3

Environmental Program Information

Introduction

Lawrence Livermore National Laboratory is committed to operating in a manner that preserves the quality of the environment. The Environmental Protection Department (EPD) leads this effort in the areas of environmental compliance and accountability. This chapter begins with a brief description of LLNL's integrated Environment, Safety, and Health (ES&H) Management System and continues with discussions of Work Smart Standards (WSS), missions, and activities of EPD and its three divisions. Performance measures (PMs) used by the U.S. Department of Energy (DOE) to evaluate the Laboratory's environmental protection efforts are then summarized. The bulk of the chapter is devoted to an account of LLNL's activities and progress in waste minimization and pollution prevention in 1999. Following descriptions of current issues and actions in the environmental program arena, this chapter concludes with a brief discussion of spill response and EPD environmental training.

Integrated Environment, Safety, and Health Management System

In 1998, LLNL began the process of developing and implementing an Integrated Safety Management System (ISMS) in accordance with the requirements of the University of California's (UC's) Prime Contract W-7405-ENG-48, Clause 6.7. The LLNL ISMS is designed to ensure the systematic integration of ES&H considerations into management and work practices so that missions are accomplished while protecting the public, workers, and the environment. "Safety" used in this context is synonymous with environment, safety, and health to encompass protection of the public, workers, and the environment (including pollution prevention and waste minimization). The core requirements of ISMS are based on the DOE's Seven Guiding Principles and Five Core Functions.

The Seven Guiding Principles can be summarized as: (1) line management is responsible for ensuring the protection of employees, the public, and the environment; (2) clear roles and responsibilities for ES&H are established and maintained; (3) personnel competence is commensurate with their responsibilities; (4) resources are effectively

allocated to address ES&H, programmatic, and operational considerations with balanced priorities; (5) safety standards and requirements are established that ensure adequate protection of the employees, the public, and the environment; (6) administrative and engineering controls to prevent and mitigate ES&H hazards are tailored to the work being performed; and (7) operations are authorized.

The Five Core Functions that describe how LLNL shall manage and perform work are summarized as: (1) define the scope of work; (2) identify and analyze the hazards associated with the work; (3) develop and implement hazards controls; (4) perform work within the controls; and (5) provide feedback on the adequacy of the controls for continuous improvement.

The implementation of a management system based on these principles and functions results in accountability at all levels of the organization, project planning with protection in mind, and excellence in program execution. The ISMS Program at LLNL employs a process of assessing hazards and the environmental implications of work; designing and implementing standards-based methods intended to control risks; and complying with applicable ES&H requirements. This process is implemented using a graded approach, which increases the level of risk management as hazards increase. The complete description of LLNL's ISMS can be found in *Integrated Safety Management System Description (*Clough 2000).

On November 15, 1999, the Laboratory declared its readiness for the DOE Phase I Verification of the institutional ISMS. DOE initiated the verification on November 29, 1999, and the results of the verification were presented on December 9, 1999. DOE recommended approval of the LLNL ISMS description after the completion of several action items.

Work Smart Standards

In 1997, LLNL and DOE's Oakland Operations Office (DOE/OAK) inaugurated a WSS process (DOE M 450.3-1), whereby safety professionals from both organizations identified ES&H hazards and established standards of operation appropriate for the particular work environment.

The WSS process requires an understanding of the work, an analysis of the hazards associated with the work, and the selection of standards from which hazard controls are developed. LLNL has traditionally identified and controlled hazards to protect the LLNL staff, the public, and the environment, but the WSS process differs from the past

in that responsibility for selection of appropriate and necessary standards is in the hands of both the DOE field office and LLNL. This process empowers the Laboratory and local DOE staffs, through consensus, to focus on the work being performed and to select sitewide ES&H standards based on the actual work being conducted and its associated hazards and threats to the environment. In 1998, several hundred individuals participated in the WSS process, including more than 100 subject matter experts (SMEs) who identified standards based on the work and the hazards. In addition, requirements for managing processes were identified to better connect project planning and execution with the standards, thereby providing protection to workers, the public, and the environment. This process resulted in the identification of almost 700 individual requirements, of which more than 250 directly relate to environmental protection. The WSS process also identified the need to develop nine local standards to either fill gaps or enhance existing standards; these ranged from standards on ergonomics to high-efficiency particulate air (HEPA) filters. For example, radioactive waste storage facility and tank system design criteria standards (Wood et al. 1999) were developed to ensure that requirements for facility design protect the environment.

WSSs were approved at the management level closest to and with the most expertise in the work. The LLNL Director and DOE/OAK Manager approved the final set of sitewide standards on August 5, 1999, after they were confirmed by an independent panel of external experts in March 1999. The WSS set was essentially considered part of the UC contract once it was signed by the LLNL Director and the DOE/OAK Manager. Reaching these agreements with DOE on new work-based standards aligns the Laboratory with industry practice, establishes common ES&H expectations for DOE and UC, and facilitates the tailoring of requirements to streamline and increase the effectiveness of management at the Laboratory. The existing ES&H methodologies and documentation are being modified to incorporate the newly identified set of standards and to reflect the requirements of ISMS.

