POLLUTION PREVENTION OPPORTUNITY ASSESSMENT

GEOCHEMISTRY LABORATORY
SANDIA NATIONAL LABORATORIES

by

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FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of materials that, if improperly dealt with, can threaten both public health and the environment. The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air and water resources. Under a mandate of national environmental laws, the agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. These laws direct the EPA to perform research to define our environmental problems, measure the impacts and search for solutions.

The Risk Reduction Engineering Laboratory is responsible for planning, implementing and managing research, development and demonstration programs to provide an authoritative, defensible engineering basis in support of the policies, programs and regulations of the EPA with respect to drinking water, waste water, pesticides, toxic substances, solid and hazardous wastes, and Superfund-related activities. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

The Pollution Prevention Research Branch of the Risk Reduction Engineering Laboratory has instituted the Waste Reduction Evaluations at Federal Sites (WREAFS) Program to identify, evaluate and demonstrate pollution prevention opportunities in industrial, military and other Federal facilities. EPA believes the WREAFS Program will show pollution prevention to be a cost-effective tool in reducing the generation and disposal of hazardous and non-hazardous wastes. This report summarizes a pollution prevention opportunity assessment of the Geochemistry Laboratory at Sandia National Laboratories in Albuquerque, New Mexico. The Geochemistry Laboratory performs analysis of earth materials and simulates extreme conditions which earth materials may be subjected to.

E. Timothy Oppelt, Director
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ABSTRACT

This report summarizes work conducted at the Geochemistry Laboratory (GL) at the Department of Energy's (DOE's) Sandia National Laboratories (SNL) facility in Albuquerque, New Mexico as part of the U.S. Environmental Protection Agency's (EPA) Waste Reduction Evaluations at Federal Sites (WREAFS) Program. This project was funded by EPA and conducted in cooperation with DOE officials.

The WREAFS program was developed to identify new technologies and techniques for reducing wastes from industrial processes at federal sites, and to enhance the implementation of pollution prevention through technology transfer. New techniques and technologies for reducing waste generation are identified through pollution prevention opportunity assessments and may be further evaluated through joint research, development, and demonstration projects.

A pollution prevention opportunity assessment (PPOA) was performed during July 1992 which identified areas for waste reduction at the GL. The assessment also examined opportunities for site-wide pollution prevention at SNL as related to the GL. The study followed procedures in the EPA Facility Pollution Prevention Guide (EPA/600/R-92/088). Preliminary evaluation of the GL revealed the greatest opportunity for pollution prevention to be associated with research project design and implementation. This report presents potential research project design and materials management initiatives, as well as recycling/reuse options to enhance current pollution prevention progress. Inclusion of pollution prevention activities in research proposals would benefit the GL, and is consistent with DOE's stance on pollution prevention. Site-wide central purchasing and central distribution could reduce the amounts of expired/unused chemicals requiring disposal. The process of escrowing closeout money at the beginning of research projects will insure adequate money for proper management of samples and chemicals in the event project funding is withdrawn in mid-project. Establishment of a "checkout system" for researchers leaving employment at SNL will reduce the amount of "orphan" chemicals and samples, and foster reuse. Modifications to the chargeback system could provide greater incentive for pollution prevention while funding site-wide pollution prevention projects. Concurrent to this work, a PPOA was performed on SNL's Manufacturing and Fabrication Repair Laboratory. The results of that study are published in a separate document.

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INTRODUCTION

The United States Government, through legislative and executive actions, has mandated waste minimization as a national environmental policy. Federal statutes, such as the Resource Conservation and Recovery Act Amendments of 1984, and the Pollution Prevention Act of 1990 have emphasized the need for generators to reduce the volume and toxicity of their waste. These laws affect all waste generators, including federal facilities. To support pollution prevention activities at federal facilities, the U.S. Environmental Protection Agency (EPA) has established the Waste Reduction Evaluations at Federal Sites (WREAFS) program. WREAFS, administered by EPA's Risk Reduction Engineering Laboratory (RREL) in Cincinnati, OH., provides funding and technical assistance for pollution prevention efforts at a wide variety of federal facilities.

Sandia National Laboratories (SNL) is a federally owned Department of Energy (DOE) facility located in Albuquerque, New Mexico. Under the purview of the WREAFS program, SNL and EPA conducted Pollution Prevention Opportunity Assessments (PPOAs) for two laboratories within the SNL complex. The PPOAs followed the general format of the Facility Pollution Prevention Guide (EPA/600/R-92/088). Portions of the PPOAs also utilized the Guides to Pollution Prevention, The Fabricated Metal Products Industry (EPA/625/7-90/006). Additional guidance was obtained from the Guides to Pollution Prevention, Research and Educational Institutions (EPA/625/7-90/010).

This report summarizes the PPOA performed for SNL's Geochemistry Lab. The major focus of the assessment was identification of pollution prevention opportunities within research project design and implementation activities. Preliminary review of the lab's operations revealed these larger issues as the best opportunities for pollution prevention. Concurrent to this work, a PPOA was performed on SNL's Manufacturing and Fabrication Repair Lab. This second PPOA examined opportunities from a semi-quantitative approach, focusing on wastes generated during repair and fabrication of electronic assemblies. This report is available under separate cover.

Purpose

The PPOAs at SNL were designed to fulfill several purposes. The primary purpose was to identify pollution prevention opportunities within two laboratories that typify a large percentage of operations at the Albuquerque facility. By participating in the PPOA process, waste minimization personnel (MinNet Representatives) would learn the mechanics of the process and be able to conduct future PPOAs themselves. Knowledge gained from the PPOAs would be distributed throughout DOE to assist other facilities in their pollution prevention efforts. Also, the findings from the PPOAs would direct future pollution prevention research and projects.

The WREAFS Program, whose purpose is to identify and promote the use of pollution prevention techniques and technologies through technology transfer, provides an appropriate vehicle to accomplish these purposes. Under the WREAFS Program, innovative pollution prevention techniques/technologies are identified through the PPOA process. Various pollution prevention opportunities and alternatives may then be evaluated through research, development, and demonstration (RD&D) projects. In the past, EPA has initiated and conducted both individual and joint RD&D projects that investigate pollution prevention alternatives. The results of these projects are then provided to both the public and private sectors through various technology transfer mechanisms, including: project reports, project summaries, conference presentations, workshops, and EPA information clearinghouses, libraries and document repositories.

Procedures

The basic approach to PPOAs is presented in EPA's Facility Pollution Prevention Guide. Figure 1 depicts the process. The major categories are: developing a pollution prevention program, developing and implementing pollution prevention projects, measuring pollution prevention progress, and maintaining the pollution prevention program.

Developing a pollution prevention program is the initiating step in the process. The first four boxes in Figure 1 outline the steps. DOE, through Order 5400.1 has required the establishment of waste minimization programs, "that will contain goals for minimizing the volume and toxicity of all wastes that are generated". Also required is the establishment of a Pollution Prevention Awareness Program. SNL has already established an active waste minimization program and published a pollution prevention awareness plan (Sandia National Laboratories, 1991). Representatives from line organizations and management have formed the waste minimization network (MinNet) to carry out this program and plan. The program and plan are good starting points for SNL's pollution prevention program, but are somewhat cursory in nature. These current initiatives are not based upon quantitative waste generation data from the laboratories, largely due to the absence of sufficient historical data on which to base the assessments.

