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Pacific Northwest Laboratory
Annual Report for 1977
to the DOE Assistant Secretary
for Environment

February 1978

Part 5

Control Technology, Overview, Health, Safety & Policy Analysis

Prepared for the
U.S. Department of Energy
under Contract EY-76-C-06-1830

Battelle
Pacific Northwest Laboratories

PNL-2500 PT5

NOTICE

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Pacific Northwest Laboratory Annual Report for 1977 to the DOE Assistant Secretary for Environment

Part 5 Control Technology, Overview, Health, Safety, and Policy Analysis

by
W. J. Bair and Staff Members
of Pacific Northwest Laboratory

February 1978

Battelle
Pacific Northwest Laboratories
Richland, Washington 99352

PREFACE

The 1977 Annual Report from Pacific Northwest Laboratory (PNL) to the DOE Assistant Secretary for Environment introduces a new cover. The earth-green color used on past annual reports has been replaced by the "environmental colors," blue and green. The cover's abstract design is not intended to represent anything specific, but we would not be unhappy if it suggests something environmental or biological to the reader. The blue and green color pattern on the cover is different for each part of this report to help distinguish the five parts.

The five parts of the Report are oriented to particular segments of our program. Parts 1-4 report research performed for the DOE Office of Biomedical and Environmental Research. Part 5 reports progress on all other research performed for the Assistant Secretary for Environment, including the Office of Environmental Control Technology, Office of Technology Impact, and Office of Operational and Environmental Safety.

Each part consists of project reports authored by scientists from several PNL research departments, reflecting the interdisciplinary nature of the research effort. Parts 1-4 are organized primarily by energy technology, although it is recognized that much of the research performed at PNL is applicable to more than one energy technology.

The parts of the 1977 Annual Report are:

Part 1: Biomedical Sciences

Program Manager - W. R. Wiley — R. C. Thompson, Report Coordinator; D. L. Felton, Editor

Part 2: Ecological Sciences

Program Manager - B. E. Vaughan — B. E. Vaughan, Report Coordinator; J. L. Helbling, Editor

Part 3: Atmospheric Sciences

Program Manager - C. L. Simpson — R. L. Drake, Report Coordinator; C. M. Gilchrist, Editor

Part 4: Physical Sciences

Program Manager - J. M. Nielsen — J. M. Nielsen, Report Coordinator; G. M. Garnant/L. Carson, Editors

Part 5: Control Technology, Overview, Health, Safety, and Policy Analysis

Program Managers - N. E. Carter
D. B. Cearlock
J. C. Fox
D. L. Hessel
H. V. Larson
S. Marks

W. J. Bair, Report Coordinator
R. W. Baalman, Editor

Activities of the scientists whose work is described in this Annual Report are broader in scope than the articles indicate. Knowledge and experience obtained by PNL staff in carrying out research in the Environment, Health, and Safety Research program have contributed to many other DOE interests. These include assistance in the preparation of several Environmental Development Plans for the Assistant Secretary for Environment, preparation of environmental statements for which the Laboratory is responsible, key membership in several national and international organizations, and numerous responses to the media on research projects of public interest.

W. J. Bair, Manager
S. Marks, Associate Manager
Environment, Health, and Safety Research Program

Previous Reports in this Series:

Annual Report for

1951	W-25021, HW-25709
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1971	BNWL-1650, Vol. 1, Pt. 1-2, BNWL-1651, Vol. 2, Pt. 1-2
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1973	BNWL-1850, Pt. 1-4
1974	BNWL-1950, Pt. 1-4
1975	BNWL-2000, Pt. 1-4
1976	BNWL-2100, Pt. 1-5

FOREWORD

Part 5 of the 1977 Annual Report to the DOE Assistant Secretary for the Enviornment presents Pacific Northwest Laboratory's progress on work performed for the Office of Technology Impact, the Office of Environmental Control Technologies, and the Office of Operational and Environmental Safety. Also included are reports on Human Health Studies performed for the Office of Biomedical and Environmental Research. The report is in five sections, introduced by blue divider pages, corresponding to the program elements: Environmental Control Technology, Technology Overview, Operational and Environmental Safety, Human Health Studies, and Environmental Policy Analysis. The Technology Overview section contains the first reports on two new projects, Interlaboratory Data Exchange and Environmental Information System.

In each section, articles describe progress made during FY-1977 on individual projects, as identified by Schedule 189 tables. Authors of these articles represent a broad spectrum of capabilities derived from various segments of the laboratory and reflecting the interdisciplinary nature of the work.

Most of the program elements reported in this part of the Annual Report are relatively new to the Laboratory. These include the projects in Environmental Control Technology, Overview, and Environmental Policy Analysis. We believe that significant progress was made in all of these areas; however, we expect this part of our program to continue evolving to meet newly identified requirements of the Department of Energy.

For additional information on any of the projects reported in this Part, contact the authors of the articles.

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1.0 Environmental Control Technology

ENVIRONMENTAL CONTROL TECHNOLOGY

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- **Assessment of Energy-Conserving Industrial Waste Treatment Technology**

The objective of the overall Environmental Control Technology Program is to assure that the environmental control capability for each DOE energy technology is complete, practical, cost effective, and available in a timely manner as the energy source is developed. Program activities are oriented to identifying control technology status and needs for emerging energy systems, then developing methods and equipment for meeting these needs.

PNL's effort in this program is growing rapidly. During 1977 we conducted studies in support of both nonnuclear and nuclear technologies, with programs in oil shale, coal, energy materials transport, geothermal and compressed air energy, and nuclear fuel cycle analysis.

- Bullets indicate 189 titles.

• Environmental Control Technology for Shale Oil Wastewaters

The capabilities and limitations of conventional treatment and disposal technology are currently being evaluated for shale oil wastewater. For these evaluations, bench-scale experimental studies are being conducted to assess how gravity sedimentation, steam stripping, and biological treatment affect oil shale retort waters. The results of investigations concerning land disposal and underground injection of retort water indicate restricted use of these options in the shale oil regions of Colorado, Utah, and Wyoming.

Analysis, Screening, and Evaluation of Control Technology for Wastewater Generated in Shale Oil Development

G. W. Dawson, B. W. Mercer

Several different types of wastewaters may be generated in the mining and processing steps leading to the recovery of oil from shale. Retort water, produced during pyrolysis of oil shale, is generally the most heavily polluted waste stream; others, such as cooling water, may have a relatively low pollution potential. Most, or all, of these wastewaters can be used to moisturize spent shale from surface retorts, but disposal or reuse must be practiced for in situ operations. The primary objective of this program is to assess the capabilities of state-of-the-art technology for the treatment and disposal of wastewaters generated in shale oil development. A comprehensive literature review has been completed, and bench-scale experimental studies have been initiated to evaluate the various treatment alternatives presently available for shale oil wastewaters.

Bench-scale Treatability Studies

Bench-scale experiments are being made on two treatment processes: steam stripping and biological treatment.

Steam Stripping. Steam stripping of retort water is being investigated to demonstrate the applicability of this process to removing ammonia and alkalinity from retort water. Steam stripping is the standard process used throughout the petroleum refining and coking industries for this purpose. Bench-scale experiments were made with a 2-in. diameter by 4-ft high stripping column packed with 1/4-in. ceramic saddles. Using a sample of retort water obtained from Geokinetics, Inc., ammonia-nitrogen was reduced from 3,060 mg/ℓ to 14 mg/ℓ and alkalinity was lowered from 14,300 mg/ℓ to 4,600 mg/ℓ as $CaCO_3$. The pH of the retort water increased through the stripper from 8.8 to about 10. This action is believed to be the result of stripping CO_2 from the bicarbonate/carbonate alkalinity. The bicarbonate/carbonate alkalinity is greater than that of the equivalent amount of ammonia present in the retort water. Some fouling of the packing in the column was observed, which may have been the result of suspended matter depositing on the packing. Although settled retort water was used, it contained about 150 mg/ℓ of suspended solids, which were reduced to about 30 mg/ℓ through the stripper.

A small volume of light oil was also removed by the steam stripping operation. Two operational modes were evaluated, one with recycle of the condensate and one without recycle. Recycle of the condensate eliminated the necessity of dealing with a separate waste stream, but it also reduced the efficiency of ammonia removal. Ammonia removal was 80% to 85% with recycle of the condensate at a boil-off rate of 4.5%.

Biological Treatment. Bench-scale biological treatment equipment, consisting of a trickling filter and an activated sludge unit, was put into operation on raw sewage. The equipment was gradually acclimated to a simulated retort wastewater composed of aliphatic acids, acetamide, phenol, cresol, and ammonia in a slightly saline solution. Total organic carbon removals of 95% were routinely achieved across both treatment units; however, organic carbon removal across the activated sludge unit was consistently better than across the trickling filter. Trickling filter performance generally varied between 10% and 50%.

Initial results with actual retort water in the biological treatment units indicate a potential toxicity problem. Removal of biochemical oxygen demand (BOD) from steam-stripped, full-level retort water was low (30% to 50%) compared to removal from mixtures of actual retort water with 80% simulated retort water (BOD removal greater than 90%).

Land Disposal and Underground Injection

Land disposal and underground injection were investigated as possible alternatives to conventional wastewater treatment and disposal. Current data in the literature indicate that the salinity of retort water from shale oil recovery operations will be too high in most cases for the irrigation of cover crops needed for effective stabilization by land treatment and disposal. Furthermore, large storage lagoons would be required to hold the retort water during the long winters encountered in the oil shale regions of Colorado, Wyoming, and Utah. Additional problems that may arise with land disposal include air pollution from volatile constituents and groundwater pollution from refractory organics and dissolved salts in the retort water.

Regulatory restraints are expected to limit the use of underground injection for disposal of highly polluted shale oil waters. Proof of confinement of injected wastes will be required to assure protection of drinking water resources; this is often difficult and expensive to accomplish because of the substantial geological survey needed.

• Assessment of Environmental Control Technologies for Commercial Coal Gasification Systems

Commercial coal conversion processes employing Koppers-Totzek (K-T) and Winkler gasifiers were reviewed to determine the availability of control technologies for meeting current environmental standards. Information on material and energy flows in the processes was obtained from manufacturers of the gasifiers and from the literature. Technologies for control of releases to air, land, and water are commercially available and are adequate for meeting current environmental release standards. The behavior of trace elements in the coal feed has not been adequately characterized. Areas where improvements in technology would benefit the conversion processes have been defined and will be presented in a final report. Construction of a demonstration plant employing these technologies for ammonia production is recommended.

Status of Environmental Control Technologies Used in Commercial Coal Gasification Systems

L. K. Mudge

Data on material and energy flows in commercial plants that use either Winkler or Koppers-Totzek gasifiers to generate synthesis gas are to be sought by contacting manufacturers of these gasifiers and by searching the literature. The objectives of the study are: 1) to determine if environmental control technologies in commercial use are adequate relative to existing and proposed standards, 2) to identify areas where improved control technologies are needed, and 3) to rank research and development programs in terms of their potential benefit.

Review of pertinent literature and contacts with suppliers (Koppers in Pittsburgh, Pennsylvania, and Davy Powergas in Lakeland, Florida) have been completed. Information was obtained on the complete process for synthesis gas manufacture, which involved coal preparation, coal storage, gasification, gas cooling, particle removal, acid gas cleanup, oxygen manufacture, wastewater cleanup, and utility operation.

Processes are available for removal of sulfur compounds in order to prevent poisoning of catalysts used to convert the synthesis gas to final product forms. The sulfur compounds can be converted to elemental sulfur, an environmentally acceptable form, by using the Claus or Rectisol processes. Emissions from the Claus plant can be reduced to less than 1% of the total sulfur input by using commercially available tail gas cleanup processes.

Particle removal is effected by use of water scrubbers, including mechanical scrubbers (Theisen disintegrators), venturi scrubbers, and packed scrubbers; cyclone separators; and electrostatic precipitators. Concentration of particles in the synthesis gas is reduced to 0.002 - 0.005 grain/scf in venturi scrubbers used with the K-T gasifiers.

Commercial technology for control of environmental emissions is available and adequate to meet current standards in related industries. Very little is known about the behavior of trace elements in the K-T and Winkler gasification systems. Unlike power plants, gasification plants do not have a stack emission since the product gas is cleaned for synthesis of chemicals. Airborne emissions of trace elements can occur from the utility boiler and from wind entrainment of discharged residue and stored coal. Ash components are discharged from the gasification processes with gasifier residues and gas-cleanup sludges and residues. The trace element composition of coal is geochemically similar to the makeup of the earth's crust and includes almost all of the elements of the periodic chart. The potential hazard from emissions of trace elements is mainly from long-term, low-level exposures to increased atmospheric pollution levels. Discharges from the K-T and Winkler processes can be expected to contribute very small levels of trace elements to atmospheric pollution.

Energy requirements for the different control technologies and process operations were estimated to assist in determining areas where advances could significantly improve process efficiency and thereby reduce environmental intrusion. The components identified as major energy users are oxygen manufacture, coal drying, gas compression, and acid gas removal. These processes represent highly developed technology areas where only limited improvement in efficiency can be expected to result from research and development.

The major recommendation of this study is that a demonstration plant employing these gasification processes for the manufacture of ammonia be contructed in an area where thorough environmental monitoring can be conducted. Emissions and their effect on the environment could be accurately characterized. The information obtained would be extremely valuable in establishing standards based on environmental needs. Results of this project were submitted at the end of FY-1977.

• Transportation Safety Studies

To plan and regulate the transport of potentially hazardous energy materials in the best public interest, the safety aspects of this activity must be understood. Research programs are one method for improving this understanding. Since 1972, Pacific Northwest Laboratory (PNL) has conducted a transportation Safety Studies Project for the Transportation Branch, Department of Energy Division of Environmental Control Technology. The initial objective of this program was to develop and use a model to assess the risk associated with shipment of radioactive materials. During FY-1976, the scope of the program was expanded to include transport of nonnuclear, energy-related materials.

Risk analysis was chosen for assessing the safety of transporting these materials. In this technique, the severity and frequency of events related to postulated releases of energy materials are examined to put the consequences of the releases into persepective.

During FY-1977, two final reports were issued, one on shipment of plutonium dioxide and liquid plutonium nitrate by train and one on shipment of plutonium dioxide by cargo aircraft. Other reports are being prepared concerning: 1) consequences of the loss of spent fuel and plutonium packages at sea; 2) shipment of uranium hexafluoride by truck and train; 3) shipment of gasoline by truck. A study on transport of spent nuclear fuel by truck was also initiated.

Safety Aspects of Transporting Potentially Hazardous Energy Materials

R. E. Rhoads, R. J. Hall, J. F. Johnson, T. I. McSweeney, S. W. Heaberlin, H. K. Elder

Work was conducted on six transportation safety studies during FY-1977: 1) the risk of shipping plutonium dioxide powder and liquid plutonium nitrate by train, 2) the risk of shipping plutonium dioxide by cargo aircraft, 3) the risk of transporting uranium hexafluoride by truck and train, 4) the risk of transporting gasoline by truck, 5) the consequences of the loss of spent fuel and plutonium packages at sea, and 6) the risk of transporting spent nuclear fuel by truck.

For the studies of shipping plutonium by rail, plutonium by aircraft, and gasoline by truck, risks were estimated on the basis of quantities of these materials projected for transportation in the 1980s. Reference shipping systems were described, fault trees were developed to identify release sequences, release consequences models were initiated, accident environments were described, and package failure thresholds were estimated. A brief summary of each analysis follows.

An Assessment of the Risk of Transporting Plutonium Dioxide and Liquid Plutonium Nitrate by Train

R. J. Hall; and

An Assessment of the Risk of Shipping Plutonium Dioxide by Cargo Aircraft

T. I. McSweeney, J. F. Johnson

Final reports on the risk assessments of shipping plutonium dioxide and plutonium nitrate by rail and plutonium dioxide by cargo aircraft were issued during the current fiscal year. These two studies complement an earlier study in this project that assessed the risk of shipping plutonium dioxide and plutonium nitrate by truck.(1) The results of all three studies are compared in Figure 1.1. The studies indicate that shipping plutonium by truck and shipping it by rail involve similar risks, and that shipping similar amounts of plutonium by cargo aircraft would produce a higher (although still low) risk.