Meeting new expectations for integrated ES&H management at the Laboratory will take several years, but the WSS approach, coupled with enhanced, integrated management, promises further safety improvements and lower costs.

Environmental Protection Department

As the lead organization at LLNL for providing environmental expertise and guidance to operations at LLNL, EPD is responsible for environmental monitoring, environmental regulatory compliance, environmental restoration, environmental community relations,

and hazardous waste management in support of the Laboratory's programs. EPD prepares and maintains environmental plans, reports, and permits; maintains the environmental portions of the *ES&H Manual*; informs management about pending changes in environmental regulations pertinent to LLNL; represents the Laboratory in day-to-day interactions with regulatory agencies and the public; and assesses the effectiveness of pollution control programs.

EPD monitors air, sewerable water, ground water, surface water, soil, sediments, vegetation, and foodstuff, as well as direct radiation; evaluates possible contaminant sources; and models the impact of LLNL operations on humans and the environment. In 1999, 13,372 samples were taken, and 252,469 analytes were tested. The type of samples collected at a specific location depends on the site and the potential pollutants to be monitored; see the specific chapters of this report for discussions of each environmental medium.

A principal part of EPD's mission is to work with LLNL programs to ensure that operations are conducted in a manner that limits environmental impacts and is in compliance with regulatory guidelines. EPD helps LLNL programs manage and minimize hazardous, radioactive, and mixed wastes; determines the concentrations of environmental contaminants remaining from past activities; cleans up environmental contamination to acceptable standards; responds to emergencies in order to minimize and assess any impact on the environment and the public; and provides training programs to improve the ability of LLNL employees to comply with environmental regulations.

LLNL programs are supported by the Hazards Control Department's four ES&H teams and by EPD's four environmental support teams (ESTs). The ESTs are integrated into the ES&H teams at the Laboratory through the environmental analyst, who chairs the ESTs. Each EST includes representatives from environmental specialties within the Operations and Regulatory Affairs Division (ORAD), the ES&H teams, and a field technician from the Hazardous Waste Management (HWM) Division. Some ESTs also include a representative from the Environmental Restoration Division (ERD) or the organizations supported by the ESTs. These teams evaluate operations, determine potential environmental impacts, and provide guidance on environmental regulations and DOE orders for existing and proposed projects. ESTs assist programs in planning, implementing, and operating projects and in understanding and meeting their environmental obligations. When permits are obtained from regulatory agencies, ESTs aid the programs in evaluating the permit conditions and implementing recordkeeping requirements.

Operations and Regulatory Affairs Division

ORAD currently consists of seven groups that specialize in environmental compliance and monitoring and provide laboratory programs with a wide range of information, data, and guidance to make more informed environmental decisions.

ORAD prepares the environmental permit applications and related documents for submittal to federal, state, and local agencies; provides the liaison between LLNL and regulatory agencies conducting inspections; tracks chemical inventories; prepares National Environmental Policy Act (NEPA) documents; conducts related field studies for DOE; oversees wetland protection and floodplain management requirements; coordinates cultural and wildlife resource protection and management; facilitates and provides support for the pollution prevention and recycling programs; teaches environmental training courses; coordinates the tank environmental compliance program; conducts compliance and surveillance monitoring; and provides environmental impact modeling and analysis, risk assessment, and reporting.

ORAD also actively assists in responding to environmental emergencies such as spills. During normal working hours, an environmental analyst from the ORAD Environmental Operations Group (EOG) responds to environmental emergencies and notifies a specially trained environmental duty officer. Environmental duty officers are on duty 24 hours a day, 7 days a week, and coordinate emergency response with LLNL's ES&H team and other first responders or environmental specialists.

Hazardous Waste Management Division

All hazardous, radioactive, and mixed wastes generated at LLNL facilities are managed by the HWM Division in accordance with state and federal requirements. HWM processes, stores, packages, solidifies, treats, and prepares waste for shipment and disposal, recycling, or discharge to the sanitary sewer.

As part of its waste management activities, HWM tracks and documents the movement of hazardous, mixed, and radioactive wastes from waste accumulation areas (WAAs) located near the waste generator to final disposition; develops and implements approved standard operating procedures; decontaminates LLNL equipment; ensures that containers for shipment of waste meet the specifications of the U.S. Department of Transportation (DOT) and other regulatory agencies; responds to emergencies; and participates in the cleanup of potential hazardous and radioactive spills at LLNL facilities. HWM prepares numerous reports, including the annual and biennial

hazardous waste reports required by the state and federal environmental protection agencies (see Appendix B). HWM also prepares waste acceptance criteria documents, safety analysis reports, and various waste guidance and management plans.

HWM meets regulations requiring the treatment and disposal of LLNL's mixed waste in accordance with the requirements of the Federal Facility Compliance Act. The schedule for this treatment is negotiated with the State of California and involves developing new on-site treatment options as well as finding off-site alternatives.

HWM is responsible for implementing a program directed at eliminating the backlog of legacy waste (waste that is not at present certified for disposal). This effort includes a large characterization effort to identify all components of the waste and a certification effort that will provide appropriate documentation for the disposal site.

