Colorado National Guard Officer, Retired, Telephone Conversation with William M. Levitan, NUS Corp., January 22.

Deb, S., 1987. Emergency Response Procedures to the MDA Toxic Gas Alarm, 212, Draft, SSR671, Solar Energy Research Institute, Golden, Colorado.

DeLaney, T., 1987a. 1988 Monitoring Program (SERI Inter-Office Memorandum to R. Duncan).

DeLaney, T., 1987b. "Draft SOP for Use of I-125" (SERI Inter-Office Memorandum), SOP Number 87-036, Solar Energy Research Institute, Golden, Colorado.

DOC (U.S. Department of Commerce), 1986. The State and Metropolitan Area Data Book 1986, DOC, Bureau of the Census, Washington, D.C.

Duncan, R., 1983. State of Colorado Air Emission Permit Forms for FTLB, Letter from R. Duncan to D.C. Rardin, DOE/SERI Site Office.

Duncan, R., 1985. Environmental Hazard Analysis (SERI Inter-Office Memorandum).

EPA (U.S. Environmental Protection Agency), 1986. Environmental Radiation Data Report 44-45, October 1985 - March 1986, EPA 52015-86-018, U.S. EPA, Washington, DC.

Fangrande, F., 1986. Revised Safety Analysis Review for Water/Pentane Direct Contact Heat Exchanger (DCHX) Test Loop, July 21, 1986/August 28, 1986.

The Forum Associates, Inc., 1987. SERI Wildlife Report, Draft, September.

Greystone Development Consultants, Inc., 1987. Water Monitoring Program, 1986-1987, Final Report, Englewood, Colorado, January.

Higginbotham & Associates, 1986. Solar Energy Research Institute Permanent Facilities Complex, Golden, Colorado, Site Development Plan for Department of Energy FY 1986, SERI/SST-332-2276A, Colorado Springs, Colorado.

Hightower, D., 1987. Colonel, Colorado National Guard, Personal Communication with William M. Levitan, NUS Corp., December 15.

Hulstrom, R., 1987. "Radiation SOP Number 87-036" (SERI Inter-Office Memorandum), SOP Number 87-036b, Solar Energy Research Institute, Golden, Colorado.

Manville Sales Corp., 1988. Health and Safety Aspects of Refractory Ceramic Fibers, Brochure #HSE66, Manville, Denver, Colorado.

MDSDD (Metropolitan Denver Sewage Disposal District No. 1), 1986. "Laboratory Services Report" (letter from H. M. Harada, Director of Laboratory Services to J. Isom of Pleasant View Water and Sanitation District), March 27, MDSDD, Denver, Colorado.

Price, A., and A. Amen, 1975. Soil Survey of Golden Area, Colorado, Parts of Denver, Douglas, Jefferson, and Park Counties. U.S. Department of Agriculture Soil Conservation Service in Cooperation with Jefferson County and the Colorado Agricultural Experiment Station.

RI (Rockwell International), 1986. Annual Environmental Monitoring Report, U.S. Department of Energy, Rocky Flats Plant, January through December 1985, RFP-ENV-85, Environmental Analysis and Control Section, Rockwell International, Golden, Colorado.

SERI (Solar Energy Research Institute), 1979. Environmental Assessment of the Proposed Solar Energy Research Institute at South Table Mountain, Jefferson County, Colorado, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), 1984. Environmental Safety and Health Manual, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), 1985. Annual Site Environmental Report - Solar Energy Research Permanent Facility - 1984, SERI/MR360-2717, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), 1986a. Annual Site Environmental Report, SERI Permanent Facility, January through December 1985, Solar Energy Research Institute, Golden, Colorado, May.

SERI (Solar Energy Research Institute), 1986b. Solar Energy Research Institute Master Plan, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), 1987a. Annual Site Environmental Report, Solar Energy Research Institute Permanent Facility, January-December 1986, SERI/MR-270-3150, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Reserarch Institute), 1987b. Addendum to Environmental Assessment, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), 1987c. SERI Chemical Inventory List, Solar Energy Research Institute, Golden, Colorado, June 2.

SERI (Solar Energy Research Institute), 1987d. SERI Master Space Plan, Solar Energy Research Institute, Golden, Colorado, March 31.

Thompson, S., 1987. Unusual Occurrence Report [(UOR) 02-87], SERI/UOR 02-87, Solar Energy Research Institute, Golden, Colorado.

BIBLIOGRAPHY

ACGIH (American Conference of Governmental Industrial Hygienists), 1987. Threshold Limit Values and Biological Exposure Indices for 1987-1988, ACGIH, Cincinnati, Ohio.

ASI (Air Sciences, Inc.), 1985. South Table Mountain Air Particulate Sampling Data Summarization, Monitoring Period April 1984 - March 1985, Final Report, Lakewood, Colorado, May.

ASI (Air Sciences, Inc.), 1985. Ground Water Monitoring, SERI Permanent Facility Year Two, Air Sciences, Inc., Albuquerque, New Mexico.

ASI (Air Sciences, Inc.), 1987. Air Quality Monitoring - 1986, SERI Laboratory Facilities, Golden, Colorado, Final Report, Lakewood, Colorado, February.

Benefield, L.D., and C.W. Randall, 1980. Biological Process Design for Wastewater Treatment, Prentice - Hall, Inc., Englewood, New Jersey.

Block, S., 1986. Standard Operating Procedure for Continuous Organosolv Pulping System at FTLB 140, SOP Number 190008610, Solar Energy Research Institute, Golden, Colorado.

Colorado APCD (Air Pollution Control Division), 1987. Colorado Air Quality Report to the Public, Colorado APCD, October.

Conway, M., 1988. Colorado National Guard Officer, Retired, Telephone Conversation with William M. Levitan, NUS Corp., January 22.

Deb, S., 1987. Emergency Response Procedures to the MDA Toxic Gas Alarm, 212, Draft, SSR671, Solar Energy Research Institute, Golden, Colorado.