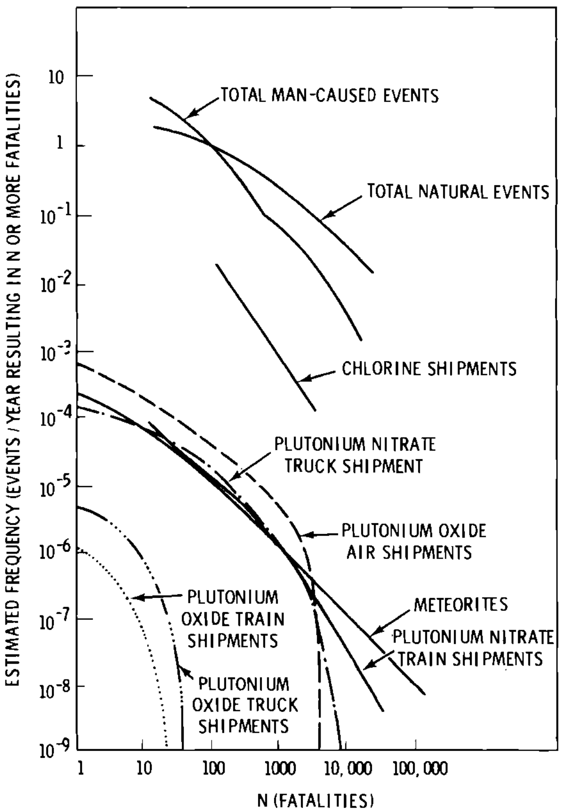

FIGURE 1.1. Comparison of Plutonium Shipment Risks with Other Risk Spectra

An Assessment of the Risk of Transporting Uranium Hexafluoride by Truck and Train

J. F. Johnson

Results have been compiled for the risk assessment of the shipment of uranium hexafluoride (UF_6) by truck and rail.

Figure 1.2 illustrates these findings. It was discovered that while UF_6 is a radioactive material, the risk from accidents involving containers of UF_6 result primarily from the toxic hexafluoride gas released when a spill of UF_6 reacts with water vapor in the atmosphere.

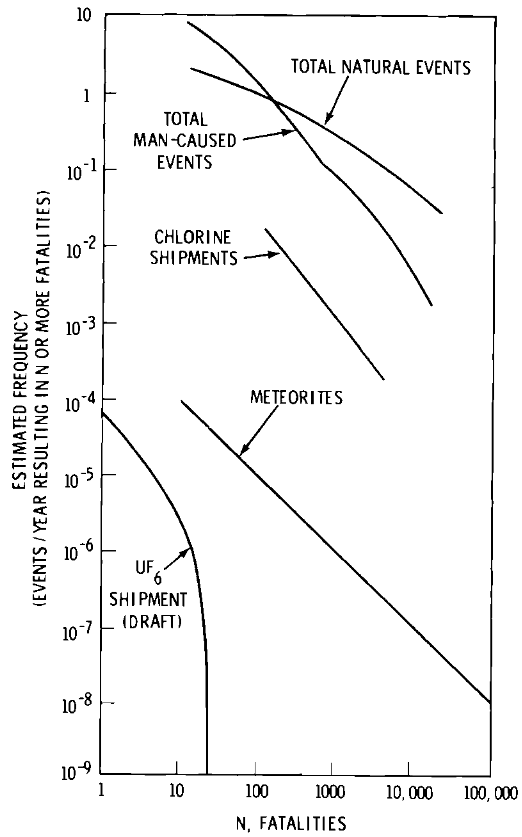

FIGURE 1.2. Comparison of UF6 Risk Spectrum Shipment with Other Risk Spectra

An Assessment of the Risk of Transporting Gasoline by Truck

R. E. Rhoads, et al.

An assessment of the risk of shipping gasoline by truck was completed early this fiscal year. The results of the analysis are shown in Table 1.1. The study showed that the use of stronger tanks, or the installation of onboard fire suppression systems on gasoline-tank trucks could reduce the risk if the current risk levels are judged unacceptable.

TABLE 1.1. Comparison of Individual Risk from Various Accidents and Natural Disasters with Risks from Gasoline-Tank Truck Accidents.

Accident Type	Total Fatalities	Individual Risk/yr
All accidents	115,821	1 in 2,000
Motor vehicle accidents	55,511	1 in 4,000
All industrial accidents[a]	14,100	1 in 6,000[a]
Falls	16,506	1 in 13,000
Drowning	7,152	1 in 29,000
Fires	6,503	1 in 32,000
Poisoning	5,335	1 in 40,000
Airplane crashes	1,668	1 in 130,000
Railway accidents	789	1 in 250,000
Lightning	160	1 in 1,300,000
Tornadoes	90	1 in 2,300,000
Gasoline-tank truck accidents	55	1 in 3,800,000

[a]Only workers included in population at risk.

Consequences of the Loss of Spent Fuel and Plutonium Shipping Packages at Sea

S. W. Heaberlin

A preliminary investigation was done on the potential consequences of the loss of a spent fuel cask or a plutonium shipping package at sea. Parallel work is being performed by the Japanese, and both countries are benefiting from the sharing of information. The final report will be issued in FY-1978.

Plutonium Transport Package Closure Survey

S. W. Heaberlin

This project was undertaken to determine if new regulations had changed the results of a similar survey conducted in 1974 in conjunction with the risk assessment of the shipment of plutonium by truck. Preliminary results of the second survey indicate that the number of nonstandard packages shipped has decreased as a result of the new regulations.

An Assessment of the Risk of Transporting Spent Nuclear Fuel by Truck

H. K. Elder, et al.

In addition to the studies completed and described above, a risk assessment of the shipment of spent fuel by truck was initiated during this fiscal year. This risk assessment is nearing completion.

Plans for Next Period

In addition to the completion of current studies, a number of new risk assessments will be made. The risks of the shipment of spent fuel by rail will be studied, and the truck and rail shipment of propane will be analyzed. The safety issues related to the increasing number of shipments of coal by rail will also be examined. An assessment of the risk of shipping chlorine by rail will be completed as a special project.

Two new areas will be examined during the next fiscal year. Shipment security studies will consider the security aspects of the transportation of energy materials and their relationship to transportation safety. Initial efforts will concentrate on nuclear fuel cycle shipments. In addition, studies will be made to incorporate economic risks into the risk assessment model. Currently, only health effects are considered.

• Integrated LNG Safety and Control Program

The objective of this project was to assist the ERDA Environmental Control Technology Division in the development and implementation of a comprehensive, integrated research, development and demonstration (RD&D) program in liquefied natural gas (LNG) safety and control. A program plan has been developed and an implementation plan is in preparation.

Integrated LNG Safety and Control Program

R. J. Hall

The goal of this program is to develop in a timely manner the liquefied natural gas (LNG) safety and control information needed by industry, regulatory agencies, and the general public in LNG decision making. In FY-1977 Pacific Northwest Laboratory (PNL) was responsible for assisting the ERDA Environmental Control Technology (ECT) Division in the development and implementation of a comprehensive integrated RD&D plan to accomplish this objective.

In December 1976 assistance was provided to ECT in planning and conducting a workshop on LNG safety and control. The participants were selected to represent a cross section from regulatory agencies, industry, research organizations, and individuals familiar with the current status, technology, and issues in the LNG safety and control area. A summary of the workshop recommendations was prepared. The workshop recommendations were a major input to the identification of unresolved LNG safety and control questions the plan is to address. Another major input to development of the plan was a state-of-the-art report prepared for PNL by Battelle's Columbus Laboratories. The report served as an initial definition of where the LNG program should start in order to build on the strengths of past LNG safety and control studies.

The following needs and constraints were considered in the program plan: 1) understanding of effects, 2) prevention and control of undesirable effects, 3) public and operational safety, 4) immediacy of the need for information, 5) an integrated approach to achieve the maximum meaningful results in the minimum time, and 6) limited resources (e.g., funds, facilities, qualified personnel, supply of LNG for experiments).

Two distinct objectives were established to meet the program goal:

1) Verified Predictive Capabilities - Development and validation of the analytical models necessary to adequately describe, from a safety and environmental control viewpoint, the behavior of LNG systems and the possible effects of LNG releases to the environment;

2) Verified Control Methods - Investigation and validation of the effects of release prevention and control methods on the likelihood, type, and magnitude of environmental consequence from LNG release.

Activities in six technical areas were identified as necessary to achieve these objectives: 1) vapor generation and dispersion, 2) fire and radiation hazards, 3) flame propagation, 4) release prevention and control, 5) instrumentation and technique development, and 6) scale effects experiments.

The first three elements are directed at development of an adequate, validated capability to predict the characteristics of, and to control, the phenomena. They will include assessing in depth the limitations of current information and conducting necessary additional experimental and analytical studies.

The fourth element of the comprehensive plan, release prevention and control, is directed at preventing or controlling the release of LNG to the environment. Research will be performed to assure the existence of adequate information concerning the control of accidental LNG release.

The fifth element of the program, instrumentation and technique development, is directed at ensuring the existence of adequate instrumentation and measurement techniques to obtain high-quality data from experimental studies in this program.

The final program element, scale effects experiments, is directed at providing the experimental data necessary to firmly establish that the analytical models can predict the effects of large-scale events (LNG release, fire, etc.). Ships presently under construction will carry up to 165,000 m^3; however, to date, research has involved releases of up to 10 m^3 of LNG. Various consequence prediction models have been developed and tested against data from these smaller LNG spills. The crucial question is whether or not such models are adequate for extrapolation to spills thousands of times larger; i.e., how do the model parameters scale with spill size?

The LNG program plan calls for conducting large outdoor experiments to study LNG vapor dispersion, flame propagation, and thermal radiation hazards. A preliminary analysis of the advantages of different experimental strategies (classical, statistical) for the various portions of the program was completed. An important advantage of the statistical approach is that it apparently would require significantly fewer experiments than the classical approach to attain the same level of confidence in validation of analytical methods. However, the classical approach has advantages that could outweigh this under some circumstances.

Preparation continues on implementation plans for the program. A final implementation plan will be completed once the program plan is finalized.

• Energy Material Transport, Now Through 2000

The objectives of this project are: 1) to provide advanced warning of potential problems that may inhibit the safe and environmentally-acceptable development of fossil and nuclear energy material transportation systems in the period now to the year 2000, and 2) to recommend research, development, and other necessary action to mitigate the potential adverse impact of these problems. The FY-1977 efforts address potential problems in coal, nuclear, petroleum, and natural gas transportation.

Energy Material Transport, Now Through 2000: System Characteristics and Potential Problems

J. G. DeSteese, G. W. Dawson,
P. L. Hendrickson, R. I. Smith

Characterizations of fossil and nuclear energy transportation systems have been completed; they include projections of growth or change in each energy system through the year 2000. The identity and priority of potential problems were delineated based on these system characterizations. Potential problems deemed most important for each energy transportation system are highlighted below, along with recommended action. The action recommended addresses apparent gaps in the coverage of other programs concerned with these problems.

Coal Transportation

The most important problems have consequences that may affect coal transportation by the early 1980s. These problem areas include public acceptance, the impact of slurry pipelines, coal freezing in hopper cars, and sludge transportation. Problems with the potential for major impact during the balance of the century include congestion on inland waterways, the effects of rate regulation on railroad incentives to haul coal, and the safety and environmental impact of advanced slurry systems.

New projects are recommended to evaluate the environmental effects of increased coal traffic and to prepare a comprehensive position paper on the coal slurry versus unit train controversy. Innovative research and development should be applied to finding better methods to deal with frozen coal. A comprehensive study should be undertaken to establish guidelines for an acceptable and effective sludge transportation program. In-depth evaluation and risk assessment of advanced liquid fuel/coal slurry pipelines is recommended, and the potential impact of regulations to discourage carriers should be studied.

Nuclear Material Transportation

Uncertainty about future fuel cycle options, regulations, and other constraints may result in a general lack of preparedness for transporting nuclear materials. Other important concerns relate to the imposition of unnecessarily severe and costly restrictions on nuclear material transportation, public and carrier acceptance, and the involvement of interested parties in planning and decision-making.

New criteria are needed to establish acceptable levels of risk based on safety/economic tradeoffs and to evaluate the impact of proposed changes in radiation and safety standards. Further investigation of the damage severity/cask integrity relationship is recommended for nuclear material shipping containers. Efforts should be increased to address the concerns of the public, carriers, and other interested parties, with the goal of reducing current opposition to nuclear material transportation.

Petroleum Transportation

Major areas of concern are the causes and effects of oil spills, the safety of unit oil trains with interconnected cars, and the adequacy of emergency oil distribution systems. Other important potential problems are associated with offshore pipeline development, licensing of deepwater ports, and inland waterway congestion.

The single greatest need identified was for the construction of a comprehensive document on the causes of oil spills, and the cost effectiveness of spill prevention devices and practices. Also, there is a need for definitive work on the environmental effects of oil spills. It is recommended that the Department of Energy establish a position on licensing requirements for deepwater ports and rights of eminent domain for siting pipelines. Further work is needed to assess the safety of unit oil trains and offshore pipelines, and to prepare contingency plans for oil transportation during emergencies.

Gas Transportation

Hazards resulting from third-party damage to gas pipelines, pipeline corrosion, and the deterioration of aging gas distribution systems are among the most important potential problems. Other potential problem areas identified were the adequacy of future gas storage capabilities, the compatibility of new fuel types, and effects of major geological disasters on gas transmission and distribution systems.

New project activities are recommended to evaluate the factors contributing to pipeline damage, and to develop RD&D programs for detecting, monitoring, and preventing deterioration and corrosion. The ability of the gas industry to meet future seasonal demands should be studied, and contingency plans should be prepared for allocating and routing energy materials to compensate potential loss of major links in the gas transportation system. An evaluation should be made to determine conditions necessary to transport other fuels in existing gas pipelines. The impacts and consequences of potential geological disturbances on gas transportation systems should also be reviewed.

• Nuclear Fuel Cycle Analysis

The operation of nuclear fuel cycle facilities will introduce noxious materials, both radiological and chemical, into the environment through routine discharges of both liquid and airborne effluents. The environmental control implications of continuing to develop existing nuclear fuel cycles and implementing new fuel cycles must be systematically determined so that technologies that control or eliminate the discharge of noxious materials to the environment can be developed and demonstrated in a timely manner.

The objective of this program is to identify areas in developing nuclear fuel cycles 1) where inadequate consideration is being given to environmental controls, 2) where inconsistencies and conflicts exist in environmental policy, and 3) where environmental control improvements can be justified on a cost/risk/benefit basis to ensure that funds are not expended for control in instances where neither the potential effects nor public concerns warrant such expenditures.

Analysis of the Light Water Reactor (LWR) Fuel Cycle

T. J. Kabele

The objective of this program is to provide the Environmental Control Technology Division of the Department of Energy with technical and economic bases for planning and analyzing research and development programs related to the treatment and control of radiologically and chemically toxic effluents and wastes generated in nuclear fuel cycles. The information developed will provide the perspective required to determine whether environmental control technologies are adequate relative to existing and proposed standards; to assure that research and development programs are warranted in terms of their potential benefits; and to establish adequate back-up options for high-risk development programs.

During FY-1977 substantial progress was made on the analysis of the standard (LWR) fuel cycle. The program was redirected at about mid-year as a result of the new Administration's policy. The project included analysis of a modified LWR fuel cycle containing no reprocessing of spent fuel, and will now focus on alternatives to fuel cycles with plutonium recycle. These fuel cycles are depicted schematically in Figures 1.3 and 1.4.

This program comprises four major task areas:

1. Fuel Cycle Computer Model - A computer code was developed to model the entire LWR fuel cycle from mine to reprocessing plant. The code handles fuel logistics as well as heat and mass balances for each nuclear facility, and includes both capital and operating cost information for each facility.

2. Facility Description - Each nuclear fuel cycle facility is described, including heat and mass balances, process flow diagrams, identification of major equipment, and details of all effluent control and waste processing technology.

3. Environmental Analysis - A generic site description was prepared for use in analyzing the environmental impacts of nuclear fuel cycle effluents. The impacts of both radioactive and nonradioactive effluents on the environment are being evaluated.