Developing and implementing pollution prevention projects is the second step of the process. The next five boxes depict this part of the program. These activities have already begun at SNL. Several pollution prevention projects (including high grade paper recycling and a chemical exchange program) are currently operational. The focus of this PPOA was to target specific generators of waste and identify opportunities that may also apply to a variety of SNL operations. Implementation of the opportunities is at the discretion of SNL.

Measuring pollution prevention progress will be accomplished at SNL through several mechanisms, including a "chargeback" system which will track waste generation in addition to providing funds for future pollution prevention projects.

Maintaining the pollution prevention program will involve continuing education in pollution prevention for SNL employees. Periodic program evaluation and reporting to DOE also increases the visibility and viability of the program.

The specific approach taken for the Geochemistry Lab (GL) differs from other PPOAs in that it focuses on the larger issues of research and testing design instead of quantitative assessment of specific waste streams. The approach was chosen after discussions with SNL staff identified termination of funding in mid-project as generating the largest amount of waste. Concerns with disposal of samples after completion of projects also pointed to opportunities for pollution prevention in research design. It was also noted that the GL engages in a variety of small research projects spanning a range of subjects. Consequently, research design modifications would produce more consistent results than identifying individual processes which are not consistently used from year to year. Finally, this approach for the GL complements the other PPOA performed concurrently at SNL under WREAFS which examined specific waste streams generated by a repair lab. This second report, Pollution Prevention Opportunity Assessment: Manufacturing and Fabrication Repair Laboratory at Sandia National Laboratories is available from the National Technical Information Service (Telephone, 703-487-4650).

The approach was implemented by involving SNL staff in the PPOA process through several meetings and tours of the GL. During these meetings representatives of SNL's pollution prevention program, GL staff, EPA-RREL personnel, and the EPA contractor discussed the genesis, development, funding and implementation of projects. Opportunities and constraints on building pollution prevention into research projects were discussed. SNL policies that impact pollution prevention also were examined. These discussions have been distilled into recommendations presented within this report. Implementation of these recommendations is at the discretion of SNL and DOE.

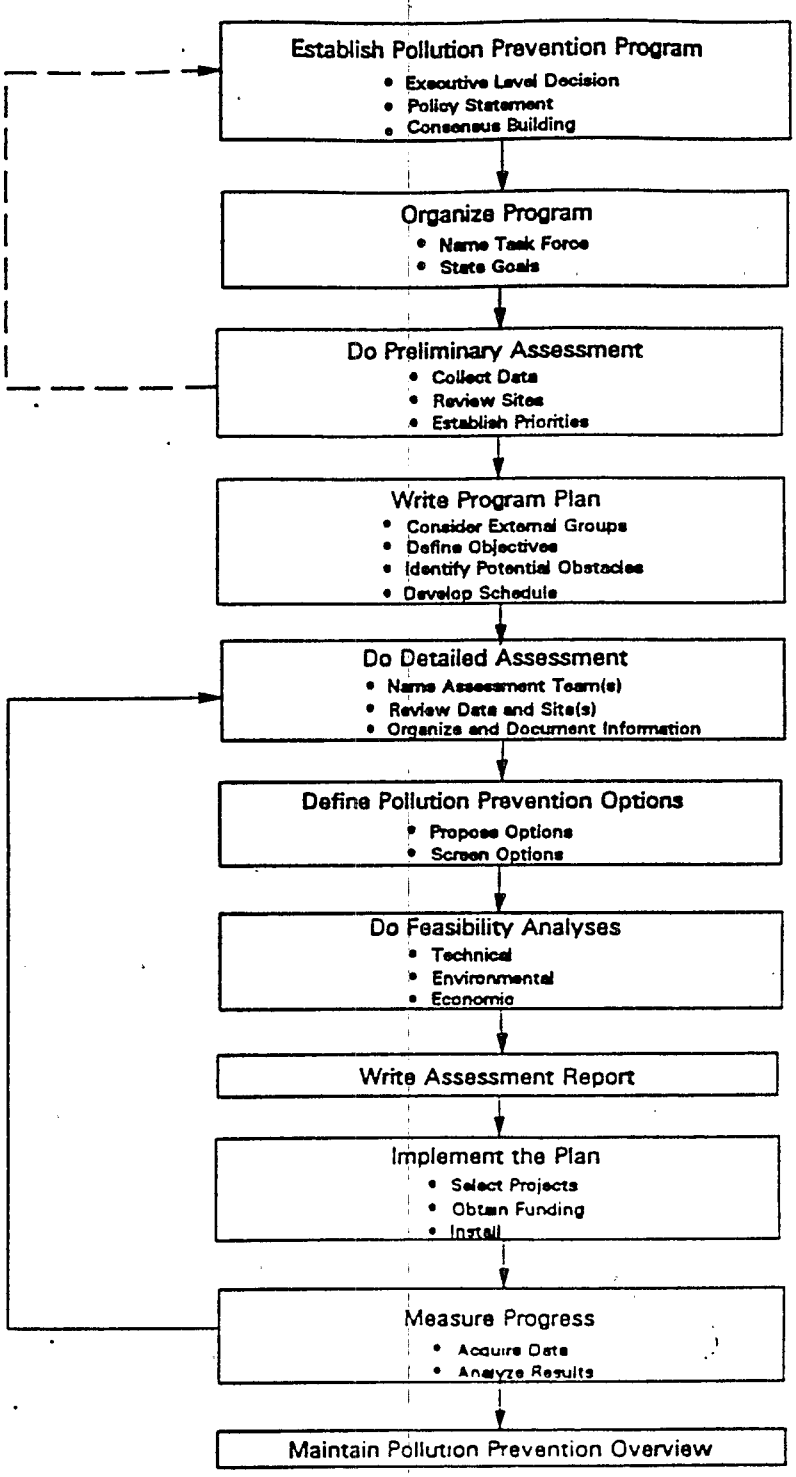

Figure 1. Pollution Prevention Program Overview.

SITE DESCRIPTION

Sandia National Laboratories (SNL) is owned by the U.S. Government and is operated by Sandia Corporation, a subsidiary of AT&T, under a prime operating contract with the DOE. SNL has two major locations, Livermore, CA and Albuquerque, NM. SNL, Albuquerque is located south of Albuquerque within the boundaries of Kirtland Air Force Base, in Bernalillo County. SNL, Albuquerque consists of five technical areas and several remote test areas. SNL's primary mission has been national security, with principle emphasis on nuclear weapons development and engineering. In the process of carrying out this mission, SNL has evolved into a multiprogram laboratory pursuing broad aspects of national security issues. As a byproduct of production, research and development, and environmental restoration activities, SNL generates a variety of waste materials that are regulated by the federal government and state and local agencies (Sandia National Laboratories, 1991).

