1 of 5

Hanford Integrated Planning Process

1993 HANFORD SITE-SPECIFIC SCIENCE
AND TECHNOLOGY PLAN

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EXECUTIVE SUMMARY

This document is the FY 1993 report on Hanford Site-specific science and technology (S&T) needs for cleanup of the Site as developed via the Hanford Integrated Planning Process (HIPP). It identifies cleanup problems that lack demonstrated technology solutions and technologies that require additional development. Recommendations are provided regarding allocation of funding to address Hanford's highest-priority technology improvement needs, technology development needs, and scientific research needs, all compiled from a Sitewide perspective.

In the past, the S&T agenda for Hanford Site cleanup was sometimes driven by scientists and technologists, with minimal input from the "problem owners" (i.e., Westinghouse Hanford Company [WHC] staff who are responsible for cleanup activities). At other times, the problem-owners made decisions to proceed with cleanup without adequate scientific and technological inputs. Under both of these scenarios, there was no significant stakeholder involvement in the decision-making process. One of the key objectives of HIPP is to develop an understanding of the integrated S&T requirements to support the cleanup mission,^(a) as defined by the needs of the problem owners, the values of the stakeholders, and the technology development expertise that exists at Hanford and elsewhere. This requires a periodic, systematic assessment of these needs and values to appropriately define a comprehensive technology development program and a complementary scientific research program. Basic to our success is a methodology that is defensible from a technical perspective and acceptable to the stakeholders.

Cleanup of the Hanford Site will require numerous decisions about technology development and implementation, which will be complicated because of

(a) The anticipated impacts of this understanding will be achieved gradually. The initial impact will be that new activity data sheets and technical task plans will focus on Hanford's highest-priority technology needs, which will provide stronger justification for obtaining funding. In the longer term, as implementation of the needs assessment methodology is refined, the resulting S&T priorities should be used to drive technology development funding allocations at Hanford.

the substantial uncertainties about the risks and the costs of new technologies. In addition, the choice of a specific technology for a specific application must be evaluated with respect to multiple (and often conflicting) objectives (e.g., risk reduction, increasing effectiveness, cost reduction, increasing public acceptability, regulatory compliance).

Integrating the conflicting viewpoints of the different Hanford stakeholders was not an easy task. The diversity of opinions among the stakeholders (e.g., problem owners who are charged with cleaning up the Site, regulators who want to see near-term progress, technologists with an investment in existing technologies, scientists who want to do research that will lead to the development of new technologies) makes planning for Site cleanup a difficult process. Decisions must be made between conflicting objectives (e.g., minimizing health and safety risks versus minimizing costs). Decisions must also be made under a great deal of uncertainty, which creates tensions between those who want action now and those who want to wait for more data.

There is widespread agreement that new technologies and new scientific research are needed to successfully clean up the Hanford Site. It appears that many cleanup problems currently have no solutions, which provides a strong driver for technology development. However, the funding is insufficient to develop every technology that is identified or to undertake every scientific research project that is proposed. Thus, the U.S. Department of Energy (DOE) must focus its resources on S&T that will have the most significant impacts on the overall cleanup effort. Hanford has recognized the importance of identifying and prioritizing its most critical problems and the most promising S&T solutions to them.

Undertaking this Sitewide S&T prioritization activity required definitions of the set of technology options to be considered and the criteria by which to rank-order them. A methodology was developed to combine technical judgements of Site experts with value judgements of Hanford stakeholders into a rigorous decision management process. WHC and Pacific Northwest Laboratory (PNL) program managers, engineers, and scientists were asked to identify and prioritize: 1) Hanford problems, 2) functional needs that must be addressed to solve the highest-priority problems, and 3) candidate technologies to

accomplish the highest-priority functional needs. In addition, Hanford stakeholders were asked to provide the values (criteria) they would use to make judgements regarding the severity of one Hanford problem versus another. Similarly, the stakeholders provided criteria to prioritize functional needs and candidate technologies. The process that was used at Hanford to prioritize S&T needs is summarized below.

Interviews were held with representatives from key stakeholder groups (e.g., problem owners, technology developers, scientists, regulators, DOE program managers) to elicit problem prioritization criteria. The individual sets of criteria were consolidated into a master list of 10 criteria: 1) short-term health and safety, 2) long-term health and safety, 3) future generations' health and safety, 4) surface water contamination, 5) groundwater contamination, 6) soil contamination, 7) land use, 8) cultural concern, 9) public concern, and 10) regulatory compliance.

Five Problem Prioritization Workshops were held in early FY 1992, with each one focused on a separate Hanford mission area (i.e., solid/liquid waste, tanks, environmental restoration [ER], facility decontamination and decommissioning [D&D], and nuclear materials). The participants (WHC problem owners plus scientists and technologists from both PNL and WHC) were asked to identify and prioritize the most important problems in their mission area. The goal of each workshop was to create a matrix of mission area problem scores using the list of problems developed by the participants and the scoring criteria developed via the stakeholder interviews. This was accomplished through a computer-aided process that helped participants apply the criteria and consistent logic to compare the relative importance of each problem under each criterion. Since the same criteria and logic were used in each of the workshops, we were able to merge the five sets of mission-specific problem priorities into a master Sitewide list of prioritized problems.

A second set of stakeholder interviews was conducted to elicit recommendations on the weights to be applied to the 10 problem prioritization criteria. These weights, coupled with the problem scores developed in the workshops, were used in a multi-attribute utility analysis to develop a prioritized list of Hanford cleanup problems for each stakeholder group. The

result of this comparison is that differences in stakeholder weights have very little impact on Hanford problem priorities. There are some slight shifts, but the overall problem priorities do not change significantly.

Additional workshops were held to begin to focus Hanford's S&T capabilities directly on identifying the most promising cleanup technologies for solving the Site's highest-priority problems. The objective of these workshops was to link the highest-priority problems in each mission area with the functional needs required to perform the necessary cleanup, and the candidate technologies to meet those functional needs. Information was developed on the alternative technology pathways to address the problems, with each pathway containing multiple technologies to perform the necessary functions. Functional needs were evaluated against four criteria: 1) technology gaps, 2) urgency, 3) cost reduction potential, and 4) effectiveness increase potential. Technologies were also evaluated against four criteria: 1) importance for meeting the functional need; 2) cost-effectiveness; 3) timeliness and development risk; and 4) contribution to other mission areas, problems, or functional needs.

There was one exception to our implementation of the methodology described above. Technologies to remediate the Hanford waste tanks were prioritized by the Tank Waste Remediation System (TWRS) National Workshop participants, rather than in a HIPPI Technology Prioritization Workshop. The TWRS Program spent 15 months during FY 1992 and FY 1993 developing an Integrated Technology Plan for remediation of tank wastes, at a much more detailed level than any of the HIPPI workshop results. The TWRS Program has 1) identified and narrowed their suites of remediation systems to be developed, 2) identified and prioritized their functional needs, and 3) identified and prioritized technologies to support their highest-priority functional needs. Implementing the TWRS methodology for integrated technology planning in the other Hanford mission areas would be useful, especially if needed technologies do not exist or there is a high risk of technical failure.

The S&T needs assessment workshop results presented in this document formed the foundation for the technology development needs crosswalk activity that was undertaken in FY 1993. This crosswalk was designed to compare

Hanford's highest-priority S&T needs with ongoing technology development activities funded by DOE's Office of Technology Development. It resulted in the identification of technology development gaps in some of the highest-priority functional needs areas to address the highest-priority problems on the Site. Recommendations for a comprehensive Hanford S&T Program to address these gaps are presented and categorized in terms of technology improvement needs, technology development needs, and science needs. Considerably more work is needed to refine these recommendations, and it will require the collaboration of Hanford problem owners and technologists (both at Hanford and elsewhere).

The goal of the HIPP S&T needs assessment task is to periodically elicit inputs from key Hanford stakeholder groups and use those inputs to develop an acceptable S&T agenda for the Site. No attempt is made to achieve consensus. Different stakeholders may have different values concerning cleanup priorities. They may also have different beliefs about the uncertainties associated with particular technologies. The goal is not to eliminate those differences, but to develop an S&T agenda that is acceptable to all stakeholders in spite of their differences. Hanford's key S&T needs will be obtained through the process of blending expert opinions of scientists and technologists with value judgements of stakeholder groups into a rigorous decision analysis framework.

Recommendations that result from implementation of this decision analysis process will be used to seek funding for S&T programs that focus on Hanford's highest-priority cleanup problems and have the potential to make substantial impacts on the Site. We will recommend a balanced S&T portfolio with both short-term and long-term components. The short-term emphasis will most likely be driven by health and safety and regulatory compliance concerns. The long-term emphasis will most likely be driven by the desire to develop and implement innovative solutions to our cleanup problems to improve upon the Site technical baseline in terms of performance, cost, safety, and/or timeliness.

Hanford problem owners are working very hard to communicate their most critical S&T needs to both local and offsite technology developers. Likewise, the technology developers are working very hard to develop potential solutions

that are targeted at the most critical Hanford problems. Together we can make near-term, visible progress in cleaning up certain areas of the Site, while at the same time investing in S&T innovation to address the longer-term, more complex cleanup problems.

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ACRONYM LIST

ADS	activity data sheet
BAT/AKART	best available technology/all known and reasonable technology
BWID	buried waste integrated demonstration
CEC	Commission for the European Community
CEPOD	an electrochemical liquid-phase decontamination technique
CH	contact handled
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CPU	compact processing unit
CRADA	Cooperative Research and Development Agreement
D&D	decontamination and decommissioning
DNAPL	dense, nonaqueous phase liquid
DOE	U.S. Department of Energy
DOE/HQ	U.S. Department of Energy/Headquarters
DoD	Department of Defense
DST	double-shell tank
DT&E	development, testing, and evaluation
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EM	environmental restoration and waste management
EMSL	Environmental and Molecular Sciences Laboratory
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ER/WM	environmental restoration/waste management
ESAAB	Energy System Acquisition Advisory Board
FND	functional needs diagram
f	functional need
FFTF	Fast Flux Test Facility
FTIR	Fourier transformed infrared
GISC	Generic Intelligent System Controller
HEPA	high-efficiency particulate air
HIPP	Hanford Integrated Planning Process

HLW	high-level waste
H&S	Health and Safety
HSSSTP	Hanford Site-Specific Science and Technology Plan
HTPP	Hanford Waste Vittrification Plant
HWVP	Hanford Waste Vittrification Plant
ICP-MS	inductively coupled plasma-mass spectrometry
ID	integrated demonstration
IP	integrated programs
IRAP	Integrated Risk Assessment Program
ISV	in situ vittrification
IX	ion exchange
KEH	Kaiser Engineers Hanford
LDR	land disposal restriction
LDUA	light-duty utility arm
LE	liquid effluent
LLW	low-level waste
LLMW	low-level mixed waste
LRA	long-reach arm
MIBK	methyl isobutyl ketone
MRS	monitored retrieval storage
MSRC	Molecular Science Research Center
NATO	North American Treaty Organization
NDA	nondestructive analysis
NDE	nondestructive evaluation
NDE/NDA	nondestructive evaluation/nondestructive analysis
NEPA	National Environmental Policy Act
NMR	nuclear magnetic resonance
NRC	National Research Council
NTS	new technical strategy
OTA	Office of Technology Assessment
PCBs	polychlorinated biphenyls
PFP	Plutonium Finishing Plant
PNL	Pacific Northwest Laboratory

RCRA	Resource Conservation and Recovery Act
R&D	research and development
RF	radiofrequency
RH	remote-handled
RL	DOE Richland Operations Office
ROD	record of decision
RWMC	Radioactive Waste Management Committee
S & T	science and technology
SITE	Superfund Innovative Technology Evaluation
SNM	special nuclear material
SPR	single-pass reactor
SRS	Savannah River Site
SST	single-shell tank
SW	solid waste
SWL	solid waste landfill
TCE	trichloroethylene
TCE/PCE	trichloroethylene/perchloroethylene
TCO	terminal clean-out
TD	technology development
TLD	technology logic diagram
TPA	Tri-Party Agreement
tpd	ton per day
TRU	transuranic
TTP	technical task plan
TSG	technical support group
TWRS	Tank Waste Remediation System
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
UST	underground storage tank
UST-ID	underground storage tank-integrated demonstrations
VOC	volatile organic compound
WBS	work breakdown structure
WESF	Waste Encapsulation and Storage Facility
WHC	Westinghouse Hanford Company
WIPP	Waste Isolation Pilot Plant

WRAP
WQF

Waste Receiving and Processing
waste form qualification

1.0 INTRODUCTION

The primary mission of the Hanford Site has changed from nuclear material production to environmental management of the Site and remediation of the wastes remaining from nearly 50 years of production activities. This new Site mission brings complex technical, legal, regulatory, and social challenges. These challenges demand a new approach to Site planning and management that integrates all of the Site's programs.

The production of plutonium and other products created large volumes of radioactive and chemical wastes (e.g., radionuclides, metals, inorganic and organic compounds, and toxic anions) that were either held within engineered structures or released into the environment. Approximately 1.4 billion m³ of hazardous and radioactive wastes have been buried or released to the environment at Hanford (Gephart and Hanson 1989). These wastes have contaminated over 100 mi² of groundwater (OTA 1991), shallow and deep soils, surface water bodies, and onsite buildings. A variety of aboveground and below-ground engineered structures at Hanford either currently contain waste, have released waste into the environment, or were part of the reactors and processing facilities that supported Hanford operations. Waste types include liquids discharged into such engineered structures as cribs, trenches, ditches, and ponds; drums, dry wastes, and contaminated equipment buried in solid waste burial grounds; high-level waste (HLW) liquids/sludges stored in underground single-shell tanks (SSTs) and double-shell tanks (DSTs); common industrial waste disposed of in shallow ground; and reactor buildings and chemical processing plants. Waste types also include low-level mixed and transuranic (TRU) wastes stored in aboveground and below-ground configurations awaiting special treatment or disposal facilities (e.g., TRU waste shipment to the Waste Isolation Pilot Plant [WIPP]).

Today, the Hanford Site contains

- one-third (approximately 1400) of all U.S. Department of Energy (DOE) inactive waste sites with 70% of these sites containing mixed (radioactive and chemical) wastes
- one-half (110,000 m³) of DOE's TRU waste volume

- two-thirds (244,000 m³) of DOE's HLW volume
- one-third (446 million Ci) of DOE's HLW radioactivity.

Across the DOE Complex, the Office of Technology Assessment (OTA) notes that contamination is widespread within shallow and deep sediments, groundwater, and surface waters from radionuclides and hazardous chemicals. About 4000 DOE waste sites across the DOE Complex will require some form of remediation. It is estimated that 0.2 million m³ of TRU waste is buried, along with 2.5 million m³ of low-level mixed waste. Contaminated soils and sediments at all DOE facilities are estimated at "billions of cubic meters." To complicate the issue, OTA found that DOE is still continuing to discover new problems, and that until characterization has been completed, effective remediation measures cannot be initiated (OTA 1991).

Hanford is a macrocosm of these contamination problems. Thus, the Site is being used as a test bed for assessing cleanup technologies and developing the underpinning science and technology.

1.1 DOE'S TECHNOLOGY DEVELOPMENT CHALLENGE

DOE is facing a major environmental effort to manage radioactive and hazardous waste contamination at some 14 major facilities distributed across the nation (OTA 1991). The legacy from producing nuclear materials and warheads has resulted in environmental contamination, community concerns over health effects, and the recognition that existing technologies are inadequate to permanently and safely solve many of DOE's environmental restoration, waste management, and decommissioning problems.

The need to bring new technologies on-line where existing technology is inadequate has been underscored in many reports, such as those from the Congress of the United States (OTA 1989 and OTA 1991), the National Research Council (NRC 1990), and the DOE Office of Energy Research (DOE/OER 1990 and DOE/OER 1991). In fact, in the late 1980s, Congress created the U.S. Environmental Protection Agency (EPA) Superfund Innovative Technology Evaluation (SITE) Program to aid in the development and implementation of innovative cleanup technologies.

The time (decades), potential cost (several hundred billion dollars), and short- and long-term risks of cleaning up DOE's waste sites are far more complex than either industry or the regulatory agencies have faced during their execution of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) programs. Thus, while the need to develop new technologies for remediating industrial waste sites has been great, the need to have an expanded technology base to solve DOE's complex problems appears even greater. For example, EPA states (EPA 1989):

Since 1980, the problem of neglected hazardous waste sites has revealed itself to be far more complex and diffuse than anyone first realized. In the fight to control conventional pollutants in air and water, EPA was able to apply proven technologies to produce fast results. With Superfund, no such resource was available. Instead, EPA and State technical managers have exercised considerable ingenuity in devising ad hoc control strategies....As a consequence the Nation is only now beginning to confront the real dilemma: how to reduce environmental risks from a growing list of sites presenting ever new complexities, in a situation characterized by incomplete knowledge, immature technology, and relentless pressure on a limited pool of resources.

1.1.1 Failure of Traditional CERCLA/RCRA Technology Approaches

When the CERCLA national waste site cleanup efforts began more than a decade ago, EPA and industry both assumed that existing technologies could be used to solve environmental contamination problems. They attempted to adapt traditional technologies from the solid waste management, construction, and mining industries. Existing environmental management activities focused on providing engineered solutions for remediating contaminated soils and water. These efforts were not successful.

A major reason for this failure was the belief that existing technologies, imposed through a stiff regulatory framework, were available and adequate to clean up the nation's waste sites. Thinking that our nation's wastes were just a special form of solid waste garbage, EPA and industry overlooked the possibility that their assumptions about the scope, nature, and extent of pre-existing and newly generated waste and technology's ability to deal with it were incorrect.

During the same time, the operators of the nuclear weapons complex were handling mixed wastes under the assumption that the primary health and environmental risk was from radiation. Thus, they saw the solution from an engineering perspective--design and engineer systems/facilities (e.g., underground storage tanks) to avoid direct exposure to radiation. The potential hazards of the chemical components of the mixed wastes, and the eventual failure of containment structures and the concomitant release of a complex mixture of contaminants into the soil and groundwater, were not the primary concerns at the time.

These perspectives helped frame both the "cradle-to-grave" RCRA and CERCLA assumption that most cleanup and waste treatment technologies were available to characterize waste sites, as well as clean them to acceptable levels.