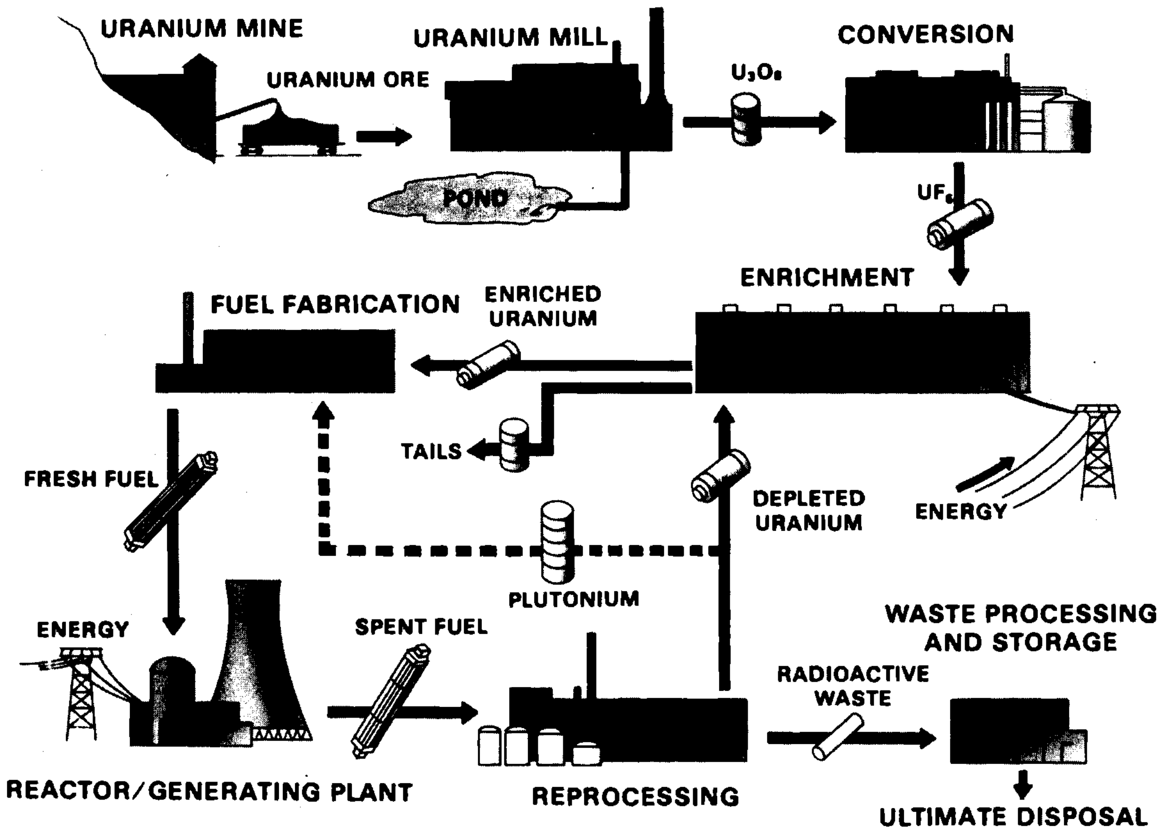

FIGURE 1.3. LWR Fuel Cycle with Reprocessing

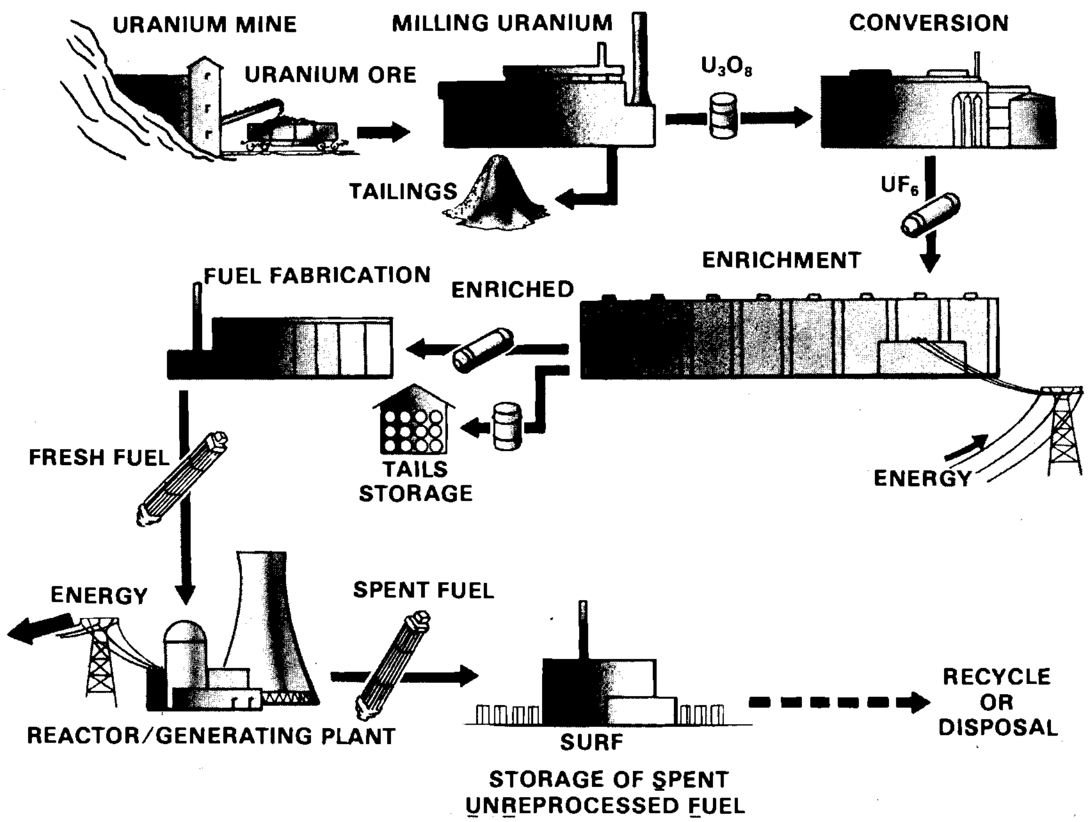

FIGURE 1.4. LWR Fuel Cycle with Spent Fuel Storage

4. Cost Analysis - This task provides operating and capital costs for each nuclear fuel cycle facility. Cost information will be used to evaluate the cost/benefits of effluent control technology options.

Analysis of the LWR fuel cycles is nearing completion. Work in the first three task areas has been completed. During the first quarter of FY-1978, a cost effectiveness analysis of effluent control technologies for the LWR fuel cycles is expected to be completed.

The completion of analyses of each nuclear fuel cycle will provide the bases to:

1) formulate a cost-effective environmental control technology improvement program well suited to the realities of the nuclear power generation economy;
2) characterize the burden on the environmental control technology of the various nuclear fuel cycle options now known to confront the nuclear industry;
3) define, on a continuing basis, the current condition of the nuclear industry with regard to environmental factors;
4) project current conditions into the immediate future on a rapid turnaround basis to gauge the effect of presently unforeseen changes in the nuclear economy.

Future work will extend the tools developed for the LWR analyses to the thorium fuel cycles (LWR breeder, gas-cooled reactors) and to fusion systems.

• Decommissioning of Retired Facilities at Hanford

The retired nuclear facility decommissioning effort at Pacific Northwest Laboratory (PNL) consists of two tasks: planning and technology. The primary objective of the planning program is to establish a long-range comprehensive plan for decommissioning surplus contaminated facilities at Hanford.[a] Secondary objectives include facility characterization and planning for demonstration decommissioning projects. Preliminary plans for Hanford decommissioning were developed in FY-1977. These consist of four plans for achieving three alternative future scenarios, including: 1) unrestricted use, 2) current trend, and 3) minimum level of effort. Plans are based on previously developed estimates of time, costs, and priorities for decommissioning compiled using a computer-based interactive planning system. Other activities of FY-1977 included completing core sampling for the 105-DR production reactor and working on a radiological design guide for D&D at Hanford.

Technology applicable to the Hanford decommissioning effort was developed in the second task. Concrete surface removal techniques were evaluated. Water cannon and rock splitter techniques were shown to be effective and potentially useful concrete decontamination methods. A program was defined to investigate the properties of concrete that are important to understanding contamination mechanisms and designing high-integrity containment structures. A "biobarrier" (rock-gravel-sand-topsoil cover) technique was shown to be a potentially useful method of preventing plant and animal penetration of contaminated burial grounds. A prototype field instrument was developed for measuring low levels of residual transuranic activity in structural materials and soils.

Decommissioning Planning

J. W. Litchfield, J. C. King

The objectives of this program are to establish a plan (methods, costs, priorities, schedules) for decommissioning retired contaminated Department of Energy (DOE) facilities at Hanford; to undertake needed site characterization of the Hanford Areas; and to initiate detailed planning for future decommissioning demonstration projects at Hanford.

Activities central to development of long-range plans for decommissioning surplus facilities include: 1) identification of planning objectives (scenarios), 2) development of plans for achieving identified scenarios, and 3) evaluation of scenarios and plans with the objective of selecting a preferred scenario and plan. Background information required to implement the planning process described above includes facility characterization data, facility priorities for decommissioning, selection, and characterization of feasible decommissioning modes. Three tasks comprise the planning phase of this project, and are discussed below.

[a] Department of Energy facilities not needed as of October 1, 1976.

Facility Characterization

Characterization of the retired DOE facilities continues. The final report, including data concerning waste management facilities, will be issued in FY-1978.

100 Area Facility Characterization. Core drilling of the 105-DR production reactor was secured in December 1976 when available funds were exhausted. An additional $40,000 became available in August 1977 allowing resumption of this program.

200 Area Facility Characterization. Identification and documentation of administrative, physical, functional, and radiological characteristics of the tank farms and waste transfer systems are under way. Completion of this work is anticipated by the end of FY-1977.

Liquid Waste Disposal Site Modeling. A model was developed to predict dispersal of radionuclides from the 216-S-1&2 crib under elevated water table conditions.

Radiological Studies

Compilation of information regarding radiological release criteria has been completed.

System Studies

Activity Characterization. Characterization of D&D activities was accomplished for the facilities listed in Table 1.2. Estimated activity characteristics included costs, project schedules, contaminated waste generation, and labor requirements.

Priorities. The system for determining facility priorities was rerun incorporating refined scores for three of the four priority criteria. It is expected that priorities for all facilities currently considered surplus will be completed by the end of FY-1977.

Integrated Planning. Three prospective scenarios were identified and four preliminary plans prepared to achieve these scenarios. The plans included decommissioning modes for all surplus facilities, a schedule of decommissioning activities, and costs, in both constant and inflated dollars (see Table 1.3).

TABLE 1.2. Summary of FY-1977 Activity Characterization Work

Representative Facility		Modes Characterized			
Type	Number	Layaway	Prot. Stor.	Entomb.	Dismantle
Gas recirculation bldg.	115-D	+	+		+
Confinement filter	117-D	+	+		+
Sample bldg.	119-DR	+			+
Stack	116-D	+			+
Reprocessing canyon	202-S				+
Production reactor	105-D				+
Metal storage bldg.	103-D				+
Transuranic (TRU) crib	216-Z-12		X		X
Mixed fission product (MFP)/TRU crib	216-S-1&2		X	X	
Mixed fission product trench	216-B-20		X	X	
Pond	216-S-17		X	X	
MFP/TRU burial ground	318-11		X		X

KEY: + Characterized by planning-level estimate
X Characterized by computer-based model

TABLE 1.3. Comparison of Four Preliminary Plans

	Unrestricted Use Case A	Unrestricted Use Case B	Current Trend	Minimum Effort
Program start	1980	1980	1980	1980
Program completion	2080	2060	2000	2000
Interim use[a]/ date achieved[b]				
100 Areas	U/2080	U/2060	R/2000	R/2000
200 Areas	C/2080	C/2060	R/2000	R/2000
300 Areas	U/2080	U/2060	U/2000	R/2000
Ultimate use[a]/ date achieved[b]				
100 Areas	—	—	U/2030	D/2000
200 Areas	U/2280	U/2280	D/2080	D/2000
300 Areas	—	—	—	D/2000
Facilities included	ECT surplus	ECT surplus	ECT surplus	ECT surplus
Budget (millions)				
Annual (1980)	8.2	10.0	10.4	1.1
Total (constant)	823	823	198	24
Total (3% inflation)	4991	3468	264	33

(a) Sites of ECT-surplus facilities only
(b) Rounded to nearest 5 years

U - Unrestricted use
C - Conditional use
R - Restricted use
D - Additional D&D action required

Major objectives for FY-1978 include:[a]

1) revising the preliminary scenarios and decommissioning plans
2) completing activity characterization for remaining representative Hanford facilities
3) estimating occupational dose and releases to the environment for feasible D&D modes on representative facilities
4) evaluating major implications and effects of proposed decommissioning plans, and
5) preparing an environmental assessment for preferred decommissioning plans.

Decommissioning Technology

R. R. King, J. M. Halter, R. G. Sullivan, J. F. Cline, R. L. Brodzinski, G. H. Beeman

The objectives of this project are to conceive, develop, and test advanced D&D technology that will be applicable to the Hanford decommissioning effort. Activities associated with the four tasks that comprise this project are discussed below, along with FY-1977 progress for each task.

(a) FY-1978 objectives have been subsequently revised in response to transfer of a major portion of Hanford decommissioning funding to the National DOE Decommisssioning Planning Project. Revised FY-1978 objectives for Hanford decommissioning planning will include: 1) transfer of the Hanford decommissioning information system from offsite to onsite computers; 2) issuance of the remaining sections of the Resource Book; 3) refinement and update of preliminary plans for decommissioning at Hanford; and 4) documentation of existing cost estimates.

Concrete Decontamination

Two novel techniques for removal of contaminated concrete surface layers are being investigated. One is a water cannon that shoots a small jet of liquid at very high pressure against the concrete surface. The other is a tool that exerts radial pressure with expanding split wedges on the sides of a shallow cylindrical hole drilled in the concrete.

The water cannon (a modified 45.8 caliber gun) was found to consistently spall craters 4 to 5 in. in diameter. After 65 firings, the nozzle and gun parts exhibited no signs of wear. A rock splitter bit continued to perform very well in tests on concrete foundations. Best results have been obtained using a triangular pattern of holes drilled 6 in. apart and 1-1/2 in. deep. An invention report has been prepared describing this latest version of the bit. The rock splitter was demonstrated for Rockwell-Hanford staff who are planning the 233-S demonstration project. They indicated the technique would be included in their plans for the project.

Concrete Properties/Structures

A program is being defined to investigate several important parameters of concrete including effect of burial; freeze/thaw cycling; chemical degradation; premeability with respect to time, stress, and thermal cycling; radiation effects; and effect of additions. The program will include detailed testing of samples under rigid controls, including samples taken from existing Hanford facilities. Concepts for in situ containment of trenches, ponds, cribs, and other burial sites are also being evaluated.

During FY-1977, a program has been defined to investigate the long-term properties of concrete and to evaluate in situ containment of contaminated burial grounds.

Burial Ground Stabilization

This program is designed to test the ability of a "biobarrier" (a rock-gravel-sand-topsoil cover) to prevent plant and animal penetration of contaminated burial grounds. Soil mixed with lithium chloride simulates radioactive wastes. A layer of cobble is placed over the simulated wastes and covered with topsoil. Different biological barriers are tested in a replicated plot design. Ant colonies and pocket mice are introduced to the test area. Ant carcasses and soil particles on the ant hill are analyzed for lithium content. The mice are trapped and their feces sampled for lithium content. Roots from the tumbleweed plants are also analyzed.

A small plot for growing two species of plants was established during FY-1977 in the drainage finger adjoining the U-Pond in the 200-West Area. The plot is intended to test availability of radionuclides in the soil to growing plants under field conditions. Soil was analyzed and the radionuclides U-235, Am-241, Cs-137, Eu-155, and Pu-239 were found in quantities from 50 to 100 pCi/g of dry soil. Several other radioelements were observed in very low concentrations. The plot has been tilled, fertilized, and planted to beans and barley. Plant tissue from these crops will be analyzed throughout the growing season for the radioisotopes mentioned above.

Mice hair and feces were collected and submitted for lithium analysis to determine if the mice had dug through the barrier into the lithium-spiked soil. Ants were also collected for lithium analysis.

D&D Survey Instrumentation

A prototype field unit has been assembled to measure very low levels of residual transuranic activity in structural materials and soils following decontamination. The instrument is based on the direct counting of low-energy photons from plutonium and americium isotopes using an intrinsic germanium diode.

A cassette tape drive and interface are used to store spectral data in the field for subsequent computer analysis. On-the-spot field information will be limited to Am-241 activity. The presence, quantity, and depth of low-energy, x-ray emitting, plutonium isotopes will be determined by computer data reduction. A FORTRAN computer code has also been initiated for rapid reduction of multichannel spectral data to yield depth-corrected americium and plutonium activities. The code will also determine the average depth of the activity and will permit unfolding spectra with interfering peaks.