DeLaney, T., 1987. 1988 Monitoring Program (SERI Inter-Office Memorandum to R. Duncan).

DOC (U.S. Department of Commerce), 1986. The State and Metropolitan Area Data Book, 1986, DOC, Bureau of the Census, Washington, D.C.

DeLaney, T., 1987. "Draft SOP for Use of I-125" (SERI Inter-Office Memorandum), SOP Number 87-036, Solar Energy Research Institute, Golden, Colorado.

DOE-CH (U.S. Department of Energy Chicago Operations Office), 1982. Environmental Protection Appraisal Report, August 25-26, Chicago, Illinois.

DOE-CH (U.S. Department of Energy Chicago Operations Office), 1985. Industrial Hygiene/Occupational Medicine Appraisal Report, March 4-8, DOE Chicago Operations Office Operational and Environmental Safety Division, Chicago, Illinois.

Duncan, R., 1983. State of Colorado Air Emission Permit Forms for FTLB, Letter from R. Duncan to D.C. Rardin, DOE/SERI Site Office.

Duncan, R., 1985. Environmental Hazard Analysis (SERI Inter-Office Memorandum).

Duncan, R., 1987. Inter-Office Memorandum on Institutional Responsibilities for Site-Wide Chemical Spill Control Program, RD-D35, Solar Energy Research Institute, March 11, Golden, Colorado.

EPA (U.S. Environmental Protection Agency), 1986. Environmental Radiation Data Report 44-45, October 1985 - March 1986, EPA 52015-86-018, U.S. EPA, Washington, DC.

Fangrande, F., 1986. Revised Safety Analysis Review for Water/Pentane Direct Contact Heat Exchanger (DCHX) Test Loop, July 21, 1986/August 28, 1986.

The Forum Associates, Inc., 1987. SERI Wildlife Report, Draft, September.

Greystone Development Consultants, 1987. Water Monitoring Program, 1986 - 1987, Final Report, Englewood, Colorado, January.

Higginbotham & Associates, 1986. Solar Energy Research Institute Permanent Facilities Complex, Golden, Colorado Site Development Plan for Department of Energy, FY 1986, SERI/SST-332-2276A, Colorado Springs, Colorado.

Hightower, D., 1987. Colonel, Colorado National Guard, Personal Communication with William M. Levitan, NUS Corporation, December 15.

Hulstrom, R., 1987. "Radiation SOP Number 87-036" (SERI Inter-Office Memorandum), SOP Number 87-036b, Solar Energy Research Institute, Golden, Colorado.

Kuenning, J. A., 1982. Airborne Particulate Concentration Study, September 1981 to September 1982, South Table Mountain, Jefferson County, Colorado, Air Sciences Inc., Lakewood, Colorado, November.

Kuenning, J. A., 1983. South Table Mountain Air Particulate Sampling Data Summarization December 1983, Final Report, December.

Manville Sales Corp., 1988. Health and Safety Aspects of Refractory Ceramic Fibers, Brochure #HSE66, Manville, Denver, Colorado.

MDSDD (Metropolitan Denver Sewage Disposal District No. 1), 1986. "Laboratory Services Report" (letter from H. M. Harada, Director of Laboratory Services to J. Isom of Pleasant View Water and Sanitation District), March 27, MDSDD, Denver, Colorado.

Price, A., and A. Amen, 1975. Soil Survey of Golden Area, Colorado, Parts of Denver, Douglas, Jefferson, and Park Counties. U.S. Department of Agriculture Soil Conservation Service in Cooperation with Jefferson County and the Colorado Agricultural Experiment Station.

RI (Rockwell International), 1986. Annual Environmental Monitoring Report, U.S. Department of Energy, Rocky Flats Plant, January through December 1985, RFP-ENV-85, Environmental Analysis and Control Section, Rockwell International, Golden, Colorado.

Robillard, G., 1984. Solar Thermal Research Report, Draft, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California.

SERI (Solar Energy Research Institute), 1978. Building 15 Neutralization Tank, drawing, revised January 13, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), 1979. Environmental Assessment of the Proposed Solar Energy Research Institute at South Table Mountain, Jefferson County, Colorado, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), 1981. Preliminary Safety Analysis Review for the Field Test Laboratory Building/Service Supporting Building (FTLB/SSB).

SERI (Solar Energy Research Institute), 1982. Wind Energy Systems Test Center Building Septic System, Profile, Details, As-Built Drawing, Solar Energy Research Institute, February 23, Golden, Colorado.

SERI (Solar Energy Research Institute), 1982. Final Safety Analysis Review, Modular Industrial Solar Retrofit (MISR), Rev:00, June.

SERI (Solar Energy Research Institute), 1983. Preliminary Safety Analysis Review, Field Test Laboratory Building Biotechnology Annex, December 2.

SERI (Solar Energy Research Institute), 1983. Unusual Occurrence Report Logbook, 1982-83.

SERI (Solar Energy Research Institute), 1983. Safety Analysis Review for Photovoltaic Advanced Research Field Test Facility, October.

SERI (Solar Energy Research Institute), 1983. Safe Operating Procedure for Transparent Gasifier and Tar Cracker/Gasifier at FTLB, June.

SERI (Solar Energy Research Institute), 1984. Annex Underground Plumbing Drawing, Solar Energy Research Institute, February 16, Golden, Colorado.

SERI (Solar Energy Research Institute), 1984. Injury/Illness Quarterly Report - 3rd Quarter 1983, Centric Corporation.

SERI (Solar Energy Research Institute), 1984. Occupational Illnesses and Injuries Report, Property Damage Report, January 1 - March 31.

SERI (Solar Energy Research Institute), 1984. Memo - Talking Paper - Preferred Location of High Flux Test Facility, August 20.

SERI (Solar Energy Research Institute), 1984. Industrial Safety and Fire Protection Appraisal, July 11-17.