Environmental Restoration Division

ERD was established to evaluate and remediate soil and ground water contaminated by past hazardous materials handling and disposal processes and from leaks and spills that have occurred at the Livermore site and Site 300, both prior to and during LLNL operations. ERD conducts field investigations at both the Livermore site and Site 300 to characterize the existence, extent, and impact of contamination. ERD evaluates and develops various remediation technologies, makes recommendations, and implements actions for site restoration. ERD is responsible for managing remedial activities, such as soil removal and ground water extraction, and for assisting in closing inactive facilities in a manner designed to prevent environmental contamination.

As part of its responsibility for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) compliance issues, ERD plans, directs, and conducts assessments to determine both the impact of past releases on the environment and the restoration activities needed to reduce contaminant concentrations to protect human health and the environment. ERD interacts with the community on these issues through Environmental Community Relations. Public meetings are held each year and information provided to the public as required in the ERD CERCLA Community Relations Plans. To comply with CERCLA ground water remedial actions at the Livermore site, ERD has to date designed, constructed, and operated five fixed ground water treatment facilities and associated pipeline networks and wells, 16 portable ground water treatment units, and two soil vapor extraction facilities (see Chapter 8). At Site 300, ERD has designed, constructed, and operated three soil vapor extraction facilities and seven ground water extraction and treatment facilities.

ERD is actively designing, testing, and applying innovative remediation and assessment technologies to contaminant problems at the Livermore site and Site 300. ERD provides the sampling and data management support for ground water surveillance and compliance monitoring activities.

Performance Measures Summary

Since 1992, UC's contract to manage and operate LLNL for DOE has contained performance objectives, criteria, and measures. Four of these performance measures (PMs) are used to evaluate LLNL's environmental protection activities.

At the end of 1999, DOE gave LLNL an average score of excellent for its environmental performance in 1998. DOE scores for individual performance measures are shown in **Table 3-1**. As indicated in the table, performance details are described in the *Environmental Report 1998* (Larson et al. 1999). Performance measure data for 1999 will be included in the annual self-assessment and evaluation conducted in 2000.

DOE Pollution Prevention Goals

The Secretary of Energy committed DOE to the following Pollution Prevention (P2) goals to be achieved throughout the DOE complex by December 31, 1999, using 1993 as a baseline:

1. Reduce total releases and off-site transfers for treatment and disposal of Emergency Planning and Community Right-to-Know Act (EPCRA) Section 313 toxic chemicals from routine operations by 50%.
2. Reduce the generation of radioactive waste from routine operations by 50%.
3. Reduce the generation of low-level mixed waste from routine operations by 50%.
4. Reduce the generation of hazardous waste from routine operations by 50%.
5. Reduce the generation of sanitary waste (after recycling) from routine operations by 33%.
6. Divert 33% of sanitary waste from all operations for recycling.
7. Increase the affirmative procurement of EPA-designated recycled products to 100%.

Table 3-1. UC Contract 48 environmental protection performance measures for environmental performance in 1998.

PM designator	Performance measure	Location in *Environmental Report 1998*	Score
1.4.b	**Radiation dose to the public** Public radiation doses to the maximally exposed individual from DOE operations will be measured or calculated and controlled to ensure that doses are kept as low as reasonably achievable (ALARA).	Chapter 13, Radiological Dose Assessment, section on Radiological Doses from 1998 Operations. Chapter 2, Compliance Summary, section on National Emission Standards for Hazardous Air Pollutants.	Outstanding
1.4.g	**Process and solid waste generation (Waste reduction and recycling)** The Laboratory continues to progress toward meeting the DOE's pollution prevention goals for the year 2000.	Chapter 3, section on Waste Minimization/Pollution Prevention.	Excellent
1.4.h	**Environmental violations** The rate of validated environmental violations from inspections and reporting requirements from regulatory agencies is kept low.	Chapter 2: Compliance Summary, **Tables 2-5a**, **2-5b,** and **2-9**.	Excellent
1.4.i	**Environmental releases** The Laboratory controls and reduces the number of occurrences of environmental releases and the number of releases that result in violations.	Chapter 2: Compliance Summary, **Table 2-9**.	Outstanding

Progress toward achieving these goals is reported annually to the Secretary of Energy in DOE's *Annual Report of Waste Generation and Pollution Prevention Progress* (U.S. Department of Energy 1994, 1996a, 1997, 1998c, and 1999a).

In November 1999, the Secretary of Energy issued a new set of pollution prevention and energy efficiency goals in response to the President's Executive Orders for Greening the Federal Government. These goals provide direction for continued promotion of pollution prevention and waste minimization beyond the year 2000. Additionally, they expand the scope of previous goals to consider the following: building and facility energy efficiency; reduction of releases of toxic chemicals, ozone-depleting substances, and greenhouse gases; increased vehicle fleet efficiency and use of alternative fuels; and the required purchasing of environmentally preferable products and services. The new goals will continue to use 1993 as a baseline and have interim measurement points in 2005 and 2010.