Future Work

In the future we plan to: 1) design and test the tooling required to dismantle a Hanford production reactor (a new task for this project); 2) develop and test new techniques for mechanical decontamination of structural concrete; 3) evaluate the use of concrete for entombment, and design entombment structures for reference Hanford facilities; 4) develop and test techniques for preventing the penetration of contaminated soil zones at liquid and solid waste disposal sites by plant roots and animals; and 5) field test survey instrumentation.

• Characterization of 300 Area Burial Ground

Substantial quantities of high-level, transuranic, and other nuclear materials have been disposed of in solid-waste burial facilities on the Hanford Reservation in Washington. The objective of this program is to develop the technologies required to conduct comprehensive geologic, geophysical, biologic, and computer model analysis of specific waste sites. These studies will provide analyses of risk associated with the alternatives of either designating sites for permanent storage or removing wastes and contaminated sediments from the Reservation.

300 Area Burial Ground Studies

S. J. Phillips

Specific tasks have been initiated to achieve program objectives; these include material analysis by 1) geophysical surveys, 2) stratigraphy, 3) geochemical analysis, 4) physical analysis of soil, 5) atmospheric and soil physics monitoring, and 6) flora and fauna surveys.

Geophysics instrumentation capable of effective collection and real-time processing of data from burial sites has been designed; fabrication of components is proceeding. The following systems have been used: 1) ground-penetrating radar, 2) acoustic holography, 3) acoustic reflection and refraction, 4) magnetics, 5) ferromagnetic detection, and 6) thermal infrared inertia. Prototype development of an optimum ground-penetrating radar, magnetic, and ferromagnetic detection system has produced a unique geophysic system capable of conducting surveys in high acoustic attenuation, high dielectric, partially indurated and desiccated sediments. Figure 1.5 illustrates this mobile computer-based system, which is currently being fabricated and tested.

Geochemical sediment-waste relationships partially control the flux of radionuclides in sedimentary materials. Contaminated sediment samples from waste burial sites have been collected, and the chemical status of materials adsorbed on mineral grains has been analyzed by specifically developed optical microscopy, x-ray fluorescence,

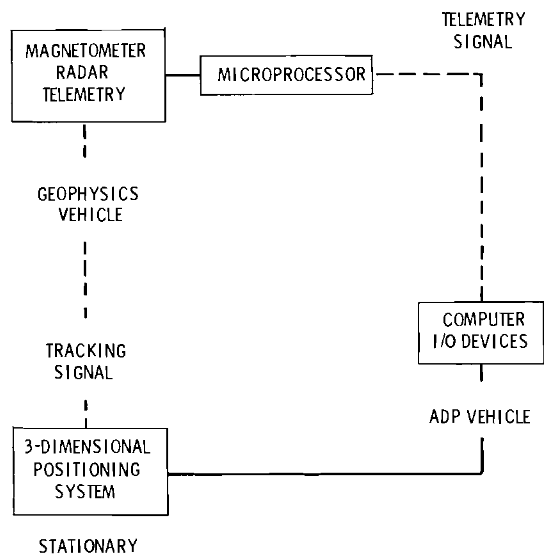

FIGURE 1.5. Generic Representation of Developed Computer-Based Geophysical System

neutron autoradiography, and electron microprobe techniques. Figure 1.6 is a neutron activation autoradiograph of mineral grains with adsorbed uranium-235. Table 1.4 is an example of electron microprobe analysis of the same material. The concurrence of phosphorous and uranium suggests complexing of an unstable phosphorous compound and uranium waste materials.

Fluid migration is the primary transport mode of radioactive material in shallow land burial sites. Determinations of both fluid and vapor phase flux as well as mass and energy balance are required to define worst-case hazard scenarios. Each atmospheric and in situ transport controlling factor is monitored by a system that will be used to collect ambient data and data from controlled field conditions simulating increased precipitation. Figure 1.7 represents a monitoring system installed adjacent to a retired burial facility. Laboratory analyses of nonisothermal liquid and vapor flux of anisotropic heterogenous flow systems are also being conducted under controlled conditions. Two nonisothermal energy balance computer models have been developed to evaluate and predict factors controlling long-term stability of various waste forms.

Various plants and animals inhabit shallow land burial sites. Specific species have the potential to uncover and transport significant quantities of waste materials into the biosphere. In vivo dosimetry of burrowing rodents has been conducted to assess the in situ dose of gamma neutron emitters. Figure 1.8 illustrates a thermoluminescent dosimeter in vivo implant used to monitor dose to rodents inhabiting subsurface contaminated zones. Beta-gamma spectroscopy analysis has delineated radionuclide uptake in plant tissue. Table 1.5 is an example of spectrographic analysis of contaminated plant tissue.

In future work, we plan to: 1) survey all designated burial sites and specifically define the location and composition of waste and containment structures; 2) core drill all waste burial sites to determine the extent of waste migration; 3) define additional waste-sediment geochemical reactions; 4) monitor one annual cycle of field energy and mass balance parameters; 5) establish quantitative nonisothermal fluid and vapor phase flux in anisotropic heterogenous sediments; 6) model liquid and vapor phase flow systems and develop long-term predictive scenarios; 7) assess biologic transport and define biologic waste contanment alternatives; and 8) develop decontamination and decommissioning alternatives and recommendations.

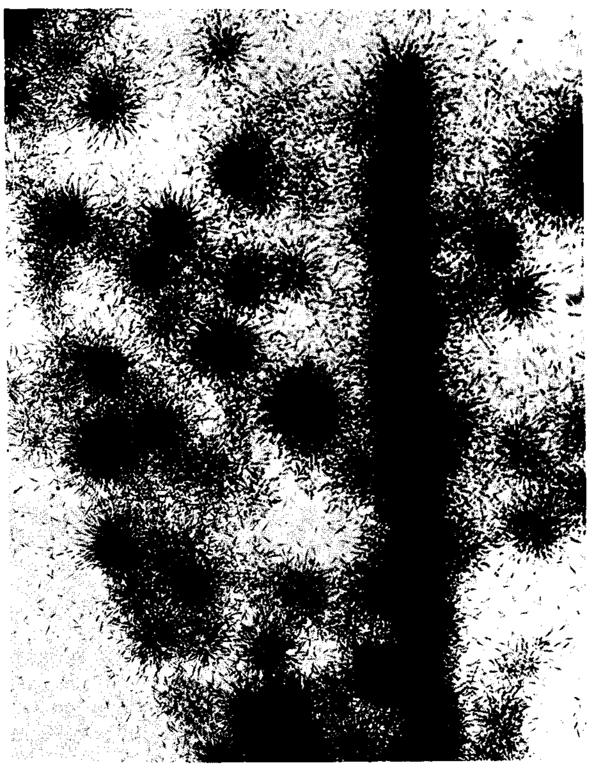

FIGURE 1.6. Neutron Activation Autoradiograph of Hexone Uranyl-Nitrate Contaminated Sediment

TABLE 1.4. Electron Microprobe Analysis of Subsamples of Contaminated Sediment.

Constituent	Wt% at Selected Locations Within Sample					
	A	B	C	D	E	F
SiO_2	2.8	98.5	16.2	8.9	7.1	2.6
TiO_2	<0.1	--	--	--	--	--
Al_2O_3	<0.1	--	9.9	5.0	7.4	0.3
FeO	1.4	0.1	3.5	2.1	1.5	2.3
MgO	<0.3	--	--	--	--	--
CaO	1.3	--	8.7	1.2	0.9	1.5
Na_2O	<1.3	--	--	--	--	--
K_2O	2.9	<0.06	1.4	2.8	1.7	1.4
P_2O_5	22.2	<0.2	21.1	25.5	27.1	27.1
UO_2	69.1	1.3	38.7	53.8	53.4	63.1
S	<0.04	--	0.6	0.7	0.8	0.1
P/U	1.2	--	2.0	1.8	1.9	1.6

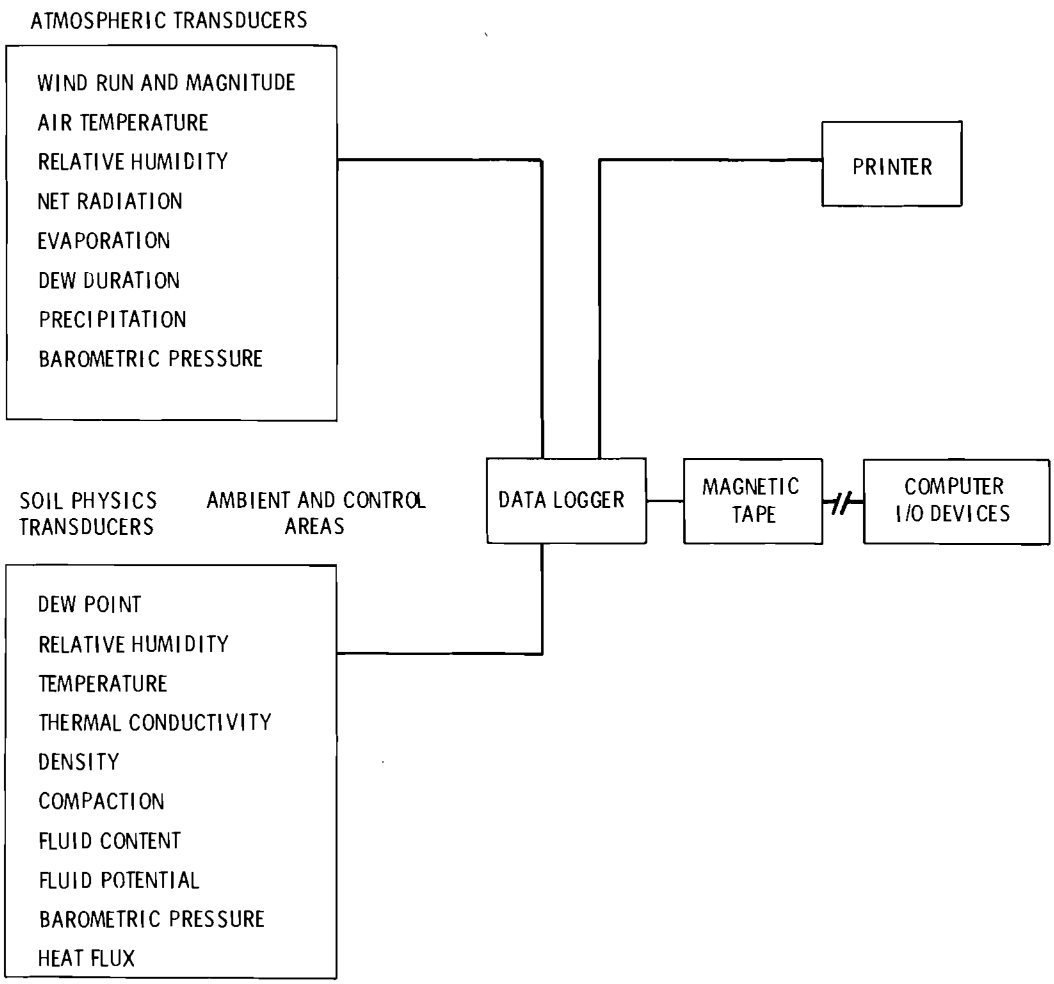

FIGURE 1.7. Atmospheric and In Situ Field Energy and Mass Balance Monitoring System

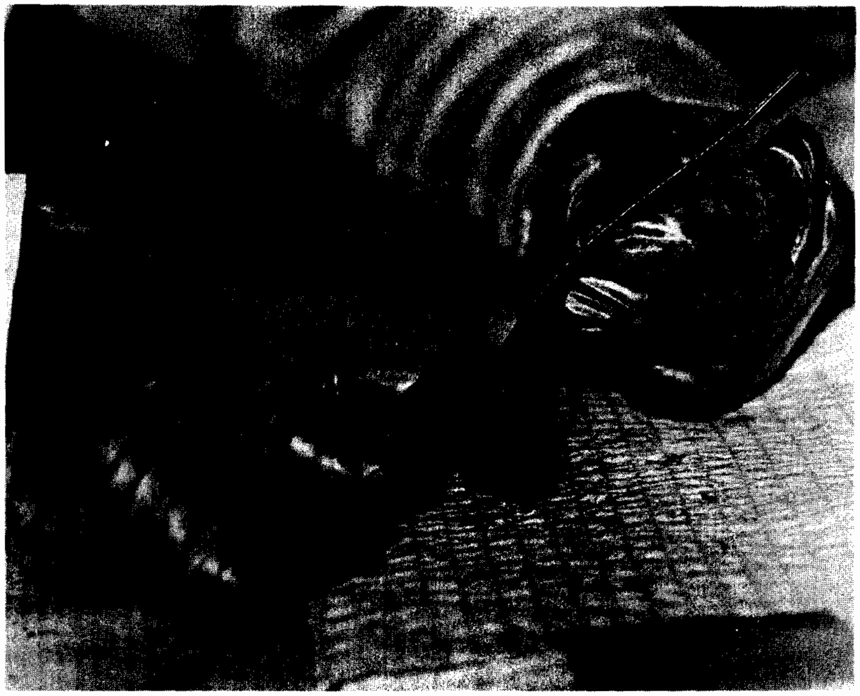

FIGURE 1.8. Thermoluminescent Dosimeter In Vivo Implant in Rodent Inhabiting Waste Burial Facilities

TABLE 1.5. Radionuclide Content of Plant Inhabiting the 300 Wye Burial Ground.

Radioisotope	dpm[a]/g
^{144}Ce	54,400
^{106}Ru	10,000
^{137}Cs	7,400
^{95}Zr	32,400
^{54}Mn	7,600
^{65}Zn	10,000

(a) Disintegrations per minute

• Geothermal Liquid Waste Disposal

A literature search was made on existing methods for disposal of geothermal liquid wastes. A review and evaluation of seven disposal methods, four surface and three subsurface, was completed. A research program plan is being developed around the research needs that were identified during the review. A final report and program plan will be published in FY-1978.

Research Program Plan for Geothermal Liquid Waste Disposal

L. J. Defferding

The objective of this program is 1) to review and evaluate the state-of-the-art disposal methods for liquid wastes from geothermal installations; and 2) to develop a research program plan to provide commercially viable techniques for waste disposal that are safe and environmentally acceptable. The review and evaluation were completed, and research needs were identified.

A program plan is being developed around the research needs and deficiencies identified in the evaluation phase. Pacific Northwest Laboratory and the Department of Energy have agreed upon a list of task force review board members. The potential members are being contacted and asked to serve on the review board. After the task force has reviewed it, the program plan will be revised and published.

- **Management Program Plan: Environmental Concerns in Compressed Air Energy Storage**

A management program plan has been prepared for use by the Division of Environmental Contol Technology in establishing its program of environmental impact assessment of compressed air energy storage (CAES). The program identifies the major environmental concerns associated with the underground reservoirs to be used in CAES plants, outlines ongoing and planned research, and proposes the additional research that is required if all CAES problems that may have environmental impacts are to be addressed. A program is suggested, and the responsibilities for carrying out this program are recommended.

<u>Management Program Plan: Environmental Concerns in Compressed Air Energy Storage</u>

W. V. Loscutoff

The objective of this study was to identify the significant technological environmental concerns associated with the underground reservoirs of compressed air energy storage (CAES) plants, and to provide the Division of Environmental Control Technology with a management program plan to mitigate these concerns.

The significant issues associated with CAES reservoirs have been identified, and on-going and planned research evaluated. Recommendations have been developed for research that is necessary to address all related environmental issues not currently addressed. A program plan for the suggested research has been formulated.

• Assessment of Energy-Conserving Industrial Waste Treatment Technology

The Water Pollution Control Acts Amendments (PL 92-500) require substantial treatment of industrial wastes. Most waste treatment processes to date have been developed with little regard to energy use. Pacific Northwest Laboratory (PNL) is developing a program to assess the possibilities of energy-conserving industrial waste treatment processes, and to look at environmental control from a total net energy utilization/pollution reduction systems concept.

This program is providing an overview of Department of Energy (DOE) work in this area and is developing a center of excellence available to DOE for such matters as pollution abatement, regulation interpretation, and appraisal of other government agency's programs. In future work, the program will analyze what is currently happening in industrial pollution control and will pinpoint key problem areas for detailed study.