While even the relatively "simple" industrial problems (a few contaminants spread over a limited area) that the RCRA and CERCLA programs have traditionally faced are yet to be resolved, DOE must address these and the more complex problems associated with large volumes of low- and high-level radioactive mixed waste. Some of the problems that are unique to DOE, such as highly radioactive tank wastes, TRU buried wastes, and mixed waste contaminated soil and groundwater, have never been addressed (or solved) in actual cleanup efforts. DOE's extensive experience in managing radioactive mixed waste can be used in providing solutions to these problems, as can the experience of EPA, the Department of Defense, and industry. However, this experience is only a starting point (i.e., a technology baseline from which to begin). It must be expanded to meet the challenges facing DOE's environmental management activities. This situation is described by OTA as follows (OTA 1991):

It may be impossible with current technology to remove contaminants from certain groundwater plumes and deeply buried soil or, even if possible, it may be extremely expensive or require prolonged periods of operation....Common problems are the technical difficulties inherent in detecting and mapping the contamination at specific sites, uncertainties regarding the effectiveness of cleanup technologies, lack of qualified personnel, and ambiguities within the regulatory system.

1.1.2 Building Upon a Technology Baseline

As a result of past operations and waste management approaches, "the scope and complexity of the contamination throughout the Weapons Complex present unprecedented challenges" (OTA 1991). DOE must prevent additional environmental insult from facility operations, while meeting the aggressive cleanup schedules negotiated in compliance agreements with EPA and the states where DOE facilities are located.

DOE can take active steps toward solving its environmental management problems by immediately demonstrating and applying technologies to problems that can be solved. To take these actions, DOE must build from the current technology knowledge base. However, we must recognize that these actions will likely not be as cost-effective as future technologies. Nonetheless, they do provide solutions for some immediate problems and will help meet the expectations of the public and regulatory agencies for immediate cleanup actions. This is consistent with OTA's statements (OTA 1991):

The procedure for developing and implementing more effective technologies could be improved by more focused analysis of the requirements and alternative solutions for the most important cleanup problems. DOE could accelerate efforts to structure a program clearly identifying immediate technological needs and timely solutions to the more urgent contamination problems.

Similarly, the technology does not exist to clean up many waste sites having longer-term human and ecological risk. The lack of permanent and cost-effective cleanup solutions significantly complicates DOE's negotiation and fulfillment of federal facility cleanup agreements--for while compliance and cleanup schedules are continuously negotiated/updated, there does not exist a sound science and technology (S&T) investment program to ensure that tomorrow's cleanup technologies will be available to meet these schedules. For example, OTA states (OTA 1991):

Technologies that could effectively remediate certain sites with extensive or complex contamination of soil, groundwater, sediments, and surface water either are not available....New technologies may be available in the future, but the most promising are still in the very early stages and will require years of research, development, and testing at specific sites.

The cleanup of soils and groundwater beneath DOE sites will require significant S&T advancements in such areas as bioremediation, chemical separations, waste processing/treatment, robotics, sensor development, analytical techniques, and waste minimization.

DOE's challenge will be to understand the science of contamination problems and cleanup solutions in sufficient detail to avoid making the problem worse or more complex if future actions should be warranted. Previous engineered solutions pursued without an understanding of the basic chemical mechanisms and processes involved have made contamination problems and the cleanup efforts more complex. For example, in the 1950s, ferrocyanide was added to the underground storage tanks at Hanford to reduce the liquid volume in the SSTs to make more tank space available. Today, DOE is spending millions of dollars to understand the basic mechanisms and processes associated with and resulting from these actions as DOE tries to remediate these tank wastes. The cleanup will likely be more difficult and costly because of these past actions.

1.2 PURPOSE OF THE HANFORD SITE-SPECIFIC SCIENCE AND TECHNOLOGY PLAN

The purpose of this plan is to document the current understanding of S&T needs for cleanup of the Hanford Site as developed via the Hanford Integrated Planning Process (HIPP). (See Section 14.0 for a detailed description of HIPP.) It presents lists of technology improvement needs, technology development needs, and scientific research needs, all compiled from a Sitewide perspective. It is planned that the document will be updated periodically. In the near term, the Hanford Site-Specific Science and Technology Plan is expected to be used by Site program managers and planners to prepare activity data sheets (ADSs) and technical task plans (TTPs) that are focused on the highest-priority cleanup problems at Hanford. In the longer term, the S&T priorities developed via this needs assessment process should be used to drive technology development funding allocations at the Site.

This document includes a description of the Hanford Site material disposition problems and the potential solutions as best known at the present time. (See the 1992 Hanford Mission Plan [DOE/RL 1992a] for more details.)

In addition, this document describes the analytical methodology that was implemented throughout the Site in FY 1992 to organize and validate the process of identifying and prioritizing S&T needs from an overall Site perspective. The implementation of this methodology will result in the S&T Needs Team^(a) gathering data once a year on Site problems and alternative technology solutions, and then providing it in the appropriate format to meet individual client needs as they arise.

A number of Hanford Site and U.S. Department of Energy/Headquarters (DOE/HQ) activities are closely related to the development of this Hanford Site-Specific Science and Technology Plan. During FY 1992 and FY 1993, the S&T Needs Team coordinated closely with the activities of the Tank Waste Remediation System (TWRS) Program in the identification and prioritization of systems, functional needs, and technologies required to remediate the Hanford waste tanks. In the future, the needs assessments of the DOE/HQ Integrated Demonstrations will also be coordinated with the development of this plan.

HIPP began with the Hanford Strategic Analysis study in October 1990. It was driven by the need to better understand the alternative strategies for Site cleanup and the technical options for each strategy. Historically, the various waste problems at Hanford (e.g., tanks, solid waste, contaminated soils) have been analyzed individually in the search for cleanup solutions. These individual cleanup efforts are in competition for funding. The primary purpose of the Hanford Strategic Analysis study is to provide an analytical tool to guide development and modification of an integrated plan for Site cleanup. This tool provides a systematic methodology for evaluating the effects of individual process changes on the overall Site material flows.

The technical evaluation of Site options and strategies includes the development of material disposition alternatives to achieve a common end state across all Site mission areas. At the core of the evaluation is a set of alternative material flow balances. The scope of the evaluation includes Sitewide material balances for bulk materials, radionuclides, and hazardous chemicals.

(a) Led by Linda Fassbender of PNL.

The Strategic Analysis Team^(a) has developed a 1992 planning basis (to represent the Hanford technical baseline for planning purposes) that will be used by the S&T Needs Team to make comparisons between "baseline" technologies and alternative technologies. The S&T Needs Team and the Strategic Analysis Team joined forces to prepare detailed technology logic diagrams (TLDs) by mission area that are an important component of the process to develop the Hanford Site-Specific Science and Technology Plan. These TLDs provide the first-cut list of Sitewide problems linked to an all-encompassing set of functional needs and candidate technologies (see Appendix A). This compilation of problems linked to functional needs and technologies was the foundation for the integrated technology needs assessment process undertaken in FY 1992.

The Hanford work breakdown structure (WBS) is categorized by mission areas representing large blocks of activities associated with disposition of the Site material inventory. Four of the mission areas correspond to general groupings of the material inventory that have common disposition activity features or functional requirements. These mission areas, or material groups, include: 1) tank waste remediation system, 2) solid/liquid waste, 3) environmental restoration, and 4) nuclear facilities. For each of these mission areas, Section 2.0 provides a brief description of the materials to be dispositioned. Section 3.0 contains a brief overview of the 1992 planning basis for the Hanford Site as described in the 1992 Hanford Mission Plan (DOE/RL 1992a). (The 1993 planning basis did not yet exist at the time that the S&T needs assessment workshops were held; thus, it is not discussed in this document.)

Section 4.0 provides an overview of the decision analysis methodology that was used Sitewide in FY 1992 to identify and prioritize S&T needs. Section 5.0 contains an overview of the results (i.e., problem priorities and technology priorities) from the S&T needs assessment workshops that were held. This overview is followed by specific mission area workshop results as follows:

(a) Led by Al Pajunen of WHC.

- Section 6.0 - Tank Workshop Results
- Section 7.0 - Solid Waste Workshop Results
- Section 8.0 - Environmental Restoration Workshop Results
- Section 9.0 - Decontamination and Decommissioning Workshop Results
- Section 10.0 - Nuclear Materials Workshop Results
- Section 11.0 - Liquid Effluents Workshop Results

Section 12.0 provides an overview of the technology needs crosswalk approach being taken at Hanford to develop an understanding of where new technologies are most urgently needed.

Section 13.0 provides conclusions and recommendations on technology improvement, technology development, and scientific research that should be funded to support the successful remediation of the Hanford Site.

Section 14.0 outlines our systematic efforts to build a Hanford Technology Program Plan and implement an integrated, needs-driven S&T Program for successful remediation of the Hanford Site.

Finally, the report contains the following appendices:

- Appendix A - Technology Logic Diagrams
- Appendix B - Functional Needs Diagrams
- Appendix C - Workshop Participants
- Appendix D - Hanford Stakeholders Interviewed
- Appendix E - Regulatory and Institutional Constraints to New Technology Applications
- Appendix F - Site-Support Long-Term Planning.

2.0 HANFORD SITE MATERIAL INVENTORY

Hanford cleanup will require disposition plans for the Site material inventory. There are six general groupings of the material inventory that have common disposition activity features or functional requirements. These material groups include: 1) tank waste, 2) solid waste, 3) liquid waste, 4) contaminated soils and groundwater, 5) retired facilities, and 6) nuclear materials. This section provides a general description of these material inventory groups. The information contained in this section is also contained in the 1992 Hanford Mission Plan (DOE/RL 1992a). It is included here because the companion documents may get separated over time, and it may be useful to have the Site material inventory described in both volumes.

2.1 TANK WASTE

Tank waste includes the contents of 149 SSTs and 28 DSTs, plus any new waste added to these tanks, and all cesium and strontium capsules stored onsite, as well as any capsules that may be returned from offsite users. The SSTs, which are reinforced concrete tanks with single steel liners, represent the initial design of waste storage tanks built at Hanford. They currently contain sludges and hard salt cake wastes, with some liquids still dispersed in pores within the solids. The DSTs, which have double-wall construction, represent the current design of waste storage tanks. They contain wastes that are primarily in liquid and slurry forms. Hanford tank wastes are not considered to be in a suitable form for disposal.

Planned tank waste disposal activities are essentially the same for both SSTs and DSTs: waste retrieval, waste pretreatment, low-level waste (LLW) immobilization and disposal, and HLW immobilization. The primary differences are in the methods used to retrieve the wastes from the tanks. In addition, there are chemical and radiological differences between the wastes stored in the two types of tanks, which may lead to differences in post-retrieval handling and pretreatment processes. (There are also many differences between individual SST wastes and between individual DST wastes.)

The SST waste consists of solids and liquids containing relatively concentrated chemicals and radionuclides stored in underground single-shell vessels in the 200 Areas of the Hanford Site. The solid tank waste is further classified as salt cake and sludge. The sludge is associated with the bulk of the long-lived radionuclides and heavy metals, while the salt cake consists primarily of mixtures of the sodium salts of hydroxide, nitrate, nitrite, carbonate, and sulfate.

There is a relatively small amount of long-lived radionuclides in the SST waste, and they are concentrated in the sludge. Thus, the technical approach to disposition of retrieved SST waste requires partitioning it into a small fraction that requires immobilization and disposal in a HLW repository and a large fraction that can be treated as LLW or chemical waste. The tank system and contaminated soil associated with the tank must also be dispositioned to achieve final Hanford Site restoration.

Because the waste quantities and compositions in the SSTs vary widely, alternatives have been developed to 1) retrieve and treat the waste, and 2) to treat the waste in situ. At this time, activities are focused on the retrieval alternative only. In situ treatment could also be applied to the tank structures and soils in the vicinity of the tanks. Likewise, waste retrieval technology could be applied to retrieve tank structures and contaminated soils.

DST waste disposal includes the contained DST waste, the tank structures, and any contaminated soil in the vicinity of the tanks. DST waste consists of solids and liquids containing relatively concentrated chemicals and radionuclides stored in large underground double-shell vessels in the 200 Areas of the Hanford Site. DST waste is divided into the following categories based on chemical composition, origin, and prior waste treatment: neutralized cladding removal waste, neutralized current acid waste, Plutonium Finishing Plant (PFP) waste, complexed concentrate, and double-shell slurry and double-shell slurry feed.

The potential material-handling strategies for DST waste include a wide range of alternatives resulting in either: a) retrieval, treatment, and disposal, or b) in situ treatment and disposal. However, prior evaluations

(including the Hanford Defense Waste Environmental Impact Statement [EIS]) have reduced the set of alternatives under consideration to those that include retrieval accompanied by treatment systems that partition retrieved waste into HLW and LLW fractions for immobilization and disposal. The previous evaluations have focused on glass and grout as the disposal forms for the HLW and LLW fractions, respectively. These alternatives for DST waste disposition all have vitrification in common, but differ in partitioning system process details which change the relative volumes of glass and grout produced, as well as the quantity of radionuclides disposed of in grout.

In addition to the partitioning system variations, alternatives to the grout/vault system are available for the LLW fraction, depending on waste contaminant content and the type of barriers installed. These alternatives include:

- polyethylene-encapsulated waste
- mineralized grout
- in situ vitrification
- ceramic in grout.

Each alternative results in onsite near-surface immobilization and disposal of the LLW fraction. While it is anticipated that the grout/vault system will be implemented in the near term, the potential exists to substitute one of the LLW treatment alternatives.

The DST system currently operates as an interim status treatment, storage, and disposal unit under a RCRA Part A permit application. The pending DST system dangerous waste permit application indicates that the closure of the DSTs will occur subsequent to closure of the SSTs. This is because the DSTs will be used in the SST closure process.

The cesium/strontium capsules consist of cesium chloride (CsCl) and strontium fluoride (SrF_2) doubly encapsulated in stainless steel or another alloy. The capsules are stored in the pool cell in the Waste Encapsulation and Storage Facility (WESF) in the 200-East Area. The disposition of the cesium and strontium capsules relates to options for continued storage, processing options for the material, and storage of the final packaged waste.

At some point in time, the current WESF will no longer be suitable for continued cesium and strontium capsule storage. A decision will be made either to dispose of the capsules or provide new interim storage capability.

It has generally been assumed that the cesium and strontium capsules will be disposed of to a geologic repository after direct overpacking (DOE/RL 1987). However, the suitability of the existing material form (particularly the cesium chloride, which is water-soluble) for repository emplacement has not been verified.

2.2 SOLID WASTE

Solid waste at Hanford includes solid materials stored in facilities as discrete packages or in burial trenches as discrete (intact and failed) packages within well-defined regions of Hanford soil. Solid waste includes a wide variety of material types and waste classes. In addition, most future Site activities generate new waste that must be handled as cleanup activities are completed. Solid waste is subdivided by major waste class for developing disposition options: 1) TRU and TRU-mixed solid waste; 2) low-level mixed solid waste; 3) solid LLW; 4) nonradioactive hazardous solid waste; and 5) nonradioactive, nonhazardous solid waste. In addition to the subdivisions by waste classification, subdivisions that represent unique disposition problems include: 6) production reactor graphite cores, 7) alkali metals (primarily sodium, potassium, and small quantities of lithium), and 8) offsite waste.

The original placement of solid waste in trenches provides sites for disposition with relatively well-defined boundaries, but may require retrieval of diverse sizes of materials. The material can be characterized as solids with relatively low concentrations of radionuclides and hazardous constituents, but may contain locally elevated concentrations.

2.2.1 TRU and TRU-Mixed Solid Waste

The Hanford Site currently stores inventories of TRU and TRU-mixed waste in near-surface trenches, caissons, and buildings. Prior to 1970, the concept of TRU waste did not exist, and solids (possibly containing transuranic

components) were buried in near-surface trenches and caissons. This material is designated "pre-1970 suspect plutonium-contaminated buried solid waste." Since 1970, solid TRU waste has been segregated from LLW and is retrievably stored in near-surface trenches, caissons, or buildings. This material is designated "retrievably stored TRU waste." In 1986, certain newly generated drums of solid TRU waste were certified to WIPP waste acceptance criteria and stored in designated buildings. This material is designated "certified TRU waste."

2.2.2 Low-Level Mixed Solid Waste

The Hanford Site stores low-level mixed waste in buildings constructed for temporary storage. Mixed waste may be identified in burial trenches filled prior to enactment of hazardous waste regulations. In addition, the pre-1970 suspect plutonium-contaminated buried solid waste is anticipated to include quantities of low-level mixed waste. While efforts will be made to minimize the generation of additional quantities of mixed waste, implementation of future process systems that generate low level mixed waste cannot be precluded.

2.2.3 Solid Low-Level Waste

The Hanford Site currently disposes of LLW materials onsite in near-surface trenches. An advanced solid LLW disposal facility has been proposed as a contingency to changes in disposal practices if mandated by performance assessments.

2.2.4 Nonradioactive Hazardous Solid Waste

The Hanford Site currently stores nonradioactive hazardous waste in two facilities (616 Nonradioactive Dangerous Waste Storage Facility and 305-B Waste Storage Facility), which are operating under RCRA interim status pending issuance of an operating permit. Wastes stored in these facilities are accumulated from other facilities throughout the Site. Additional nonradioactive hazardous waste is projected to be generated by remediation of soil sites. Currently, hazardous waste is shipped offsite for treatment and disposal.

2.2.5 Nonradioactive Nonhazardous Solid Waste

The Hanford Site currently disposes of nonradioactive nonhazardous waste materials onsite at the Hanford Solid Waste Landfill (SWL). The SWL is located 5 miles southeast of the 200-East Area and is 65 acres in size. The near-surface disposal trenches are monitored for groundwater contamination and methane gas build-up. The SWL is scheduled to remain in operation until 1994-1995. A proposal for construction of a replacement SWL, also to be located on the Hanford Site, is in the planning stages. However, using municipal landfills for nonradioactive, nonhazardous solid waste disposal remains an alternative option.

2.2.6 Production Reactor Graphite Cores

The Hanford production reactors, located in the 100 Areas, are all graphite-moderated. This means that each reactor is comprised of a large graphite block that forms the reactor core, surrounded by steel and/or concrete shields. According to the EIS on production reactor decommissioning (DOE 1992), reactor decommissioning results in transferring the reactor core graphite and portions of the shields to the solid waste burial grounds in the 200 Areas for disposal in some cases.

2.2.7 Alkali Metals

Alkali metals also pose a unique type of solid waste that requires disposition from the Site material inventory. While sodium metal represents the largest fraction of stored alkali metal materials onsite, quantities of lithium, potassium, and mixtures of the three metals are also stored. The largest quantity of alkali metals is associated with operation of the Fast Flux Test Facility (FFTF) and is not yet considered waste. However, once the FFTF reaches the end of its useful life, this material will also require dispositioning.

2.2.8 Offsite Waste

A number of offsite locations transfer a variety of solid wastes to the Hanford Site for disposal. These materials will continue to be received per existing agreements and disposed according to waste class, along with the existing waste currently in the Hanford Site inventory.