In the process of pursuing compliance with DOE orders requiring organization and implementation of waste minimization projects, SNL has developed an active pollution prevention program. In Sandia National Laboratories Waste Minimization and Pollution Prevention Awareness Plan, the level of importance is established by the Statement of Management Support and Commitment:

> "Sandia's Environment, Safety and Health Council (SEC), comprised of the President, the Executive Vice Presidents, all of the Vice Presidents, and the Director of Environment, Safety and Health, is totally committed to minimizing the generation of waste by giving preference to source reduction, material substitution, and environmentally sound recycling over treatment, control and disposal of wastes. The SEC will take appropriate action to provide adequate personnel, budget, training, and material on a continuing basis to ensure that the objectives of the Waste Minimization and Pollution Prevention Awareness Program are met."

SNL has established the Waste Minimization Steering Committee composed of a cross-section of SNL staff. A network of waste minimization representatives (MinNet Reps) also has been developed. MinNet Reps assist the line organizations in planning, organizing and directing activities to meet pollution prevention goals within the line organizations. They participate in review of proposed projects, and receive pollution prevention training at SNL, Albuquerque and Livermore.

PROCESS REVIEW

The GL, located in Building 823, was chosen for one of the two WREAFS PPOAs. The lab performs analysis of earth materials (primarily physical and composition analysis) and simulates earth conditions (e.g., subjecting rocks to high temperatures and pressures). The types of research performed by the GL fall into three major categories. For the purposes of this PPOA these project types are considered the three types of processes performed by the lab. Figures 2 through 4 show the process flow diagrams. All types of projects produce relatively similar types of wastes, including: used samples; materials generated in the process of sample analysis; and synthesized materials from sample preparation.

Type 1 projects are those where the GL prepares an unsolicited proposal and submits it to one of several DOE sponsors for approval and funding (see Figure 2). The DOE sponsors include Basic Energy Sciences, Energy Services, and other DOE groups funding military/intelligence projects. The proposals are developed from the researcher's interests in areas of geochemistry that could further DOE's research objectives. An example of proposals for type 1 research projects is, "*Isotopic and Mineralogical Indicators of Infiltration in Unsaturated Zones*" (Lambert, 1992). The general approach for these projects is: preparation and submission of proposal; acceptance by a sponsor; implementation of the project; and shutdown/closeout. Type 1 projects are the largest in scope and budget, typically generating funding for 1 or 2 people for several years ($100,000 to $300,000/yr). While funding is renewable, the funding is approved on a one year basis. Typically less than 10 percent of these projects are terminated before the anticipated project end; this would only happen if there were major changes in DOE policy/funding. This type of project accounts for approximately 40 percent of the lab's workload.

Type 2 projects are those where a proposal is being implemented by another group and the GL is asked to assist due to their capabilities and expertise (see Figure 3). These projects are the most likely to be prematurely terminated and, consequently, are the largest producers of waste. Bench top wet chemistry research in this type of project also contributes to GL waste production. Type 2 projects are usually of medium duration and funding. This type of project typically does not have a formal statement of work (SOW) or similar instructions. An example of this type of project is the examination of brine inclusions in salt formations at DOE's Waste Isolation Pilot Plant (WIPP) site. Funding for this project was withdrawn before completion, leaving the GL with 50 pounds of rock salt that reportedly must be disposed of as chemical waste. The project did not generate any unique chemicals that could not be used in ongoing or future projects. These projects account for approximately 50 percent of the GL workload.