Assessment of Energy-conserving Industrial Waste Treatment Processes

H. E. McGuire

Pacific Northwest Laboratory is preparing a plan to recommend alternative possibilities of energy-conserving industrial waste treatment processes. This program is providing overview of DOE work in this area and is developing a center of excellence available to DOE for such matters as pollution abatement, regulation interpretation, and appraisal of other government agencies' programs. This program provides assistance to DOE for reviewing the likely energy commitments/requirements of proposed policies and regulations. Additionally, the program is analyzing what is currently happening in industrial pollution control, is forming a quantitative data bank, and is pinpointing key problem areas for detailed study.

In FY-1977, PNL classified industries, for purposes of pollution control, according to the amount of energy they use. PNL also started preparation of a baseline description of industry manufacturing technologies.

In FY-1978, PNL will complete the industry descriptions, define and describe current treatment technologies, and investigate new energy-conserving, industrial waste treatment technologies. The final report will be a working document for use by DOE in assessing future funding areas.

1.0 REFERENCES

1. T. I. McSweeney, et al., An Assessment of the Risk of Transporting Plutonium Oxide and Liquid Plutonium Nitrate by Truck, BNWL-1846, Battelle, Pacific Northwest Laboratories, Richland, WA 99352, August 1975.

2.0 Technology Overview

TECHNOLOGY OVERVIEW

- **Pacific Northwest Energy-Related Regional Studies**
- **Assessment of Social Values in Thermal Power Plant Siting**
- **Social Impact Methodology Evaluation**
- **Interlaboratory Data Exchange**
- **Environmental Information System**

The Integrated Assessment Program, funded by the DOE Division of Technology Overview, is the mechanism by which health, environmental, social, economic, and institutional factors are combined into a form useful for energy planning and decision making. This program selectively combines information about effects of alternative energy technologies (such as waste releases, land and water use, and social effects) to produce broad-based assessments of the advantages and disadvantages of energy and conservation options. As a corollary, needs for further research, development, and technology transfer are identified.

The program is focused on four interrelated activities: 1) supporting systems analysis, to develop and improve methods for use in assessing and comparing impacts of energy and conservation options; 2) integrated technological impact assessment, applying these methods to help DOE select technologies for development that are safe, clean, and environmentally acceptable; 3) regional comparative assessments, applying the results of the technological impact assessments to identification of regional energy strategies; and 4) a regional outreach effort to assist regional and state agencies in their energy planning programs.

Pacific Northwest Laboratory carries out these activities for the Pacific Northwest Region. As lead laboratory for oil, gas and oil shale technologies, PNL is responsible for the primary analyses of these energy resources and for directing other national laboratories in analyzing specific regional problems.

• Pacific Northwest Energy-Related Regional Studies

The objective of the Regional Assessment Program is to assess the implications of various energy technologies and development scenarios on the Pacific Northwest and to solve energy-related problems of concern to the region. Using models developed in the first year of the program, an analysis was made of the impact expected from the increased use of coal in the region. It was determined that a new mining area, the Beluga Field, Cook Inlet, Alaska, could be opened to supply an increasing coal demand in the continental United States. The opening of this mine would have the greatest regional impact. Aside from this, the combustion of coal for power generation will have the largest impact, particularly on air quality. Although the National Ambient Air Quality Standards (particularly for average annual concentration) can probably be met with little trouble, satisfying the Clean Air Act Amendments of 1977 may be a serious problem. Prevention of significant deterioration in Class I areas (such as national parks and wilderness areas) could impose serious siting restrictions. Assessment of the oil-gas and oil shale technologies is beginning. While the latter is a new technology that will require a long-term continuing environmental program, the oil-gas technologies are relatively well understood. With the exception of newer facets of this industry, such as tertiary recovery and outer continental shelf drilling, most oil-gas environmental effects are probably on the wane and require relatively little environmental research.

Overview

J. B. Burnham

The objectives of the Regional Assessment Program are to assess the implications of various energy technologies and development scenarios on the Pacific Northwest and to solve energy-related problems of concern to the region. Under the direction of Argonne National Laboratory, a National Coal Utilization Assessment (NCUA) was conducted. Pacific Northwest Laboratory (PNL) studied the impacts to be expected from increased coal consumption in the states of Alaska, Washington, Oregon, and Idaho.

A major portion of the Integrated Assessment budget was devoted to the NCUA. An important conclusion of the assessment was that many areas of the region may have difficulty in meeting the provisions of the Clean Air Act Amendments of 1977. Severe restrictions could arise just from the number of national parks and wilderness areas and wildlife refuges in the region. Since the air quality is presently high in most sections, they might be designated as Class I zones, which would further limit the siting possibilities.

Although there are only two coal mines presently operating in the region (one in Centralia, Washington and one in Healy, Alaska), it was concluded that increased demand from the lower 48 states could induce the opening of a large strip mine on Cook Inlet, Alaska. The potential environmental and socioeconomic impacts of such a venture were deemed to be large; baseline data is so scanty that no quantitative judgments were made on these impacts. Several tasks in FY-1978 will be addressed toward the specific assessment of the expected impacts (and potential mitigation strategies) involved in opening the Beluga coal field. These tasks will address the water, air, and socioeconomic impacts to be expected from several levels of development in that area. Another task will analyze the potential revegetation methods which could be utilized for post-mining reclamation.

The results of the impact assessment have been compiled; a final report will be issued early in CY-1978. The results of the work were reported at an Alaskan Coal Workshop, cosponsored by the Governor's Office of Alaska, in Juneau, Alaska September 22 and 23, 1977.

PNL has been assigned lead laboratory responsibility for oil-gas and oil shale technology assessment. The major areas of oil-gas environmental uncertainty, in our perception, lie in outer continental shelf developments and in tertiary recovery techniques. Several tasks have been planned for FY-1978 to analyze these subjects.

Oil shale technology, though, has many areas of potential environmental concern. The nature, quantities, dispersion, and health effects of the residuals released at various steps of the process represent major areas of uncertainty. FY-1978 tasks have been designed to identify the major classes of releases, their sources, and their relative threat. This data will be assembled in a decision-tree model (already operative) to help establish R&D priorities.

Socioeconomic Modeling Sector

J.J. Jacobsen, M.E. Olsen

The objective of this work was to develop a forecasting tool that would allow an analyst to rapidly and systematically analyze the socioeconomic impact on a local community resulting from the construction and operation of large-scale energy facilities. To accomplish this, the Local Impact Management and Assessment (LIMA) computer model was developed. LIMA has several attractive features for use as a forecasting tool. These include its ability to quickly reveal the probable outcome of policy alternatives on a number of geographical regions, and its capability to reveal, through the use of sensitivity analysis, parameters that maximally affect model behavior. These parameters may then be investigated further. Throughout the model development, emphasis was placed on the use of existing data and previously developed PNL analysis methods. As a result, LIMA uses readily available data and was developed with minimum time and effort.

There are five major sectors in the LIMA model: a power plant sector, a population sector, a public service capital sector, a private service capital sector, and a social indicator sector. These sectors allow LIMA to forecast population impacts, environmental impacts of the energy facility, amounts of public service capital available (related to local property taxes), retail and private service capital (investments in private business), and several indicators of the social well-being of the community.

Socioeconomic Analysis

M. E. Olsen, M. Curry, M. Greene

The participation of the Human Affairs Research Centers (HARC) in the Pacific Northwest Regional Assessment Program during FY-1977 focused primarily on two tasks: 1) social indicator methodology development, and 2) socioeconomic impact assessment of coal utilization.

The first of these tasks was a continuation of work begun in FY-1976 to develop a quantitative methodology for conducting social impact assessments using quality-of-life social indicators. The efforts during FY-1977 involved:

1) refining the set of indicators used with this method and identifying sources of data with which to measure these indicators;

2) constructing a set of ten flow charts, or causal models depicting expected relationships among all of these indicators; and

3) exploring the process of social impact management and developing a set of planning guidelines for this process.[1]

The principal objective of the second task was to forecast the social and economic impacts that might result from the construction and operation of coal-fired electric generating plants in 14 Pacific Northwest counties between 1980 and 2020, under the two alternative scenarios of "recent trends" and "high-coal electric." Data were gathered on current conditions in these candidate counties, using 25 of the social indicators developed in the methodology described above and several measures of social planning capabilities. A computer model (Local Impact Management and Assessment) was then used to project (for both development scenarios) values for 13 of these indicators in each county to the year

2020; the flow charts were used to estimate future conditions on eight other social indicators. Using these data, each of the candidate counties was evaluated in terms of the extent of its expected impacts and its capabilities for managing these impacts. In general, counties with current populations under 25,000 could be severely affected by coal utilization projects and would have few resources for coping with these impacts; counties with current populations between 25,000 and 50,000 might be seriously affected by the construction of multiple installations.(2)

In addition, HARC researchers examined the social and economic impacts typically associated with coal development in the West, and they identified a range of planning strategies and techniques to manage these impacts. The impact management strategies were categorized by impact and by the government or private sector most often responsible for the management effort--local, state, Federal or the energy facility developer.(3)

A small HARC effort was also conducted to complete a literature review of citizen acceptance and energy development. Literature identifying public attitudes toward the various energy modes and literature describing public actions and behavior in the energy decision-making process were briefly discussed.(4)

Water and Land Use Sector

M. L. Warner, S. J. Shupe

The objective of the water and land use sector during FY-1977 was to quantitatively assess regional impacts of alternative coal development scenarios for the Pacific Northwest states, including Alaska. Two studies were completed, both as part of the National Coal Utilization Assessment (NCUA). One study assessed water use, land use, and water quality impacts of two scenarios for 1975-2020 coal-fired electrical generating capacity growth in the Northwest. Assuming that all projected power plants use evaporative cooling and withdraw their water supply from the Columbia River, Snake River, or coastal estuaries, water withdrawals and consumptive use associated with the projected plants were shown to represent only a small fraction of the physically available flows.

Storage of water will, in many cases, be desirable or required to provide assured supplies and to minimize conflicts with instream uses and with other out-of-bank uses (principally for irrigation) during summer low-flow periods. If all plants meet mandated new source performance standards, pollutants released to water (principally dissolved solids) will be barely detectable because of the large flows of the affected receiving waters and existing background pollutant loadings. Heightened use of existing hydropower facilities to supply peak power demands increases diurnal and seasonal fluctuations in stream flow. Stream flow fluctuation was identified as a potentially important indirect impact of coal-related development on regional instream water uses as coal-fired thermal plants come on line to supply base power. This study also projected power plant land requirements by county for 19 affected counties and two areas of Alaska. The significance of the projected land requirements was not evaluated because potential sites were not identified below the county level.

The second study carried out as part of the NCUA utilized modeling capabilities developed under the program in FY-1976 to assess the potential impact of instream flow requirements on the availability of water for energy developments in the Powder River region of Wyoming and Montana. Computer simulations of potential reservoir sites demonstrated that sufficient water supplies could be made available to meet projected industrial (energy development) needs without instream flows, but if suggested minimum flow requirements were instituted, supplies could not meet projected demand. The results of this analysis have been published.(5)

Air Quality Sector

D. S. Renne, D. L. Elliott, W. J. Eadie

Air quality impacts to the year 2020 for the two coal development scenarios were estimated by developing a current and projected emission inventory for the western United States and incorporating these emissions into air quality diffusion models. Emissions for coal-fired power plants have been estimated assuming that they are equivalent to the Federal New Source Performance Standards (NSPS) and that the plant operates at a 60% load factor.

Using a standard point source diffusion model, short range ($\leq$ 50 km) annual average air quality impacts resulting from sulfur dioxide (SO_2), particulate, and nitrogen oxide (NO_x) emissions from a reference 3000

MWe power plant were estimated for various counties around the Pacific Northwest. Data from meteorological stations near the candidate siting areas were used as model input. Estimates of maximum annual average SO_2 concentrations for a 3000 MWe facility ranged from 1 to 7 $\mu g/m^3$, well below the 80 $\mu g/m^3$ allowed under the National Ambient Air Quality Standards (NAAQS).

Short-term maximum concentrations for a reference 3000 MWe facility have been estimated for nonspecific sites by Argonne National Laboratory,(6) based on a study by the General Electric Company.(7) These estimates are considered applicable to the Pacific Northwest. The analysis shows that maximum 24-hr concentrations may approach the NAAQS under some meteorological conditions.

Long-range impacts of sulfur are also very significant. Much of the SO_2 emitted transforms to sulfate aerosols, which can have adverse health effects. A regional transport, transformation, and removal model has been applied to estimate the sulfur impacts of the coal-related energy development scenario to the year 2020 for the western United States. Figure 2.1 shows the combined SO_2 concentrations from the large existing sources (coal-related and industrial) as well as the projected high-coal electric scenario to the year 2020.

While the results show no apparent violation of the NAAQS on a regional scale from intensive coal development in the western United States, they are significant when examined in the context of the Clean Air Act Amendments of 1977. These amendments include regulations for the prevention of significant deterioration, mandating limits to incremental increases in SO_2 and particulate concentrations in three types of regional classes. Energy development would be most severely constrained for regions in Class I areas (national parks greater than 6000 acres and wilderness areas greater than 5000 acres), where no more than 2 $\mu g/m^3$ increase in annual average SO_2 concentrations are allowed.

Regional-scale sulfate concentrations are greater than SO_2 concentrations. Estimated sulfate concentrations of 3 $\mu g/m^3$ or greater, resulting from the existing, plus the high-coal electric scenarios to the year 2020, cover large areas in the Great Plains, Southwest, and Northwest. Although NAAQS for sulfates have not been established, some states (e.g., Montana and North Dakota) have established their own air quality standards for sulfates allowing a maximum annual average concentration of 4 $\mu g/m^3$. Therefore, a limiting constraint to future development in some regions could result from regulations on sulfate concentrations, if emission levels up to the NSPS are permitted.

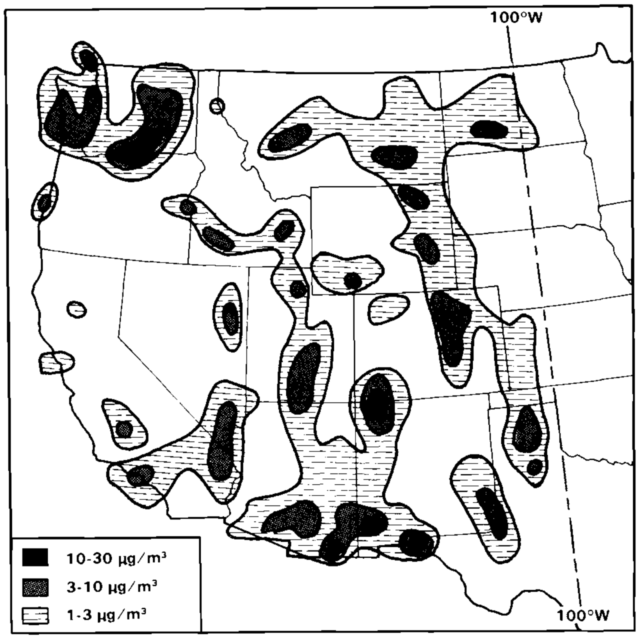

FIGURE 2.1. Estimated SO_2 Concentrations for Existing Sources and the High-Coal Electric Scenario Projected to the Year 2020. Values represent average for October 1974 upper air data.

Economic Modeling

D. W. Fraley, A. E. Davis, W. H. Swift

The economic modeling effort during FY-1977 consisted of both econometric modeling and scenario construction. The objective was to gain a better understanding of the parameters affecting future electricity demand and supply and the attendant use of coal.

Guidance in this effort was provided by a series of national scenarios, with regional breakdown, consisting of estimates of future patterns of energy production and consumption (including coal). Because PNL's area of responsibility under this program (Federal Region Ten, consisting of Oregon, Washington, Idaho, and Alaska) was not consistent with the regional decomposition of the national scenarios, it was necessary to estimate the Region Ten component of two of the western national scenario regions. To assist in this task, models of electricity demand and supply were used to estimate future electricity and, hence, coal use since electricity generation is the only significant use of coal in the area.

The first of these models, ELSA (Electric Power Supply Analysis Model)[8] is an aggregated supply model of the electric energy system in the Northwest. ELSA allows the analyst to examine the structure of the region's utility industry, to postulate possible scenarios and policy decisions, and to simulate their effect on the cost and availability of power and on the market share of various generating sources. The major problem areas addressed are interfuel substitution and the financing of new generating capacity. Extensive modifications were made in adopting or "regionalizing" the model to reflect the unique characteristics of the Pacific Northwest, such as the historical abundance of inexpensive hydropower and the development and influence of the Bonneville Power Administration (BPA).