LLNL prepares a P2 Plan that meets the requirements of (1) DOE Orders 5820.2A and 5400.1; (2) Resource Conservation and Recovery Act of 1976 (RCRA) Sections 3002(b) and 3005(h); and (3) Title 22 of the California Code of Regulations. This plan is reviewed annually and is typically updated every three years. The plan reviews past and current pollution prevention activities and states the objectives of LLNL's waste minimization and pollution prevention efforts. It was last updated and submitted to DOE in May 1997 (Celeste 1997). The timeline for the expected 2000 update to the LLNL P2 Plan has been deferred per DOE guidance.

The P2 Program at LLNL is an organized, comprehensive, and continuing effort to systematically reduce solid, hazardous, radioactive, and mixed-waste generation. The P2 Program is designed to eliminate or minimize pollutant releases to all environmental media from all aspects of the site's operations. These efforts help protect public health and the environment by reducing or eliminating waste management and compliance costs, resource usage, inventories and releases of hazardous chemicals, and civil and criminal liabilities under environmental laws.

In accordance with EPA guidelines and DOE policy, a hierarchical approach to waste reduction (i.e., source elimination or reduction, material substitution, reuse and recycling, and treatment and disposal) has been adopted and is applied to all types of waste.

Waste Minimization/Pollution Prevention

LLNL is required by UC Contract performance measure 1.4.g to annually review its waste generation for pollution prevention opportunities and to propose implementation projects. Previously, waste streams at LLNL were evaluated in terms of the total quantities of waste generated. However, the waste streams of greatest concern are not necessarily those having the largest volume. Each process that generates waste must be considered, as well as the individual characteristics of the components within each waste stream.

LLNL continues to use a weighted system to better rank the waste streams and to improve the prioritization of waste minimization efforts. The methodology assigns to each waste stream three weighting factors plus a factor based on annual quantity of waste generated. The three weighting factors use the following criteria: cost, waste type (which includes compliance and liability considerations), and operational aspects (such as routine vs nonroutine) as discussed in *A Comprehensive Opportunity Assessment for Pollution Prevention at Lawrence Livermore National Laboratory* (Celeste et al. 1998). This weighting system was used to prioritize waste minimization efforts for waste streams

identified in LLNL's input to the document *Source Reduction Evaluation and Plan, Hazardous Waste Management Performance Report, Summary Progress Report* (U.S. Department of Energy 1999c).

In general, the 20 waste stream components having the highest priority (ranked by summing the four weighting factors) are entirely different from the top 20 sources ranked by quantity only. For example, transuranic waste (TRU)/TRU mixed and low-level wastes, which are problematic at LLNL, are now ranked as having the highest priority, though their relative quantities are somewhat low.

The Environmental Protection Department's Pollution Prevention Team reviews HWM's Total Waste Management System (TWMS) database monthly. By reviewing this database, which tracks waste generation, the Pollution Prevention Team can identify waste streams with potential problems for each directorate and address issues in a timely manner. Routine waste generation by waste category, from 1993 through 1999, is shown in **Table 3-2.** The trend from 1993 on shows a dramatic reduction in all waste categories, which is the result of LLNL's proactive P2 program.

Table 3-2. Routine waste generation totals (tons), 1993–1999.

Waste category	1993[a] (baseline)	1994	1995	1996	1997	1998	1999
Low-level radioactive	256	181	136	91	68	73	66
Low-level mixed	34	26	36	23	21	25	11
Hazardous	628	368	368	360	240	232	188
Sanitary	2600	2246	2246	2001	2017	2201	2210
LLNL totals	**3518**	**2821**	**2786**	**2475**	**2346**	**2531**	**2475**

[a] Baseline values 1993 through 1997 adjusted per agreement between DOE/OAK and LLNL on Feb. 20, 1998.

Table 3-3 presents the percent reductions in routine waste generation for 1999 compared with the 1993 baseline. With the decreases in routine radioactive and hazardous waste generation, the Laboratory met the 50% reduction goal for the performance measure in 1997. The 50% reduction goal for low-level mixed waste was achieved in 1999, largely because of an improved treatment technology and a decrease in programmatic generation. Reduction of the sanitary waste stream from the baseline of 1993 is currently at 15%. Further discussion of the sanitary waste stream occurs in the following section.

Table 3-3. Routine waste reduction, 1999.

Waste category	Reduction 1999 vs 1993 (%)
Radioactive	75
Mixed	68
Hazardous	71
Sanitary	15

Nonhazardous Solid Waste Minimization

In 1999, LLNL sent 5684 tons of routine and nonroutine, nonhazardous waste (also designated as sanitary waste) to a landfill. The routine portion was 2210 tons (see **Table 3-2**), and the nonroutine portion was 3474 tons. The breakdown for routine and nonroutine waste is shown in **Table 3-4**.

Diverted Waste

The total waste diverted from landfills in 1999 was 47,161.5 tons. This year's total diversions, over two times that of 1996 (**Table 3-5**), reflects the continued success of LLNL's diversion programs.

The recycling rate for nonhazardous waste is calculated by dividing the total of diverted waste by the sum of the nonhazardous landfill total and the diverted waste total. For 1999, the total of diverted waste plus nonhazardous waste generated was 52,846 tons. This results in a recycling rate of 89% for nonhazardous waste in 1999.