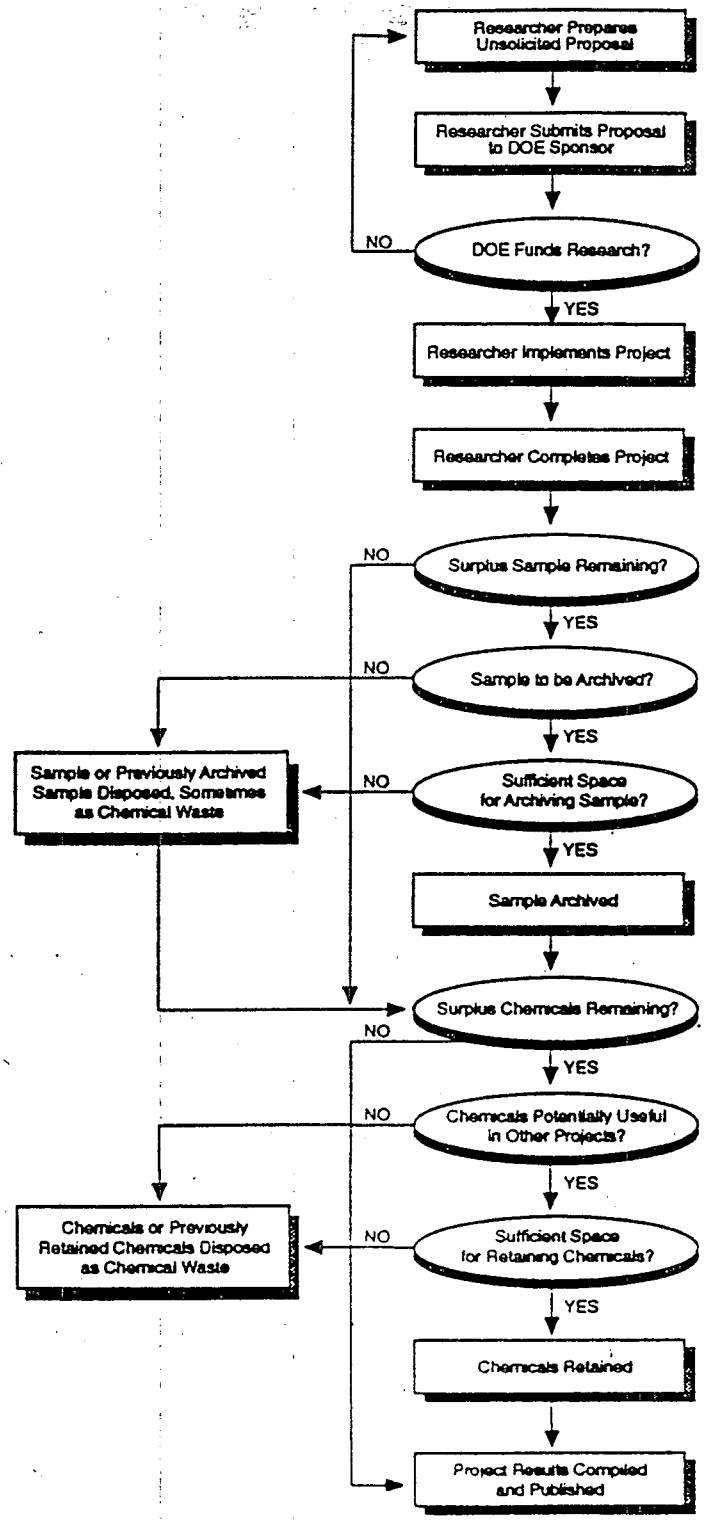

Figure 2. Division 6118 Geochemistry Lab.
Type 1 Research Projects. Process Flow

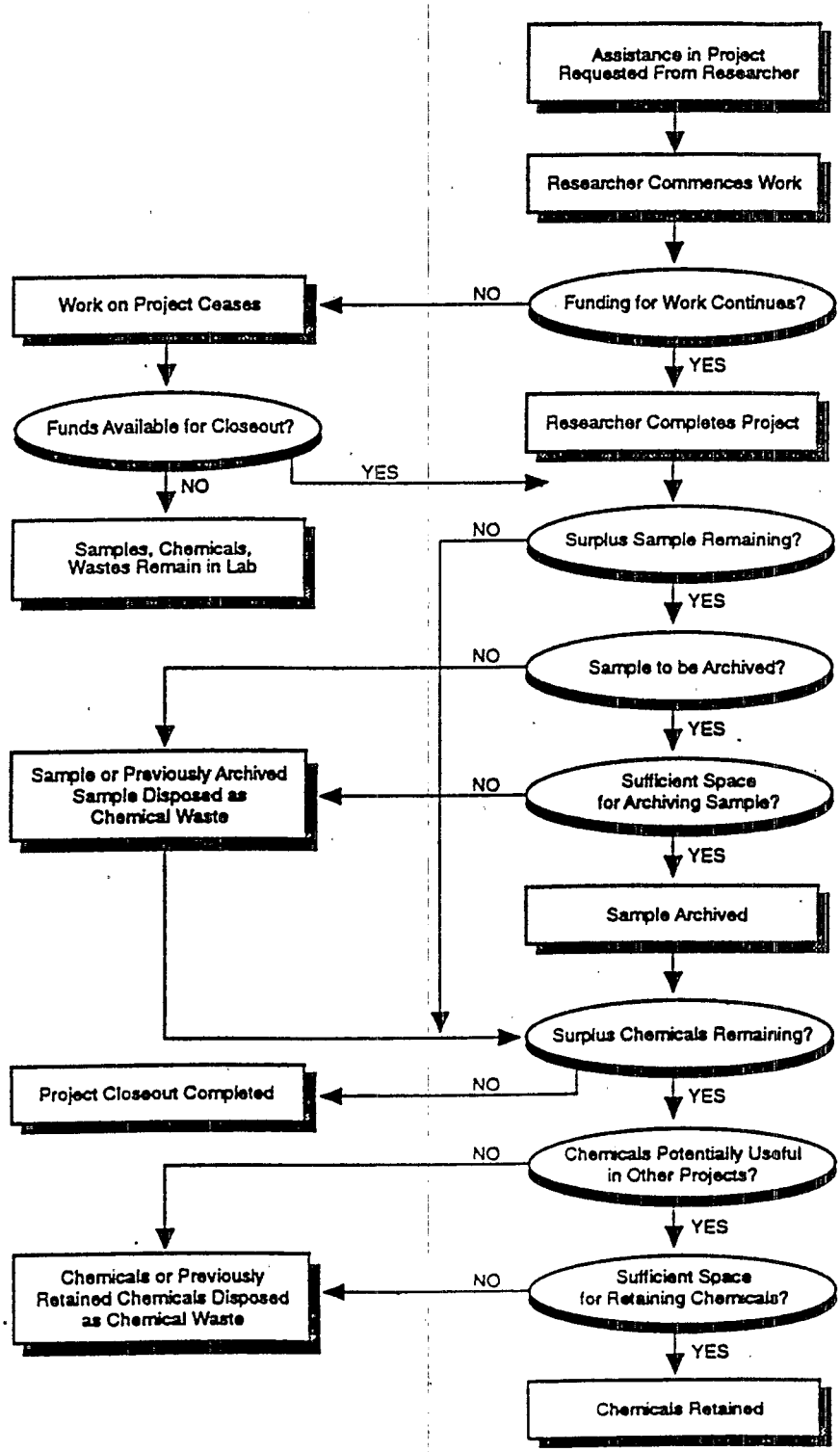

Figure 3. Division 6118 Geochemistry Lab.
Type 2 Research Projects, Process Flow

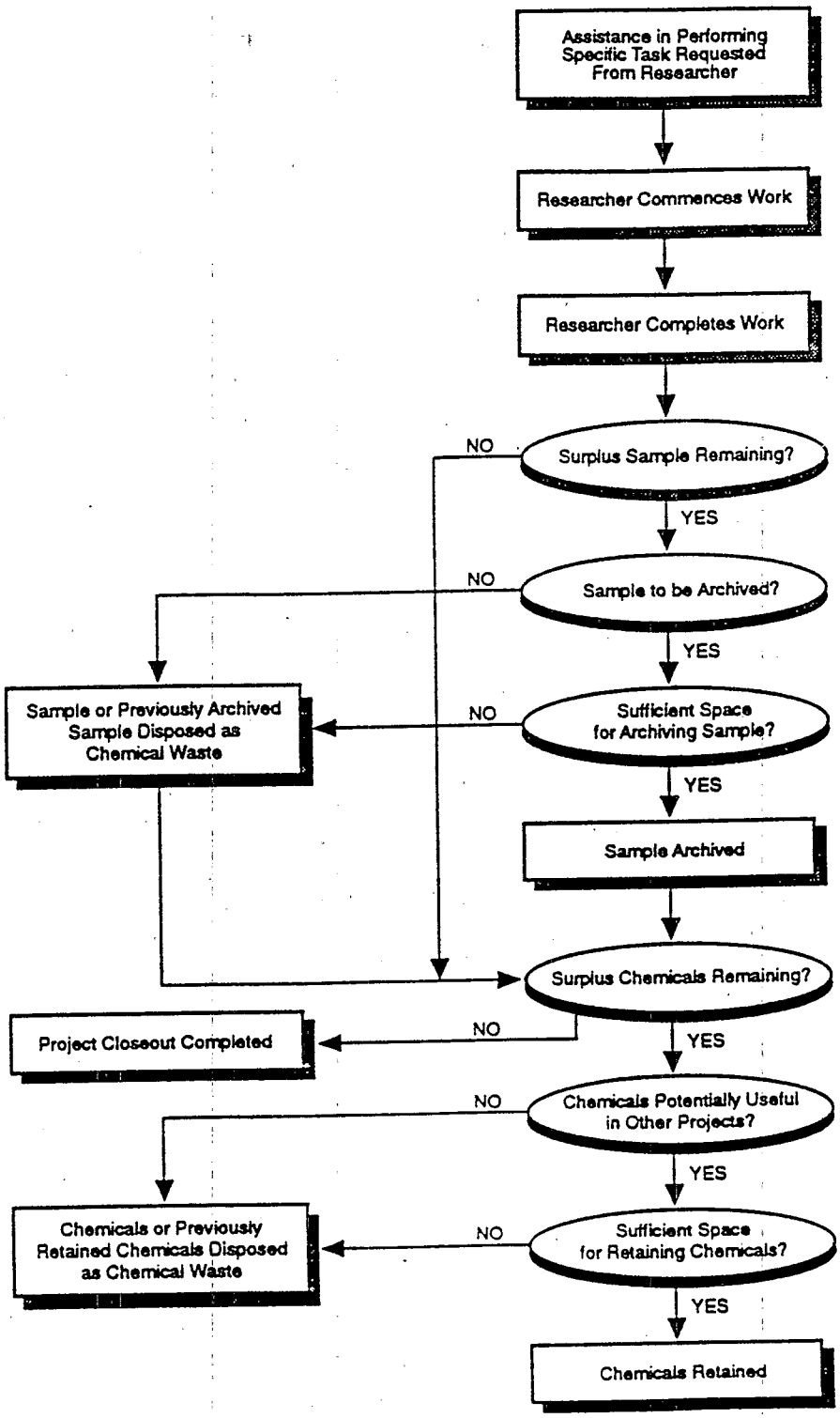

Figure 4. Division 6118 Geochemistry Lab.
Type 3 Research Projects. Process Flow

Type 3 projects are those where the GL is requested by other SNL researchers to do a specific task (see Figure 4). An example of this type of project is where the GL is asked to determine the types of chromium compounds in a soil sample. For these projects neither a formal SOW, nor a work request is generated. These projects are commonly done as "freebies" which, if successful, can turn into type 2 projects. They are of short duration, usually requiring one to three days of laboratory work. These projects account for approximately 10 percent of the GL workload.