During the year, ELDA (Electric Demand Analysis Model),[9] an econometric model of the demand for electric power, was linked to ELSA so that supply and demand factors are considered simultaneously. To forecast electric consumption, ELDA utilizes own- and cross-elasticities of demand along with externally specified rates of growth for key variables, such as the prices of electricity and fossil fuels, population, personal income, and value-added. The combined models were utilized to examine the effects of the national scenarios on the future electric supply system in the Pacific Northwest.

Having obtained estimates of the amount of coal expected to be used for electric generation in the Northwest, the specific areas likely to be affected were identified by means of a siting analysis. Candidate siting areas were screened on the basis of availability of water, suitability of terrain and atmospheric conditions, access to transportation facilities, and proximity to transmission corridors and load centers.

Energy and Water Consumption of Pacific Northwest Irrigation Systems

L. D. King, R. B. Wensink, J. W. Wolfe, M. N. Shearer

Oregon State University, under subcontract, began the task of determining the energy, water, and labor requirements of irrigated agriculture in Idaho, Oregon, and Washington. This determination of a data base is the prelude to a projection of these demands to the year 2000. The final objective of the study is to determine the relative tradeoffs among energy consumption, water utilization, and labor requirements.

The water and energy consumption were determined for 14 subregions. Water applications ranged from 1.5 to 5.5 acre-ft/acre, with an average of 3.1 acre-ft/acre. Energy consumption varied from 170 to 2700 kWh/acre with a regional average of 800 kWh/acre. Washington had the highest level of both water and energy use. Of the total 7.3 million acres under irrigation in the region, over half is in the state of Idaho.

Gravity systems represent about 55% of the total acreage under irrigation. Handmove irrigation accounts for about 20%, followed in order by side roll, center pivot, solid set, permanent, big gun, and drip.

• Assessment of Social Values in Thermal Power Plant Siting

A methodology was developed to facilitate the selection of favorable thermal power plant site and design alternatives from the community perspective. A two-stage, multicriteria decision technique was employed to combine technical assessments of effects of the proposed site/design alternatives with corresponding community values. In the the first stage, submodels are used to develop indices of plant impact on each of ten decision criteria. These criteria include effects on aesthetics, water quality, cost of power, air quality, ecology, social quality, local economy, recreational opportunities, cultural resources, and human health and safety. In the second stage, each of the impact indices is weighted by corresponding community values and then summed to provide an overall index of plant acceptability.

Assessment of Social Values in Thermal Power Plant Siting

J. C. King, J. A. Hébert

The objective of this project was to develop a methodology for incorporating early in the power plant siting and design process the values of the potentially affected community. A multiple-criteria decision technique is used which combines technical estimates of plant effects in ten areas of potential impact with measures of community values in these same areas. Auxiliary methodologies are provided for obtaining community values from representative citizenry and for assessment of plant effects in the ten areas of potential impact.

Originally, FY-1977 funds for this project were to be largely devoted to developing the methodologies for assessing effects of proposed power plants relative to the ten judgment criteria. Remaining funds were to be allocated to select a suitable site for initial testing of the methodology. FY-1978 funds were to be used to ready the assessment methodologies for application and to test application of the methodology.

In March of 1977, however, word was received that FY-1978 funding would not be available for this project. Consequently, the remaining FY-1977 funds were redirected to accelerated completion of the criteria assessment methodologies. By the end of FY-1977, eight impact assessment methodologies, representing five of the original eight judgment criteria, were complete.[a] Completed assessment methodologies include those for aesthetics, water quality, local economic effects, recreational opportunities, and cultural resources. Methodologies for assessing effects on air quality and human health and safety are currently being compiled. The land use criterion, although discarded as redundant with other criteria early in the development of this project, should be reexamined for unique attributes.

Although the site assessment methodology is near completion in the sense that the components are present, we would recommend a comprehensive review of the methodology <u>as a system</u>. This should be followed by refinements as necessary and testing prior to application. The review of the whole system, although scheduled for FY-1977, was preempted by the need to complete all assessment methodologies prior to expiration of the funding.

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[a] One of the original judgment criteria, cultural/recreational effects, was judged too complex for treatment as a single criterion and was subsequently split into four criteria, each with a separate assessment methodology.

Work in FY-1977 focused on completion of the methodologies for assessing power plant impact for the judgment criteria discussed below:

Cost of Power

This work included an assessment of how the mechanisms by which alternative power plant sites and designs affect local and system-wide electrical rates. An index measuring the impact of local and service area commercial, industrial, and residential rate changes was developed and reported.

Water Quality

A report was issued describing the method for assessing water quality impacts.[10]

Ecological Effects

The methodology initially developed in FY-1976 for quantifying ecological effects of plant construction and operation was extensively revised. The method is now based on diversity and importance of affected habitat.

Social Quality and Local Economic Effects

The original cultural/recreational criterion, judged too complex for treatment as a single criterion, was split into four independent criteria: social quality, local economic effects, recreational opportunities, and cultural resources. Separate methodologies, based on multiple-criteria decision techniques, were developed for quantified assessment of plant impact on social quality and the local economy. Major factors in the index of social quality effects included public services, social structure, housing, and government capability to accommodate growth. Principal factors used for the local economic effects index included employment, wages and salaries, business opportunities, and public revenues.

Recreational Opportunities and Cultural Resources

Separate indices were developed for impacts on recreational opportunities and cultural resources. Methodologically similar, the assessments are based on evaluation of the quality of resources preempted from public access by plant construction.

Human Health and Safety

Funding available in FY-1977 was inadequate to thoroughly treat the human health and safety criterion. However, an approach was outlined based on probable local concentration of plant emissions known to have adverse health effects.

• Social Impact Methodology Evaluation

Both beneficial and adverse changes in way of life can occur with the siting of a large electric power plant in a community. In order to permit adequate planning for these social and economic changes, it is important that they be accurately predicted. In this research project, we are evaluating the accuracy of available methods for predicting the social and economic changes that may occur in communities, and we are assessing the effectiveness of ways in which communities and utilities have managed adverse changes. Two approaches are being used to accomplish this. First, we will identify social and economic changes as they occur during the construction of Puget Sound Power and Light Company's Skagit Nuclear Project in Skagit County, Washington. To date, we have developed a means of identifying these changes and a description of current conditions in Skagit County for six aspects of community life, including demography, economy, housing, public services, community structure, and social well-being. Second, we are identifying changes that have occurred in communities at other western energy sites during power plant construction. For each site, actual social and economic changes will be compared with those that were predicted in order to identify the strengths and weaknesses of the methods used.

Social Impact Assessment Methodology: Pacific Northwest Plants

D. J. Merwin

The ability to accurately predict both the occurrence and the magnitude of social and economic impacts associated with thermal power plant construction is a critical prerequisite to effective impact assessment and management. Since only a few research efforts have either monitored or identified these impacts through post hoc studies, however, the strengths and weaknesses of available predictive methods and management strategies remain unclear. Until the adequacy of these methods and strategies is determined, progress in the area of social impact assessment and management will be impeded. By monitoring social and economic impacts as they occur during construction at a site in Washington and by performing retrospective analyses at other western energy sites, this research will contribute to the development of both more accurate predictive methods and more effective management strategies.

The site that has been selected for a detailed case study is Puget Sound Power and Light Company's Skagit Nuclear Project in Skagit County, Washington. It is anticipated that construction of this project, which will be monitored for social and economic impacts as they occur during construction, will begin in June 1978. To date, a monitoring system and a baseline profile of current social and economic conditions in Skagit County and four "impact communities" have been developed. Six major aspects of community life are described in the profile and will be monitored during construction: demography, economy, housing, public services, community structure, and social well-being. In addition, the profile includes a description of the county's planning and growth management capabilities. Changes resulting from the Skagit Nuclear Project will be isolated from those that are already occurring in Skagit County.

In preparation for the retrospective studies of other western energy sites, contact has already been made with other utilities. In addition, preliminary social and economic information on a number of sites at various stages of construction and operation has been obtained and reviewed. A final selection of sites will be made during the first quarter of FY-1978. These retrospective studies of the social impact predictive methods, monitoring systems, and impact management strategies used at these sites will be carried out by collecting and analyzing secondary data.

• Interlaboratory Data Exchange

Department of Energy (DOE) objectives require the unprecedented exchange and utilization of large amounts of computerized descriptive information among the national laboratories. FY-1977 accomplishments in this endeavor included: 1) attending coordination meetings at Oak Ridge, Argonne, and ERDA Headquarters; 2) implementing a magnetic tape exchange standard; 3) presenting computer graphics capabilities of Pacific Northwest Laboratory (PNL) at the ERDA-sponsored graphics conference; and 4) reinitiating the Geographic Data Exchange Standard Subcommittee.

Interlaboratory Data Exchange

P. J. Dionne

DOE objectives require the unprecedented exchange and utilization of large amounts of computerized descriptive information among the national laboratories. Regional and nationwide analyses and assessments are the ultimate objective of these energy- and environment-oriented programs. Resource sharing, the standardization of computer readable files, and programs for exchange purposes have become key issues. To comply with these demands, the Interlaboratory Working Group for Data Exchange (IWGDE) was formed to address this multifaceted problem.

Representatives from each laboratory serving on the IWGDE have made progress in several areas, with the most significant accomplishment being the creation and installation of computer independent magnetic tape read and write software at several of the laboratories. Much of the funding for this implementation came from the Savannah River Laboratory's KX - Alternative Fuel Cycle Technologies (AFCT) program. The purpose of creating the exchange standard is to facilitate the transfer of data and models among DOE laboratories. Use of the exchange standard, because it is designed for operation on any computer, removes the necessity of creating special read/write routines each time a researcher wishes to exchange data with other DOE laboratories. The American National Standards Institute (ANSI) is reviewing the proposed standard and, should they distribute it as an ANSI standard, wider utilization is anticipated.

During FY-1977 PNL staff installed the (level 1) first implementation on the Richland CDC CYBER 74. The software we installed was created by staff at Brookhaven and Los Alamos National Laboratories. In order to test PNL's implementation of the standard, we have tried to read a magnetic tape sent to us from Oak Ridge. Also, to meet AFCT programmatic requirements, we have written a tape of meteorological data generated by the PNL U.S. Scale Assessment Model and sent it to Savannah River.

PNL staff were involved in other activities that fell in the data exchange area. For example, we presented our graphics capabilities at an ERDA-sponsored Computer Graphics Conference at Germantown, Maryland in June. Each of the laboratories presented its graphics applications at the conference to people from numerous government agencies. Subsequently, a paper was written describing our philosophy, systems, and some applications.

Problems associated with implementation of the exchange software were addressed at several IWGDE meetings. We also discussed the availability of various data bases at the laboratories and the establishment of a geographic subcommittee for the purpose of creating a geocoding and cartographic exchange standard using the already existing magnetic tape standard.

• Environmental Information System

Starting in FY-1978, the Department of Energy is establishing a focal point for information coordination at each of the multiprogram laboratories. During FY-1977 the task was to establish the guidelines and procedures for this activity; accomplishments included attendance at coordinating meetings and preparation and submission of the Pacific Northwest Laboratory (PNL) work plan for FY-1978.

Focal Point for Information Coordination

P. J. Dionne

In FY-1978, the Department of Energy (DOE) is establishing a focal point for information coordination at each of the multiprogram laboratories. During FY-1977 the task was to establish the guidelines and procedures for this activity. Because the need for environmental, health, and safety information relating to the energy technologies is expected to increase significantly, the Information Coordination Focal Point (ICFP) was established to provide a single contact point for knowledge of the energy-environmental research projects at each laboratory. The ICFP at each laboratory will coordinate improvements in information handling and dissemination and the interchange of information between laboratories. Initial emphasis will include data bases, models, and computer graphics capabilities.

PNL identified a coordinator, prepared a work plan for FY-1978, and submitted it to DOE Headquarters at the end of the fiscal year.

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3.0 Human Health Studies

HUMAN HEALTH STUDIES

- **Evaluation of Radionuclides in Man**
- **Statistical Health Effects**
- **Radioisotope Customer List**

The program of low-level analysis of plutonium and other radioactive elements in human tissues has provided major support to the U.S. Transuranium Registry since it was started by the Hanford Environmental Health Foundation several years ago. This function has been extended to the analysis of tissues of persons resident in the Richland area who have not worked at Hanford, in order to establish baseline values for plutonium deposition in tissues. Surgical specimens of interest obtained from plutonium workers have also been analyzed in this program. For lack of continued funding the project will be phased out during FY-1978.

A program of accumulation of data on the mortality of workers at the Hanford plant has been in progress for 13 years. Since 1975, this epidemiologic data set has been analyzed here by statistical procedures alternative to those used by other investigators. The PNL analyses indicated that the general health of Hanford employees is favorable with respect to cancer generally and to other diseases. The study disclosed possibilities that warrant additional follow-up in two cancer types. The Hanford Environmental Health Foundation is associated with PNL in this continuing study.

• Evaluation of Radionuclides in Man

This project is concerned with the development and application of methods for evaluating the radiological impact of the nuclear industry on its workers and on residents in the environs. During the past year, the project included postmortem studies in which the quantities of radionuclides, particularly plutonium, were measured in samples of tissues obtained at autopsy from former workers and residents in the local environs of the Hanford Reservation and from individuals at more distant locations. In addition, this project supported the work of the U.S. Transuranium Registry (USTR) by performing radiochemical analyses of samples obtained by the Registry from exposed workers and unexposed controls throughout the country. The development of methods to separate marrow from bone, to analyze plutonium in these fractions, and the conduct of an interlaboratory calibration exercise have also been important thrusts of this project. Analysis of urine samples from residents of the Marshall Islands was included in the year's effort but is not normally a part of this project.

Evaluation of Postmortem Tissue Samples

F. T. Cross, L. J. Kirby, V. W. Thomas, Jr.; D. T. Harless, F. N. Eichner

Collection and radiochemical analyses of postmortem tissue samples (lung, liver, bone, and tracheobronchial lymph nodes) from individuals formerly residing in the vicinity of the Hanford project continued during FY-1977. During the year commencing November 5, 1976, 18 analyses for Pu-238 and Pu-239, Pu-240 were made on such tissue samples. In addition, 19 analyses were made for gamma emitters.

Postmortem tissue samples and blood samples were also analyzed for the U.S. Transuranium Registry. During the year, 104 analyses for Pu-238 and Pu-239, Pu-240, and 54 analyses for uranium were performed.

At the request of the USTR, a study was made of separate analyses for plutonium in human bone and bone marrow. This necessitated the development of methods for separating marrow from bone.

The program of interlaboratory calibration cross-check measurements, initiated in 1975, continued. Twenty bone samples were analyzed during the past year. The results of the interlaboratory calibration exercise were presented at the twenty-third Annual Bioassay, Environmental and Analytical Chemistry meeting at Jackson Lake Lodge, Moran, Wyoming. Probably the most important finding was that there were few significant differences between the results reported by the four laboratories used in the study. A fifth laboratory is still analyzing its comparison samples.

In June 1977, 51 large-volume urine samples taken in the Marshall Islands were received from Dr. Robert Connard of Brookhaven National Laboratory. These samples were collected in (or near) February 1977 from the inhabitants of Bikini, Rongelap, Ebeye, and Utirik Islands, and from the medical teams directing the samplings. These samples were analyzed for Pu-239, Pu-240, Pu-238, and secondarily for Cs-137 and Sr-90. Each of the 51 samples was analyzed for Cs-137 by gamma-ray spectrometry, but many samples were composited for plutonium and strontium analyses.

Our laboratory, while having extensive experience with small urine samples up to a few hundred milliliters, had not analyzed urine samples as large as would be required to measure the expected amounts of plutonium in these samples (i.e., 10 to 20 liters per analysis). Considerable effort was expended to evaluate our procedures and those of the Environmental Surveillance Laboratory for the analysis of plutonium. The procedure we selected is a combination of dry and wet ashing followed by coprecipitation of plutonium with calcium ammonium phosphate and final purification by multiple anion exchange chemistry in the nitrate form. The 18 samples (5 composite and 13 individual samples) are expected to be completed by the end of December.

• Statistical Health Effects

The purpose of this program is to develop and evaluate methods for assessing health effects of chronic low-level exposure to environmental agents, particularly ionizing radiation. A major part of our effort has been directed to the analysis of the Hanford mortality data. We have completed a population-based analysis that includes both a comparison of Hanford death rates with those of the U.S. population and an examination of the possible relationship of the mortality rates to radiation exposure. Our work has also included methodological research in the area of occupational mortality.