Table 3-4. Nonhazardous landfill totals (tons), 1999.

Landfill	1999 total
Routine	
Compacted	2130
Industrial (TWMS)[a]	80
Routine subtotal	2210
Nonroutine	
Construction demonstration (noncompacted)	3363
Industrial (TWMS)	111
Nonroutine subtotal	3474
LLNL total	**5684**

[a] TWMS = Total Waste Management System.

Table 3-5. Diverted waste totals (tons), 1996–1999.

	1996	1997	1998	1999
Diverted waste totals	20,266	323,465[a]	31,513	47,161.5

[a] The 1997 solid waste diversion total of 323,465 reflects an increase in soil reuse, predominately driven by construction of the National Ignition Facility.

Table 3-6 shows a breakdown of waste diversion categories for 1999, reflecting the variety of diversion programs in place at LLNL. Soil, a major contributor to diversion totals, is reused both on site and at the landfill for daily cover. Asphalt and concrete are reused as road base material at the landfill. Wood waste, created by broken pallets, shipping crates, and demolition or construction scrap, cannot be cost-effectively reused on site, so it is gathered in a collection yard for recycling by a vendor at a cost lower than that of other disposal alternatives. Intact pallets and other reusable wood remain on site for internal reuse.

Table 3-6. Waste diversion summary table, 1999.

Description	Cumulative 1999 total (tons)
Asphalt/concrete	2,782
Batteries	25
Cardboard	172
Compost	336
Cooking grease/food	3
Diverted soil	40,877
HWM recycled materials	76
Magazines, newspapers, and phone books	33
Metals	2,028
Paper	309
Tires and scrap	64
Toner cartridges	3
Wood	453
Beverage containers	0.5
LLNL diversion total	**47,161.5**

Another waste reduction method converts landscape clippings from the site's lawns, trees, shrubs, and annual plantings into compost. Once it is properly aged, the compost is used on site as a soil amendment. By generating its own soil builders, LLNL benefits

twice: by eliminating an organic waste stream (with no tipping fees or hauling required), and by saving the purchase cost of new material. Gardeners also create a bright and attractive mulch by chipping office Christmas trees at the end of the holiday season. This mulch is used year-round, reducing the amount of dry-season irrigation necessary in tree wells.

Another well-developed and highly visible component of the LLNL recycling effort is the office-paper collection and reclamation project. The Laboratory operates a full-site program, with more than 122 facility collection points. Unclassified paper is transported to a contract firm, where it is shredded and recycled into toilet paper and egg cartons. Classified paper is preprocessed at the Livermore site using a hammer mill destruction process. LLNL also collects and recycles external and internal phone books, newspapers, and magazines by placing recycling bins on site for pickup by a local vendor. These items would otherwise contribute to the solid waste stream. In 1999, LLNL expanded the program to allow employees who are located in areas where drop-off bins are not easily accessible to mail in these items.

LLNL continues to look for diversion opportunities. A new beverage container recycling program serving all three on-site cafeterias was initiated in late 1999. This program collects aluminum, glass, and plastic containers, which are picked up and taken off site for recycling by a local vendor. Preliminary data from the fourth quarter of 1999 show that a half ton of beverage containers was recycled.

LLNL's goal in its UC contract was to reduce the routine nonhazardous waste by 33% by December 31, 1999. As shown in **Table 3-4**, LLNL generated 2210 tons of routine nonhazardous waste in 1999, a reduction of 15% with respect to the baseline. Because the 33% reduction goal was not achieved, despite an impressive 89% recycling rate for nonhazardous waste, the Laboratory has a strong incentive to continue to identify new waste reduction measures.

Cities and counties have been required by California law to reduce nonhazardous solid waste by 25% and 50% between the baseline year of 1990, and 1995 and 2000, respectively. LLNL contributes to this effort by tracking and reporting its waste diversions to the County of Alameda. Significant reductions have already been achieved. Compared with the 1990 baseline, by 1995 LLNL reduced its nonhazardous waste by 46% (see **Table 3-7**), which compared favorably with unincorporated Alameda County (8.9%) and the City of Livermore (13.8%) for 1995. Additional details are discussed in *Assessing the Nonhazardous Solid Waste Stream at Lawrence Livermore National Laboratory* (Wilson 1999).

Table 3-7. Nonhazardous solid waste summary table, 1990–2000.

	1990	1995
Nonhazardous solid waste (routine and nonroutine)	8332	4560
Percent reduction	NA	46%

Source Reduction and Pollution Prevention

In 1999, LLNL continued to survey on-site operations for opportunities to eliminate, reduce, recover, or recycle potential pollutants to all media, including air, water, soil, sediments, and biota.

Toxic Reporting Inventory Information

At LLNL only one chemical, Freon 113 (1,1,2-trichloro-1,2,2-trifluoroethane, also known as CFC 113), was tracked and reported as part of the Toxic Release Inventory for 1999. This reporting is required by EPCRA. All other chemicals are present in quantities below the threshold reporting levels or are in a form that does not require reporting.