SERI (Solar Energy Research Institute), 1984. Environmental Safety and Health Manual, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), 1984. DOE/OSHA Inspection Report, April 26 & 27.

SERI (Solar Energy Research Institute), 1984. Concept Definition of a Small High Flux Research Experiment at SERI, March, Draft.

SERI (Solar Energy Research Institute), 1984. Injury/Illness Quarterly Report - 4th Quarter 1983, Centric Corporation.

SERI (Solar Energy Research Institute), 1984, Quarterly Status Report, December 28, 1984 IS/FP Appraisal 7/11-17/84, IH/OM Appraisal 3/36-30/84, Safety Management Appraisal June 14-22, 1984.

SERI (Solar Energy Research Institute), 1984. Preliminary Safety Analysis Report, Gasification Process, December.

SERI (Solar Energy Research Institute), 1984. Occupational Injury and Illness Report, Property Damage Report, July 1 - September 30.

SERI (Solar Energy Research Institute), 1984. Occupational Illnesses and Injuries Report, Property Damage Report, April 1 - June 30.

SERI (Solar Energy Research Institute), 1985. Standard Operating Procedure for Entrained Flow Ablative Pyrolysis Process, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), 1985. Unusual Occurrence Report Logbook, 1984, and 1985.

SERI (Solar Energy Research Institute), 1985. Quarterly Status Report of Safety Recommendations Industrial Hygiene/Occupational Medicine, Appraisal March 26-30, 1984, January 11.

SERI (Solar Energy Research Institute), 1985. Quarterly Status Report of Safety Recommendations, April 29.

SERI (Solar Energy Research Institute), 1985. Quarterly Status Report of Safety Recommendations, July 9.

SERI (Solar Energy Research Institute), 1985. Quarterly Status Report of Recommendations for (1) Health Physics, (2) Emergency Preparedness, and (3) Environmental Protection, January 14-17, March 4-8.

SERI (Solar Energy Research Institute), 1985. Quarterly Status Report March 1985 Industrial Safety and Fire Protection Appraisal July 11-17, 1984 & Ind. Hyg./Occ.Med. Appraisal, March 26-30, 1984.

SERI (Solar Energy Research Institute), 1985. Occupational Injury and Illness Report, Property Damage Report, October 1 - December 31, 1984.

SERI (Solar Energy Research Institute), 1985. Occupational Injury and Illness Report, Property Damage Report, January 1 - March 31.

SERI (Solar Energy Research Institute), 1985. Occupational Injury and Illness Report, Property Damage Report, April 1 - June 30.

SERI (Solar Energy Research Institute), 1985. Occupational Injury and Illness Report, July 1 - September 30.

SERI (Solar Energy Research Institute), 1985. Occupational Injury and Illness Report, October 1 - December 31.

SERI (Solar Energy Research Institute), 1985. Preliminary Safety Analysis Report, Entrained-Flow, Ablative Pyrolysis Process.

SERI (Solar Energy Research Institute), 1985. Environmental Protection Appraisal Report, March 4-8.

SERI (Solar Energy Research Institute), 1985. Health Physics Appraisal Report, November 20-21.

SERI (Solar Energy Research Institute), 1985. Industrial Safety and Fire Protection Appraisal Report, July 10-16.

SERI (Solar Energy Research Institute), 1985. Annual Site Environmental Report, SERI Permanent Facility, January - December 1984, SERI/MR-360-2717, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), 1986. Annual Site Environmental Report, SERI Permanent Facility, January through December 1985, Solar Energy Research Institute, May.

SERI (Solar Energy Research Institute), 1986. Monthly Status Report of DOE/OSHA Violations, June 6.

SERI (Solar Energy Research Institute), 1986. Industrial Hygiene/Occupational Medicine Appraisal Report, July 7-10.

SERI (Solar Energy Research Institute), 1986. Environmental Safety and Health Management Appraisal, February 26.

SERI (Solar Energy Research Institute), 1986. Emergency Preparedness Appraisal Report, January 7-9.

SERI (Solar Energy Research Institute), 1986. Quality Assurance Policy and Guidelines, July.

SERI (Solar Energy Research Institute), 1986. SERI Emergency Preparedness Manual, June 1.

SERI (Solar Energy Research Institute), 1986. Safety Management Appraisal Report, June 4 - 10.

SERI (Solar Energy Research Institute), 1986. Solar Energy Research Institute Master Plan, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), 1987. SERI Standard Operating Procedure Status List, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), 1987. Occupational Injury and Illness Report, Property Damage Report, January 1 - March 31.

SERI (Solar Energy Research Institute), 1987. Occupational Injury and Illness Report, Property Damage Report, April 1 - June 30.

SERI (Solar Energy Research Institute), 1987. Occupational Injury and Illness Report, Property Damage Report, July 1 - September 30.

SERI (Solar Energy Research Institute), 1987. Quality Assurance Management Appraisal, Draft, August 25-27.

SERI (Solar Energy Research Institute), 1987. Environmental Correspondence File, 1984 - 1987.

SERI (Solar Energy Research Institute), 1987. Chemical Inventory List, Solar Energy Research Institute, Golden, Colorado, June 2.

SERI (Solar Energy Research Institute), 1987. Annual Site Environmental Report, Solar Energy Research Institute Permanent Facility, January - December 1986, SERI/MR-270-3150, Solar Energy Research Institute, Golden, Colorado, May.

SERI (Solar Energy Research Institute), 1987. Addendum to Environmental Assessment, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), 1987. SERI Master Space Plan, Solar Energy Research Institute, Golden, Colorado, March 31.

SERI (Solar Energy Research Institute), ND. FTLB Settling and Neutralization Tanks, Drawing, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), ND. Photographs (3) of Permanent Site, Solar Energy Research Institute, Golden, Colorado.