Statistical Health Effect Studies to Assess the Influence of Low-level Exposure to Environmental Contaminants

E. S. Gilbert

The overall purpose of this project is the evaluation of epidemiological and statistical methods for studying low-level exposures to environmental contaminants. This includes both the development of the needed statistical methodology as well as its application to the analysis of human data and the critical evaluation of other studies concerning human risks. Ionizing radiation is a principal factor of concern in the study.

The study of mortality of the Hanford employee population is the major part of our current work. This study, which is a joint activity between the Hanford Environmental Health Foundation (HEHF) and the Pacific Northwest Laboratory (PNL), has been and is now the principal source of information regarding the health of workers in the nuclear industry. The unusually good quality of data with regard to exposure when compared with other environmental hazards, combined with the excellent occupational information, makes this study an excellent prototype for similar investigations of workers' health in the overall energy industry. Furthermore, the favorable data set provides excellent material for methodological development in the area of occupational mortality.

An analysis of the mortality experience up to April 1, 1974 of over 20,000 white male workers has been completed. This analysis includes both a comparison of Hanford death rates with those of the U.S. population and an examination of the relationship of these death rates to radiation exposure.

In the analyses to date, mortality from all causes for white males employed at Hanford for at least two years is 75% of that expected on the basis of U.S. vital statistics. Mortality from cancer is 85% of that expected. These results are typical of a working population. Neither death from all causes nor death from all cancers shows a positive correlation with external radiation exposure. In fact, death rates from all causes are slightly lower for Hanford workers with higher exposures than for those with lower exposures. It is particularly noteworthy that leukemia, the disease that several studies[1,2] have found to be associated most strongly with radiation exposure, is not correlated with external radiation exposure of Hanford workers. However, because of the size of this population and the magnitude of the exposures, our results are not inconsistent with estimates of cancer and leukemia effects in such documents as the BEIR report.[3]

Two specific cancers, multiple myeloma and, to a lesser extent, carcinoma of the pancreas were found to be positively correlated with radiation exposure. While these associations warrant attention, one must consider the possibility that they may be due to other occupational exposures, pre-Hanford exposures, or biases resulting from regional variation in diagnosis. These cancer types have not been regarded as radiation-related in studies of the Japanese survivors of bombings.

Experience with the Hanford data has led to new areas of scientific interest in the search for appropriate methods of analysis. In particular, we have explored many studies of occupational hazards as well as the literature dealing with problems resulting from the selective biases encountered in a worker population or from the use of standardized mortality ratios. This research has affected our choice of procedures for analyzing the Hanford data.

In the course of this work we have compared our methods and results with those of Mancuso, Stewart, and Kneale.[4] Their work was performed on the same data base but gave rise to conclusions different from ours.

• Radioisotope Customer List

J. R. Sletager

The purpose of this program is to prepare and distribute the annual document entitled List of ERDA Radioisotope Customers with Summary of Radioisotope Shipments. This document lists the FY-1976 Transition Quarter and the FY-1977 commercial radioisotope production and distribution activities of ERDA (now the Department of Energy) facilities at Argonne National Laboratory, Pacific Northwest Laboratory, Brookhaven National Laboratory, Hanford Engineering Development Laboratory, Idaho Operations Office, Mound Laboratory, Oak Ridge National Laboratory, Savannah River Plant, and United Nuclear Industries, Inc.

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4.0 Operational Safety

OPERATIONAL AND ENVIRONMENTAL SAFETY

- **Guidelines for Radiation Exposure—ALAP**
- **Environmental Monitoring Handbook**
- **Environmental, Safety, and Health Standards for Geothermal Energy**
- **Assessment of Criticality Safety**

The responsibility of the DOE Office of Operational and Environmental Safety is to assure that DOE-controlled activities are conducted in a manner that will minimize risks to the public and employees and will provide protection for property and the environment. The program supports the various energy technologies by identifying and resolving safety problems; developing and issuing safety policies, standards, and criteria; assuring compliance with DOE, Federal, and state safety regulations; and establishing procedures for reporting and investigating accidents in DOE operations.

The PNL Operational and Environmental Safety Program contributes to these objectives through projects in the nuclear and nonnuclear areas. Nonnuclear R&D is assuming growing significance and in the future will comprise a major portion of the program. During 1977 the major emphasis was on developing criteria, instruments and methods to assure that radiation exposure to occupational personnel and to people in the environs of nuclear-related facilities is maintained at the lowest level technically and economically practicable.

• Guidelines for Radiation Exposure—ALAP

A three-phase project was planned to assist the nuclear industry in ensuring that personnel radiation doses shall be maintained "as low as practicable" (ALAP), technically and economically. For the second phase of the project, the ALAP efforts at facilities owned by the Department of Energy (DOE) have been summarized. All 16 participating DOE contractors are assisting in the evaluation of this information, which will be incorporated in a topical report.

Technical Guidelines for Maintaining Occupational Exposures as Low as Practicable (ALAP)

J. M. Selby, R. L. Gilchrist, H. L. Wedlick, L. G. Faust

The objective of this project is the preparation of a technical document that will provide the basis for assuring that radiation dose to DOE personnel, DOE contractors, and nuclear industry radiation workers is maintained at levels as low as practicable. ("Radiation dose" means the dose from sources either within or outside the body--also referred to simply as "exposure.") The need for such a document results from an industry commitment that not only shall worker and public exposures not exceed specified limits, but that "operations shall be conducted in a manner to assure that radiation dose to individuals and population groups is limited to the lowest levels technically and economically practicable."

Although interim guidance for meeting this commitment has been provided, an in-depth analysis must be conducted to look at recent radiation exposure trends, present radiation protection practices, production needs, and alternatives for reducing exposure at contractor sites throughout the country. Based upon this analysis and other available information including computer modeling, a document will be prepared with guidelines for assuring ALAP exposures for radiation workers. The document will be used in on-going programs, and in particular for inclusion in the design stage of future programs.

The project as planned has three phases: 1) identification and characterization of activities at DOE-owned facilities resulting in "reasonably avoidable" radiation exposure, 2) in-depth analyses of data and identification methods for exposure reduction, and 3) development of minimum ALAP performance criteria. The initial phase has involved reviews of facilities' exposure records, instrumentation, training, facility layout and design, and any relevant studies and discussions with health physics and operating personnel at the facilities.

The information gathered in the ALAP interviews, completed at 16 DOE contractor sites, is being evaluated by the respective contractors. The interview data have also been catalogued and analyzed in order to identify common practices among contractors and to determine areas of discrepancies and deficiencies in current methods of exposure reduction. These data, which will be presented in a topical report, are being used to develop a manual delineating good ALAP practices. Several deficient areas have been identified including training, documentation of procedures, dosimeters, instrument correction factors, and cost/risk benefit; these are to be included in the forthcoming manual.

• Environmental Monitoring Handbook

A Guide for Environmental Radiological Surveillance at ERDA Installations was published as ERDA-77-24. The primary effort during FY-1977 was a comparison of environmental radiological programs for the 26 ERDA sites with the requirements of ERDA Manual Chapter 0513 and the suggestions and recommendations of ERDA-77-24. Forms were developed for future use by Department of Energy (DOE) staff for similar reviews.

Handbooks of Recommended Practices for Environmental and Effluent Monitoring and Reporting

J. P. Corley, J. J. Fix, D. H. Denham[a], D. A. Waite

The objectives of this program are to provide:

1) suggested methods and procedures to bring greater uniformity and comparability to DOE contractor systems for environmental and effluent radiological monitoring and reporting, and

2) guidelines of suggested environmental and effluent radiological monitoring practices for the Office of Operational and Environmental Safety.

A Guide for Environmental Radiological Surveillance at ERDA Installations, previously submitted by Pacific Northwest Laboratory to ERDA, was published with a few changes in March 1977, as ERDA-77-24. Professionals working in this technical area, but not associated with ERDA, expressed considerable interest in the Guide. One refresher course session on environmental data treatment at the 1977 annual Health Physics Society meeting was based largely on related sections of the Guide.

By agreement with the sponsor, program effort during FY-1977 was largely devoted to a review of the potential impact of ERDA-77-24 on ERDA research and operational site environmental radiological surveillance programs. The major effort was a comparison of the programs at 26 sites, primarily based on their 1976 annual environmental surveillance reports, with the suggestions and recommendations of ERDA-77-24, as well as the unchanged requirements of ERDA Manual Chapter 0513. From this limited information base, many questions of consistency could not be answered, particularly on details of data treatment. However, the participants in the review were in agreement on the improved overall content since the Handbook's effort was initiated. A form for future DOE reviews of site environmental radiological programs and for annual environmental reports was developed and used in these reviews.

Development of companion guidelines for effluent monitoring was halted at an early stage.

[a] Lawrence Livermore Laboratory, University of California

• Environmental, Safety, and Health Standards for Geothermal Energy

Environmental, safety, and health (ES&H) standards are being identified and evaluated for their potential application to geothermal energy development. Environmental and occupational safety problem areas were thoroughly studied prior to a literature search for existing standards. A search of Environmental Protection Agency documents and the Index of U.S. Voluntary Engineering Standards provided the standards that are currently being reviewed and evaluated.

ES&H Standards Identification for Geothermal Energy

J. B. Martin, N. E. Maguire, R. A. Walter

The objective of this project is to identify and assess existing environmental, safety, and health standards that may be applicable to geothermal energy development. In those specialized areas where standards are nonexistent or inappropriate, the objective is to make recommendations for research that would provide a suitable data base for the development of ES&H standards.

A comprehensive study of environmental and occupational safety problem areas was completed. The major problem areas studied are listed in Tables 4.1 and 4.2. The study was accomplished through a review of pertinent literature, consultation with industry and government experts, and visits to geothermal energy sites at the Geysers and Imperial Valley, California and Cerro Prieto, Mexico. The onsite visits provided first-hand experience in assessing the magnitude of ES&H problems. A risk tree type analysis (MORT) was used to assure that all significant ES&H problems would be addressed during the literature search.

The Environmental Protection Agency (EPA) has primary responsibility for setting environmental standards that apply to energy technologies. Bibliographies of all EPA reports have been reviewed to identify those standards applied to other technologies that also pertain to geothermal energy. A detailed review of these and other standards set by state and local governments will provide the basis for recommendations for additional environmental standards needs.

TABLE 4.1. Environmental Impacts of Geothermal Energy Development.

Air Pollution	Water Pollution
Noncondensable gases Particles Micrometeorological changes Odors (hydrogen sulfide)[a]	Groundwater pollution Stream sedimentation Thermal pollution Brine disposal[a]
Land Effects	**Other Effects**
Soil erosion and modification Slope failure and slumping Crop/agricultural damage Damage to plants and wildlife Modifications to nutrient cycling systems	Subsidence[a] Induced seismicity[a] Noise[a] Naturally occurring radioactive effluents

(a)Top priority problem areas

A National Bureau of Standards publication entitled Index of U.S. Voluntary Engineering Standards was found to be the primary reference in the area of occupational safety and health standards. The index and its most recent supplements list nearly 45,000 standards, which were reviewed by title. About 400 standards were identified as having potential application to geothermal energy.

Most of these have been acquired and are undergoing detailed review and evaluation.

TABLE 4.2. Occupational Safety and Health Problems Associated with Geothermal Energy Development.

Hazardous Substances	Equipment Operations	Other Hazards
Noncondensable gases[a]	Construction	Electrical hazards
Hot water/steam releases[a]	Heavy equipment operation	Fire hazards
Toxic chemicals	Rotating equipment	Noise[a]
Acids	Welding/cutting	Extreme weather conditions[a]
Explosives	Vehicle driving hazards	Climbing hazards
Compressed gases		Housekeeping

[a] Top priority problem areas

A decision tree was constructed to provide a systematic and logical method for comparing existing standards with specific geothermal problem areas. These comparisons will follow the decision tree to help assure that proper perspectives are maintained during the review process. Decisions reached on applicability of existing standards will lead to one or more recommendations. Recommendations made through this evaluation process will be circulated widely for review and comment. This will provide all interested parties, including geothermal industry utilities and developers, an opportunity to provide their input on standards for geothermal energy.

• Assessment of Criticality Safety

A study of criticality safety violations was made to better understand their underlying causes and to form suggestions for improvement. An analysis of past data on these violations, in terms of criticality safety philosophy and the human and mechanical factors involved, permits judgments that may help reduce the number of future violations. Further, these data may be utilized in a fault-tree analysis wherein cause factors can be assigned frequency values. When high-frequency causes of violations are identified, corrective action can be taken to reduce their occurrence in the most efficient way.

Analysis of Criticality Safety Programs

R. C. Lloyd, S. W. Heaberlin, E. D. Clayton

The objective of this program is to develop and apply a systematic method to analyze the criticality safety programs in Department of Energy (DOE) facilities. Accordingly, a study was made of 100 criticality safety specification (CSS) violations that were reported during the ten years, 1967 through 1976. These violations were classified by assigning a severity index to each; the method of disclosure and the cause of the violation were further delineated. The severity of the violation was represented by a number from zero to five: 0) a violation where no fissile material was involved; 1) a violation with quantities of fissile material that fell close to exemption limit but had no criticality safety specification (CSS), or a violation outside of CSS but within expected or logical error limits; 2) a violation where material quantities were definitely more than CSS allows, but no logical way existed for criticality to occur; 3) a violation with quantities of fissile material in considerable amount over CSS, or where its accumulation could be made critical if operation continued; 4) a violation where quantities of fissile material were such that a critical condition was nearly approached; 5) a violation that resulted in a critical condition. Table 4.3 is a summary of violations by detection group; Table 4.4 is a summary of the data analysis by severity index.

TABLE 4.3. Criticality Safety Specification Violations by Detection Group.

Detection of Violation	% of Total[(a)]
Plant personnel	46
Auditors	54

[(a)]Total of 100 violations in the study.

TABLE 4.4. Criticality Safety Specification Violations by Severity Index.

Severity Index	% of Total[(a)]	Detected by Plant Personnel		Detected by Auditors	
0	47	3	(6%)	44	(94%)
1	26	19	(73%)	7	(27%)
2	24	21	(88%)	3	(12%)
3	3	3	(100%)	0	
4	0	0		0	
5	0	0		0	

[(a)]Total of 100 violations in the study.

Approximately half of the violations were detected and reported by plant personnel and half by auditors. Figure 4.1 is a graph of the percent of violations in each severity index by detection group, plotted against severity index. This clearly shows that plant personnel reported a lower percentage of low severity index violations and a much higher percentage of high severity index violations than did the auditors.

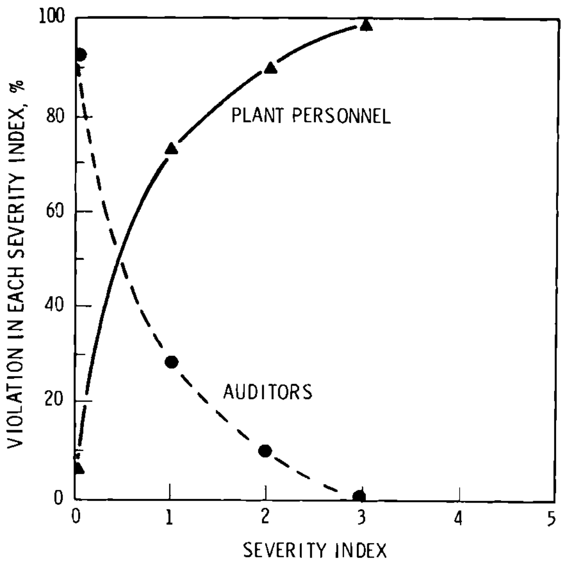


FIGURE 4.1. Comparison of Severity Index by Detection Group

Although in the recent past the trend has been toward more frequent audits by larger auditing groups, these curves indicate that little benefit is to be expected by further emphasis in this area. Rather, if further improvements are to be made, the emphasis might well be placed on training plant personnel and encouraging them to report violations. At present, they appear to be doing a reliable job.

As noted in Table 4.5, the causes behind the violations in order of frequency are: 1) lack of CSS clarity, 2) lack of care, 3) insufficient training, and 4) mechanical breakdown. The fact that mechanical breakdown is responsible for 2% of the violations indicates that equipment is being adequately maintained. The 2% value can be considered normal since equipment failure is responsible for about the same percentage of problems in other areas, such as auto accidents and general plant injuries. Since lack of CSS clarity, lack of care, and insufficient training were essentially equal contributors to the violations, efforts for improvements in these areas should be equally shared. From the analysis of violation reports and interviews of individuals involved with criticality safety specifications (either in writing them or in using them), suggestions for improvement were devised and are summarized below.