2.3 LIQUID EFFLUENTS

Liquid effluents consist of water discharges from facilities associated with all Hanford mission areas. These water discharges include contaminated and potentially contaminated liquids which, because of design features, continue to be generated whether or not a facility is in operation. Thirty-three liquid streams from existing facilities have been identified for which action is required. The past practice of discharging liquid effluents that exceed acceptable standards to the soil column will be discontinued.

2.4 CONTAMINATED SOILS AND GROUNDWATER

Past-practice production activities at the Hanford Site have resulted in the creation of more than 1400 waste sites, most of which are soils contaminated with mixtures of radioactive materials and hazardous chemicals. Contamination from some of these sites has reached portions of the groundwater under the Site, resulting in degradation of that resource.

The potential material-handling strategies for contaminated soils and groundwater are dictated by the characteristics of the contaminants and the environment, namely low concentrations of chemicals and radionuclides dispersed in large areas with indistinct boundaries. Because of the large amount of material that is anticipated to be handled, partitioning may be desirable to reduce the volume of radionuclides and hazardous chemicals requiring disposal. Alternatively, in situ fixation/destruction techniques may be cost-effective.

Because environmental contamination is not contained, it may be important to define the type, extent, and characteristics of the contaminated site prior to remediation. The benefits of such characterization are uncertainty reduction and, subsequently, a more informed choice among alternative treatment and disposal technologies. However, the value of the characterization information obtained must be continually assessed to ensure that it is significantly reducing uncertainty and resulting in better cleanup decisions.

2.5 RETIRED FACILITIES

All facilities on the Hanford Site will ultimately require some level of decontamination and decommissioning (D&D). For example, facilities in the 200 Areas may only require decontamination and be left standing. Hanford facilities can be divided into two major groups: 1) existing facilities, and 2) future facilities required to support cleanup activities. Existing facilities, which include both listed surplus facilities and unlisted facilities, must be addressed regardless of future Site direction. Future facilities requiring D&D depend on the processing capabilities selected to support Site cleanup activities; thus, they remain undefined until the Site processing configuration becomes firm.

2.5.1 Listed Surplus Facilities

At the present time, there are approximately 112 listed surplus facilities across the Hanford Site. These facilities were used during early Site activities, and because they have no current use, they were retired and declared excess. A majority of the facilities have residual radioactive contamination requiring surveillance, maintenance, and ultimate disposition. The facilities include large concrete and cement block structures used to house chemical separation processes, plutonium production reactors, support systems, storage tanks, and ancillary buildings.

2.5.2 Unlisted Facilities

Unlisted facilities are onsite facilities which are not included in the Surplus Facilities Management Program because 1) they have not yet been declared excess (i.e., they are currently being used) or 2) they have not yet been brought into suitable condition for acceptance into the program. Ultimately, it is anticipated that the facilities will be transferred to the Surplus Facilities Management Program as they are retired from service and declared excess. About 870 existing facilities will eventually be considered for D&D. Each facility must initially be deactivated and placed under safe, economical surveillance prior to acceptance into the Surplus Facilities Management Program.

2.5.3 Future Facilities

Facilities constructed at the Hanford Site to support future cleanup activities also must be considered for D&D. The facilities will be dispositioned along with the unlisted facilities. The number of future facilities requiring D&D depends on the selected Site configuration to support cleanup. However, a number of facilities, such as the Hanford Waste Vitrification Plant (HWVP) and Waste Receiving and Processing (WRAP) Facility, are contained in all alternative configurations.

2.6 NUCLEAR MATERIALS

Disposition is required for radionuclides stored on the Hanford Site as discrete packages or items. Retrieval of these nuclear materials will be relatively simple due to storage configurations which allow them to be readily transferred to material disposition functions. The nuclear materials are divided into the following subgroups with relatively common disposition processing characteristics: irradiated fuel, special nuclear material (SNM), and uranium materials.

Most of the nuclear materials consist of inventories that were left in various stages of the defense material production processes when these activities were halted. The materials are in existing interim storage facilities designed to accommodate safe temporary storage of the production sequence intermediates. However, limited quantities are stored in forms that are considered suitable for disposition or shipment.

2.6.1 Irradiated Fuel

Four general types of irradiated fuel are stored on the Hanford Site: 1) N-Reactor fuel, 2) single-pass reactor (SPR) fuel, 3) FFTF fuel, and 4) fuel discharged from the Shippingport Naval Reactor (known as PWR Core 2). In addition, there are small amounts of other miscellaneous fuels stored in the 300 Area. The bulk of the radionuclides are contained in the N-Reactor and FFTF fuels. Each stored fuel type has unique characteristics, such as chemical form or physical geometry, which differentiate the material from

typical commercial reactor spent fuel. These unique characteristics add a complexity to the disposition requirements for irradiated fuels at Hanford.

The N-Reactor fuel is composed of uranium metal tubes clad with zircaloy metal. The N-Reactor fuel represents about 99% of the total mass and nearly half of the total radioactivity present in irradiated fuels stored at Hanford.

The SPR fuel originated from older Hanford production reactor operations. The SPR fuel is composed of uranium metal cylinders clad with an aluminum metal alloy. Very little of this fuel is left in storage at the Site, representing far less than 1% of both the mass and radioactivity present in the irradiated fuel inventory.

The FFTF fuel is produced as a result of operating the FFTF. This fuel is composed of pellets formed from a mixture of uranium and plutonium oxide that are clad in stainless steel tubes. The current inventory of FFTF fuel represents less than 1% of the total mass and about half of the radioactivity present in the irradiated fuel inventory.

The PWR Core 2 fuel was irradiated in the DOE Shippingport Reactor, which has subsequently been dismantled. The assemblies were discharged from the reactor in 1974 and transferred to Hanford for storage in 1978. The PWR Core 2 fuel is generally composed of uranium oxide fuel pellets pressed into zircaloy plates which are then clad in zircaloy. The inventory of PWR Core 2 fuel represents less than 1% of the total mass and less than 5% of the total radioactivity present in irradiated fuel.

2.6.2 Special Nuclear Materials

The SNMs primarily consist of plutonium held in secured storage on the Hanford Site. The bulk of the materials are stored within the PFP facilities. Some of the materials also contain uranium in varying enrichments, as well as plutonium. These materials exist in many different chemical forms and are of various degrees of purity. For the purpose of SNM processing considerations, all the SNM has been grouped into 10 categories of plutonium residue: ash; polycubes; sludge; oxide; sand, slag, and crucible; filters; metal; miscellaneous; liquids; and contaminated equipment. All these materials are currently in secured storage, with the exception of the material associated with the

contaminated equipment. Most of the plutonium residue, excluding the contaminated equipment, is present as either oxide or solutions, with metals being the next largest category.

The potential material-handling strategies for SNM depend on a variety of factors that influence processing, storage, and disposal requirements. If the SNM is presently in an unstable form or contains hazardous materials that must be removed or destroyed, then treatment will be necessary. It might also be desirable to process the material to either reduce the volume of stabilized material that must be disposed of, or to change the waste classification such that waste disposal costs are minimized. If the SNM is needed by DOE as a resource for either defense or nondefense-related activities, then the material must be stored within secured facilities in a form suitable for safe, long-term storage. This form could be either a purified plutonium compound or an impure, but stable, compound.

2.6.3 Uranium Materials

There are four categories of uranium materials stored at Hanford: 1) uranium oxide (UO_3) recovered from fuel processing; 2) depleted UO_3 stored at the UO_3 Plant in the 200 Areas; 3) zircaloy-clad finished and unfinished fuel elements, including the unirradiated fuel that was recovered from N-Reactor; and 4) uranium metal billets stored in several buildings in the 300 Area.

The technical handling alternatives for uranium depend on whether it is to be recycled for beneficial use or disposed of as waste. In the former case, the uranium will be partitioned and converted, as required, to uranium metal or oxide. The material will be packaged and placed in interim storage and shipped to the ultimate user. These activities could be conducted at Hanford or at another DOE-designated site. In the latter case, the uranium would be treated as a low-specific-activity waste. The different uranium forms would be treated and converted to forms that satisfy waste disposal criteria.

3.0 HANFORD PLANNING BASIS

Development of a firm technical baseline for disposition of Hanford wastes is limited by decisions that must be made under CERCLA, RCRA, and other applicable environmental regulations. The Hanford Defense Waste EIS (DOE/RL 1987) describes the primary disposition decisions completed for Hanford wastes. The record of decision (ROD) based on this EIS covers disposition of wastes contained in DSTs, retrievably stored TRU solid waste stored in the 200 Areas, pre-1970 suspect plutonium-contaminated buried solid waste in the 618-11 Burial Trench, newly generated TRU solid waste, and cesium and strontium capsules. Material disposition plans are generally undefined by RODs for the remaining Hanford wastes at this time, including SST waste, pre-1970 suspect plutonium-contaminated buried solid waste, solid LLW, nuclear materials, contaminated soils, contaminated groundwater, and surplus facilities.

To evaluate the potential impacts that might result from completing the disposition of all Hanford wastes, the HIPP Strategic Systems Analysis Task developed an interim technical baseline (for Site-level planning purposes only) in two parts. First, a core technical baseline was developed based on currently available decisions (i.e., the results of the Hanford Defense Waste EIS). Second, a 1992 planning basis was developed by anticipating certain results of key decisions that ultimately must be made via the CERCLA/RCRA processes. Although a 1993 planning basis has been developed, it is not described herein because the 1992 planning basis was actually used for the S&T needs assessment workshops held during FY 1992. The only difference between the two planning bases is that the 1993 planning basis follows the macro-engineering approach (Kearney et al. 1991) to soil and groundwater treatment more closely than the 1992 planning basis did. Both the 1992 and 1993 planning bases assume the 200-Area disposal end-state. Differences between the two planning bases are described below.

<u>1992 Planning Basis</u>	<u>1993 Planning Basis</u>
Pump and treat technology is applied to contaminated groundwater.	No groundwater treatment.
All excavated contaminated soils are treated by soil washing.	300-Area soils are treated. 100-Area soils are disposed in the 200 Areas without treatment. 200-Area soils are disposed in situ.
All TRU material is retrieved for offsite disposal, independent of location.	TRU material in pre-1970 buried solid waste located in the 200 Areas is disposed in situ.

The 1992 planning basis addresses the entire Hanford Site inventory of materials and attempts to integrate the cleanup actions into a single system. It depicts one of many options for implementing a potential future Site use strategy. In general, the 1992 planning basis uses the 200 Areas and vicinity as a collection/storage/disposal area for the entire inventory of Site materials. It focuses on converting all wastes into stable solid materials that can be disposed of either onsite or offsite, or shipped offsite as usable materials.

Cleanup activities in the 1992 planning basis focus on removing materials from the 100 Areas, the 300 Area, and other areas to allow unrestricted use of soils in those areas. Groundwater cleanup activities are directed toward protecting the Columbia River from levels of contamination that would exceed drinking water standards, while requiring institutional controls restricting groundwater use throughout portions of the Site for an indeterminate time period. The 200 Areas are assumed to be maintained in perpetuity for waste disposal and other DOE activities.

3.1 TANK WASTE

The 1992 planning basis for DSTs is retrieval of all tank wastes. The wastes are pretreated to produce HLW and LLW fractions for immobilization and disposal. The HLW fraction is converted to a glass form and packaged for geologic disposal. The LLW fraction is converted to a solid grout waste form for onsite disposal.

The 1992 planning basis for SSTs is also retrieval of all tank waste, followed by interim storage in DSTs and partitioning to separate the waste into HLW and LLW fractions. As with the DST waste, the SST HLW fraction is converted to glass for geologic disposal, and the LLW fraction is converted to a solid form for onsite disposal.

Final disposition of the tank structures and any related soil contamination will be done in accordance with the Washington State dangerous waste closure regulations. The 1992 planning basis for tank structures and waste residuals emphasizes in situ disposal of the structures. This assumes that waste material retrieval is completed to the extent required to comply with criteria established via the RCRA closure process for in situ disposal. In addition, since the tanks are located within the 200 Areas, in situ disposition of the residual complies with the defined Site use scenario used as the planning basis.

The 1992 planning basis for cesium and strontium capsules assumes conversion to glass for geologic disposal. The CsCl and SrF₂ are removed from the capsules and blended with pretreated tank waste to make a feed suitable for vitrification. Low-specific-heat vitrification plant feeds, such as those originating with pretreatment of complexed concentrate or PFP waste, are candidates for blend stock in order to minimize the number of glass canisters created for disposal.^(a)

3.2 SOLID WASTE

The 1992 planning basis for solid waste disposition is summarized as follows:

- TRU and TRU-Mixed Solid Waste. Stored and newly generated TRU and TRU-mixed solid waste is retrieved for treatment. The waste is treated to segregate the TRU and TRU-mixed fractions from materials in other waste groups. The TRU and TRU-mixed fractions are converted to a disposal form by simple stabilization and volume

(a) The TWRS Program's current planning basis for the cesium and strontium capsules is to overpack them for shipment to the repository. In the meantime, they will all be returned and stored at Hanford.

reduction processes, repackaged, and transferred to a storage facility for ultimate shipment offsite to WIPP in New Mexico.

- Low-Level Mixed Solid Waste. Buried waste is retrieved for treatment with stored and newly generated materials as required by permits. The majority of the mixed waste is converted to a disposal form using stabilization and volume-reduction process systems and is disposed of onsite in permitted near-surface disposal systems. Land disposal restrictions (LDRs) may require further treatment of some mixed wastes. (This assumption has been changed in the 1993 planning basis to in-place disposal.)
- Low-Level Solid Waste. Material continues to be disposed of in near-surface trenches, which are closed as landfills. LLW buried outside the 200 Areas is retrieved and transferred to similar near-surface trenches in the 200 Areas.
- Pre-1970 Suspect Plutonium-Contaminated Buried Solid Waste. The 1992 planning basis for solid waste located in inactive waste sites (i.e., pre-1970 suspect plutonium-contaminated buried solid waste) is equivalent to the 1992 planning basis for the three solid waste categories described above. In general, all suspect plutonium-contaminated buried solid waste will be retrieved for treatment and ultimate disposal offsite (if the waste is determined to be plutonium waste). Solid LLW and low-level mixed waste sites located outside the 200 Areas will be retrieved for treatment (as necessary) and disposal in systems located within the 200 Areas, and solid LLW within the 200 Areas will be disposed of in place.
- Nonradioactive Hazardous Solid Waste. Hazardous waste materials continue to be shipped offsite for treatment and disposal.
- Nonradioactive, Nonhazardous Solid Waste. Disposition options for nonradioactive, nonhazardous solid waste are developed as part of the general Hanford Site support activities.
- Production Reactor Graphite Cores. A decommissioning option that transfers the reactor cores and shields to the 200 Areas as solid waste is assumed to have been selected by a ROD.
- Alkali Metals. In the past, the primary option available for dispositioning sodium was material recycle by conversion to a hydroxide for reuse in fuel reprocessing operations. With the discontinuation of fuel reprocessing at Hanford, alternatives to onsite recycle disposition are needed, including:
 - identification of alternative process systems as potential long-term users of contaminated sodium hydroxide
 - identification of alternative disposition techniques for each alkali metal type and mixture in the inventory.

Recently, DOE's Office of Nuclear Energy has declared that the sodium stored in the 100, 200, and 300 Areas at Hanford is no longer needed by the U.S. Advanced Liquid Metal Reactor Program. (This does not apply to the sodium currently in the FFTF.) Thus, Hanford is beginning a 2-year excessing process to identify other potential users of the stored sodium. If no users are found, then the sodium may be declared waste. A plan will be developed for the disposition of excess sodium. This plan may include chemical conversion of sodium metal to sodium carbonate, which is a chemically stable sodium compound.

- Offsite Waste. A variety of offsite locations transfer solid waste to Hanford for disposal. These materials will continue to be received per existing agreements and will be disposed of according to waste class, along with the waste currently in the Hanford Site inventory.

3.3 LIQUID EFFLUENTS

The Hanford Site is committed to stop discharging liquid effluents that do not comply with acceptable standards. The 1992 planning basis for liquid effluents focuses on implementing the best-available treatment technology that is economically achievable. The current strategy relies on individual generator facilities implementing primary source control or other waste minimization measures, with the Site liquid effluent treatment system providing back-up capability to accommodate off-standard conditions.

Liquid effluent treatment systems will generate secondary waste streams containing the contaminants removed by the treatment systems. The removed contaminants will be stored and packaged, and the resulting hazardous and mixed waste will be transferred to the solid waste burial grounds for disposal as newly generated waste from cleanup activities.

3.4 CONTAMINATED SOILS AND GROUNDWATER

The 1992 planning basis for contaminated soils and groundwater is subject to major modifications until the ultimate Hanford Site future-use/cleanup decisions are established by interactions with external groups and by completion of the National Environmental Policy Act (NEPA) process.

For the 1992 planning basis, contaminated soils outside the 200 Areas are excavated and treated with simple classification process steps to provide

a coarse separation between contaminated and contamination-free materials. This separation process is projected to be accomplished in the vicinity of the excavation sites and to convert the bulk of the soil into material suitable for return to excavation backfill activities. The smaller soil volume with concentrated contaminants is transferred to a central soil treatment facility for treatment (as necessary), stabilization, TRU component segregation (if appropriate), and disposal in the 200 Areas.

Use of the 200 Areas for waste disposal will not eliminate the need for soil remediation in those areas. Surface sites will be remediated to provide long-term stabilization of contaminated zones and reduce the potential for contamination spread. Soil sites containing materials exceeding the TRU classification limit in the 200 Areas will be excavated for treatment and disposal so that TRU material is not disposed near-surface at the Hanford Site. This is based on the assumption that near-surface disposal of TRU wastes will be unacceptable.

The 1992 planning basis for contaminated groundwater, which is intended to be consistent with Scenario 2 in the integrated macro-engineering study for groundwater (Kearney et al. 1991), is primarily directed toward protection of the Columbia River. Groundwater remediation activities will incorporate the impacts of liquid effluent disposal plans. Restrictions on groundwater use throughout major portions of the Site, including the 200 Areas, are assumed to be maintained in perpetuity for planning purposes.

For the 1992 planning basis, groundwater treatment consists of a combination of groundwater plume extraction systems, treatment systems to remove contaminants except tritium, disposal of nontritiated treated water to the Columbia River, injection of treated tritium-bearing water into the aquifer near the center of the Site, and barriers to modify groundwater flow patterns that generally isolate portions of the Site groundwater. While estimates indicate this approach will ultimately allow general use of groundwater outside the 200 Areas, the time frame projected to achieve this release is long enough such that it is equivalent to perpetual control of the groundwater, which may require special regulatory modifications.

3.5 RETIRED FACILITIES

The 1992 planning basis for facility D&D utilizes a combination of methods, all based on accumulating waste materials in the 200 Areas while completing cleanup of the other areas to allow a wide range of land-use options. Therefore, in most areas, facility decontamination followed by complete demolition will form the basis for D&D baseline planning. For facilities located in the 200 Areas, D&D options such as demolition or partial decontamination with in situ disposal of below-grade structures may be considered. Entombment of the major process structures within the 200 Areas is assumed for the 1992 planning basis.