SERI (Solar Energy Research Institute), ND. Underground Storage Tank Inventory and EPA Reporting Status, Solar Energy Research Institute, Golden, Colorado.

Thompson, S., 1987. Unusual Occurrence Report [(UOR) 02-87], SERI/UOR 02-87, Solar Energy Research Institute, Golden, Colorado.

Veltrie, J., 1985. Inter-Office Memorandum on Water Analysis of Buildings 15, 16, and 17, FTLB, JV-B131-85, Solar Energy Research Institute, Golden, Colorado.

APPENDIX A

SURVEY PARTICIPANTS

SOLAR ENERGY RESEARCH INSTITUTE
SURVEY PARTICIPANTS
DECEMBER 14-18, 1987

DOE

Team Leader	Joseph Boda
Assistant Team Leader	Lee Stevens
Chicago Operations Office Representative	Ronald Kolzow
SERI Area Office Representative	Jeffrey Baker

Technical Specialists

Air	Robert Lanza (ICF)
Surface/Drinking Water	William Levitan* (NUS)
Groundwater	Wayne Downey (NUS)
Waste Management	Dwight Worley* (NUS)
	Donald Habib (NUS)
Toxic and Chemical Materials	Wayne Downey (NUS)
Direct Radiation	Robert Lanza (ICF)
Quality Assurance	Wayne Downey (NUS)
Inactive Waste Sites and Releases	William Levitan (NUS)

*Contractor Coordinators

APPENDIX B

SITE-SPECIFIC SURVEY ACTIVITIES

B.1 Pre-Survey Preparation

The DOE Office of Environmental Audit, Assistant Secretary for Environment, Safety and Health, selected a Survey team for the Solar Energy Research Institute (SERI) in late 1987. The site is managed by the DOE Chicago Operations Office (CH) and SERI Area Office (SAO) and is operated by a division of Midwest Research Institute. Mr. Joseph Boda was designated the DOE Team Leader, Mr. Lee Stevens the Assistant Team Leader, and Mr. Ron Kolzow and Mr. Jeffrey Baker were CH and SAO representatives, respectively.

Survey team members began reviewing SERI general environmental documents and reports in August 1987. Messrs. Boda, Stevens, and Kolzow, along with two members of the NUS Corporation, conducted a pre-Survey site visit on November 3-4, 1987, to become familiar with key DOE and SERI personnel. They toured the facility and completed a cursory review of the documents assembled in response to an information request submitted on August 28, 1987. The request listed environmental documents and reports required by the Survey team for Survey planning purposes. During the pre-Survey visit, a meeting was held with representatives of CH, SAO, and SERI as well as officials of the U.S. Fish and Wildlife Service, the Environmental Protection Agency, the Jefferson County Health and Sheriff's Departments, and the Lakewood Fire Department. The purpose of this meeting was to review environmental issues of concern to the Federal and local government representatives and explain the scope of the Survey.

The Survey team reviewed the information received during the pre-Survey visit and prepared a Survey Plan (Appendix C) for the SERI facility. 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. A Health and Safety Plan was also prepared for use by the Survey team.

B.2 On-Site Activities

The on-site phase of the Survey was conducted during the period of December 14-18, 1987. The opening meeting was held on December 14, 1987, at SERI and was attended by representatives from CH, SAO, SERI, and the Survey team members.

Discussions during this meeting primarily concerned the purpose of the Survey, logistics at SERI, and an introduction of the key personnel involved in the Survey.

During the Survey, team members reviewed pertinent file documents including permits and applications, background studies, engineering drawings, accident reports, chemical releases, and spills, as well as various operating logbooks. The research activities were carefully analyzed to identify existing and potential pollutants. Site operations and monitoring procedures were observed, where possible. Extensive interviews were held with SERI personnel concerning environmental controls, operations, monitoring and analysis, regulatory permits, and waste management.

The Survey team members met daily to report observations, discuss findings, and evaluate progress. These meetings were also useful for planning schedule changes, if required, to meet the overall objectives of the Survey.

A site closeout briefing was held on December 18, 1987, at which the DOE Team Leader and Assistant Team Leader presented the Survey team's preliminary findings and observations. The findings were considered preliminary pending additional research and review.

B.3 Sampling and Analysis

Based on the on-site SERI Survey, no Survey-related sampling needs were identified.

B.4 Report Preparation

The Environmental Survey Preliminary Report for the SERI site will be prepared for DOE review. The preliminary findings are subject to modification based on comments from CH concerning their technical accuracy. The modified findings will be incorporated into the Environmental Survey Summary Report.

APPENDIX C

SERI SURVEY PLAN

DOE ENVIRONMENTAL SURVEY
SOLAR ENERGY RESEARCH INSTITUTE (SERI), GOLDEN, CO
DECEMBER 14-18, 1987

1.0 INTRODUCTION

The Environmental Survey is a onetime baseline inventory of existing environmental information and environmental problems and risks at DOE operating facilities. The Survey will be conducted in accordance with the principles and procedures contained in the DOE Environmental Survey Manual.

The Survey is an internal management tool to aid the Secretary and Under Secretary in allocating resources for maintaining aggressive environmental programs and for mitigating environmental problems at DOE facilities.

2.0 SURVEY IMPLEMENTATION

The Environmental Survey at SERI will be managed by the DOE Team Leader, Joseph Boda, and the Assistant Team Leader, Lee Stevens. Ron Kolzow will serve as the Chicago Operations Office (CH) representative on the Survey team. Technical support will be provided by contractor personnel as follows:

Radiation:	Robert Lanza, ICF Technology Inc.
Surface/Drinking Water:	William Levitan, NUS Corporation
Waste Management:	Donald Habib, NUS Corporation Dwight Worley, NUS Corporation *
Inactive Waste Sites/Releases:	William Levitan, NUS Corporation
Hydrogeology/Storage Tanks:	Wayne Downey, NUS Corporation
QA and TSCA:	Wayne Downey, NUS Corporation
Air:	Robert Lanza, ICF Technology Inc.