TABLE 4.5. Causes of Violations in Order of Frequency.

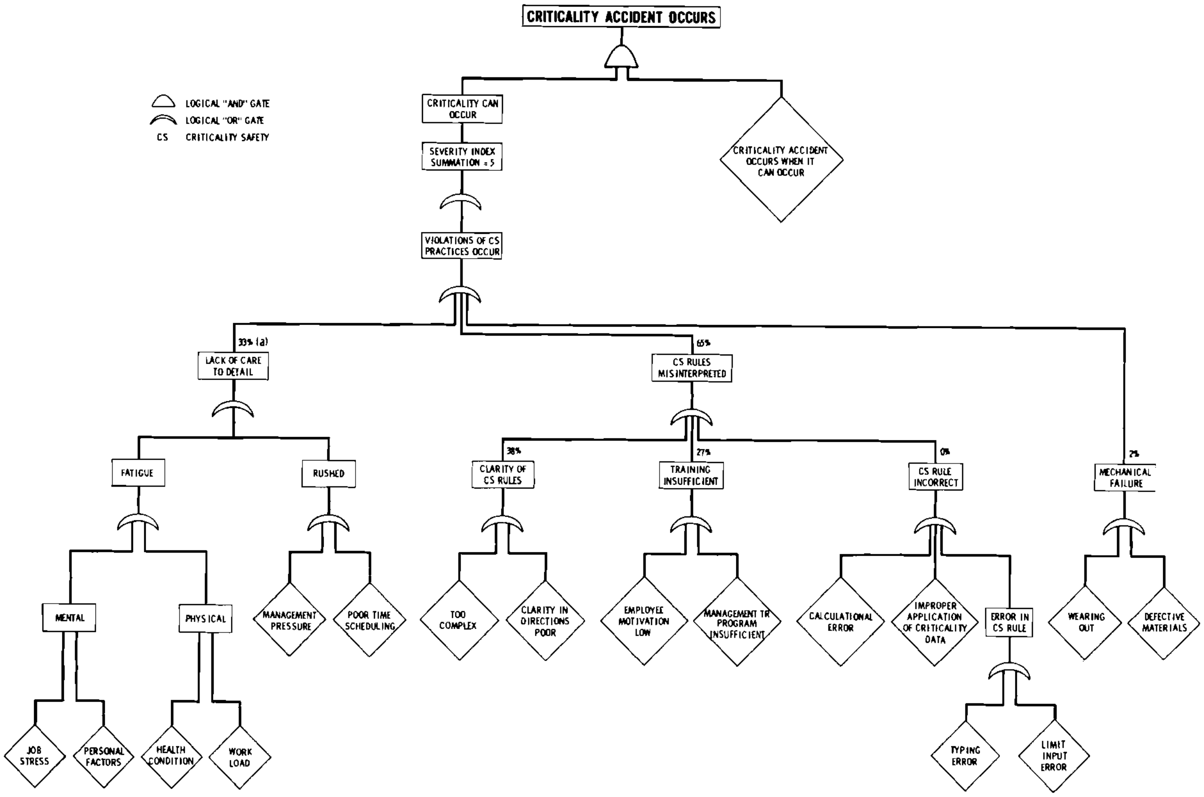
Cause of CSS Violations	% of Total
Lack of care	33
Insufficient training	27
CSS clarity	38
Mechanical failure	2

CSS clarity is very important for the reduction of violations. The CSS representative and the operations engineer should work together closely when developing criticality safety specifications to ensure that they are easily understood by individuals doing the actual physical work. The limits should be written as briefly and clearly as possible. Once written, the CSS should not be changed unless good reasons exist for doing so, e.g., changes in the process. A practice of revising the CSS periodically, involving only unnecessary and insignificant changes, often confuses the operation technicians. This does not mean that review for applicability, on a periodic basis, is not worthwhile. Some of the violations studied occurred because the facility involved was in violation of a CSS as issued or revised, i.e., the normal operation was not covered properly by the CSS. This is an indication of lack of interchange at the operations level.

The violations caused by lack of care appear to arise when operations are rushed, when there are too many operations involved, or when there is lack of attention to details. One of the more obvious areas of difficulty concerns communication at shift change. A second area of concern is planning. Proper planning can eliminate the need to rush to complete a job before the end of a shift.

Insufficient training is normally associated with new employees and employees who have recently changed jobs. Discussion of criticality safety specifications should be a regular part of the general safety training program. Facility workers should read and understand all new and revised specifications. This is especially true for employees in a new work function.

A fault tree, shown in Figure 4.2, was devised using the parameters found when



(a) PERCENTAGE VALUES FOR VIOLATION CAUSES

FIGURE 4.2. Criticality Safety Violations Fault Tree

analyzing the 100 violations. Fault-tree analysis, which is well suited to analysis of criticality safety, is a form of risk assessment in which the pathways to the failure of a system are identified.[a] The fault tree is constructed from knowledge of the interrelationships of the various conditions, events, and components in the system. By correctly manipulating the probabilities of occurrence of each event (e.g., violation of a criticality safety limit) along the pathways, the overall probability of system failure can be determined. It is therefore possible to assess the system's failure rate and the failure mode most likely involved. This assessment can be based on failure of the system's components, even though there may be little or no experience with complete failure of the system. The fault tree in Figure 4.2 shows the percentage of violations attributable to specified causes, as determined by the data analysis.

An event tree has also been constructed that demonstrates the potential pathways to an accidental criticality. With suitable data input and analysis, information can be obtained concerning the probability that an accident will occur.

[a] Failure in this case would be the occurrence of a criticality accident.

5.0 Environmental Policy Analysis

ENVIRONMENTAL POLICY ANALYSIS

- **Environmental Policy Analysis**

The Environmental Policy Analysis Program was established to improve the formation of energy development and environmental policies with due mutual regard for national environmental and energy development needs. As a separate office under the Assistant Secretary for Environment, the program is implemented by the Director and by Offices of Environmental Policy Analysis in the eight DOE multiprogram laboratories. The program provides the Assistant Secretary with information on alternatives for decision making and early warning of environmental problems and considerations that may affect energy policy decisions. The program is intended to be a continuing activity, with its scope determined progressively as issues are defined.

The PNL Environmental Policy Analysis Program draws upon the broad scientific and technical capabilities available within the laboratory, from other DOE multiprogram laboratories, and from qualified outside consultants. Teams representing the particular skills, knowledge, and perspectives relevant to the issues being analyzed are organized as needed. Activities fall into three broad categories: 1) surveillance of current regional, state, and local developments; 2) quick response reviews, studies, and analyses; and 3) formulation, exploration, and analysis of broad issues.

• Environmental Policy Analysis

The Environmental Policy Analysis Program was instituted in 1976 to improve the formulation of energy development and environmental policies that have due regard for national environmental and energy development needs. Activities include surveillance of environmental and energy problems and conditions of regional significance in the Pacific Northwest, short term assignments involving analyses of issues of immediate importance or reviews of critical documents, and in-depth analyses of various broader issues.

Policy Surveillance and Issue Formulation in the Environmental Policy Analysis Program

D. L. Hessel

During FY-1977, the Environmental Policy Analysis Program at PNL focused on four broad issues:

1) Transuranics in the Environment - This effort involved coordinating laboratory reviews of three drafts of a Federal guidance document from the Environmental Protection Agency that seeks to determine levels of plutonium and other transuranic elements and compounds in soils that would render the affected areas unsafe for unlimited use.[1] The project also involved analysis of the cost to the government as well as some environmental and health impacts that would be associated with implementation of the guidance. This assignment was largely completed during the year.

2) Impacts of Water Pollution Control Laws on Energy Technologies - For this project, an analysis was made of problems experienced by the energy production industry from the implementation of Federal and state water pollution control laws. Contacts were made with nearly 100 Federal and state agencies, industrial firms, utilities, and environmental interest groups. Exploration of the overall issue was largely completed in FY-1977; work in FY-1978 will focus on specific problems identified in the exploration.

3) Comparative Health Risks from Energy Technologies - Late in the year an effort was begun to collect, evaluate, and list useful estimates of health risks associated with various energy technologies. At the same time, annotated bibliographies were prepared concerning perceptions of risk by individuals, groups, and agencies, and likely responses to such perceptions.

4) Costs of Changes in Radiation Standards - This project, also started late in the year, is designed to assess the cost and related impacts on the nuclear industry arising from changes in radiation standards during the past 15 years. Both environmental and occupational regulations are included. The project will also investigate potential future changes.

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ORGANIZATION CHARTS

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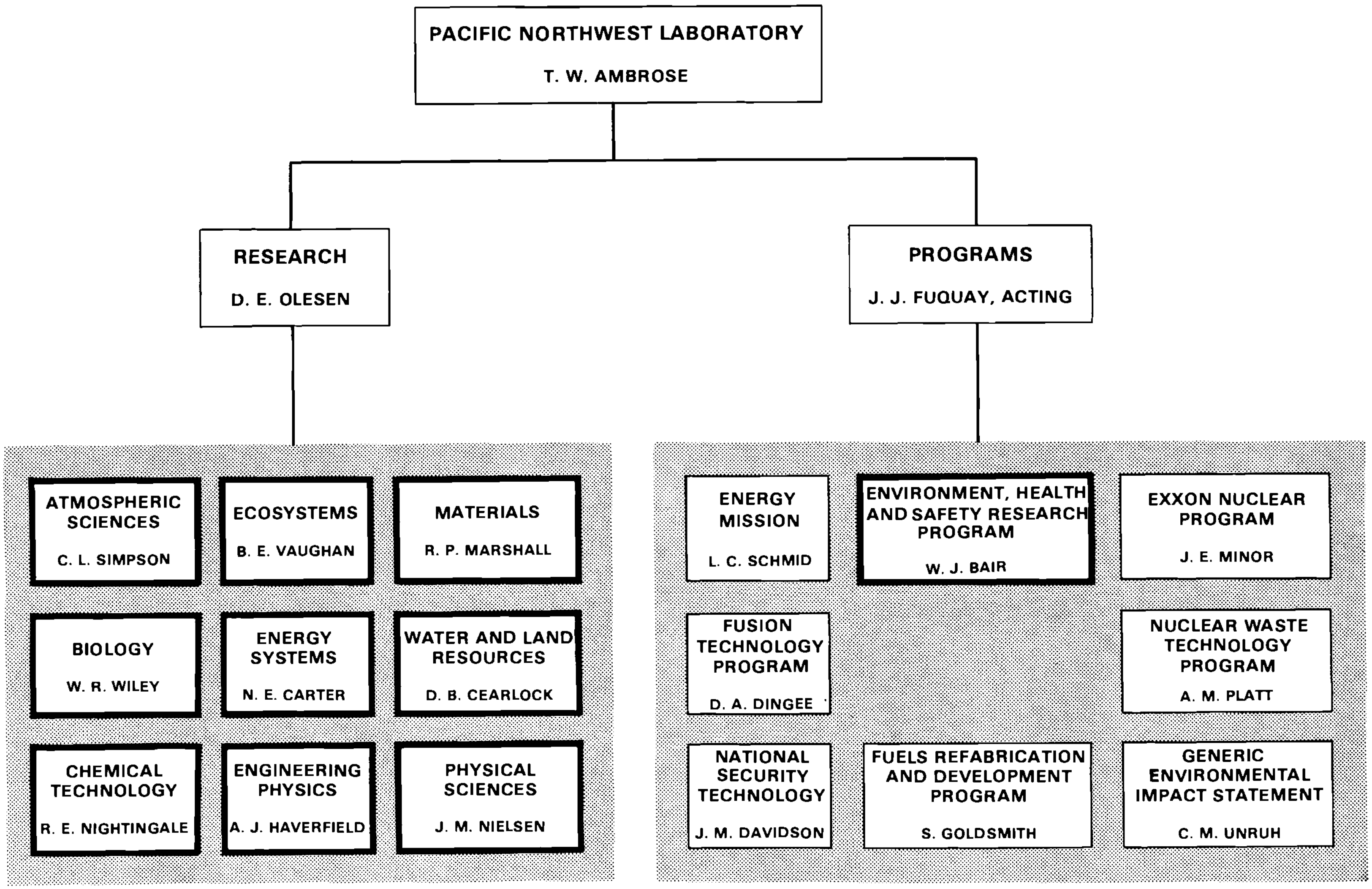

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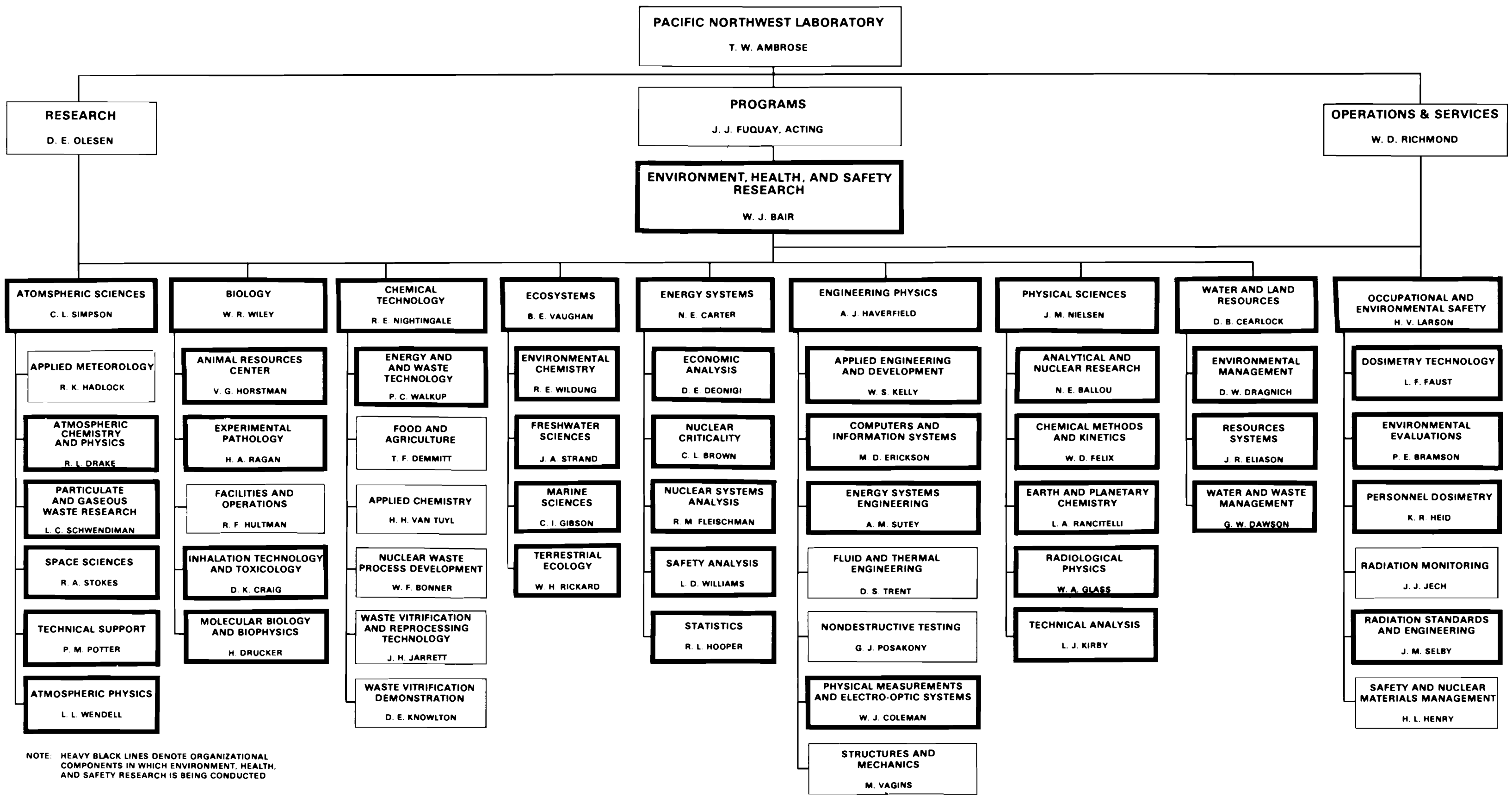

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