3.6 NUCLEAR MATERIALS

The 1992 planning basis for irradiated fuel presupposes the results for a ROD from an EIS on irradiated fuel disposition. All fuel is repackaged in the existing form and stored in interim storage facilities for up to 50 years. The likely strategy of disposition is projected to result in the conversion of N-Reactor and SPR fuel to an oxide form, which is packaged for repository disposal. The FFTF fuel, Shippingport Naval Reactor fuel, and other miscellaneous oxide fuels are projected to be directly packaged for repository disposal. The fuel forms packaged for repository disposal are then placed in a facility for extended onsite storage, awaiting availability of a repository.

The 1992 planning basis for SNM containing high concentrations of plutonium (e.g., oxide and metal) is based on treatment via partitioning flowsheets, with the recovered SNM placed in onsite secured storage. SNM that contains low concentrations of plutonium, or is in a form for which recovery is difficult (e.g., filters, ash, and sludge), is treated via a conversion flowsheet and placed in secured storage. After an indeterminate storage period, all material will be available for offsite shipment.

The 1992 planning basis for uranium materials uses uranium oxide and metal as the preferred storage forms. The uranium billets are packaged and stored as metal billets, and the clad fuel is converted to uranium oxide. The material is stored for an indeterminate period pending future offsite shipment.

4.0 SCIENCE AND TECHNOLOGY NEEDS ASSESSMENT METHODOLOGY

Hanford's integrated S&T needs planning activities are evolving and improving as new information from field experience, engineering studies, regulatory assessments, and S&T development programs becomes available. Therefore, there is a continuing effort to update and improve the process through a Sitewide integrated planning activity. On January 8, 1991, the DOE Richland Operations Office (RL), Westinghouse Hanford Company (WHC), and Pacific Northwest Laboratory (PNL) initiated HIPP with the objective of ensuring that technically sound and publicly acceptable decisions are made that support the environmental management mission at Hanford. A key part of HIPP's S&T needs assessment effort is developing an understanding of the technology requirements to support implementation of the 1992 planning basis, as well as knowledge of alternative technologies that show promise. This includes conducting an annual systematic assessment of the S&T needs at Hanford to support a comprehensive technology development and complementary scientific research program.

The HIPP will provide the Sitewide basis for all environmental restoration and waste management (EM) programs, including identification and prioritization of Site problems and potential S&T solutions. RL, PNL, and WHC are working closely to develop specific S&T program plans that are focused on providing solutions to environmental management problems at Hanford. These programs will be developed with support from the DOE Office of Technology Development (EM-50), Office of Environmental Restoration (EM-40), and Office of Waste Operations (EM-30).

The S&T needs assessment process will result in a needs-driven, time-phased S&T program that is comprised of basic and applied research and technical support programs. These programs will continue to be refined, and S&T will be redirected as new information becomes available through field experience gained at Hanford. The planning process and needs assessment activities will be continued throughout the Hanford cleanup. Basic to the success of the Hanford program is a planning and assessment methodology that

is defensible from a technical perspective and acceptable to the various stakeholders with an interest in Hanford cleanup activities.

Technology improvement, technology development, and scientific research are needed to support the 1992 planning basis defined in the 1992 Hanford Mission Plan (DOE/RL 1992a) as well as many alternate options. Because there is insufficient funding to develop every technology that is identified or to undertake every scientific research project that is proposed, DOE must focus its resources on S&T development that will have the most significant impacts on the overall cleanup program. Thus, the S&T needs assessment process will be designed to identify and prioritize the most critical problems and the most promising technology solutions.

The Hanford cleanup process involves numerous decisions about the development and implementation of technologies. The decisions are complicated because of the substantial uncertainties about the risks and the costs of these technologies. Further, the choice of a specific cleanup technology must be evaluated with respect to multiple (and often conflicting) objectives (e.g., reducing risks, increasing effectiveness, reducing costs, increasing public acceptability, regulatory compliance, land use). Decision analysis was developed to address problems with uncertainty and multiple objectives. An adaptation of the decision analysis methodology was developed for identifying and prioritizing Hanford problems.

The linkage should be strengthened between Site operational problems and alternative technology solutions. Improved definitions of key S&T needs and the existing technical baseline will help DOE to better understand the nature of the cleanup tasks. However, this information must be linked to the different types of technologies that are available today or that may be developed in the future. The TLDs partially address this concern. However, knowledge that a technology will do a particular job is only a first step. Further questions that must be answered include: How well will the technology perform? How likely is it to operate successfully? How expensive is it expected to be? Can adequate throughput ever be achieved? Are staff requirements likely to be excessive, either in terms of numbers or in terms of the training and technical skill requirements? Is the likely time period for development

and implementation excessive for the anticipated application? What further information would be helpful to know about it? Are other, better technologies likely to be developed soon?

Additional information about Hanford Site problems and possible solutions is being generated continuously within WHC, PNL, other national laboratories, and private industry. The assessment of S&T needs, therefore, is not a one-time decision, but rather a series of decisions that should be made on a recurring basis, with a detailed plan and schedule set out to gather and integrate the necessary data. The new S&T needs assessment process, and especially decision-making regarding technology acceptance and/or insertion into the technical baseline, is an integrated Site effort that involves key staff from all the mission areas as well as PNL and WHC scientists and technologists. It is not intended to be a parallel effort to the ongoing mission-specific program planning activities, but rather an integral part of them. It is only through teamwork and cooperation that Hanford will be able to determine its most pressing problems, obtain the technologies required to solve them, and be successful in cleaning up the Site.

Further, a formal linkage should be created between the HIPPI S&T needs assessment process and Site technology use decisions (e.g., When do we need to make a decision to ensure that a technology will be available in time to be implemented? When is a technology considered to be good enough to adopt? How should research funding for the development of new technologies be allocated?).

4.1 NEEDS ASSESSMENT STRATEGY

Decision analysis techniques were used to help identify and prioritize problems and S&T needs at Hanford on a Sitewide basis. The approach utilized structured elicitations with WHC, PNL, RL, DOE/HQ, EPA, and the Washington State Department of Ecology, hence bringing many Hanford stakeholders into this process. Decision analysis is based on the axioms and methods of utility and probability theory. It is especially useful in problems characterized by uncertainties and multiple objectives. Decision analysis addresses

uncertainties by laying out a logical sequence of decisions, events, and consequences, and by quantifying event and consequence probabilities on the basis of expert judgements.

For example, the initial choice of a characterization technology involves significant uncertainties about the nature of the wastes. After these uncertainties are resolved, further decisions need to be made about waste separation, treatment, and disposal; each of these steps has its own uncertainties that must be addressed explicitly. The consequences of the technology decisions in terms of costs, effectiveness of cleanup, risks, and so forth accrue along the way (i.e., as intermediate consequences) as well as at the end (e.g., long-term effects of final waste disposal).

Technology assessment also has to address multiple conflicting objectives. For example, considerations involved in the selection of a preferred alternative may include minimizing health and safety hazards, maximizing economic benefits, and keeping environmental impacts below a specified level. These different objectives are likely to conflict, in the sense that one alternative will best achieve one objective, but some other alternative is best from the perspective of a different objective. Selecting from among the different alternatives, therefore, involves making critical value judgements that reflect the relative desirability of these different objectives. The needs assessment methodology explicitly separates technical and value judgements and provides a basis for stakeholder input to, and review of, key value judgements.

The overall objective of this S&T needs assessment task is to provide guidance for decision-makers charged with allocating scarce resources to competing technology development opportunities based on the real needs for Site cleanup. Because any resource allocation must build on the relative priorities among technology needs, the goal is to provide such a prioritization in a consistent manner across all the Site's problems. A standard approach to prioritization is to: 1) create a master list of candidate technologies, 2) develop criteria for evaluating them, 3) score the technologies against the criteria, and 4) calculate aggregate scores that

reflect the relative priorities of the technologies. Unfortunately, there are at least three complications that prevent the application of this standard approach.

First, the problems on the Hanford Site are extremely diverse, and there is a wide variety of functional needs and candidate technologies required to address them. It seemed unreasonable to consider all Site problems in a single assessment. Instead, we utilized the existing Hanford Site WBS, which essentially partitioned the assessment into five mission areas: ER, solid/liquid waste, nuclear materials, D&D, and tank wastes.

A second difficulty with the standard approach to prioritization stems from the dependencies and interactions between problems, overall strategies to solve them, functional needs, and candidate technologies. Beginning with a specific problem (e.g., SST wastes), an overall strategy must be devised to effectively solve this problem (e.g., a strategy of substantial onsite pre-treatment coupled with solidifying LLWs in grout and vitrifying HLWs). This strategy will invoke specific functional needs (e.g., the need for partitioning low-level and high-level constituents) and these needs, in turn, may be met by specific technologies (e.g., TRUEX/CMPO for acid-side removal of TRUs). It is misleading and potentially irrelevant to discuss technology priorities without an understanding of their dependency on problems, strategies, and functional needs.

To accommodate the hierarchical dependencies of technologies on functional needs, strategies, and problems, we considered the technology assessment problems from the top down. First, the problems within a mission area were prioritized. Second, three strategies were considered for solving each problem: a complete cleanup strategy with subsequent unrestricted use of the Site, a cleanup strategy that would leave certain LLWs in the 200 Areas, and a very limited cleanup strategy that would leave several areas of the Site with some level of contamination and restricted access. For simplicity, only the 200-Area disposal strategy was carried through the entire analysis. Third, functional needs were identified and prioritized, but only for the most important problems in each mission area. Typically, there were at least two levels of needs: functional needs (e.g., retrieval) and subfunctional needs

(e.g., mechanical robotic retrieval). Fourth, technologies were identified and prioritized, but only for those functional needs that received high scores.

A third difficulty with the standard approach to prioritization is the nonexclusive nature of technology needs. In the standard approach, technologies are treated as if they were competing against each other. In complex problems such as the Hanford Site cleanup, many technologies are, in contrast, needed in the form of packages that are all required to accomplish a particular task. In the SST waste problem, for example, technologies are needed for sampling and analysis, retrieval, pretreatment, processing, solidification, transportation, and disposal. We call these nonexclusive elements of an overall problem-solving strategy "functional needs." It makes no sense to consider these functional needs as competing. Instead, a proper allocation of overall resources is required so that each functional need is funded at the appropriate level of urgency and importance to the overall strategy and mission.

To meet the challenge of identifying appropriate portfolios of technologies, functional needs were prioritized by allocating the relative importance of effort that they deserved across a consistent package of needs associated with the 200-Area disposal strategy. There was no sense of exclusiveness among functional needs. On the other hand, the technologies that were identified and prioritized to meet the functional needs were sometimes treated as competing. This was acceptable when the list of technologies under consideration represented alternative options (e.g., alternative LLW disposal form conversion technologies such as grout, glass, and ceramics). Other technologies were treated as being nonexclusive members of a set of technologies required to address different aspects of a functional need (e.g., buried solid waste treatment will require combinations of sorting, size reduction, decontamination, and thermal treatment technologies).

In FY 1992, multiple workshops were conducted with Site experts in each of the mission areas (see Appendix C). These workshops provided the basic information required to assess the nature of Hanford Site cleanup problems and the anticipated performance of the alternative characterization and cleanup

technologies that were identified. The use of decision-analysis techniques did not by itself add to the information already available. Instead, the benefit of decision analysis came from creating a systematic process for thinking through the decision problem, for eliciting information about what matters from the potentially affected stakeholders (end-users, technology developers, scientists, regulators, and DOE program managers), and for structuring the knowledge of experts.

Four sets of workshops and two sets of interviews were held in FY 1992:

- Criteria Elicitation Interviews
- Problem Prioritization Workshops
- Criteria Weighting Elicitations
- Functional Needs Structuring Workshops
- Functional Needs Prioritization Workshops
- Technology Prioritization Workshops.

In general, the workshop strategy was to first open the discussions of Site problems as wide as possible to ensure that no significant problems were overlooked. However, once the universe of problems was defined, the workshops were designed around a process of narrowing the scope to focus on the most important problems and S&T needs. This was accomplished by first prioritizing problems in each mission area, and then focusing all remaining workshops on only the highest-priority problems. Next, the participants were asked to prioritize functional needs to address the highest-priority problems. From that point, all remaining workshops focused only on the highest-priority functional needs and subfunctional needs. Finally, the participants were asked to prioritize technology development needs for the highest-priority functional needs and subfunctional needs. In essence, the participants were engaged in a systematic process of sequentially addressing the following issues:

1. How big of a problem is it?
2. How well does the strategy (i.e., the 200-Area disposal strategy encompassed in the 1992 planning basis) accomplish the goal of eliminating the problem?

3. How well does the functional need contribute to the overall strategy?
4. How well does the subfunctional need contribute to the higher-level functional need?
5. How well does the technology development meet the subfunctional need?

The Problem Prioritization Workshops focused on identification and prioritization of the problems for each of the designated mission areas. The remaining workshops focused on preliminary assessments of the functional needs and the known technology alternatives to address the highest-priority problems. The workshop results will be used to develop an integrated technical approach to Site cleanup. In the future, promising technology alternatives will be evaluated from a strategic systems analysis perspective to develop an understanding of the overall cost, performance, and schedule improvements that might be achievable.

4.2 NEEDS ASSESSMENT PROCESS IMPLEMENTATION

This section provides a brief overview of the S&T needs assessment process for development of a prioritized list of S&T needs addressing Hanford's EM problems.^(a) This activity posed some special problems that required innovative adaptation of standard decision analysis approaches. The most difficult problem was created by the inter-dependencies among technologies (e.g., selection of a treatment process depends on selection of a disposal form conversion process) and the overall dependency of technology priorities on strategic decisions (e.g., complete Site cleanup versus onsite disposal). Other problems were related to the wide variety of technology needs, often cutting across organizational or programmatic boundaries, and the need for identifying portfolios of appropriate technology packages.

4.2.1 Criteria Elicitation Interviews

Interviews with 17 individuals from key stakeholder groups (e.g., the Washington State Department of Ecology, EPA Region X, DOE/HQ, RL, WHC, and

(a) Conclusions regarding the process are presented in Section 5.5.

PNL) occurred between September 1991 and February 1992 (see Appendix D). The stakeholders were asked to focus their thoughts on the question: "What makes something a problem at Hanford?" The interviewers: 1) explained the purpose of the HIPP S&T needs assessment task, 2) elicited recommended criteria for prioritizing Hanford's problems, and 3) elicited recommended criteria for prioritizing technology solutions. The list of groups to be interviewed will be expanded in future years to include additional Hanford stakeholders (e.g., the Yakima Indian Nation and local environmental groups).

The individual sets of criteria obtained from the stakeholder interviews were consolidated into a master list of 10 criteria that were used in the Problem Prioritization Workshops (see Section 4.2.2) for prioritizing Hanford's problems: 1) short-term health and safety, 2) long-term health and safety, 3) future generations' health and safety, 4) surface water contamination, 5) groundwater contamination, 6) soil contamination, 7) land use, 8) cultural concern, 9) public concern, and 10) regulatory compliance. The scales used for these 10 criteria are shown in Table 4.1.

4.2.2 Problem Prioritization Workshops

The Problem Prioritization Workshops were held between November 1991 and January 1992. Each of these 1-day workshops focused on one Hanford mission area. Participants included mainly key Hanford "problem-owners" (e.g., onsite program and project managers) plus a few technology experts. Problem evaluation criteria obtained during the stakeholder interviews were presented to the workshop participants. Detailed descriptions and categorizations of cleanup problems were supplied by the participants.

In each workshop, working groups of 10-20 participants were asked to identify, structure, and prioritize the most important problems. Those problems that cut across different mission areas will require special attention because technology development in one mission area has the potential to yield benefits across other mission areas.

The main goal of each of these workshops was to create a matrix of the highest-priority near-term and long-term problems based on the problem evaluation criteria developed via the stakeholder interviews. This was

TABLE 4.1. Problem Evaluation Criteria

Criterion	Score = 100	Score = 0
Health & Safety - Short Term	The short-term health and safety risks are significant. For example, there is a 1:100 chance of one person dying due to this problem next year, or a 1:1,000 chance of 10 people dying next year, or a 1:10,000 chance of 100 people dying next year. The expected number of deaths is 0.01 next year.	There are no short-term health and safety risks.
Health & Safety - Long Term	The long-term health and safety risks are significant. For example, one person is expected to die due to this problem every 10 years, unless the problem is corrected. The expected number of deaths is 0.1 per year.	There are no long-term health and safety risks.
Health & Safety - Future Generations	The risks to future generations are significant. For example, there is a possibility (1:1,000) of a major health problem involving 1,000 deaths in the very far future. The expected number of deaths is 1 in the very far future.	There are no health and safety risks to future generations.
Environmental Impacts - Surface Water	The problem poses significant short-term and long-term risks to the surface water. For example, a large quantity (10,000 gallons or more) of mixed liquids exceeding federal standards will begin seeping into the Columbia River within 10 years.	There is no risk to the surface water.
Environmental Impacts - Groundwater	The problem poses significant short-term and long-term risks to the groundwater. For example, a large quantity (10,000 gallons or more) of mixed liquids exceeding federal standards will begin seeping into an aquifer within 10 years.	There is no risk to the groundwater.
Environmental Impacts - Soil	The problem poses a significant soil pollution problem. For example, a large volume of soil (10,000 cubic feet) is contaminated by chemicals and radionuclides exceeding federal standards.	The problem does not cause any soil pollution.
Land Use	The problem significantly interferes with future land use of the Hanford Site. For example, 2 mi ² of land will have to be permanently zoned off.	The problem does not interfere with future land use.
Cultural Concern	The problem is near a historical, archaeological, or religious site of significance. For example, it is only 100 yards from a known Indian burial ground.	The problem is not near any historical, archaeological, or religious sites.
Public Concern	The problem is of very strong public concern. For example, there is frequent media coverage about this problem and environmental groups refer to it as one of their major concerns with Hanford.	There is very little or no public concern.
Regulatory Compliance	The problem is out of compliance with at least one federal law or regulation, and it has attracted attention by State regulators and the EPA. Fines and sanctions are imminent.	There is no current compliance problem.

accomplished through an on-line, computer-aided process that helped participants identify and structure cleanup problems, and apply common scoring criteria and logic for comparing the relative importance of each problem. The workshop participants were also asked to supply numerical weights for the 10 criteria. Other goals of the workshops were: 1) to get everyone thinking along similar lines (e.g., evaluating problems in terms of the 10 criteria), 2) to get groups to coordinate their cleanup activities (e.g., to improve communications across the Site), and 3) to get inputs regarding the S&T needs assessment process (i.e., what we ended up doing was based, in part, on the reactions and responses of workshop participants).