The GL has established at least two "libraries" where materials accumulate. The sample library is where rock and soil samples are archived. Samples are usually archived to allow retesting, should the validity of previous results be questioned. Other samples are archived due to their uniqueness of origin or composition. Samples continue to accumulate until there is no more space. They are then disposed usually as chemical waste. Unique samples are either retained indefinitely or archived at sites where they were collected. The chemical library is the second collection, consisting of chemicals that were not consumed during projects.

The GL utilizes a variety of analytical instruments in performing research, including: an atomic emission spectrophotometer; scanning electron microscope (SEM); x-ray diffraction analyzer; scintillation counter; and an ion chromatograph. Various wet chemistry techniques are also utilized. Sample preparation employs grinding, sieving and polishing equipment. Additionally, a small machine shop, comprised of a drill press, lathe and grinder, is located in the lab.

The largest waste stream, by volume, generated by the GL is Polaroid film backs from SEM photography. The estimated annual production of this waste is 14 kg. The largest waste stream, by weight, is discarded unused samples (e.g. cement cores, rocks, soils, etc.). As discussed above, this waste stream is generated on an infrequent basis. Consequently, annual generation data is not available. The balance of remaining wastes are mostly spent solutions and solids from various analytical techniques employed in the GL. The estimated annual production of these wastes is 77 kg. Due to the varied nature of research performed in the GL, waste generation is not consistent between projects and/or years. The use of prior waste generation data, therefore, is not an optimal indicator of future waste generation, or a sufficient "yardstick" for measuring the success of pollution prevention projects.

ASSESSMENT OF POLLUTION PREVENTION OPPORTUNITIES

While this report proposes pollution prevention opportunities related to laboratory research, it acknowledges that investigators must primarily focus on performance of successful research. If researchers have the perception that pollution prevention projects could jeopardize reproducible scientific results, they may be resistant to implementation of the concepts. Hopefully, there is some middle ground between pollution prevention and research concerns that will allow research work to proceed efficiently while simultaneously reducing the amount of waste generated.

Each of the three types of research projects performed by the GL presents opportunities for pollution prevention. The ability to affect pollution prevention increases with increasing control of the project by GL staff. Table 1 lists pollution prevention options for the GL, as well as site-wide options for SNL. Additional pollution prevention ideas for SNL can be found in Guides to Pollution Prevention, Research and Educational Institutions (EPA/625/7-90/010).

Type 1 Projects

Type 1 projects afford the most opportunity to design pollution prevention into research activities. Since the research hypothesis is generated by laboratory personnel, the research design is limited only by imagination, technology, and perceived budgetary constraints. The design can therefore take into consideration potential wastes generated and methods to reduce their quantities and toxicity.

Proposals for research should reflect DOE's stated commitment to pollution prevention. While the proposal may include increased cost due to pollution prevention activities, the document should emphasize the need for these aspects within research, and point out the benefits to DOE derived from funding environmentally sound research. These benefits include: transferable experience in applying pollution prevention to research projects; increased publicity of DOE's environmental efforts; and decreased liability associated with funding research that generates excessive amounts of environmental pollutants. Inclusion of pollution prevention activities in research proposals also will increase DOE awareness of implementation opportunities.

When designing the proposal, the researcher has the opportunity to incorporate micro-techniques for analysis and good laboratory practices for waste handling. Several pertinent references for obtaining information in these areas are available. One such reference, published by the American Chemical Society is, Less is Better, Laboratory Chemical Management for Waste Reduction (1985).

Type 1 research projects also offer the best opportunity to build in funding for proper waste management. A portion of the budget could be allocated for waste characterization, to reduce the amount of nonhazardous waste that is disposed as hazardous. The funds necessary to implement in-lab treatment of wastes, such as neutralization of acids, could be included. This treatment would reduce the quantity of hazardous waste disposed through less appropriate practices (e.g., incineration of acids present in lab packs). Current federal regulations allow elemental neutralization of acids at the laboratory (40 CFR, 1991).

Another opportunity to reduce the quantities of waste generated by these projects is to include mechanisms and funding for return of unused, uncontaminated samples of environmental media to the point of collection, or to the SNL grounds. While the initial perception of such a practice may be negative, EPA, through their "contained in" policy has stated that environmental media are not solid waste (56 FR 24456, 1991). Unused portions of samples that were not collected from contaminated sites, and were not contaminated while at the laboratory would not meet the federal definition of solid waste. As such, these samples could be stored until transportation back to the point of collection became available. Another alternative would be to place the media with like materials at the SNL complex. Analytical records from initial analyses, or sample testing could be retained in order to verify the non-waste status of the material. This approach could be expanded to include construction material samples, such as concrete. These uncontaminated samples could be processed into usable materials (e.g., concrete and rock samples could be reduced to appropriate size and used as aggregate in road construction activities.)

Given DOE's commitment to waste minimization, researchers could submit proposals for the development of pollution prevention techniques within their research specialty. These proposals could include research on microanalytical techniques, minimum quantities of samples needed to generate reproducible results, and comparison of standard and innovative methods. Funding of pollution prevention research would have immediate and long term benefits for DOE.

Type 2 Projects

As previously discussed, this type of GL project generates the largest amount of waste, primarily due to withdrawal of funding (and consequent shutdown of the project) prior to project completion. Researchers in this situation have no money to complete the work, or to clean up from the project. Samples and specialty chemicals may remain in the lab until storage capacity requires disposal. If a significant amount of time has elapsed, the composition and regulatory status of materials may no longer be known, requiring "worst case scenario" disposal.

Prior to participating in this type of project, a portion of available funds could be escrowed to cover the cost of project closeout. This money would remain available for characterization and disposal of wastes from the project.