Freon 113, which is used in parts cleaning operations and as a coolant or refrigerant, is an ozone-depleting substance whose consumption and production are slated for elimination by the year 2000. For this reason, the replacement and recycling of Freon 113 is a high priority at LLNL.

Implementing Cost-Saving Pollution Prevention (P2) Projects

As previously reported (Celeste et al. 1998) Pollution Prevention Opportunity Assessments (PPOAs) are conducted before the implementation of P2 projects. The purpose of PPOAs is to characterize waste streams and identify those P2 options that can be implemented cost effectively.

The DOE funds P2 projects through the High-Return-on-Investment (ROI) P2 Program. To date, DOE has funded high ROI projects at LLNL worth over $2.6 million. The annual savings attributed to the projects were reassessed in the fall of 1999. Revised estimates of annual savings from implemented ROI projects are $1.5 million per year. LLNL additionally uses ROI calculations and estimates of project cost-effectiveness to prioritize P2 projects for resource allocation and implementation at the Laboratory.

Review of New Processes or Experiments

Many organizations at LLNL use a "front-end" review process that applies to new programs, projects, or experiments that could have a significant impact on the environment. In this review process, the initial hazardous materials projected to be used are identified, and concentrations of both the starting materials and the wastes produced are estimated. The possibility for chemical substitution, process changes, and recycling is then addressed. If an opportunity for P2 is identified, the Pollution Prevention Team assists the generator in evaluating the options. Researchers and project managers are encouraged to implement alternatives that are less hazardous or nonhazardous.

In general, P2 activities are covered by the *FY97 Pollution Prevention Plan* (Celeste 1997). New activities are reviewed to identify possible P2 techniques. All personnel are encouraged to implement reasonable P2 opportunities that have been identified.

Design for Environment

Design for environment is a concept that involves developing an understanding of potential environmental impacts over the lifetime of a project, with the goal of minimizing or mitigating those potential impacts through modifications to the project at the design stage. Federal facilities are now required, under Executive Order 12856, to apply life-cycle analysis and total cost accounting principles to the greatest extent practicable when estimating P2 opportunities. Both of these can be considered elements of a new federally funded facility. In addition, Executive Order 13101, which replaced Executive Order 12873 in September 1998, requires federal facilities to implement P2 by giving preference to the purchase of environmentally preferable products and requires that P2 and life-cycle analysis be considered when plans, drawings, work statements, and specifications are developed. Executive Order 13101 also allows the use of "multimedia" EPA inspections of federal facilities for compliance with this order.

In 1997, the Pollution Prevention Team and National Ignition Facility (NIF) project management completed a design-for-environment evaluation of the opportunities within the NIF project. The *NIF Pollution Prevention and Waste Minimization Plan* (NIF P2/WMin Plan) was completed in 1998 (Cantwell and Celeste 1998). Based on this evaluation, the laboratory implemented recycling programs during NIF construction, began a Pollution Prevention Plan for NIF, and implemented aqueous cleaning concepts in the design for parts and optics cleaning. The NIF P2/WMin Plan included PPOAs on the predicted waste streams identified in the preliminary environmental

impact statement. The PPOAs were aimed at developing waste minimization options before NIF becomes operational.

Implementing P2 Employee Training and Awareness Programs

Pollution prevention awareness information, which covers all disciplines, is disseminated in documents such as the *Pollution Prevention Plan* (Celeste 1997) and *A Comprehensive Opportunity Assessment for Pollution Prevention at Lawrence Livermore National Laboratory* (Celeste et al. 1998); posters and videos at events such as Earth Day; training and orientation; conferences and workshops; membership on LLNL committees; and formal presentations to groups such as the ES&H Working Group's Environmental Subcommittee.

P2 awareness is promoted through new employee and awareness briefings as well as articles in *Newsline* (LLNL's weekly newspaper) and administrative memos. The Pollution Prevention Team developed a website to electronically distribute P2 information and prepared brochures that briefly describe the P2 program at LLNL. The Pollution Prevention Team also sponsors a yearly Earth Expo event open to employees, their families, and the local community to provide awareness of environmentally sound technologies and LLNL waste diversion initiatives.

Current Return-on-Investment Projects

LLNL prepared several high ROI P2 project proposals in 1999. Major high ROI projects that received funding and began in 1999 are listed in **Table 3-8**.

Table 3-8. Major high return-on-investment projects, 1999.

Operation	Project
Low-Hg fluorescent lighting pilot at LBNL and LLNL	Studies the benefits and drawbacks of converting to low-Hg fluorescent tubes in office and shop space
Executive Order 13101 specification upgrade	Updates the LLNL facilities specification masters to bring them into compliance with EPA comprehensive procurement guidelines

ChemTrack

ChemTrack, which is a computerized chemical inventory system, serves as an important tool for ensuring that LLNL complies with the Superfund Amendment and Reauthorization Act (SARA) Title III and California Business Plan reporting requirements and for improving the overall management of hazardous materials. ChemTrack enhances LLNL's ability to obtain the toxic release information necessary to complete SARA 313 submittals, to improve emergency response capabilities and management of material safety data sheets (MSDSs), to more closely track specific high-hazard chemicals and other regulated substances, and to screen selected LLNL facilities for preliminary hazard analyses. ChemTrack currently has an inventory of approximately 176,000 chemical containers ranging from 210-L drums to gram-quantity vials.