4.2.3 Criteria Weighting Elicitations

In February and March 1992, a second set of interviews took place to elicit recommendations on the numerical weights to be applied to the 10 criteria used to develop problem scores in the workshops. These weights, coupled with the problem scores, were used in a multi-attribute utility analysis to develop a prioritized list of Hanford cleanup problems for each stakeholder group. Interviewees included a subset of those stakeholders interviewed previously.

4.2.4 Functional Needs Structuring Workshops

The Functional Needs Structuring Workshops were held in January and February 1992 to begin to focus Hanford's S&T capabilities directly on identifying the most promising cleanup technologies for solving the Site's highest-priority problems. The objective of the workshops was to link the highest-priority problems in each mission area with the functional needs required to perform the necessary cleanup, and to identify the candidate technologies to meet those functional needs.

The participants were asked to focus on the following questions: 1) Given the most important problems in your mission area, what are the basic strategies to solve these problems? 2) What functional needs arise in carrying out these strategies? Information was developed on the alternative technology pathways to address the problems, where each pathway contains multiple technologies to perform the necessary functions. This information

was incorporated into functional needs diagrams for use in subsequent workshops (see Appendix B). The Functional Needs Structuring Workshops required heavy participation from onsite technology experts and problem-owners.

4.2.5 Functional Needs Prioritization Workshops

The Functional Needs Prioritization Workshops were held between April and June 1992. The purpose of these workshops was to prioritize the functional needs that were identified earlier to address the highest-priority problems in each mission area. Functional needs were evaluated against four criteria: 1) technology gaps, 2) urgency, 3) cost reduction potential, and 4) effectiveness increase potential. The definitions used for these criteria are shown in Table 4.2. The participants were asked to assign points to each functional need such that the points reflected the relative importance of carrying out technology development efforts in those functional needs areas. Their assessments were conditional on the specific high-priority problem being evaluated, on the overall cleanup strategy (i.e., the 200-Area disposal strategy used as the HIPP 1992 planning basis), and on the specific criterion under consideration.

The participants began by assigning importance points to the highest-level functional needs of a particular problem (e.g., characterization, retrieval, pretreatment). Most mission areas addressed two to five high-priority problems. Subsequently, the participants were asked to allocate

TABLE 4.2. Functional Needs Evaluation Criteria

Gaps/Missing Technologies	Technologies in this functional need area are missing or in a very immature state of development. Knowledge is missing to properly deal with this functional need area.
Urgency/Timeliness	Technologies in this functional need area need to be developed urgently in order to meet the time schedule of the strategy/higher-level functional need.
Cost Reduction Potential	This functional need area has the potential for significant cost reductions for the strategy/ higher-level functional need.
Effectiveness Increase Potential	This functional need area has the potential for significant increases in the effectiveness of the strategy/higher-level functional need.

importance points for lower-level functional needs (i.e., subfunctional needs) conditional on the higher-level need, the 200-Area disposal strategy, and the problem under consideration. Only the most important functional needs areas were split into subfunctional needs.

After assessing the relative importance of the functional needs against the four criteria, the last task was to assign weights to the criteria. Participants were asked to spread 100 points across the criteria such that the points reflected the relative importance of each criterion. An aggregate priority score was then calculated for each functional need by summing the weighted average scores across the four functional needs criteria.

4.2.6 Technology Prioritization Workshops

The Technology Prioritization Workshops were held between June and December 1992. The purpose of these workshops was to prioritize the technology development needs to meet the highest-priority functional needs identified at the Functional Needs Prioritization Workshops. Technologies were evaluated against four criteria: 1) importance for meeting the functional need; 2) cost-effectiveness; 3) timeliness/development risk; and 4) contribution to other mission areas, functional needs, or problems.

After the criteria were presented and discussed, the participants were introduced to a draft list of technologies that the S&T Needs Team had developed for the most important problems and functional needs as determined in the previous workshops. The discussions and interactive revisions were facilitated through use of an overhead computer display. The participants were asked to rate each technology against each technology evaluation criterion on a scale from 0 to 100 (see definitions of scales in Table 4.3). In addition, participants were asked to assign weights to the criteria. The overall priority of a technology was then calculated by summing its weighted-average scores across all criteria.

The criterion "importance for meeting the functional need" was omitted from the summation since it indicates the importance of the technology itself, rather than the importance of developing the technology. Instead, this criterion was used as a multiplier in the model; in essence, it serves as a

TABLE 4.3. Technology Evaluation Criteria

Criterion	Score = 100	Score = 50	Score = 0
Importance for Meeting the Functional Need	This technology is very important for meeting the functional need, and development is required. Any package of technologies designed for meeting this functional need must include development and use of this technology.	This technology is somewhat important for meeting the functional need, and some development is required. Most sensible packages of technologies designed to meet the functional need would include some development and use of this technology.	Development of this technology is not important for meeting the functional need, or development is not required. Packages of technologies can be designed to meet the functional need without development or use of this technology.
Cost-Effectiveness	This technology provides a very cost-effective way to meet the functional need, compared to commercially available technologies or to other technologies under development.	This technology provides a moderately cost-effective means to meet the functional need, compared to commercially available technologies or to other technologies under development.	This technology is not particularly cost-effective compared to commercially available technologies or to other technologies under development.
Timeliness/ Development Risk	This technology can definitely be developed and deployed within planned schedules for addressing the problem/functional need. There is very little (less than 1%) risk of upsetting important schedules because of delays in the development of the technology.	This technology can probably be developed and deployed within planned schedules for addressing the problem/functional need. There is some (10%) risk of upsetting important schedules because of delays in the development of the technology.	It may not be possible to develop and deploy this technology within planned schedules for addressing the problem/functional need. There is a significant (50%) risk of upsetting important schedules because of delays in the development of the technology.
Contribution to Other Mission Areas, Functional Needs, or Problems	This technology is applicable to a broad range of mission areas, functional needs, and problems.	This technology can be applied to at least one other mission area and to several functional needs and problems.	This technology has a fairly limited range of applications.

discount factor for the aggregate score of the other three criteria. The idea is that the overall importance of a technology development effort should increase or decrease proportionally with the importance of the technology for meeting the functional need. In the extreme case, a technology that is not important for meeting a functional need should have a zero priority score for technology development regardless of the scores it receives on the other three criteria.

The Technology Prioritization Workshops resulted in the identification of preferred technologies to meet the highest-priority functional needs,

which, in turn, address the highest-priority problems on the Site. The workshop results provide a tool for management at RL, WHC, and PNL to utilize in making S&T funding requests. Of course, the ultimate selection of baseline technologies remains a program decision in each mission area.

There was one exception to our implementation of the methodology described above. Technologies to remediate the Hanford waste tanks were prioritized by the TWRS National Workshop participants as described in Section 6.0, rather than in a HIPP Technology Prioritization Workshop. The TWRS Program spent 15 months during FY 1992 and FY 1993 developing an Integrated Technology Plan for remediation of tank wastes. TWRS technology development activities are divided into three categories to meet their planning objectives:

- Reference system technologies: Technologies required to implement the technical strategy for the program, including technology development required to support reference system selection.
- Enhancements: Technologies within the program strategy that 1) provide backup technology where reference technology is very uncertain, 2) potentially could improve performance, and 3) if proven, could replace the reference system.
- Alternative systems technologies: Technologies within the program strategy that 1) support significantly different approaches, 2) potentially could significantly improve performance, and 3) if proven, would make it possible to replace the reference system with an alternative approach.

Technologies that are currently being developed will be reassessed against the highest-priority needs each year. With limited funding, it cannot be assumed that money will be available each year for starting new R&D efforts. Rather, the HIPP technology needs assessment effort must determine if and when the ongoing development of a particular technology should be stopped because it will not be available when needed or it has insurmountable technical, economic, regulatory, or institutional problems.

Future technology assessment workshops may emphasize the development of more detailed structures (decision trees) appropriate to specific problems and a preliminary assessment of the alternative technology options identified in the earlier workshops. Criteria that are considered to be important to the

choice of a technology (e.g., the confidence placed in the success of a technology, the expected benefits of waiting so that further improvements could be made to the technology before it is implemented, or the possibility that cost escalations over time may make one technology less attractive than another) may be used in the technology assessment process.

Characterization technologies have a special structure within decision analysis. Since the benefit of characterization is uncertainty reduction and subsequently a more informed choice among the treatment and disposal technologies, one has to establish the value of the information for characterization technologies. Thus, a value-of-information model may be developed in the future to assist workshop participants and HIPP staff in making defensible characterization decisions.

As described in Section 13.0, the Hanford S&T needs assessment process has identified:

- technologies ready for insertion into the technical baseline (i.e., deployment onsite)
- technologies ready for demonstration, testing, and evaluation
- opportunities to increase the performance or reduce the cost of existing technologies
- technologies currently under development that need further R&D to become technically feasible
- Site operational problems/needs with no demonstrated technology solutions (i.e., opportunities for development of new technologies, equipment, processes, analytical instrumentation)
- problem areas where there is an incomplete understanding of the underlying scientific phenomena (e.g., fundamental chemical and/or physical interactions).

Each year the goal is to elicit inputs from key Hanford stakeholders and use them to develop an acceptable S&T agenda for the Site that includes recommendations regarding:

- technologies requiring further R&D
- new technologies to be developed
- scientific research needs.

The Sitewide recommendations will be incorporated into the next round of ADSs and TTPs to move the highest-priority needs forward into the DOE/HQ funding process. In addition, the information will be shared with the relevant EM-50 Integrated Demonstrations and Integrated Programs (see Section 12.2) for their future planning activities. Needs that also relate to other DOE sites will be forwarded for inclusion in the DOE/HQ national technology development (TD) program. It is quite possible that a decision to use a particular technology at another site could drive what is selected at Hanford, or vice versa. Our results must be integrated with similar results from other sites so DOE/HQ can make technology development decisions in a systematic fashion.

4.3 FUTURE HSSSTP METHODOLOGY IMPROVEMENT: INTEGRATED RISK ASSESSMENT

An Integrated Risk Assessment Program (IRAP) for the Hanford Site was recently funded by RL. The mission of IRAP is to provide health and ecological risk assessment inputs to support risk-based decision-making about Hanford cleanup. Components of IRAP include: 1) developing and maintaining a systems context of risk (a high-level, Sitewide assessment of risks before, during, and after cleanup) to justify and prioritize activities for long-term management of Site cleanup, and 2) conducting research that will provide a solid basis on which to better define the nature and extent of short- and long-term risks. Longer-term research activities will be undertaken to improve the scientific justification and methods for assessing occupational and public health risks and ecological risks. In addition, processes will be established for linking this program to other related activities at Hanford.

There will be several major consequences of this work. First, RL will establish increased credibility for how it conducts business at Hanford. Second, cleanup decisions will be truly risk-based and cleanup can be managed so net risks at Hanford are reduced. IRAP will provide information for several types of actions by decision-makers. These actions include

- negotiating with regulators for relief or changes to regulations, including to the Tri-Party Agreement
- requesting funding from Congress for appropriate cleanup actions at Hanford and for allocating Hanford funding

- communicating with the public about relative risks of various activities and involving the public in decision-making
- communicating with the scientific community about research that is needed to reduce uncertainties in the systems context of risk
- deciding among cleanup strategies and technologies.

There are numerous motivations for developing and implementing IRAP at the Hanford Site. These include

- considering health and ecological risks in Hanford cleanup decisions, which makes remedial actions more efficient, effective, and protective of worker, public, and environmental health and safety, both currently and in the future
- improving the technology and scientific basis for establishing Hanford worker protection programs for chemicals and physical hazards that are similar to the radiation protection program that currently exists at the Site
- linking the large bodies of existing risk information and supporting science to DOE decision-making, and driving health and ecological risk research to reduce uncertainties in risk information
- validating Hanford's S&T priorities with a quantitative risk assessment process to replace the gut-level judgements of relative risks presented in this document
- providing RL with risk information to establish credibility with Congress and other stakeholders, including the scientific community and the public, regarding Hanford cleanup
- providing RL with a technical basis for prioritizing activities based on expected risk reductions, both within Hanford Site programs and in interactions with DOE/EM.

The IRAP will provide comprehensive, state-of-art health and ecological risk information to decision-makers to integrate into key Site-level decisions. Without a comprehensive risk assessment for the Hanford Site, cleanup priorities and actions tend to be driven by factors that have little correlation with protecting health, safety, or the environment. Decisions and activities regarding EM at the Hanford Site have been responsive to public or expert opinion and to demands by regulatory agencies on specific issues rather than based on a Sitewide, high-level understanding of risks with an underlying scientific basis. There has been no overriding context to keep decisions in

perspective. Further, existing regulations and public perception do not necessarily have a firm scientific foundation and can drive actions that do not make sense from a health and safety standpoint and that do not use public funds wisely.

5.0 OVERVIEW OF WORKSHOP RESULTS

The process used to develop a prioritized list of S&T needs addressing Hanford's cleanup problems was described in Section 4.0. The process consisted of criteria elicitation interviews, problem prioritization workshops, criteria weighting elicitations, functional needs structuring workshops, functional needs prioritization workshops, and technology prioritization workshops. An overview of the results of the HIPP workshops held in FY 1992 is provided in this section, followed by mission-specific results in Sections 6.0 through 11.0.

5.1 PROBLEM PRIORITIES

Each of the five Problem Prioritization Workshops focused on a separate Hanford mission area: ER (held on November 21, 1991), D&D (held on December 11, 1991), nuclear materials (held on December 12, 1991), solid and liquid waste (held on December 13, 1991), and tanks (held on January 8, 1992). The participants, who were either key Hanford program managers or technologists, were asked to identify and prioritize the most important cleanup problems in their mission area.

The goal of each workshop was to prioritize mission area problems identified by the participants using the scoring criteria developed via the stakeholder interviews. This was accomplished through a computer-aided process that helped participants apply the scoring criteria and consistent logic to compare the relative importance of each problem under each criterion.

After the workshops were completed, the five lists of problems ranked by the five mission area workshops were merged. Table 5.1 shows the top problems at Hanford as prioritized by the workshop participants using the 10 criteria and the individual mission area group weights. Brief explanations of the top 20 problems at the Hanford Site, as determined at the Problem Prioritization Workshops, are provided below.

- Pre-1970 suspect plutonium-contaminated buried waste: The total quantity of buried waste on the Hanford Site is about 600,000 m³. About 285,000 m³ of this total is pre-1970 buried waste (containing

TABLE 5.1. Top Hanford Cleanup Problems

Score	Workshop Group ^(a)	Problem
51	Solid Waste	Pre-1970 plutonium-contaminated buried waste
50	Liquid Effluents	Contaminated groundwater
49	Liquid Effluents	Mixed/land disposal restriction (LDR) waste
46	Liquid Effluents	Low-level waste
46	Solid Waste	Spent fuel storage
42	Tanks	Single-shell tanks (SSTs) with integrity problems
41	Solid Waste	Pyrophorics
41	D&D	Irradiated fuel storage facilities
41	Nuclear Materials	Irradiated fuel in K-Basins
40	Tanks	SSTs containing ferrocyanide
40	Tanks	Hydrogen-generating SSTs
40	Tanks	SSTs containing organics
40	Solid Waste	Alkali metal materials
40	Solid Waste	Alkali metal wastes
38	Tanks	Chemically reactive double-shell tanks (DSTs)
37	Solid Waste	Drag-off waste
36	ER	Liquid discharges to cribs containing mixed waste
35	Solid Waste	Munitions
35	D&D	Plutonium-processing (non-canyon) facilities
34	Tanks	High-heat tank (106-C)
34	Solid Waste	Tunnel waste
34	Nuclear Materials	Residual holdup (terminal clean-out)
34	Solid Waste	Canyon waste
34	Solid Waste	Remote-handled hazardous TRU and TRU-mixed post-1970 solid waste
34	ER	Higher-level radioactive liquid discharges to cribs
34	Tanks	Noxious-gas-generating SSTs
34	ER	Groundwater in the 100 Areas
34	Solid Waste	Class 3 remote-handled low-level mixed waste
34	Nuclear Materials	Nonshippable (need stabilization) mixed hazardous liquid solutions
34	Solid Waste	Offsite waste
33	ER	Mixed liquid discharges to trenches and ponds

TABLE 5.1. (contd)

Score	Workshop Group ^(a)	Problem
33	Solid Waste	Class 3 contact-handled low-level mixed waste
32	Solid Waste	Class 1 contact-handled low-level mixed waste
32	Solid Waste	Greater than Class 3 remote-handled low-level mixed waste
32	Solid Waste	Class 1 remote-handled low-level mixed waste
31	Solid Waste	Hazardous contact-handled TRU and TRU-mixed post-1970 solid waste
31	ER	Higher-level radioactive liquid discharges to trenches and ponds
31	Solid Waste	Greater than Class 3 contact-handled low-level mixed waste
30	Tanks	High-TRU SSTs
30	Tanks	High-fission-product SSTs
(a) The mission area listed is the one that scored the problem, not necessarily the one responsible for managing the waste or disposing of it. The ER Program staff believe that the high scores on problems 1 and 2 reflect uncertainties due to unfamiliarity with the specific cleanup plans.		

both LLW and suspect plutonium-contaminated waste) which is located in trenches in the 100, 200, and 300 Areas. An estimated 300 kg of plutonium is associated with the pre-1970 buried wastes. The hazardous chemical content is unknown and is the primary reason that this is a high-priority need. Dealing with pre-1970 buried waste at Hanford is complicated by the lack of information regarding what is buried, where it is, and the physical condition of the containers.

- Contaminated groundwater: Contaminated groundwater on the Hanford Site has occurred because of the past practice of discharging liquid effluents (contaminated water from Site facilities and carbon tetrachloride and other organic liquids from plutonium extraction processes) directly to the soil column. Only past-practice liquid discharges are included in the ER mission area; current discharges, which are included in the liquid effluents mission area, are much reduced in volume and activity levels, and are being terminated as soon as practicable. One of the priority ER contaminated groundwater issues is the past discharge of an estimated 580 to 920 metric tons of carbon tetrachloride to the soil column in the 200-West Area between 1955 and 1973, resulting in a groundwater contamination concentration of up to 6000 ppb in an area approximately .8 km². (The EPA's maximum drinking water concentration is 5 ppb.) Compared to this problem, other

groundwater contamination problems (e.g., tritium contamination) are relatively low-risk and are, therefore, of much lower priority to the ER Program at Hanford.