TABLE 1. POLLUTION PREVENTION OPTIONS

AREA	OPTION
Geochemistry Lab	
Type 1 Projects	Design pollution prevention into proposals for research activities.
	Build in funding for proper waste management.
	Include mechanisms and funding for return of unused uncontaminated samples of environmental media to the point of collection, or to the SNL grounds.
Type 2 Projects	Escrow a portion of available funds to cover the cost of project closeout.
	Contact other labs within SNL before ordering chemicals in order to determine their availability.
	Encourage chemical suppliers to accept returned, unopened chemicals and issue refund or credit.
	Exert tighter controls on sample sizes sent to GL.
Type 3 Projects	Determine sample quantities needed and alternatives to sample analysis.
	Continue/expand use of microanalytical techniques.
	Return to requestor unused portions of samples.
Site-Wide	
CMMS	Provide a life cycling and control mechanism for chemical materials from the point of entry to departure from the facility.
Central Purchasing	Educate procurement personnel to spot material substitution opportunities.
Central Distribution	Determine usage patterns of operations that commonly use and dispose of certain chemicals.
	Order specialty chemicals through a site-wide stockroom.
	Identify other potential users in order to utilize the remaining portion of the minimum lot prior to the expiration date.
Checkout System	Require employees retiring or leaving the lab to report the status of chemicals and samples present in their labs.
Chemical Exchange	Require supplying researcher to certify that the contents of an opened container have not been altered by the addition of contaminants or improper storage.
	Explore ways to use expired chemicals for other applications.
Chargeback System	Use chargeback money for site-wide pollution prevention projects instead of laboratory-specific applications.

Timely determination of waste status would decrease the need for "worst case scenario" disposal. These funds could also be used to locate potential users of remaining chemicals within SNL.

Before ordering chemicals for the project, other labs within SNL could be contacted to determine the availability of the materials. The GL could use a portion or all of the chemical in demand, reimbursing the providing lab with laboratory funds or the same amount of chemical the next time the GL receives a supply. This sharing could have the added benefit of using older chemicals first, reducing the quantities of expired chemicals generated by SNL.

Due to the potential for type 2 projects to be terminated prior to completion, suppliers should be urged to accept returned, unopened chemicals and issue a refund or credit. Agreements with suppliers concerning this practice will reduce the need for disposal of specialty chemicals for which no other need is apparent over the material's shelf life.

Although the exact amount of sample needed for this type of project is difficult to estimate, tighter controls on sample size sent to the GL would reduce the quantities of waste requiring disposal. Samples could be collected (and homogenized if necessary) at the site, with only the estimated quantities required for analysis shipped to the lab. If additional quantities are needed, the "stockpiled" sample could be shipped to the lab to continue the analysis.

The form in which samples are generated could be specified to facilitate use of samples not required for analysis or archival. For example, samples of uncontaminated concrete could be cast into usable shapes, such as paving blocks, and used at SNL after subsamples were collected and the project completed.

Type 3 Projects

Since this type of project is dictated by the requester, (e.g., determination of the species of chromium present in soil samples) pollution prevention opportunities are the most constrained. Notwithstanding, measures can be taken to reduce the amount of waste generated. Through discussions with the requester, sample quantities needed and alternatives to standard analyses could be determined. The data quality objectives for the analysis could allow a reduction in the number of replicate analyses, reducing the amount of sample required. As with the other types of projects, microanalytical techniques could be employed to reduce waste generation. These techniques are currently used in the GL, and could be expanded as new methods are developed. If subsequent analyses are to be performed on the material in question, unused portions of the sample could either be retained by the GL (if that lab is performing the next analysis) or returned to the requester, in order that the same samples can be forwarded to the next lab for analysis.

Site-wide Opportunities

In addition to pollution prevention opportunities described above, additional approaches, if implemented site-wide, could offer significant reduction in waste generation at SNL. These opportunities cut across laboratory

boundaries and are applicable to a variety of SNL operations.

Chemical Materials Management System

A comprehensive Chemical Materials Management System (CMMS) could be an effective pollution prevention tool at SNL. This type of system (called CIS) is currently in use at SNL, Livermore and in the design stages at SNL, Albuquerque. The CMMS at Kelly Air Force Base's San Antonio Logistics Center has proven to be an effective chemical use and waste tracking system. The system provides a life cycle tracking and control mechanism for chemical materials from the point of entry to departure from the Center. The system was designed to satisfy several objectives, including:

- meeting federally mandated chemical exposure and release ("right-to-know") information standards.
- assessing the hazardous nature of chemicals to be used at the facility prior to use
- development of a "paper trail" to keep managers informed of quantities and locations of materials currently in use
- identification of unauthorized practices, such as improper storage and excessive stockpiling of chemicals

While changes in the form of chemicals, via chemical reactions, may make tracking by mass-balance analysis difficult in smaller labs, the system still could be an important pollution prevention tool.

Central Purchasing

At SNL the current practice is for individual laboratories, or at most, divisions to identify their chemical needs and order supplies through a central purchasing department. Central purchasing treats this request as an individual need, ordering the specific type and quantity requested. Depending on usage rates, shelf life and minimum lot sizes, the potential exists for generation of significant quantities of waste in the form of unused chemicals. This type of waste represents a double cost to SNL, since the chemicals were purchased and never used, and now must be disposed.

SNL could potentially reduce the amount of waste generated by educating procurement personnel to spot material substitution opportunities. It is realized that procurement personnel cannot order less hazardous materials when specific chemicals are requested by researchers. Personnel can be trained, however, to identify and purchase less hazardous materials for more generic functions. Implementation could begin with chemicals used in large quantities.

Central purchasing personnel also could require potential suppliers to forward information on chemical manufactures' assignment of expiration dates. Chemical manufacturers often set expiration dates based upon worst case storage scenarios or conservative judgement. By requiring documentation on expiration

date testing, SNL can assess the actual site specific shelf life of chemicals, and reduce the quantity of unused chemicals that are disposed.

Central Distribution

SNL also could reduce the amount of unused chemical waste by establishing a central distribution system, or site-wide stockroom. Using central purchasing and waste disposal records, operations that commonly use and dispose of certain chemicals could be identified and their usage patterns determined. These chemicals could be purchased in bulk, or minimum lots (depending on usage). The end users could then receive the needed amount from the stockroom. Specialty chemicals for which a laboratory uses less than minimum lot quantities during a lot's shelf life could also be ordered through the site-wide stockroom. Other potential users could be identified (including operations that could substitute one of these chemicals for those currently in use) and the remaining portion of the minimum lot could be utilized prior to the expiration date. One example of the benefit of this system is with the Materials Fabrication Repair Lab (MFRL). This lab repairs electronic equipment by, among other operations, applying an adhesive to connect electronic parts. The type of adhesive can only be purchased in minimum lot quantities that the MFRL cannot use prior to exceeding the expiration date for the shipment. Usual operations require several drops of adhesive, and since the adhesive comes in 1 ml syringes, the remaining amount is routinely discarded. The MFRL currently shares the purchased adhesive with another operation, but still does not utilize the entire lot prior to expiration. If a site-wide stockroom purchased the adhesive, and identified other users of adhesives, SNL could potentially use the entire lot prior to the expiration date.

Checkout System

SNL could establish a "checkout system" for researchers that are retiring or otherwise leaving employment. These researchers possess the most detailed knowledge of their laboratory operations and the status of samples and chemicals present in their labs. Prior to terminating employment, the researcher could review all retained samples, properly disposing of those no longer needed, and clearly documenting the composition and regulatory status of those remaining. If this procedure were followed, subsequent researchers in that lab would not be saddled with disposal of samples of unknown materials.