* Team Coordinator

2.1 Pre-Survey Activities

Members of the Survey team began reviewing SERI environmental documentation available at the DOE Office of Environmental Audit in July 1987. From that review, a memorandum dated August 28, 1987, was sent to the SERI Area Office requesting additional information. Messrs. Boda, Stevens, Worley, and Levitan conducted a pre-Survey site visit on November 2-4, 1987, to become familiar with the site, to identify any potential environmental problems, and to coordinate plans for the upcoming Survey with CH, SERI Area Office (SAO), and SERI contractor personnel. During the pre-Survey visit, the team met with representatives of CH, SAO, SERI Contractor personnel, representatives of the USEPA and, the Colorado State and Municipal regulatory agencies. In addition, the team toured the facilities and gathered documents assembled by site personnel in response to the information request memorandum. Additional information was requested and received from SAO personnel during and after the pre- Survey visit, based upon the review of available data on-site.

2.2 On-Site Activities and Reports

The Environmental Survey of the SERI site will be conducted from December 14-18, 1987. The Survey will include the facilities operated by the Midwest Research Institute located at SERI. The agenda for this Survey can be found in the attached Table I. Table II provides a summary of the separate technical discipline agendas contained in Table I. Modifications to this plan may be made during the course of the Survey. All modifications will be coordinated with the site officials designated as Survey contact. The on-site activities of the Survey team will consist of interviews and consultations with, among others, environmental, safety, operations, waste management, purchasing, and warehousing personnel; a review of files and documents unavailable prior to the on-site portion of the Survey; and project- specific and area-specific tours of the facility. Table III indicates specific areas of interest for each of the technical specialists.

A closeout meeting will be conducted on Friday, December 18, to describe observations and initial findings of the on-site activities. A status report stating the findings identified at the closeout meeting will be sent to CH within 4 weeks of the conclusion of the Survey. A Survey Preliminary Report will be prepared within about 4 months of the conclusion of the on-site effort. Approximately 4 months after the completion of the on-site portion of the Survey, the Sampling and Analysis (S&A) Team will initiate its on- site sampling. Subsequently, S&A will be conducted to strengthen the Survey findings and fill important data gaps. The S&A on-site activities and data analysis will require approximately 2 months to complete. The results of this S&A effort will then be used in the preparation of a Survey Interim Report, which should be completed 3 months after the finalized S&A data are received. The findings of each of the Interim Reports from all scheduled Surveys will be updated as appropriate and included in the Survey Summary Report to the Secretary, which is scheduled for completion in 1989.

2.3 Sampling and Analysis

Based upon the results of the on-site portion of the Survey, the Survey team will identify any sampling and analysis (S&A) needs. Sampling and analysis for the SERI Survey will be conducted by a team from Battelle-Columbus. Mr. Mark Hampton will be the Battelle Sampling and Analysis Field Sampling Leader. The Battelle sampling team will draft an S&A Plan based upon the needs identified by the Survey team.

The Assistant Team Leader, Lee Stevens, will coordinate the review of this Sampling Plan with CH, SAO, SERI contractor, and EPA's Laboratory at Las Vegas, which has quality assurance responsibility for the Survey's S&A efforts. The on-site sampling is projected to start in April 1988. The sampling will take approximately 1 week to complete. Results of the S&A will be transmitted to the Survey Team Leader for incorporation into the Interim Report. The Interim Report should be available in late 1988.

3.0 AIR EMISSIONS AND RADIOACTIVE MATERIALS

3.1 Issue Identification

The radioactive and regulated/hazardous air-related Survey activities will involve an assessment of the laboratory-wide air emission sources, emissions controls and sampling/monitoring data, and the acquisition and processing of ambient air quality data. Areas of investigation will include laboratory emissions of tritium, carbon-14, phosphorus-32, and sulfur-35 labeled compounds, acid fumes, toxic metals and organics, volatile hydrocarbons (VOCs), and the emissions of carbon monoxide, nitrogen and sulfur oxides from fuel burning equipment. Operational and procedural practices associated with emission controls and sampling/monitoring will be evaluated.

The general approach to the Survey will involve a review of existing environmental reports, chemical inventories, operating procedures, ventilation diagrams, stack monitoring reports, radioactive storage and handling procedures, and other relevant documents to identify significant sources of air emissions. Following the document review will be the physical inspection of significant processes, control and monitoring equipment. The Survey will identify air contaminants from significant laboratory sources, identify and evaluate existing control and monitoring equipment for the air contaminants, and assess the potential for environmental problems from the emissions.

The radiological materials assessment will involve inspection of radioactive materials and storage and handling areas, and review of storage, handling and waste management procedures.

Several areas for specific investigation have been identified during a review of available documentation:

- Airborne releases of tritium, carbon-14, phosphorous-32, and sulfur-35 labeled compounds including potential accidental releases;
- VOC emissions from Building 16, Field Test Laboratory Building (FTLB), Biotech Annex and other areas;
- Toxic metal particulates, toxic gases and toxic organic emissions from Building 16, FTLB, Biotech Annex and other areas;
- Emissions from Ocean Thermal Energy Conversion (OTEC) and Biotech Annex boilers and other combustion sources;
- Ambient air concentrations of particulates, toxic metals and volatile organic compounds, on and off-site, and evaluation of the effect of laboratory emissions on air quality;
- Radioactive materials storage, handling and monitoring procedures;

- Potential/actual emissions of regulated/hazardous pollutants radionuclides, carcinogens, and toxic substances from unpermitted and/or uncharacterized sources.

3.2 Records Required

- Local ambient air quality data for radiological and criteria pollutants;
- Identification of significant potential accidental release points;
- Descriptive documentation on existing and proposed add-on air emission control equipment;
- Ventilation system drawings;
- Operating, testing and maintenance procedures for air emission control and monitoring equipment;
- Correspondence between SERI and regulatory agencies related to radionuclide and/or toxic airborne contaminant releases;
- Radioactive material and waste shipment inventory;
- Radioactive waste management procedures.