- Liquid effluent containing mixed/LDR waste: This liquid effluent stream containing mixed/LDR waste is the process condensate from the 242-A Evaporator, which contains both radioactive and hazardous chemical constituents. The stream, which has been designated a federally listed waste and a state dangerous waste, is subject to LDRs because of the hazardous nature and concentration of its constituents. Because LDRs were written primarily to regulate single-contaminant streams, it is more difficult to treat the multiple-contaminant effluent stream from the 242-A Evaporator to meet the LDR requirements. The radioactive constituents include cesium, strontium, and tritium fission products. Hazardous chemical components include ammonia (up to 9000 ppm), butanol, acetone, and methyl isobutyl ketone (MIBK).
- Liquid effluents containing LLW: The majority of the 33 identified liquid effluent streams that require treatment contain low levels of radioactivity. Most of these waste streams are process condensate, cooling water, or laboratory wastewater. The streams are below hazardous concentration limits, but above groundwater protection standards. The radioactive constituents include tritium (which is largely untreatable at the low concentrations encountered) and radionuclides emitting alpha, beta, and gamma activity. The inability to detect the low concentration levels of individual radionuclides in high-volume streams makes it difficult to predict whether they exceed regulatory discharge limits before and/or after treatment. In many instances, technology is not available for the desired in-line monitoring of these streams. In addition, many of these streams also contain mixed organic and nonradioactive heavy metal contaminants.
- Spent fuel storage: Approximately 140 m³ of irradiated reactor fuel is stored in sealed, shielded containers in Hanford burial trenches, but the exact location of all the spent fuel rods is unknown. Most of the rods are encased in schedule-80, 120-inch pipe that is capped on both ends. This waste could be extremely pyrophoric, so inert-gas remote-handling technologies will be required.
- SSTs with integrity problems: These SSTs received the highest score of all the tank problems that were evaluated in the Tank Problem Identification Workshop, largely because of public concern and because 68 of them are suspected of having contaminated the underlying soil. In addition, the remaining SSTs could start leaking in the future. The primary concern for tanks with integrity problems is that the addition of water for either cooling or retrieval by sluicing would most likely increase the leakage problems. From a technology perspective, unique issues include how to

best build interim containment barriers, how to develop retrieval strategies that minimize the use of fluids, and how to plug the leaks.

- Pyrophorics: These highly reactive solid wastes, which may or may not be mixed with other wastes, could ignite if exposed to air (e.g., zircaloy cladding). The ability to identify pyrophorics within other wastes is the major characterization need. Separation of the pyrophorics from the other waste components is one of the safest ways to ensure proper handling and disposal.
- Irradiated fuel storage facilities: The K-Basins in the 100 Areas are normally cited as the main example of these facilities, but there are also basins in the 100-KW Area and the 100-N Area. Spent fuel is currently held in these basins, and there is a 3- to 4-inch layer of silt in the bottom containing iron oxides, uranium, and plutonium. If no D&D is performed on the storage basins, there are high risks for future health and safety and significant long-term risk to the groundwater. In addition, the basins are located near the Columbia River and could, thus, result in surface water contamination.
- Irradiated fuel in K-Basins: Irradiated N-Reactor fuel is being stored in water basins in the 100-K Areas. This includes 2100 metric tons of uranium (6000 to 7000 canisters containing up to 14 elements per canister). Uranium metal elements are stored in a combination of open-top and closed-top canisters. The metal slowly reacts with the water over time to produce potentially reactive uranium compounds.
- SSTs containing ferrocyanide: Twenty-four SSTs may contain ferrocyanide precipitates. The safety concern regarding these tanks is that ferrocyanide decomposes to explosive gasses at higher temperatures. Unique characterization and mitigation technologies may be required.
- Hydrogen-generating SSTs: Eighteen SSTs have the potential for flammable gas accumulation, entrapment below the crust layer, and periodic release. The safety concern regarding these tanks is that the hydrogen/nitrous oxide mixture that is periodically released could be explosive above certain concentration limits. Unique characterization and mitigation technologies may be required.
- SSTs containing organics: The safety concern regarding these tanks is that they contain unacceptable concentrations of organics, which could react unpredictably under certain conditions. Eight SSTs may contain unacceptable concentrations of organic chemicals which could result in exothermic reactions. Unique characterization and mitigation technologies may be required.

- Alkali metal materials: Alkali metals are a unique type of solid waste that requires disposition from the Site material inventory. While sodium metal represents the largest fraction of stored alkali metal materials on Site, quantities of lithium and potassium as well as mixtures of the three metals are also stored. The liquid sodium associated with operation of the FFTF is not yet considered waste. Alkali metals are highly reactive materials that could ignite if exposed to moisture, and they will require special handling similar to pyrophorics, as discussed above.
- Alkali metal wastes: Alkali metal wastes consist of alkali metal materials that have been used and are now considered wastes. As mentioned previously, they are highly reactive and could ignite if exposed to moisture. They will require special handling similar to pyrophorics, as discussed above.
- Chemically reactive DSTs: In the Tank Problem Identification Workshop, chemically reactive DSTs were designated to include both hydrogen-generating tanks (especially Tank 241-SY-101) and tanks containing organics. This problem was ranked high primarily because 1) there is a high level of public concern regarding a potential explosion in Tank 241-SY-101, and 2) there is some potential for environmental contamination resulting from an accidental release.
- Drag-off waste: Drag-off boxes are boxes full of very "hot" waste. These boxes were dragged by chains or cables attached to vehicles into trenches or pits and then buried. The contents could include LLW, TRU, or mixed waste. The exact location of all these boxes is not known. Remote-handling methods will be required to retrieve, transport, and treat the drag-off boxes. If they are intact, the boxes will most likely be retrieved intact and opened at the central treatment facility for disposal rather than opened in the field.
- Liquid discharges to cribs containing mixed waste: These past liquid discharges to cribs received high scores due to soil and groundwater contamination, as well as regulatory compliance. There are several types of cribs on the Site, including timber cribs, open pits, leach trenches, and the 100-N Area Crib. Some have immediate health and safety impacts. Timber cribs are large wooden boxes in the ground that contain B Plant wastes, reactor wastes, high-activity wastes, TRU-contaminated wastes, and heavy metals. The Z-9 Crib is a shallow pit in the ground (covered with a concrete barrier) containing TRU-contaminated waste, and it may also contain hazardous waste (e.g., cadmium). Leach trenches contain PUREX waste materials. At N Springs in the 100-N Area, there is a crib containing petroleum products and mixed fission products.

- Munitions: Munitions are another category of highly reactive buried solid wastes that could ignite if exposed to air. They will require special handling similar to pyrophorics, as discussed above.
- Plutonium processing (non-canyon) facilities: The 233-S Building is an example of Hanford's non-canyon plutonium-processing facilities. The primary problem with these facilities is dispersable plutonium, which exists in the ductwork and in hot cells of these facilities. Breaching of these facilities could release plutonium into the environment. Plutonium processing facilities scored the highest long-term health and safety risks of all 18 D&D problems (if they are left unattended) that were evaluated in the D&D Problem Identification Workshop.
- High-heat tank (106-C): The high-heat SST refers mainly to Tank 241-C-106. This tank contains heat-generating sludge that is periodically wet with water to promote evaporative cooling. If Tank 241-C-106 should leak, the addition of cooling water could result in contamination of the underlying soil. If water is not added periodically, the sludge could heat to temperatures that could result in tank structural damage.

The problem prioritization results surprised many people, which demonstrates the value of comparing all Site cleanup problems on a systematic basis. The results introduce new perspectives and new issues to be evaluated. For example, it is important to note that the informed expert opinion of the workshop participants regarding cleanup problem priorities is inconsistent with current funding allocations at Hanford. That is, the highest-priority cleanup problems identified in the workshops are not receiving the largest budgets in all cases. We cannot definitively state that either the funding allocations are "wrong" or the workshop participants' judgments are "wrong." However, we can strongly suggest that quantitative data on the relative risks of all Hanford cleanup problems be obtained from IRAP prior to undertaking any future S&T needs assessment workshops. This quantitative risk data will serve as a more accurate replacement for the gut-level judgments of relative risks that were made by the workshop participants.

Four individual Hanford stakeholders who participated in the criteria elicitation interviews were asked to supply weights for the 10 problem prioritization criteria in order to compare their individual perceptions of

Hanford's top-priority problems. The weights were elicited using a swing-weighting procedure that proved to be quite easy for the stakeholders to understand and to implement. These meetings also provided an opportunity to talk with the stakeholders about the status of the S&T needs assessment process and to respond to any concerns they might have.

The four individuals who provided weights represented the perspectives of EPA, Washington State Department of Ecology (Ecology), RL, and WHC. Table 5.2 shows the weights that were assigned to the 10 problem evaluation criteria by these four stakeholders. Table 5.3 contains a list of top Site problems identified in the FY 1992 HIPP workshops, listed in order of priority based on the average weights of the four stakeholders. It also shows the problem priorities based on each individual stakeholder's weights. The result of this comparison is that differences in stakeholder weights have very little impact on Hanford problem priorities. There are some slight shifts, but the overall problem priorities do not change significantly. The only conclusion to be reached by looking at Table 5.3 is that the same set of problems was scored at the high end of the scale by each of the four individuals, regardless of the differences in their criteria weights.

TABLE 5.2. Weights Assigned to Problem Evaluation Criteria by Four Hanford Stakeholders

Problem Evaluation Criteria	Stakeholders			
	EPA	Ecology	RL	WHC
Health and Safety - Short Term	0.17	0.24	0.18	0.20
Health and Safety - Long Term	0.16	0.15	0.15	0.16
Health and Safety - Future Generations	0.12	0.12	0.06	0.14
Environmental Impacts - Surface Water	0.02	0.10	0.09	0.08
Environmental Impacts - Groundwater	0.15	0.07	0.09	0.06
Environmental Impacts - Soil	0.13	0.09	0.09	0.05
Land Use	0.05	0.02	0.06	0.02
Cultural Concern	0.04	0.02	0.06	0.01
Public Concern	0.10	0.07	0.09	0.14
Regulatory Compliance	0.07	0.11	0.12	0.16

TABLE 5.3. Comparison of Hanford Problem Priority Scores for Four Stakeholders

Problem Evaluation Criteria	Stakeholders				
	Average Stakeholder Weights	EPA	Ecology	RL	WHC
Pre-1970 Plutonium-Contaminated Buried Waste	53	55	51	54	52
Contaminated Groundwater	50	55	45	52	49
Liquid Effluents Containing Mixed/LDR Waste	47	48	43	49	48
Spent Fuel Storage (Solid Waste)	46	45	42	48	50
Liquid Effluents Containing Low-Level Waste	46	49	41	47	46
SSTs with Integrity Problems	44	46	40	41	48
Pyrophorics	42	38	40	44	47
SSTs Containing Ferrocyanide	42	40	39	39	49
Hydrogen-Generating SSTs	42	40	39	39	49
SSTs Containing Organics	42	40	39	39	49
Alkali Metal Materials	41	39	39	43	43
Alkali Metal Wastes	41	39	39	42	43
Irradiated Fuel Storage Facilities	38	43	37	37	36
Drag-Off Waste	38	38	35	41	39
Chemically Reactive DSTs	37	40	34	34	41
Mixed Liquid Discharges to Cribs	37	40	33	39	34
Remote-Handled Hazardous TRU and TRU-Mixed Post-1970 Solid Waste	36	40	33	38	35
Munitions	36	33	33	38	41
Plutonium-Processing (Non-Canyon) Facilities	36	37	37	30	39
Irradiated Fuel in K-Basins	36	38	34	38	32
Class 3 Remote-Handled Low-Level Mixed Waste	36	37	32	39	35
High-Heat Tank (106-C)	35	34	33	33	40
Class 3 Contact-Handled Low-Level Mixed Waste	35	36	31	38	34
Higher-Level Radioactive Liquid Discharges to Cribs	35	38	31	37	33
Tunnel Waste	34	32	32	37	37
Canyon Waste	34	32	31	37	37
Hazardous Contact-Handled TRU and TRU-Mixed Post-1970 Solid Waste	34	38	31	36	32
Class 1 Contact-Handled Low-Level Mixed Waste	34	35	30	37	33
Offsite Waste	34	31	29	30	39
Greater Than Class 3 Remote-Handled Low-Level Mixed Waste	34	33	30	37	35
Class 1 Remote-Handled Low-Level Mixed Waste	34	35	30	37	33
Noxious-Gas-Generating SSTs	34	31	33	31	40

5.2 TECHNOLOGY PRIORITIES

The remaining workshops focused on identifying the highest-priority functional needs and the most promising cleanup technologies for solving the highest-priority problems at Hanford. Technology options included those that could be implemented immediately and those requiring further research and/or development before they can be considered deployable.

The S&T needs for Hanford cleanup will be substantial. In some cases, the needs are poorly defined because the ultimate cleanup goals remain unclear. Even when the needs are defined, many technologies that are needed do not currently exist. Others exist, but these are still in an early stage of development. Of the few technologies that have been proven in the field, many could benefit substantially from performance improvement and cost reduction.

A comprehensive risk assessment must be one of the first steps taken to help determine the extent of new technology development needs for the Hanford Site. The IRAP baseline risk assessment will provide answers that will enable the Site to move away from current regulatory-driven cleanup limits to support more affordable cleanup decisions that minimize risks to both the workers and the public. The S&T needs assessment described in this document does not presuppose answers to cleanup issues that have not yet been decided (e.g., Does the pre-1970 suspect TRU-contaminated buried waste need to be retrieved and treated?). If the IRAP data show that the TRU species are adequately immobilized by Hanford soils, then the stakeholders may agree that extensive retrieval and treatment are unnecessary, thus, technology development is not required. However, if a decision is made that no TRU will be disposed of on the Hanford Site, then characterization and/or retrieval technologies for TRU waste may be of critical importance.

Table 5.4 contains the prioritized nontank technology development needs across Hanford mission areas. (Technology needs for the Tank Waste Remediation System Program are presented in Section 6.0.) According to the logic of our S&T needs assessment approach, the overall technology need score (TP) is

**TABLE 5.4. Prioritized Nontank Technology Development Needs
Across Hanford Mission Areas**

Mission Area (Problem)	Functional Need: Science and Technology Need	Technology Need Scores	
		t	p·f·t
SW	Treatment (partitioning/pretreatment): sorting	81	372
SW	Buried waste retrieval (remotely handled material): dust control and air handling system	76	349
LE	Treatment: filtration	75	930
LE	Generation: recycle/reuse of waste water	73	1078
SW	Buried waste retrieval (remotely handled material): Radioactive/hazardous materials containment and control	72	330
LE	Pre-cleanup inventory management: continuous in-line monitoring for organics	71	1132
LE	Treatment: ion exchange	71	879
LE	Treatment: ultraviolet oxidation	71	879
LE	Generation: waste minimization (source reduction)	69	1018
SW	Buried waste retrieval (remotely handled material): robotics/removal equipment	68	312
SW	Characterization (in situ measurement/sampling): NDE/NDA methods (chemical and radioactive)	66	370
SW	In situ treatment (toxicity/mobility reduction): dust control technologies	65	332
SW	Characterization (in situ measurement/sampling): sensors (radioactive and hazardous materials, non-bulk)	64	359
LE	Treatment: tritium removal via membrane	60	726
ER (TCP)	In situ/field measurement of soils (chemical): sensors	57	492
LE	Pre-cleanup inventory management: continuous in-line monitoring for alpha radiation	56	873
LE	Pre-cleanup inventory management: continuous in-line monitoring for beta radiation	56	873
LE	Treatment: reverse osmosis	56	713
LE	Treatment: polymerization	55	701
SW	Treatment (partitioning/pretreatment): size reduction with shredders, torches, shears, etc.	55	252
SW	Treatment (disposal form conversion): vitrification	55	252
SW	Treatment (partitioning/pretreatment): thermal treatment technologies	54	248
ER (TCP)	In situ/field measurement of soils: process monitoring and control technologies	54	467

TABLE 5.4. (contd)

Mission Area (Problem)	Functional Need: Science and Technology Need	Technology Need Scores	
		t	p·f·t
LE	Pre-cleanup inventory management: continuous in-line monitoring for inorganics	54	873
NM (SNM)	Existing inventory management (monitoring/ characterization): remote inventory system for exposure reduction	53	396
LE	Treatment: chemical oxidation	52	637
SW	In situ treatment (toxicity/mobility reduction): vitrification	51	260
SW	Treatment (disposal form conversion): stabilized waste forms	50	230
LE	Treatment: freeze drying (secondary waste treatment)	49	548
SW	Treatment (partitioning/pretreatment): decontamination with mechanical, chemical, and aqueous methods	47	216
ER (TCP)	In situ/field measurement of soils: radiological measurement	47	406
ER (TCP)	In situ treatment/isolation of soils: bioremediation	47	203
ER (GW)	In situ treatment of groundwater: bioremediation	47	431
SW	Characterization (in situ measurement/sampling): bulk analysis and instrumentation	46	258
SW	Characterization (heterogeneous material sampling methods): real-time/on-line sensor instrumentation	45	252
NM (SNM)	Existing inventory management: interim stabilization/ storage of liquid solutions	45	337
SW	Characterization (heterogeneous material sampling methods): sound statistical-based approach to minimize sampling	44	247
NM (IF)	Existing inventory management (interim storage systems): inventory characterization (laboratory/engineering studies) - metal fuel safety in new dry storage	44	487
D&D	Characterization (nonintrusive): rapid field detection instruments for hazardous chemicals	43	494
NM (SNM)	Existing SNM inventory management: repackaging for long-term storage	43	322
LE	Treatment: electrolytically regenerated ion exchange	43	522
LE	Treatment: filter press	43	510
NM (SNM)	Retrieval and recovery of residual holdup: ductwork remediation (downstream of HEPA filters)	42	457
D&D	In situ pretreatment (recycle): metal	42	431
D&D	In situ pretreatment (liquid-phase decontamination): electrochemical - CEPD	41	420

TABLE 5.4. (contd)

Mission Area (Problem)	Functional Need: Science and Technology Need	Technology Need Scores	
		t	p·f·t
LE	Treatment: freeze drying (chemical pretreatment)	40	395
D&D	In situ pretreatment (high-intensity radiant energy decontamination): remote laser decontamination	39	400
LE	Treatment: electrodialysis	39	484
D&D	In situ pretreatment: gas- or vapor-phase decontamination	38	390
LE	Pre-cleanup inventory management: continuous in-line monitoring for gamma radiation	38	614
SW	In situ treatment (toxicity/mobility reduction): soil washing technologies	37	189
SW	Buried waste retrieval (remotely handled material): retrieval of unstable/reactive chemical waste	37	170
D&D	Characterization (intrusive): rapid field analysis - hazardous	37	425
ER (TCP)	In situ/field measurement of soils (chemical): ion-specific electrodes	37	320
LE	Treatment: adsorption	37	484
ER (TCP)	In situ treatment/isolation of soils: Hanford barrier	36	156
ER (GW)	In situ treatment of groundwater: technologies for treatment of DNAPLs	36	330
ER (GW)	In situ treatment of groundwater: local treatment	35	321
LE	Treatment: chelation	35	420
LE	Treatment: microorganisms	34	420
SW	In situ treatment (toxicity/mobility reduction): interim stabilization technologies	34	173
D&D	In situ pretreatment (liquid-phase decontamination): aqueous/water jets	34	349
ER (TCP)	In situ/field measurement of soils (physical/geophysical): fiber optic probe	34	294
ER (TCP)	Ex situ treatment of soils: washing (chemical extraction)	34	282
SW	Characterization (heterogeneous material sampling methods): integrated information system driven by expert systems	33	185
SW	Treatment (disposal form conversion): metal waste forms	33	151
D&D	Characterization (nonintrusive): rapid field detection instruments - radioactive	33	379