Similarly, laboratory chemicals used by the researcher could be inventoried and properly managed. All chemicals remaining in the lab after departure of the researcher could be clearly labeled with a minimum of chemical name, manufacturer and expiration date. Chemicals that will no longer be used by the lab should be made available to other researchers via the chemical exchange system. Chemicals for which there are no further uses, and wastes, could be disposed while the researcher is still available to answer questions about the materials.

Chemical Exchange

SNL could further reduce disposal of chemicals by modifying the chemical exchange program to include opened, expired and waste chemicals. The primary concerns with these materials are adulteration and performance. Concerns with

adulteration potentially could be alleviated by requiring the supplying researcher to certify, through personal knowledge, that the contents of opened containers have not been altered by addition of contaminants or improper storage. This type of accountability should decrease concerns about quality, since researchers will be certifying usability to their peers. While the supplying researcher may be reluctant to certify chemical purity (due to perception concerns), savings in costs incurred via the chargeback system, and heightened awareness of the need for effective pollution prevention, may offset concerns.

Many chemicals used for laboratory purposes are produced in differing grades of purity (e.g. HPLC, analytical, technical). While expired chemicals may not be suitable for use within their original grade, they could be used for other applications. For example, expired HPLC grade acetone would still be suitable for cleaning glassware. Acids that are no longer suitable for making reagents could be used for cleaning or neutralizing basic solutions prior to disposal.

Chemicals that have been used and are considered waste by a laboratory at SNL may still have value through reuse or reclamation. Dilute acids with known contaminants could be used in other processes where the contaminants would not effect process quality. Exotic chemicals used at SNL could be reclaimed at a centralized reclamation area. The value of these exotic chemicals, or exotic contaminants, may offset the cost of reclamation through reuse or resale. Development of a reclamation operation would proceed slowly with initial efforts focusing on easily reclaimed, extremely expensive chemicals that are currently disposed as hazardous waste.

Chargeback System

SNL, as part of its pollution prevention program, has developed a chargeback system for waste generation. The system currently requires the payment of $11.00/kg of hazardous waste disposed. Funds collected from a laboratory are available to the lab to be used for pollution prevention activities. These activities could include library research, or laboratory projects aimed at reduction of waste generation. By design, the money collected from a lab must be reinvested in that organization. Funds collected via the chargeback system also will be used to fund the corresponding MinNet Representative position.

The chargeback system could be made even more effective if funds were also used for site-wide projects. While laboratory specific projects benefit a particular lab, and, ideally, analogous operations, site-wide pollution prevention projects usually produce a larger benefit by positively affecting more operations. The flexibility of being able to fund both specific and site-wide pollution prevention initiatives could increase the cost-effectiveness of the chargeback system.

Education

Perhaps the most important key to reducing waste at SNL is educating laboratory personnel to be conscious of both the amounts of waste they generate and potential ways to reduce those amounts. Pollution prevention concepts could

be emphasized by "MinNet champions" who specialize in specific areas. SNL, through its pollution prevention awareness plan, is addressing this area. Still, a researcher may not consider his or her waste contributions a problem. When multiplied by the number of researchers at SNL however, the cumulative amounts are large. Completion of process waste assessments (PWAs) for SNL laboratories would call attention to the types and amounts of wastes generated by individual labs, but may not be cost-effective in all situations. Alternatives to a comprehensive PWA program could be explored. Continued dissemination of pollution prevention initiatives and findings throughout SNL and DOE could reinforce the global need for pollution prevention.

FEASIBILITY

The nature of waste generation at SNL presents certain obstacles to pollution prevention initiatives. The number of laboratories and the nature of laboratory work result in a large number of small quantity waste streams being generated. Conducting quantitative analysis of the feasibility of pollution prevention opportunities may not be cost effective, given the small amounts of waste generated by individual labs.

The need for generation of reproducible lab results and the strong reliance on standard methods hinder implementation of pollution prevention initiatives that could call into question a researcher's findings. The complexity of federal and state hazardous waste regulations also makes scientists reluctant to implement many pollution prevention activities. The feasibility of pollution prevention opportunities discussed in this report, therefore, is largely dependant on the attitude and confidence of SNL's researchers. If, through education and training, the importance of pollution prevention is elevated to the level of other crucial scientific principles, significant reductions in waste generation within SNL's labs can be achieved.

Many of the pollution prevention opportunities discussed in this report are feasible and readily implementable through researcher and administration initiatives. Tables 2 and 3 present qualitative ratings of pollution prevention options for GL projects and site-wide, respectively. Each option was subjected to eight criteria and rated (see appendix A for criteria definitions). Options affording the greatest benefit or least detrimental effect for a criterion were assigned a "5" for that criterion. Options affording the least benefit, or most detrimental effect were assigned a "1". The ratings were summed and a total score given for each option. While the totals indicate that implementation of certain options would be more feasible than others, the range of totals is sufficiently narrow to require SNL discretion in prioritizing the options.

Given DOE's stated commitment to pollution prevention, proposals that include waste minimization components should be favored over similar research that does not address waste generation. Submission of these types of proposals would require researchers to invest additional time in proposal preparation. The increased chances of DOE funding the proposal (due to its pollution prevention aspects) and the potential savings in disposal cost, however, justify the increased effort. Building pollution prevention into research proposals consequently is one of the most feasible initiatives.

Closeout of projects that end prior to scheduled completion is feasible only if the organization supplying the funding is willing to "escrow" closeout costs up front. Many of the mechanisms for funding SNL research projects do not provide for the carry over of money between fiscal years. Consequently,

implementation of this option must be in concert with DOE. Implementation of this option by the researcher should be feasible, as long as funding is available.

Site-wide pollution prevention opportunities offer the greatest potential for waste reduction. The site-wide options identified in this report are technically feasible. Many of the options are already being developed and implemented at SNL. With the recommended modifications, implementation of these options will be even more effective. Although increased costs would be incurred, the increase would be offset by savings in disposal costs. While researchers would have to modify procurement habits, and may have to spend increased time in tracking materials, the program may assist researchers in preparing for future projects by being aware of intra- and inter-laboratory resources.

CROSSFEED TO OTHER DOE FACILITIES

Many DOE facilities contain research laboratories and almost all use chemicals in support of facility operations. Both laboratory specific and site-wide pollution prevention opportunities could be implemented at other locations. As a result of DOE's proactive stance on pollution prevention, successfully implemented options at SNL would be quickly disseminated to other locations.

MEASUREMENT OF POLLUTION PREVENTION

The success of implemented pollution prevention options for research projects may not be easily measured, since projects vary widely in scope and waste generation. Researchers would have to estimate baseline waste generation using previous records and best judgement. Waste quantities and types generated during subsequent research could then be compared. The effectiveness of site-wide pollution prevention projects could be better measured once SNL implements the CMMS.

IMPLEMENTATION PLAN

Implementation of pollution prevention opportunities identified by the PPOA is at the discretion of SNL. Many opportunities, such as controlling sample size could be implemented in the near future. Others, such as centralized distribution, will require additional planning and resources. Implementation of some pollution prevention techniques will not be feasible until researchers obtain a clearer understanding of waste regulations and policies. Concerns with "doing the right thing"are often amplified in researchers and other professionals used to relying on empirical data to make decisions. Unless waste management issues are clearly documented, researchers will be reluctant to deviate from current waste management approaches.