4.0 SURFACE/DRINKING WATER (SW)

4.1 Issue Identification

A number of documents provided in response to the information request have been reviewed with regard to the surface water technical specialty area. SERI activities that generate wastewaters will be reviewed through a detailed field evaluation. Discrete liquid discharge points will be identified and evaluated to develop an inventory of wastewater sources. A review of the present condition of the wastewater collection and treatment systems will be made. Liquid waste treatment, processing, collection, and handling equipment will be examined and records of operations will be reviewed. The objective of the review is to build a Survey information data base for the identification of physical evidence of existing or potential environmental contamination.

The Survey will concentrate on areas of acknowledged concern, including the discharge of contaminants into drain fields, seepage ponds and ditches. The Survey will also include an identification of potential cross-contamination between chemical/radiological, potable, sanitary, and stormwater sewer systems. Specific attention will be paid to unknown or potential discharges into an inappropriate sewer system, which might cause a particular contaminant to be undetected or untreated. This will be accomplished by a thorough review of site facilities in conjunction with a review of standard operating procedures (SOPs) for the operation and maintenance of wastewater discharge equipment, followed by record review, interviews with site personnel, and observation of procedures.

A review of past water and wastewater conveyance, treatment, and disposal systems will also be accomplished during the Survey to evaluate what environmental problems may exist as a result of past practices, if any. Site surface drainage features, including channels, swales, culverts and catch basins, will also be reviewed.

4.2 Records Required

- Pleasant View Water and Sanitation District (PVW&SD) permit and regulations
- Wastewater piping diagrams
- SPCC plans

5.0 WASTE MANAGEMENT

5.1 Issue Identification

The Survey procedure for activities related to the waste management is to review known sources of activities and identify any additional sources or activities that have the potential to result in contamination of environmental media.

Hazardous/mixed/radioactive/solid wastes will be tracked through the system and waste- related site activities and records will be reviewed to develop an inventory and assess SERI's waste management practices.

The hazardous waste portion of the Survey will concentrate on those facilities mentioned in the SERI RCRA Part B applications. The team will devote a significant portion of the time on-site to a detailed facility investigation of hazardous or mixed waste generation, storage, and treatment practices. In addition, hazardous waste storage and treatment areas will be examined.

The review of radioactive and nonhazardous solid waste will be similar to that for hazardous wastes. Procedures will be evaluated to determine the SERI waste classification practices. The detailed investigation described above will produce information on radioactive and nonhazardous solid wastes so as to delineate any previously unidentified sources of waste that have the potential to result in environmental contamination.

Discussions will be held with individuals knowledgeable on current and past waste management practices. This will be accomplished during the investigation and in the process of reviewing facility records and documentation. The objective is to develop an understanding of past and existing waste management activities that may serve as the basis for problem identification by the Survey team.

The review of activities related to the waste management will be coordinated closely with the inactive waste site, hydrogeologic, QA/TSCA, surface/drinking water discipline activities to identify any possible releases that may pose a threat to the environment.

Several areas for specific investigation have been identified during a review of available documentation:

- Waste oil management practices
- Hazardous waste identification and documentation
- Solid waste management procedures and waste segregation practices
- Storage and disposition of scrap/salvage materials

5.2 Records Required

No additional waste management records are required at this time.

6.0 INACTIVE WASTE SITES/RELEASES

6.1 Issue Identification

The inactive waste sites/releases specialty area review will identify environmental problems associated with the historical handling, storage, and disposal of hazardous substances at the site. The review will involve the evaluation of information developed in response to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations. The Survey will focus on current and future environmental problems related to past land disposal practice and past spills/releases.

As part of the Survey, records indicating the types and quantities of materials disposed of in the inactive sites will be evaluated, as will the facility design and methods of waste containment. Information available through historical aerial photography, interviews, and site documents, such as SOPs and Unusual Occurrence Reports (UORs), will be assessed to identify inactive waste sites and releases, disturbed land areas, and to further define site locations and associated changes in appearance over time. Visual inspections will be conducted for inactive sites and releases to note surface features and to locate potential monitoring points.

Any sites that have undergone remediation will also be addressed. Records and analytical data in support of the site cleanup will be obtained for review. Inactive tanks or containers that may have held hazardous substances will be located and their status assessed. Former storage areas and staging locations will be included in this effort. Each of these facilities will be evaluated in terms of the potential to cause a present or future risk to workers, the neighboring population, or the environment.

6.2 Records Required

- Unusual Occurrence Reports (exclusive of those provided)
- Aerial/historical photographs
- Environmental Appraisals (other than 1985)

7.0 HYDROGEOLOGY

7.1 Issue Identification

A major concern for the Survey is the potential sources of groundwater contamination. In addition, the potential impacts of the existing contamination on deeper aquifers need to be assessed by the Survey team. Furthermore, the potential impacts of off-site movement of contaminated groundwater in the shallow aquifer are also of concern.

A general review of existing data will be required to determine the usefulness of this information for the purposes of the Survey. This will include a review of sampling procedures, chain-of-custody and quality assurance/quality control procedures, and data from various sources. The reliability, construction, and placement of wells used for groundwater monitoring will be examined. Interviews with site personnel will be conducted.

Several areas for specific investigation were identified during a review of available documentation:

- Underground storage tank leak testing, age, construction material, content, and location
- Aboveground storage tank spill containment
- Solid and liquid waste management operations
- Adequacy of existing wells to characterize groundwater conditions

7.2 Records Required

- Piezometric level records for all wells for last record date
- Maps or records of locations of water supply wells within 2 miles of the site boundary
- Well logs for all wells

8.0 QUALITY ASSURANCE (QA)

8.1 Issue Identification

The quality assurance (QA) review of the environmental program will examine the site S&A capabilities. The intent of this review will be to assess the quality of the environmental monitoring data. All aspects of the QA program relating to the environmental S&A effort will be reviewed.