Current Issues and Actions

Many current issues and actions are described in this report according to chapter subjects. This section lists several not covered elsewhere.

Miniature Optical Lair Explorer

In 1994, ORAD developed and began using the Miniature Optical Lair Explorer (MOLE) to perform biological assessment studies at Site 300. The MOLE is a miniature tracked vehicle with a tiny camera that allows scientists to investigate subterranean tunnel systems of special-status wildlife species to determine their presence and numbers.

LLNL has used the MOLE successfully to survey for the presence of several special-status species with subterranean habitats (e.g., the San Joaquin kit fox, burrowing owl, American badger, California tiger salamander, and California red-legged frog) before starting ground-disturbing activities to ensure that, if they are present, they are protected. Further development and use of the MOLE will continue in 2000.

Leaking Underground Fuel Tank Studies

As part of continuing state-funded leaking underground fuel tank studies, LLNL completed an 18-month study evaluating impacts of the fuel oxygenate methyl tertiary-butyl ether (MTBE) and submitted it to the California State Water Resources Control

Board (SWRCB). Conclusions of the study are found in *Environmental Report 1998* (Larson et al. 1998).

LLNL is continuing to work with the California SWRCB to identify groundwater resources that may be vulnerable to MTBE impacts.

Evaluation of the Use of Ethanol to Replace MTBE in Gasoline

On March 25, 1999, California Governor Gray Davis issued Executive Order D-5-99, calling for the removal of MTBE from gasoline at the earliest possible date but no later than December 31, 2002. Task 10 of the Executive Order states "the California Air Resources Board (ARB) and the SWRCB shall conduct an environmental fate and transport analysis of ethanol in air, surface water, and groundwater. The Office of Environmental Health Hazard Assessment (OEHHA) shall prepare an analysis of the health risks of ethanol in gasoline, the products of incomplete combustion of ethanol in gasoline, and any resulting secondary transformation products."

To assist the SWRCB, LLNL has led a team of researchers in evaluating the potential ground and surface water impacts that may occur if ethanol is used to replace MTBE. These findings are reported in the document entitled *Health and Environmental Assessment of the Use of Ethanol as a Fuel Oxygenate* (Rice and Cannon 1999). This document has been presented to the California Environmental Policy Council and may be viewed at: http://www-erd.llnl.gov/ethanol/

Ethanol may be used in oxygenated and reformulated gasoline (8% in federal oxyfuel or 6% in federal reformulated gasoline [RFG], by volume). Oxygenated gasoline must contain at least 2.7% oxygen by weight unless a state obtains a waiver from the U.S. Environmental Protection Agency (EPA). Such oxygenated gasoline is used in federally designated carbon monoxide nonattainment zones. RFG contains a minimum average of 2% oxygen (by weight), no more than 1% benzene (by weight), and no heavy metals. RFG is used in locations that exceed the ozone standard. Currently, about 70% of gasoline used statewide is RFG. Ethanol is a renewable, biomass-based source of fuel with tax incentives. Initial studies indicate that its environmental impacts are less than those associated with the use of MTBE. Although California has implemented improved containment practices for its underground storage tanks, releases of gasoline that may impact surface water and groundwater resources can still be expected.

Several abiotic and biotic processes or mechanisms that affect the fate of ethanol and ethanol-gasolines in the subsurface have been identified. Ethanol in gasoline will affect

the concentrations of BTEX that dissolve into groundwater and the residence time of fuel hydrocarbons in contact with the water table (saturated zone). The presence of ethanol in groundwater may alter micobially mediated BTEX fate and transport processes and could contribute to increased benzene plume lengths. Biodegradation of fuel alcohols contributes to the depletion of electron-acceptor pools, and this depletion is likely to affect temporal and spatial transitions in electron-acceptor conditions during natural attenuation of petroleum-product releases. Several modeling efforts evaluating the behavior of benzene groundwater plumes in the presence of ethanol indicate that benzene plumes are likely to increase in length, but the amount of this increase is not well known. A number of recommendations have been made to address knowledge gaps in the potential ground- and surface-water impacts associated with using ethanol to replace MTBE.

During evaluation of ground- and surface-water impacts, LLNL began to develop a comprehensive life-cycle model. This life-cycle model systematically addresses impacts from fugitive and accidental releases associated with the production, distribution, and use of ethanol-containing gasoline. LLNL also examined the salient environmental properties of alkylates, which are nonoxygenated compounds likely to be used in greater amounts in gasoline after an MTBE phaseout.

Initiative to Improve Volatile Organic Compound Cleanup Process by Using Historical Case Analysis

The goal of this initiative is to evaluate a large number of nationwide historical cases to identify common VOC release conditions that pose low risks and can be managed with minimal effort and cost, versus release conditions that pose higher risks and warrant larger expenditures. The key to this initiative is a cross-cutting evaluation of the large amount of VOC case data that is available.