TABLE 2. RATING OF POLLUTION PREVENTION OPTIONS FOR GL: TYPE 1, 2, and 3 PROJECTS*

Pollution Prevention Option	Media Impact	Pollution Prevention Hierarchy Factor	Potential Economic Recovery	Ease of Implementation	Crossfeed Potential	Mission Impact	Material Control	Increased Staff Required	Total
TYPE 1 PROJECTS									
Designing pollution prevention into proposals for research activities	5	5	5	4	5	5	5	5	39
Build in funding for proper waste management	4	3	5	4	1	5	5	5	32
Return of unused, contaminated samples to point of collection or SNL grounds	5	3	4	3	1	5	5	4	30
TYPE 2 PROJECTS									
Escrow a portion of available funds to cover the cost of project closeout	4	2	4	2	1	3	5	5	26
Contact other labs within SNL before ordering chemicals in order to determine their availability	5	5	5	3	3	4	5	5	35
Encourage chemical suppliers to accept returned, unopened chemicals and issue refund or credit	5	4	4	3	3	4	4	5	32
Exert tighter controls on sample sizes sent to GL	5	5	3	3	3	4	4	5	32
TYPE 3 PROJECTS									
Determine sample quantities needed and alternatives to sample analyses	5	5	4	4	3	5	5	4	35
Expand use of microanalytical techniques	4	5	4	3	3	5	4	3	31
Retain or return to requester unused portions of samples	5	3	4	2	1	5	5	5	30

* Pollution prevention options rated with 5 signifying most favorable effect and 1 signifying least favorable effect.

TABLE 3. RATING OF POLLUTION PREVENTION OPTIONS: SITE-WIDE PROJECTS*

Site-Wide Options	Media Impact	Pollution Prevention Hierarchy Factor	Potential Economic Recovery	Ease of Implementation	Crossfeed Potential	Mission Impact	Material Control	Increased Staff Required	Total
CMMS									
Provide a life cycling and control mechanism for chemical materials	4	3	3	3	4	5	5	4	31
Central Purchasing									
Educate procurement personnel to spot material substitution opportunities	5	5	4	3	5	5	5	3	35
Central Distribution									
Determine usage patterns of operations that commonly use and dispose of certain chemicals	5	4	4	3	4	5	5	4	34
Order specialty chemicals through the site-wide stockroom	5	4	4	3	4	5	5	4	34
Identify other potential users	5	3	5	3	1	5	5	4	31
Checkout System									
Require employees retiring or leaving the lab to report the status of chemicals and samples present in their labs	4	4	4	4	4	5	5	5	35
Chemical Exchange									
Require supplying researcher to certify contents of an opened container have not been altered by the addition of contaminants or improper storage	5	3	4	3	1	4	5	5	30
Explore ways to use expired chemicals for other applications	5	5	4	3	5	5	5	4	36
Chargeback System									
Use chargeback money for site-wide pollution prevention options	5	5	4	4	5	5	5	4	37

* Pollution prevention options rated with 5 signifying most favorable effect and 1 signifying least favorable effect.

RESEARCH DEVELOPMENT AND DEMONSTRATION NEEDS

Given the research orientation of the GL, RD & D opportunities for pollution prevention should be readily embraced. Submission of type 1 research project proposals that investigate pollution prevention techniques within the researcher's area of interest would be an excellent vehicle for addressing RD & D needs. DOE could facilitate this process by designating a pool of research money to fund such proposals. Proposals for research on "traditional" geochemistry issues should include pollution prevention components. These proposals could include research on the minimum sample quantities needed for analyses. Development and use of microanalytical techniques also merit further research. Subsequent use of remaining unused samples should be investigated, both from a technical and administrative perspective.

RD & D needs for site-wide opportunities could be explored through the existing waste management organizations and the MinNet. The viability of central distribution and expanded chemical exchange should be researched. Potential uses of expired chemicals will also require research and demonstration before implementation.

RECOMMENDATIONS/CONCLUSIONS

Sandia National Laboratories continues to expand its pollution prevention efforts. Implementation of concepts identified during this WREAFS project would further enhance SNL's pollution prevention program. To that end, EPA recommends that DOE and SNL investigate the following topics:

- Research Proposals - Build pollution prevention into research projects from the start. Researchers should share their ideas in this area, possibly through the MinNet. An on-site compendium of pollution prevention ideas could be generated to assist researchers in this area.

- Central Purchasing/Central Distribution - Implementation and refinement of these systems could result in significant reduction in waste generation. When combined with an expanded chemical exchange system, disposal of expired chemicals could be virtually eliminated.

- Escrowed Closeout Money - By setting aside this money at the beginning of a project, potential reuse, proper characterization, and appropriate management of chemicals can be maximized.

- Checkout System - As with the escrowed closeout money, potential reuse, proper characterization, and appropriate management of chemicals can be built into the procedures for researchers leaving SNL employment.

- Chargeback System - Modifications to the system that promote funding of site-wide projects would make the system more effective.

The recommendation with the largest potential for pollution prevention gains is to continue SNL's education and training efforts. Through these efforts pollution prevention can become an integral part of research design, implementation, and conclusion. As researchers modify their perceptions toward waste generation, new concepts and approaches which extend beyond individual labs will emerge and be assimilated into site-wide pollution prevention efforts.

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APPENDIX

DEFINITIONS OF CRITERIA USED IN RATING OF POLLUTION PREVENTION OPTIONS

The following criteria and corresponding definitions were used in rating the pollution prevention options identified in this report. Results of the qualitative rating process are presented in Tables 2 and 3 within the report.

Media Impact

This criterion assesses the potential for reduced impact to one or more environmental media if this option is implemented. Higher ratings are assigned to options that effect the greatest reduction in impact. Options where impact to environmental media are not significantly reduced are rated low under this criterion.

Pollution Prevention Hierarchy Factor

This factor rates the option based upon the type of pollution prevention accomplished. Source reduction is the highest priority in the pollution prevention hierarchy and is consequently rated high. Recycling options receive a lower rating. Disposal is positioned at the bottom of the hierarchy and, therefore, receives the lowest rating.

Potential Economic Recovery

This criterion examines potential economic savings from implementation of the option. Savings may be immediate, when no money is required to implement the option. These options are rated high. Options with a "payback" period may be rated high, if the period is short, or low if longer time frames are required.

Ease of Implementation

If the option is readily available, or requires little refinement or modification prior to implementation, it is assigned a high rating. Options that require substantial planning and coordination prior to implementation are rated lower.

Crossfeed Potential

This criterion rates an option for its ability to be used elsewhere within SNL and other DOE facilities. Options with the greatest potential for use elsewhere are rated high.

Mission Impact

Any option that disrupts or negatively impacts the mission of the GL or the entire SNL facility would be rated low. Options that do not impact, or even enhance, the mission of these entities are rated high.

Material Control

Options that increase the accountability and management of chemicals and samples are rated high. Also highly rated are options that provide better management of wastes.

Increased Staff Required

Options that do not require increases in staff to implement are rated higher than those initiatives where additional staff must be obtained. If additional research must be performed prior to implementation of an option, the rating also is lower.