The environmental sampling performed by SERI contractors will be evaluated by reviewing protocols, procedures, data handling, and records. Field techniques may be observed to determine actual sampling practices.

The quality assurance program will be reviewed through the evaluation of contracts for analytical services.

8.2 Records Required

- Contracts for analytical services
- S&A protocols and procedures
- Analytical reports

9.0 TOXIC AND CHEMICAL MATERIALS--TSCA

9.1 Issue Identification

The toxic and chemical materials review will address the raw materials and handling of chemical products used at SERI. The use, handling, and disposal of PCBs, asbestos, pesticides, and herbicides will also be within the scope of this effort.

All toxic and hazardous substances purchased, used, or manufactured on-site will be evaluated. The tracking, control, and management of these substances will be reviewed. Records of usage will be evaluated to determine the potential for environmental contamination.

The use of asbestos at SERI will be reviewed to identify pathways of contamination. Also, asbestos removal and disposal practices will be evaluated, and disposal sites visited, if any, to define potential areas of concern.

Pesticide/herbicide usage on the site will be reviewed to determine the risks of environmental contamination. The review will focus on application records, storage and disposal practices, and environmental monitoring procedures.

Several areas for specific investigation were identified during a review of available documentation:

- Chemical procurement procedures
- Material QA procedures
- Toxic and hazardous materials inventory.
- Operator and technician training
- Decontamination/disposal manifests and records
- Maintenance/inspection logbooks.
- Chemical storage

9.2 Records Required

- Purchase inventory list of chemicals for the most recent year.

TABLE I
SERI ENVIRONMENTAL SURVEY AGENDA
DISCIPLINE: AIR/RAD (Lanza)

	AM	PM
Monday 12/14/87	Site orientation	Building 16 air emissions - ventilation systems, laboratory hoods, roof vents/stacks radionuclide storage/handling, solvent recovery areas, emission control/monitoring systems
Tuesday	--All day -- Continue Building 16 air emissions survey	
Wednesday	FTLB air emissions - ventilation systems, laboratory hoods, roof vents/stacks, stack monitoring locations, radionuclide storage/handling solvent recovery areas, emission control/monitoring systems	Bioannex/OTEC air emissions - Boilers, laboratory hoods/vents, roof vents/, stacks
Thursday	Ambient air quality monitoring locations/equipment and procedures (active/inactive locations). Meteorological tower locations, followup work	Findings, S&A Request development
Friday	Closeout	

TABLE I
SERI ENVIRONMENTAL SURVEY AGENDA
DISCIPLINE: Inactive Sites/Surface Water (Levitan)

	AM	PM
Monday 12/14/87	Orientation	Document Review UORs; aerial/historical photos; SPCCs; Environmental Appraisals (other than 1985); PVW&SD Permits, regs, stds; Piping diagrams (wastewater).
Tuesday	WERC Wastewater system Water supply system General site inspection	Camp George West Historical photo review Interview retirees Aerial/historical photos w/other agencies
Wednesday	Permanent facility (w/TSCA/ Hydrogeology) Wastewater system (including sampling points, Bioannex sump), Storm drain system and drainageways (esp. one w/rubble), Forest Service Sawmill, General site inspection (FETA, trailers, boneyard, etc.)	Bldg. 16 Wastewater system (noting sample points)
Thursday	Revisits	Findings, S&A Request development
Friday	Close-out	

TABLE I
SERI ENVIRONMENTAL SURVEY AGENDA
DISCIPLINE: TSCA/Hydrogeology (Downey)

	AM	PM
Monday 12/14/87	Orientation	Bldg. 16, 15, 17 (Interface w/Waste Mgt.)
Tuesday	WERC Groundwater issues and septic tanks	Locate monitoring wells and outside storage tanks
Wednesday	Bioannex FTLB Lab	Environmental monitoring QA/QC contract check and data review/evaluation
Thursday	OTEC Lab - Chem storage MSALT Lab- Chem storage	Findings, S&A Request development
Friday	Closeout	

TABLE I
SERI ENVIRONMENTAL SURVEY AGENDA
DISCIPLINE: Waste Management (D. Habib, D. Worley)

	AM	PM
Monday 12/14/87	Orientation	Bldgs. 15 & 17 general inspection Bldg. 16- - satellite HW accumulation areas - central HW temp. storage area - lab chem. handling - rad waste handling - SW solid waste bins - lab drain usage
Tuesday	WERC - temp. HW storage area - drum storage area - wooden boneyard - septic overflow tank - battery storage - maintenance sheds - SW accumulation bins	Bldg. 16 Continue Monday PM Schedule
Wednesday	Permanent Facility - FTLB labs - boneyard - Biotech labs - chemical storage - FETA labs - OTEC facilities	Permanent Facility - Bioannex drum storage - temp. HW storage area - rad waste handling - SW accumulation
Thursday	Revisits	Findings, S&A Request development
Friday	Close out	

TABLE II
SERI ENVIRONMENTAL SURVEY AGENDA SUMMARY

	Air/Rad. (Lanza)	SW/Inactive Waste (Levitan)	TSCA/Hydro (Downey)	Waste Mgt. (Habib/Worley)
Monday 12/14/87 AM	Orientation	Orientation	Orientation	Orientation
PM	Bldg. 16-Vent Diagram Review	Document Review	Bldgs. 15,16,17-Chem storage (w/Waste Mgt.)	Bldgs. 15,16, 17-Waste/ chemical handling (w/Hydro/TSCA)
Tuesday AM	Bldg. 16-Ventilation systems; emissions control/monitoring	WERC-Wastewater and water supply systems	WERC-Groundwater issues, septic tank	WERC-Septic tank, drum storage, maintenance sheds
PM	Continuation of morning schedule	Camp George West-Historical photo review and interviews	Locate offsite moni-toring wells, outside storage tanks	Bldg. 16-Waste/Chemical handling
Wednesday AM	FTLB-Ventilation systems, emissions control/monitoring	Permanent Facility-Drainage areas, Sawmill, general site (w/Hydro/TSCA)	Permanent Facility - General site (w/SW/ Inactive Waste)	Permanent Facility - Waste/chemical handling
PM	Bioannex/OTEC-Air emissions	Bldg. 16-Wastewater systems	Contract review of environmental monitoring program for QA/QC	Continuation of morning schedule