This study is ongoing, and LLNL is continuing to gather chlorinated VOC historical case data to improve the evaluation of the behavior of chlorinated VOC plumes. A Phase 1 final report, entitled, *Historical Case Analysis of Chlorinated Volatile Organic Compound Plumes* (McNab et al. 1999), has been completed and can be viewed on the Internet at: http://www-erd.llnl.gov/library/AR-133361.html

Response to Spills and Other Environmental Emergencies

All spills and leaks (releases) at LLNL that are potentially hazardous to the environment are investigated and evaluated. The release response process includes identifying the release, shutting off the source (if it is safe to do so), eliminating ignition sources, contacting appropriate emergency personnel, cordoning off the area containing the released material, absorbing and neutralizing the released material, assisting in cleanup, determining if a release must be reported to regulatory agencies, and verifying that cleanup (including decontaminating and replenishing spill equipment) is complete. Environmental analysts provide guidance to the programs on preventing spill recurrence.

To maximize efficient and effective emergency environmental response, EPD established a 7-day-a-week, 24-hour-a-day, on-call rotational position entitled the environmental duty officer (EDO). Specialized EDO training includes simulated accidents to provide the response personnel with the experience of working together to mitigate an environmental emergency, determine any reporting requirements to regulatory agencies and DOE, and resolve environmental and regulatory issues within the LLNL emergency response organization. The on-duty EDO can be reached by pager or cellular phone at any time.

During normal work hours, Laboratory employees report all environmental incidents to the Environmental Operations Group (EOG) environmental analyst assigned to support their program area. The EOG environmental analyst then notifies the on-duty EDO of the incident, and together they determine applicable reporting requirements to local, state, and federal regulatory agencies and to DOE. The EDO and the EOG environmental analyst also notify and consult with program management and have 7-day-a-week, 24-hour-a-day access to the office of Laboratory Counsel for questions concerning regulatory reporting requirements.

During off hours, Laboratory employees report all environmental incidents to the Fire Dispatcher, who, in turn, notifies the EDO and the Fire Department, if required. The EDO then calls out additional EPD support to the incident scene as necessary, and follows the same procedures as outlined above for normal work hours.

Environmental Training

Major efforts are ongoing to provide LLNL employees with training on environmental topics aimed at improved compliance. Training tasks address both specialized training for environmental professionals and training in a variety of environmental topics for

employees at all levels throughout LLNL. Courses presented by EPD's Training Section are listed in **Table 3-9**.

Table 3-9. EPD training courses.

Air Source Management	Packaging and Shipping Operations
Drills and Exercises for HWM	Petroleum Product Storage Tank Management
Emergency Response for Environmental Duty Officers	RCRA[b] for EWSF/EWTF[c]
Environmental Duty Officer Briefings	RCRA Facility Management
Field Fingerprint Verification Analyses	SARA/OSHA[d] Field Experience
Hazardous Waste Generation and Certification	SARA/OSHA Refresher Training
Hazardous Waste Generation and Certification Review	Spill Prevention, Control, and Countermeasure Training
Hazardous Waste Sampling	Storm Water Pollution Prevention
Hazardous Waste Transportation	TRU[e] Waste Generation and Certification
Identification of Hazardous Material	Waste Accumulation Area Operations
Legacy Waste Process Knowledge Evaluation	Waste Characterization Approval
Low-Level Waste Generation and Certification	Waste Management Unit OJT[f]
NEPA[a] Compliance	Waste Process and Matrix Identification
New Hire Orientation	Waste Retention Tank Management

a NEPA = National Environmental Policy Act.

b RCRA = Resource Conservation and Recovery Act.

c EWSF/EWTF = Explosive Waste Storage Facility/Explosive Waste Treatment Facility.

d SARA/OSHA = Superfund Amendment and Reauthorization Act/Occupational Safety and Health Administration.

e TRU = Transuranic.

f OJT = On-the-job training.

LLNL's Other Environmental Programs

While EPD plays a central role, every directorate at LLNL is responsible for environmental compliance and minimizing the impacts of its operations. Several directorates have taken particularly noteworthy steps in this direction. Some examples include the plans for Defense Nuclear Technologies Program's Contained Firing Facility at Site 300 that will move explosive tests inside a facility where the debris is contained, the Laser Program's efforts to design the National Ignition Facility to have minimal environmental impact, Engineering's Metal Finishing Group's efforts to reduce waste and substitute

less hazardous chemicals in many of its processes, and the Education Program's efforts to enhance environmental education.

Integral to LLNL's environmental research is the Environmental Programs Directorate that conducts multidisciplinary research to assess and mitigate environmental and human risk from natural and man-made hazards and to develop and demonstrate new tools and technologies for environmental restoration. This work includes studies in the design, analysis, and testing of advanced waste-treatment technologies; in situ environmental remediation using natural and engineered processes; pathway, dosimetry, and risk analysis of radioactive and toxic substances; atmospheric dynamics; subsurface imaging and characterization; and seismic processes.

Contributing Authors Acknowledgment

Major contributors to this diverse chapter were Katharine Gabor, Winifred A. Burks-Houck, C. Susi Jackson, Constance E. De Grange, David Rice, Bert Heffner, Stephanie S. Goodwin, Joseph Woods, and James S. Woollett, Jr.