TABLE 5.4. (contd)

Mission Area (Problem)	Functional Need: Science and Technology Need	Technology Need Scores	
		t	p.f.t
NM (SNM)	Existing SNM inventory management (monitoring/characterization): nondestructive characterization	33	247
ER (TCP)	Soil retrieval: robotics applications for remote handling	33	131
ER (GW)	Ex situ treatment of groundwater: bioremediation	33	157
NM (SNM)	Retrieval and recovery of residual holdup: assessment of portable NDA/NDE systems	32	348
D&D	In situ pretreatment (liquid-phase decontamination): foams and gels	32	328
D&D	In situ pretreatment (recycle): concrete	32	326
ER (TCP)	Ex situ treatment of soils: bioremediation	32	265
SW	Characterization (in situ measurement/sampling): ground-penetrating radar	31	174
D&D	Characterization (intrusive): remote sampling technologies	31	356
NM (IF)	Existing irradiated fuel inventory management (interim storage form conversion): mechanical size reduction/oxidation for metal fuel (alternative oxidants)	31	343
D&D	In situ pretreatment (dismantle components): noncontamination imbedding sectioning technologies - nonthermal dismantling	31	318
ER (TCP)	In situ/field measurement of soils (physical/geophysical): drilling	31	268
ER (TCP)	Ex situ treatment of soils: ex situ vitrification	31	257
D&D	Characterization (nonintrusive): scanner with robotic interface	31	344
ER (TCP)	Soil retrieval: dust control/containment	30	119
D&D	Characterization (intrusive): rapid field analysis - radioactive	29	333
NM (IF)	Irradiated fuel disposal form conversion: mechanical size reduction/oxidation for metal fuel (alternative oxidants), including offgas treatment for high-temperature spent fuel treatment	29	321
NM (SNM)	Existing SNM inventory management (monitoring/characterization): sampling/chemical analyses	29	217
ER (TCP)	Soil retrieval: soil fixant and foam technologies	29	115
ER (GW)	Ex situ treatment of groundwater: membrane separations (e.g., reverse osmosis)	29	138

TABLE 5.4. (contd)

Mission Area (Problem)	Functional Need: Science and Technology Need	Technology Need Scores	
		t	p·f·t
SW	In situ treatment (toxicity/mobility reduction): grout/cementation	28	143
ER (GW)	Subsurface manipulation/retrieval of groundwater: chemical	28	133
D&D	In situ pretreatment (decontamination): removable coatings	26	267
D&D	In situ pretreatment (dismantle components): size reduction methods	26	267
ER (TCP)	In situ/field measurement of soils (physical/ geophysical): ground-penetrating radar	26	225
ER (TCP)	In situ treatment/isolation of soils: soil heating	26	112
NM (IF)	Irradiated fuel disposal form conversion: shear/dissolve/vitrify in high-fissile-content Vitrification Process	25	277
D&D	In situ pretreatment (immobilization): fixatives and foams	25	256
LE	Treatment: pervaporation	25	293
LE	Treatment: glass	25	293
SW	In situ treatment (toxicity/mobility reduction): encapsulation	24	122
D&D	In situ pretreatment (decontamination): remote mechanical devices	24	246
D&D	In situ pretreatment (dismantle components): noncontamination imbedding sectioning technologies - liquid metal embrittlement	24	246
NM (IF)	Existing irradiated fuel inventory management (interim storage systems): enhanced current storage - barriers/liners for existing water-filled basins	23	255
ER (TCP)	In situ/field measurement of soils (physical/geophysical): electrical resistivity technologies	23	190
ER (GW)	Subsurface manipulation/retrieval of groundwater (subsurface barriers): grout	23	109
SW	Characterization (in situ measurement/sampling): package integrity analysis	22	123
D&D	Characterization (nonintrusive): rapid field detection instruments - physical	22	253
D&D	In situ pretreatment (decontamination): abrasives	22	226
D&D	In situ pretreatment (liquid-phase decontamination): electro-polishing	22	226
ER (TCP)	In situ/field measurement of soils (chemical): soil gas analysis	22	190

TABLE 5.4. (contd)

Mission Area (Problem)	Functional Need: Science and Technology Need	Technology Need Scores	
		t	p·f·t
ER (TCP)	Ex situ treatment of soils: grout	22	182
ER (TCP)	In situ treatment/isolation of soils: in situ vitrification	22	95
LE	Treatment: supported liquid membrane	22	229
NM (IF)	Existing irradiated fuel inventory management (interim storage systems): new dry storage - encapsulation for dry storage	21	232
ER (TCP)	In situ treatment/isolation of soils: electrokinetics/electro-osmosis	21	91
ER (TCP)	Ex situ treatment of soils: electrokinetics/electro-osmosis	20	166
ER (TCP)	In situ treatment/isolation of soils: in situ grouting	20	86
ER (GW)	Subsurface manipulation/retrieval of groundwater (subsurface barriers): biological	20	95
LE	Treatment: biopolymers	20	229
D&D	In situ pretreatment (dismantle components): physical dismantling - concrete	19	195
ER (GW)	Subsurface manipulation/retrieval of groundwater: physical	19	90
D&D	Characterization (intrusive): rapid field analysis - physical	18	207
NM (IF)	Irradiated fuel disposal form conversion: alternate waste form technologies	18	199
D&D	In situ pretreatment (dismantle components): physical dismantling - metal	18	185
ER (TCP)	Ex situ treatment of soils: heat (thermal desorption)	18	149
ER (GW)	Subsurface manipulation/retrieval of groundwater (subsurface barriers): cryogenic	18	86
SW	Treatment (disposal form conversion): ceramic waste forms	17	78
NM (IF)	Existing irradiated fuel inventory management (basin sludge removal): sludge disposition characteristics	17	188
D&D	In situ pretreatment (decontamination): thermal	17	174
D&D	In situ pretreatment (liquid-phase decontamination): chelating agents	17	174
ER (TCP)	In situ/field measurement of soils (physical/geophysical): infrared thermal imaging	17	147
LE	Treatment: supercritical water oxidation	17	191

TABLE 5.4. (contd)

Mission Area (Problem)	Functional Need: Science and Technology Need	Technology Need Scores	
		t	p·f·t
D&D	In situ pretreatment (dismantle components): thermal dismantling - metal	16	164
ER (TCP)	In situ treatment/isolation of soils: vapor extraction	16	69
D&D	In situ pretreatment dismantle components): thermal dismantling - concrete	14	144
NM (IF)	Existing irradiated fuel inventory management (interim storage systems): enhanced current storage - consolidation racking	13	144
D&D	In situ pretreatment: isolation	13	133
LE	Treatment: coagulation/filtration	13	140
NM (IF)	Existing irradiated fuel inventory management (basin sludge removal): commercial vacuum transfer and solidification as applied to metal fuels	12	133
ER (GW)	Subsurface manipulation/retrieval of groundwater (subsurface barriers): electrokinetic	12	57
ER (GW)	Subsurface manipulation/retrieval of groundwater (subsurface barriers): membrane	11	52
LE	Treatment: precipitation	11	127
LE	Treatment: grout	10	102
NM (IF)	Existing irradiated fuel inventory management (interim storage systems): enhanced current storage - encapsulation of N-fuel	10	111
ER (GW)	Ex situ treatment of groundwater: precipitation	9	43
LE	Treatment: incineration	6	76
SW	Buried waste retrieval (remotely handled material): self-contained mobile retrieval system (WORM)	5	23
LE	Treatment: air stripping	3	25
LE	Pre-cleanup inventory management: time composite sampling	2	32
LE	Pre-Cleanup inventory management: flow composite sampling	2	32
LE	Pre-cleanup inventory management: grab sample	2	32

TABLE 5.4. (contd)

Mission Area (Problem)	Functional Need: Science and Technology Need	Technology Need Scores	
		t	p·f·t
NM (IF)	Existing irradiated fuel inventory management (interim storage form conversion): sodium removal by water reaction (FFTF only)	0	0
Key: DNAPL = dense nonaqueous phase liquid f = functional need score GW = groundwater IF = irradiated fuel LE = liquid effluents (problem focus = mixed/land disposal restricted effluents) NM = nuclear materials p = problem score SNM = special nuclear materials SW = solid waste (problem focus = buried waste) t = technology need score TCP = contaminated soils in trenches, cribs, and ponds			

proportional to the product of the problem score (p), the functional need score (f), and the technology score (t):

$$TP = 100 \cdot p \cdot f \cdot t,$$

where p and f are standardized scores (between 0 and 1), and $T = 100 \cdot t$. Sub-functional needs scores are omitted from this calculation because they are not available for all mission areas and because workshop participants conditioned their judgements on the problems and higher-level functional needs, rather than on the lower-level functional needs. The main contenders for comparing technology priorities are the technology score (t) and the overall technology need score (TP). In Table 5.4, the technology needs are ranked by the technology score (t), but the overall technology need score (TP) is also shown.

With Table 5.4 ordered by the technology scores (t), the solid waste technology needs clearly dominate, with 14 of the top 20 technology needs being from the solid waste mission area. The Solid Waste Workshop participants provided a very detailed list of functional needs, and rated the

technologies addressing these functional needs as very important. The more specific the functional need, the more vital a technology is to meet the need. This effect was counterbalanced, as it should be, by the many functional needs defined by the Solid Waste Workshop participants, which led to lower functional needs scores.

If Table 5.4 were ordered by overall technology need scores (TP), the results would show that many of the liquid effluents technology needs would dominate, since half of their TP scores were greater than 500, whereas the highest technology score for any of the other (nontank) mission areas was 494. In fact, three technology scores in the liquid effluents mission area were over 1000. This phenomenon is due to the fact that the liquid effluents mission area identified only four functional needs as being key, which gave those functional needs scores between 20 and 30, whereas typical functional needs scores in the other mission areas were less than 10. Thus, we believe that the ordering of technology needs by raw technology score (t) is more appropriate for this document.

The moderating role of the functional need priority proved to be an influential element in this analysis. By design, the functional need priority is dependent on the number of functional needs. Thus, a mission area with many functional needs will "dilute" their allocation of technology priorities in the overall model. This is appropriate and logical, but the strong role of this dilution effect came as a surprise to the S&T Needs Team. Comparatively, the problem scores had a much lesser influence on the overall technology need score (TP), since only high-priority problems were analyzed.

To date, there has been no cross-check of these results against the professional judgements of the workshop participants. It is important to provide this feedback and examine cases where clear discrepancies exist between model results and these judgements. These discrepancies could be due to omitting important model considerations, or perhaps are indications of biased judgements. In any case, the model provides a road map and a rationale for the scores presented in Table 5.4.

5.3 CROSS-CUTTING SCIENCE AND TECHNOLOGY NEEDS

This section describes cross-cutting S&T needs areas to enable the Hanford programs to identify areas of mutual interest and potential opportunities to leverage their technology development resources. Table 5.5 presents the highest-priority functional needs/subfunctional needs and technology development needs areas, correlated with the Hanford programs. Six high-priority functional needs (in bold) are listed in the left column, in the order in which they would be performed (from inventory management to treatment) to manage and dispose of Hanford's waste inventories.

The highest-priority subfunctional needs are shown beneath the six functional needs. Except for in situ measurement (under the characterization function), the technology needs of each of these subfunctions were compared across the Hanford programs. The in situ measurement subfunction was split into three technology development needs areas for further differentiation, and technology needs were compared at the lower level.

As shown in the table, the characterization function has the most cross-cutting technology development needs areas. In particular, the need to measure radiological constituents in situ was ranked highly by all Hanford programs. Partitioning/separations and ex situ treatment also have several cross-cutting needs areas. In partitioning/separations, chemical and physical methods were seen as high-priority technology development needs across most Hanford programs.

The retrieval function did not have many cross-cutting needs because the subfunctions describe the materials to be retrieved, and these materials are specific to a single Hanford program in most cases. The needs identified under retrieval are restricted to the particular waste form to be retrieved.

Each of the technology development needs areas that are marked in Table 5.5 has been further examined and divided into specific technology needs. For example, in situ measurement of physical properties in the Solid Waste Program has the following specific needs: analysis of bulk objects in

TABLE 5.5. Cross-Cutting Technology Development Needs

	<u>D&D</u>	<u>Environmental Restoration</u>	<u>Liquid Effluents</u>	<u>Nuclear Material</u>	<u>Solid Waste</u>	<u>Tanks</u>
Inventory Management						
Interim Stabilization/Conversion	X	X		X		
Repackaging/Enhanced Storage				X		
Waste Minimization			X			
Recycle/Reuse	X		X			
Characterization						
In Situ Measurement:						
chemical constituents	X	X	X		X	X
radiological constituents	X	X	X	X	X	X
physical properties	X	X			X	X
Sampling/Lab Analysis	X		X	X	X	X
Retrieval						
Soil/Groundwater		X				
Equipment/Facilities	X			X		X
Buried Waste					X	
Tank Waste						X
Partitioning/Separations						
Chemical	X	X	X		X	X
Biological		X	X			
Physical	X	X	X		X	X
Ex Situ Treatment						
Stabilization/Solidification		X	X	X	X	X
Destruction		X	X	X	X	X
In Situ Treatment						
Stabilization/Solidification		X			X	
Destruction		X			X	

the ground, ground-penetrating radar, and package integrity analysis. Similar specific needs have been identified for all areas marked with an X in the table.

5.4 CROSS-CUTTING SCIENCE AND TECHNOLOGY ISSUES

Several issues were raised during the various S&T workshops that appear to be cross-cutting in nature. These issues involve more than one mission area, and in most cases, derive from a particular mission area being held responsible for a waste problem that best fits in another mission area. For example, the ER Program (rather than the Solid Waste Program) is responsible for pre-1970 suspect plutonium-contaminated buried solid waste under CERCLA.

The foremost example of such a cross-cutting S&T issue relates to the inventory of pre-1970 suspect plutonium-contaminated buried waste at Hanford. The ER Problem Identification Workshop participants gave pre-1970 buried waste in the 200 Areas a score of 18, pre-1970 buried waste in the 100 Areas a score of 21, and pre-1970 buried waste in the 300 Area a score of 19. By contrast, the Solid Waste Problem Identification Workshop participants gave the pre-1970 buried waste a score of 51. This was, in fact, the highest-scoring problem on the Site. This discrepancy underscores the complexity and lack of information surrounding pre-1970 suspect plutonium-contaminated buried waste and the potential dangers of retrieval and treatment of this waste.

An example of good agreement between workshop results exists for irradiated fuel storage facilities. This waste category refers to the inventory of spent N-Reactor fuel stored in the K-Basins in the 100 Areas. The Nuclear Materials Problem Identification Workshop participants gave this problem a score of 41, based on their knowledge of the state of the irradiated fuel. At the D&D Problem Identification Workshop, the participants gave the irradiated fuel storage facilities (the K-Basins) a score of 41. Thus, it appears that there is good agreement between two of the Site mission areas regarding the seriousness of this problem area, even though one group focused on the waste and the other focused on the storage basins.

Another cross-cutting issue involves the responsibility for facility deactivation. Currently, it is the responsibility of each mission area to

deactivate its own facilities prior to transferring them to the D&D mission area for decontamination. There seems to be an issue of how much of the cleanup can be termed "deactivation" and how much can be termed "decommissioning."

There is another issue of questionable responsibility related to spent fuel in the burial grounds. Post-1970 buried waste is the responsibility of the solid waste mission area. However, other inventories of spent fuel on the Site belong to the nuclear materials mission area. Because the expertise to handle spent fuel resides in the nuclear materials mission area, it seems logical that they would be responsible for the buried spent fuel after it is retrieved. In fact, there should be a joint effort of the two mission areas to determine when and how to retrieve the buried spent fuel and what to do with it once it is retrieved.

Finally, there is a potential mission area interface issue related to disposition of contaminated soils. Projections show large material volumes generated by environmental restoration activities which are destined for onsite solid waste disposal. However, development and deployment of soil washing technology could potentially reduce the volume of solid waste requiring disposal. On the other hand, soil washing systems would produce liquid wastes that might impact other mission areas. The extent of any impact depends on the specific soil washing technology developed as well as the deployment method selected. One deployment method could treat and dispose of the resulting liquids as part of the ER mission area activities. Alternatively, soil washing liquid treatment and disposal could be integrated with similar systems in either the solid and liquid waste mission area (liquid effluent systems) or the TWRS mission area (low-level liquid waste solidification by the Grout Treatment Facility). These potential interactions between mission areas need to be addressed as soil treatment technology is developed and deployed by the ER mission area.

5.5 CONCLUSIONS REGARDING THE PROCESS

We have reached several conclusions related to the creation of a master list of potentially high-priority S&T needs. The tables showing numerical

prioritizations that were generated in the workshops provide an indication, based on several criteria, of why certain needs are considered to be high priority and why others are considered to be low priority. The mission-specific conclusions are discussed in the following sections of this document.

There were four main lessons learned regarding the process used for this S&T needs assessment activity. First, the prioritization process that we tested can be done, but is complex and time consuming. Second, S&T needs assessments can be compared across mission areas, and they can lead to meaningful results. However, care must be taken to use identical criteria and, if possible, similar numbers of functional needs categories. Third, the process will identify sure technology candidates (i.e., those that address high-priority problems and functional needs), but it may miss smaller opportunities for improving cost-effectiveness in areas of lesser importance. Fourth, many improvements of the process are possible, both in structuring and in the actual assessments.

The decision analysis team was aware of the fact that it stepped into new methodological territory. As it turned out, the process was successfully implemented, but at a higher cost than we had anticipated. We had originally planned only two workshops per mission area (i.e., one to prioritize problems and one to prioritize technologies). These two workshops gradually expanded to four, resulting in a total of 19 workshops that required a considerable amount of time from all the participants. Not all workshops were equally effective. For example, the second workshop on structuring strategies and functional needs overlapped somewhat with the TLD exercise that had been carried out earlier. If we had decided to evaluate multiple disposal strategies, we would have needed another series of workshops. Therefore, the entire exercise was limited to assessing needs for the 200-Area disposal strategy.