TABLE II
SERI ENVIRONMENTAL SURVEY AGENDA SUMMARY (Continued)

	Air/Rad (Lanza)	SW/Inactive Waste (Levitan)	Hydro/TSCA (Downey)	Waste Mgmt. (Habib/Worley)
Thursday AM	Ambient air quality and met tower locations	Revisits	OTEC/MSALT lab - Chem storage	Revisits
PM	Findings and S&A	Findings and S&A	Findings and S&A	Findings and S&A
Friday AM	Close-out	Close-out	Close-out	Close-out
PM				

TABLE III

SERI ENVIRONMENTAL SURVEY

AREAS OF INTEREST FOR TECHNICAL SPECIALISTS

WASTE MANAGEMENT D. Worley D. Habib	-	Hazardous Waste Non-Hazardous Waste RCRA/Solid Waste Permits Mixed Waste Radioactive Waste
RADIATION R. Lanza	-	Radioactive Emissions and Effluents Source Controls and Monitoring Environmental Monitoring - Rad Laboratory Analysis - Rad Radioactive Waste
AIR R. Lanza	-	Meteorology Local Air Quality Data Emission Sources, Control and Monitoring Environmental Monitoring - Air Air Permits and Air Emissions Inventory
SURFACE/DRINKING W. Levitan	-	Effluent Sources Wastewater (Process and Sanitary Treatment) Facilities Cooling Water System Drinking Water Distribution Stormwater Management Spill Prevention, Control and Countermeasure Plan Aboveground Storage Tanks
HYDROGEOLOGY/STORAGE TANKS W. Downey	-	Waste Storage and Disposal Sites (Past and Active) Spill/Accident Locations Regional Geology and Groundwater Well Inventory and Construction Groundwater Monitoring Program and Studies Underground Storage Tanks

TABLE III

SERI ENVIRONMENTAL SURVEY

AREAS OF INTEREST FOR TECHNICAL SPECIALISTS (Continued)

INACTIVE WASTE SITES/ RELEASES W. Levitan	-	Past Waste Site Locations Characterization Studies Spill/Accident Locations Remediation Work Former Production Locations
QUALITY ASSURANCE W. Downey	-	Environmental Sampling Program Environmental Analytical Program Data Management and Handling QA Program Overview
TOXIC AND CHEMICAL MATERIALS-TSCA W. Downey	-	Process Chemicals and Substances Inventory Asbestos Use Evaluation Asbestos Removal and Disposal PCBs In-Service, Storage, and Disposal Pesticide Use, Storage, and Disposal Warehousing and Storage Tanks for Process Chemicals

APPENDIX D

LIST OF ABBREVIATIONS, ACRONYMS, AND INITIALISMS

LIST OF ABBREVIATIONS, ACRONYMS, AND INITIALISMS

AAQs	Ambient Air Quality Standards
ACGIH	American Conference of Governmental Industrial Hygienists
APEN	air pollution emissions notice
BOD	biochemical oxygen demand
Btu	British thermal unit
CAS	Chemical Abstract Service
cfm	cubic feet per minute
CFR	Code of Federal Regulations
cfs	cubic feet per second
CH	Chicago Operations Office (DOE)
CO	carbon monoxide
COD	chemical oxygen demand
Con Mutual	Consolidated Mutual Water District
DAS	Deputy Assistant Secretary
DCEA	dichloroethane
DCG	Derived Concentration Guides
DCHX	Direct Contact Heat Exchanger
DOE	U.S. Department of Energy
EP	Extraction Procedure
EPA	U.S. Environmental Protection Agency
ES&H	Environment, Safety and Health
FTLB	Field Test Laboratory Building
gpd	gallons per day
kg	kilogram
HF	hydrofluoric acid
IA	Installation Assessment
IDLH	immediately dangerous to life and health

LIST OF ABBREVIATIONS, ACRONYMS, AND INITIALISMS (continued)

LEL	Lower Explosive Limit
MDSDD	Metropolitan Denver Sewage Disposal District
mg/L	milligram per liter
mL	milliliter
mgd	million gallons per day
MOCVD	metal organic chemical vapor deposition
mph	miles per hour
MRI	Midwest Research Institute
m/s	meters per second
MSDS	Material Safety Data Sheets
MSL	Molten Salt Laboratory
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NRVOC	Negligibly reactive volatile organic compounds
OEGC	Office of Environmental Guidance and Compliance
OSCO	Oil and Solvent Process Company
OTEC	Ocean Thermal Energy Conversion
POTW	publicly-owned treatment works
PVC	polyvinyl chloride
PVSD	Pleasant View Sanitation District
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
S&A	sampling and analysis
SAO	SERI Area Office (DOE)
SERI	Solar Energy Research Institute
SOP	Safe Operating Procedure
SPCC	spill prevention, control, and countermeasures
SQG	Small Quantity Generator
STEL	short term exposure limit

TCE	trichloroethylene
TLD	thermoluminescent dosimetry
TLV	threshold limit value
TSD	treatment, storage, and disposal
TSP	total suspended particulates
TSS	total suspended solids
TWA	time weighted average
UST	underground storage tank
VOC	volatile organic compound
WERC	Wind Energy Research Center

END

DATE FILMED

11 / 16 / 90