We are fairly certain that no truly unimportant technologies have been identified by this process. However, we cannot be sure that we did not miss some technologies that are outside the path of most importance, yet could yield significant payoffs by increasing effectiveness or reducing cost for a less-important functional need.

The effect of the number of functional needs categories will require further study. In one sense, "spreading the functional needs too thinly" should logically lead to lower technology priorities. However, participants should be made aware of this effect, and care should be taken to control and standardize the number of functional needs categories used.

Improvements are also possible in the methodology, based on lessons learned in the series of workshops. Many of the prioritizations are highly correlated; therefore, a simpler scheme for assigning priorities could be devised. By streamlining the process, the number of workshops could be reduced to two per mission area. The clarity and ease of use of the criteria should be improved. It would be useful to have a group of Hanford Site experts help develop the definitions for the criteria to be used. The role of the functional needs and the priorities assigned to them should be explored more carefully. Finally, alternative waste management strategies should be considered to examine whether they lead to alternative technology needs.

6.0 TANK WORKSHOP RESULTS

6.1 PROBLEMS

The physical problems associated with tank wastes at Hanford were structured into 18 problem areas within 3 major categories. The categories and problem areas are listed and briefly described below.

Single-Shell Tanks

chemically reactive tanks^(a)

1. 24 ferrocyanide tanks (potential for explosive mixtures of ferrocyanide)
2. 18 flammable-gas-accumulating tanks
3. 8 organics tanks (potential for runaway organic-nitrate reactions)
4. tanks with integrity problems (68 known leakers; all other SSTs can be considered potential leakers)
5. high-heat tank (refers mainly to water additions needed to cool Tank 106-C)
6. noxious-gas-generating tanks
7. high-fission-product tanks (mainly a heat-generation issue)
8. high-TRU tanks (refers to in-tank criticality issue)
9. low-level tank waste.

Double-Shell Tanks

10. chemically reactive tanks (i.e., six flammable-gas-accumulating tanks; refers mainly to Tank 101-SY)
11. high-fission-product tanks
12. high-TRU tanks
13. low-level tank wastes.

(a) Supplemented using information from WHC. 1993. Strategy Plan for Management of Hanford Tanks Wastes. WHC-EP-0501, Rev. 1.

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Underground Tank Structures^(a)

14. contaminated soil
15. SST shells
16. DST shells
17. ancillary equipment between tanks
18. miscellaneous tanks.

These 18 problems were scored against the 10 problem evaluation criteria presented in Section 4.2. The total scores received by each problem, as well as their intermediate scores on the individual criteria, are shown in Table 6.1. Each participant provided weights for the 10 problem criteria, and then the facilitator calculated the average normalized weights for each criterion (shown at the top of Table 6.1). The actual problem scoring was performed by dividing the participants into two working groups. One group focused on the three health and safety (H&S) criteria and land use and compliance. The other group focused on the three environmental criteria and cultural and public concerns.

Several assumptions were made during the process of scoring the tank waste problems:

- The problems were evaluated based on the disposal scenario in the 200 Areas.
- The problems were evaluated "as is" without applying any technology.
- All tank problems were assigned a score of 100 for land-use impacts, because the 200 Areas would not be accessible to the public if used as a disposal site.

(a) Problems include removal of residual waste (i.e., heel left in the tank after retrieval), D&D, and RCRA closure of the tanks. Remediation of the tank structures and underlying contaminated soils will ultimately be the responsibility of the ER Program.

TABLE 6.1. Tank Waste Problem Prioritization

		Normalized Weights									
		0.19	0.16	0.15	0.07	0.11	0.08	0.04	0.04	0.08	0.09
		Problem Criteria									
Tank Waste Problems	Total Score	Health and Safety Short Term	Health and Safety Long Term	Health and Safety Future Gen.	Surface Water	Groundwater	Soil	Land Use	Cultural Concern	Public Concern	Regulatory Compliance
Single-Shell Tanks											
Chemically Reactive Tanks											
Ferrocyanide Tanks	40	5	5	100	20	5	30	100	0	90	100
Hydrogen-Generating Tanks	40	5	5	100	20	5	30	100	0	90	100
Organics Tanks	40	5	5	100	20	5	30	100	0	90	100
High-TRU Tanks	30	0	0	100	0	0	10	100	0	30	100
Tanks with Integrity Problems	42	0	1	100	2	2	100	100	0	80	100
High-Fission-Products Tanks	30	0	0	100	0	0	10	100	0	30	100
High-Heat Tank (106-C)	34	0	0	100	1	1	40	100	0	50	100
Noxious-Gas-Generating Tanks	34	10	10	100	0	0	10	100	0	30	100
Low-Level Tank Waste	29	0	0	100	0	0	10	100	0	20	100
Double-Shell Tanks											
Chemically Reactive Tanks	38	7	7	100	20	30	30	100	0	100	25
High-TRU Tanks	24	0	0	100	0	0	10	100	0	30	25
High-Fission-Products Tanks	24	0	0	100	0	0	10	100	0	30	25
Low-Level Tank Waste	23	0	0	100	0	0	10	100	0	20	25
Underground Tank Structures											
Double-Shell Tank Material	7	0	0	5	0	1	5	100	0	20	10

TABLE 6.1. (contd)

		Normalized Weights									
		0.19	0.16	0.15	0.07	0.11	0.08	0.04	0.04	0.08	0.09
		Problem Criteria									
Tank Waste Problems	Total Score	Health and Safety Short Term	Health and Safety Long Term	Health and Safety Future Gen.	Surface Water	Groundwater	Soil	Land Use	Cultural Concern	Public Concern	Regulatory Compliance
Single-Shell Tank Material	7	0	0	5	0	1	5	100	0	20	10
Ancillary Equipment Between Tanks	7	0	0	0	1	1	5	100	0	20	10
Contaminated Soil	15	0	1	5	5	2	0	100	0	20	100
Miscellaneous Tanks	10	0	0	3	0	1	5	100	0	20	40

- DSTs and SSTs include mixed waste (i.e., radionuclides and hazardous chemicals). The hazardous constituents are assumed to maintain their integrity indefinitely. Radionuclides will eventually decay to more stable isotopes, and, thus, represent minimal H&S hazards to future generations.
- All DSTs and SSTs are assumed to pose a H&S risk to future generations if no action is taken (score = 100). This risk is primarily due to the hazardous constituents in the waste, as the radionuclides will have decayed to more stable isotopes.
- Air emissions are assumed to be included in the near-term H&S criterion rather than as a separate criterion.
- The surface water, soil, and groundwater criteria represent ecological impacts rather than human health impacts. Soil contamination is assumed to eventually reach the groundwater. Contamination from airborne releases is assumed to eventually reach surface water.
- Compliance scores represent problems where Hanford is currently out of compliance or will likely be out of compliance in the future if nothing is done. All SSTs were given a score of 100 because they are currently out of compliance. DSTs were given a score of 25, as they will eventually be out of compliance if no action is taken.
- The problems related to underground tank structures include waste residuals, D&D, and RCRA tank closures.
- External pressures on Hanford to do more tank characterization will likely result in more workers being exposed to toxic vapors.
- The high-heat SST (Tank 106-C) is a H&S problem for future generations (not a near-term or long-term problem as defined in Section 4.2) and only if it eventually leaks and the waste gets to the groundwater.
- Surface water contamination could result from fallout due to catastrophic failure of chemically reactive tanks or malfunctioning filters on vents, or from migration of contaminants in the groundwater to the river.
- Soil contamination could result from catastrophic failure of chemically reactive tanks, leaking tanks, or contaminated equipment moving around the Site.

As shown in Table 6.1, the workshop participants ranked the tank waste problems as follows:

1. SSTs with integrity problems (total score = 42). There is considerable public concern (score = 80). Several of these tanks have contaminated the underlying soil (score = 100).
2. Chemically reactive SSTs and DSTs (total SST score = 40, total DST score = 38). There is significant public concern regarding the potential for environmental contamination due to an accidental release (e.g., an explosion). There is some risk of resulting contamination to soil, surface water, and groundwater if such a release occurs, but only a small probability exists that any tank will actually rupture.
3. Noxious-gas-generating SSTs (total score = 34) and high-heat SST (Tank 106-C, total score = 34). Some tanks may be generating and periodically releasing noxious gases that pose short-term H&S risks to workers (mitigated by the fact that workers are required to be on fresh air whenever they are near these tanks). Equipment moving in and out of the area to investigate the problem may spread contamination to soil. The most significant concern for the high-heat SST is for possible soil contamination in the event of a leak.
4. High-fission-product SSTs (total score = 30), high-TRU SSTs (total score = 30), low-level SST wastes (total score = 29), high-fission-product DSTs (total score = 24), high-TRU DSTs (total score = 24), and low-level DST wastes (total score = 23). There is public concern about these tank wastes. Future H&S risks for low-level tank waste refer to the hazardous constituents rather than the radionuclides.
5. Underground tank structures including contaminated soil (total score = 15), miscellaneous tanks, DST shells, SST shells, and ancillary equipment between tanks (total scores of 10 or less). Contaminated soil was given a higher overall score because it is out of compliance. However, H&S and other environmental impacts were assumed to be very low because none of the contaminants in the soil have migrated to the groundwater.

A number of generic issues were also identified at the workshops. Opinions expressed on the resolution of these issues are described below.

- End-state issue. Disposal in the 200 Areas should be the chosen option. Even if the tank waste is treated offsite, some portion will be disposed of onsite in the 200 Areas.
- In situ treatment issue. In situ treatment of tank waste eliminates the needs for ex situ pretreatment, transportation of the waste, and construction of large facilities such as grout plants,

grout vaults, and vitrification plants. In situ treatment is a likely candidate for residual wastes left in the tank following the retrieval process.

- Waste form specification. Technologies for disposal form conversion must be able to handle a wide range of input streams. New treatment methods will need to be developed for those streams that glass and grout are not capable of handling.
- Predictive modeling of tank waste chemistry. Technology performance issues must be resolved with a scientific basis. This is especially true for resolution of safety issues, or it may be possible to engage in quick fixes that actually make the problem worse. Small-scale experiments based on surrogate wastes may be a timely and cost-effective approach. Elements of both modeling and laboratory testing need to be pursued, particularly in light of current uncertainties about the explosive potential of the chemically reactive tanks.

6.2 FUNCTIONAL NEEDS

Subsequent workshops were held to identify, structure, and prioritize functional needs associated with tank waste remediation. The corresponding functional needs diagram developed for tank waste remediation is shown in Figure 6.1. Functional needs are defined as programmatic needs requiring the application of technology. Dividing the overall tank waste remediation problem into a series of functional needs helps determine where technology improvements (e.g., in performance, safety, cost, timeliness) would be most beneficial to the overall system. The functional needs defined by the workshop participants are listed below.

- Existing storage management. Activities to ensure safe storage and interim stabilization of "watch list" tanks and to safely maintain, upgrade, and operate tank farm facilities.
- In situ measurement. Activities associated with measuring the radionuclide, chemical, and physical properties of tank wastes at or very near the tank.
- Laboratory/field sampling, analysis, and testing. Activities associated with determining the radionuclide, chemical, and physical properties of materials at offsite and onsite laboratories or at mobile labs near the tanks.

FIGURE 6.1. Overview of Tank Waste Functional Needs

- Material retrieval. Activities associated with physical removal of inventories from the tanks for subsequent processing and disposition.
- Retrieved material staging. Physical storage and stabilization of tank wastes prior to entering final waste form conversion facilities.
- Partitioning. Activities associated with separation and stabilization of tank wastes prior to conversion to final waste forms.
- Disposal form conversion. Activities to convert tank wastes to stable waste forms.
- HLW packaging, storage, and shipment. Activities associated with transporting HLW forms to offsite locations for final disposition.
- LLW packaging and disposal. Activities associated with transporting and disposing of LLW forms either offsite or onsite.

The HIPP workshop participants prioritized these functional needs using the criteria described in Section 4.2, and the results are shown in Table 6.2. It should be noted that the functional needs were defined prior to initiation of the TWRS program rebaselining activity, and functional needs do not directly correspond to existing TWRS program elements.^(a) However, the TWRS

(a) The TWRS program is tasked with ensuring that Hanford tank wastes are effectively remediated. The TWRS Integrated Technology Plan (DOE/RL 1993) defines the technologies required to fulfill this mission.

program elements include all of the functional needs listed above. The results of the HIPP functional needs ranking and the corresponding TWRS program elements are as follows:

HIPP Score	HIPP Functional Need	TWRS Program Element
23	Partitioning	Pretreatment
20	Disposal Form Conversion	HLW Immobilization and LLW Immobilization and Disposal
15	In Situ Measurement	Characterization
14	Materials Retrieval	Retrieval
11	Laboratory/Field Sampling, Analysis, Testing	Characterization
6	LLW Packaging and Disposal	LLW Immobilization and Disposal
5	HLW Packaging, Storage, Shipment	HLW Immobilization
4	Retrieved Material Staging	Retrieval
3	Existing Storage Management	Waste Tank Safety and Operations

TABLE 6.2. Tank Waste Functional Needs Prioritization

		Normalized Weights			
		0.25	0.25	0.25	0.25
		Functional Needs Criteria			
Functional Needs	Total Score	Gaps/ Missing Technologies	Urgency/ Timeliness	Cost Reduction Potential	Effective Increase Potential
Existing Storage Management	3	3	5	3	2
In Situ Measurement	15	13	16	16	14
Laboratory Field Analysis	11	12	14	10	10
Material Retrieval	14	14	13	17	10
Retrieved Material Staging	4	4	5	2	4
Partitioning	23	26	18	22	25
Disposal Form Conversion	20	16	20	20	23
HLW Packaging, Storage, and Shipment	5	5	5	6	5
LLW Packaging and Disposal	6	5	5	5	7

Technology development to support HIPP functional needs and corresponding TWRS program elements is based on the TWRS proposed new technical strategy (NTS). The NTS requires development of two bounding technology paths for sludge treatment. It also mandates proceeding as fast as practicable to pretreat the supernatants and soluble saltcakes. As the two bounding approaches are evaluated, an optimized approach will likely emerge between the two approaches. The two bounding approaches as described in the TWRS Integrated Technology Plan (DOE/RL 1993) are as follows:

- Extensive separations. Yet-to-be developed technologies separate the tank waste into a small-volume HLW fraction and a large-volume LLW fraction. The HLW is processed into glass in a vitrification plant smaller than the HWVP. The LLW fraction radionuclide concentration is within 10 CFR 61 Class A waste limits, with reduced chemical toxicity, and is disposed of onsite as grout. Under this approach, a variant is used to solidify the waste at Hanford and then ship it to another DOE site (e.g., Savannah River) for vitrification.
- High-capacity vitrification. Current technologies separate the tank waste into HLW and LLW fractions. A melter capacity greater than the currently sized HWVP melter immobilizes the larger volume of HLW. This increased vitrification capacity is achieved by developing a new high-capacity melter or by increasing the HWVP melter to 3 to 5 times its current capacity. A new large-capacity melter is developed to vitrify the LLW to produce an improved LLW form for onsite disposal. HLW vitrification is accomplished either in a separate facility or in a common facility with the LLW vitrification system. The LLW fraction meets regulatory requirements but contains higher radionuclide concentrations than the LLW fraction in the extensive separations approach.

Drivers of technology development for existing storage management are strongly linked to the type of tank problem (e.g., whether the tank is a leaking tank or a chemically reactive tank). The overall TWRS remediation strategy is a phased approach. Tank retrieval sequence strongly influences the technology development priorities for tank waste remediation and disposal.

6.3 TECHNOLOGIES

The HIPP S&T Needs Assessment Team did not conduct a Technology Prioritization Workshop for the tank mission area. An integrated list of the

high-priority technology needs across TWRS program elements, as developed in the TWRS Integrated Technology Plan (DOE/RL 1993), is provided below:

Priority 1: Resolve Tank Safety Issues

The Priority 1 activities include the following:

- technologies to evaluate and/or mitigate flammable gas, vapor releases, ferrocyanide, organic materials, and high-heat tanks (waste tank safety)
- technologies to automatically acquire, store, and manage tank safety and operations data; perform structural integrity evaluations of SSTs; and develop models for predicting, evaluating, and controlling corrosion problems in SSTs (waste tank operations)
- technologies for sampling hard saltcake, gathering physical and radiochemical data in situ, and sampling tank sludges and gases (characterization)
- technologies required to initiate retrieval of Tank 241-SY-101 and to create tank space, including waste transport and mixer pump retrieval systems for DSTs, and a first-generation long-reach arm (LRA) system for SSTs (retrieval)
- technologies to initiate Phase 1 (see definitions in Section 6.3.1) of pretreatment, focused on organic/ferrocyanide destruction for tank safety issue resolution (pretreatment)
- technologies required to effectively dispose of selected watch list tanks by grouting them (LLW).

Priority 2: Initiate Disposal of Supernatant and Saltcake LLW Fraction

The Priority 2 activities include the following:

- technologies for corrosion control, enhanced leak detection, improved DST designs, and structural evaluations intended to enhance the TWRS program's ability to meet compliance issues related to tank structures (waste tank operations)
- technologies required for screening core samples in hot cells to significantly accelerate tank waste characterization and moving hot cell technology into the tanks (characterization)

- technologies for safely retrieving tank waste from leaking tanks (long-arm retrieval system, barriers, and limited sluicing capabilities) and for retrieving saltcake and other waste from tanks with in-tank hardware, including deploying a first-generation mechanical arm in the tanks (retrieval)
- technologies for pretreatment Phases 2 and 3 (early pretreatment and supernatant/saltcake pretreatment), including process chemistry development for early pretreatment and technologies required for removing cesium and other radionuclides from LLW streams (to class A limits), enhancements for organic/ferrocyanide destruction, technetium removal, nitrate destruction, and solid/liquid separation (pretreatment)
- enhancements to grout technology, including enhanced characterization, process formulation and facility/process evaluation, quality verification methods, barrier and disposal systems, performance assessment methods, and integrated waste form flowsheets (LLW).

Priority 3: Provide Data for Selecting a HLW Pretreatment and Immobilization Strategy for Sludge Wastes

The Priority 3 activities include the following:

- technologies for Phase 4 pretreatment (sludge pretreatment), including sludge washing and selective leaching, sludge dissolution, and radionuclide separation by solvent extraction or alternative processes (pretreatment)
- technologies to support development and testing of 10-, 20-, and 100-ton per day (tpd) high-capacity melter systems and associated glass waste form development (LLW and HLW).

Priority 4: Reduce Technical Uncertainty and Cost by Developing Enhancements and Alternative System Technologies

The Priority 4 activities include the following:

- additional technologies for evaluating and defining high-heat tanks, developing hydroxide consumption models, evaluating and mitigating flammable gas or organic tanks, and evaluating miscellaneous underground tanks that contain radioactive waste (waste tank safety)
- enhancements for detecting tank leaks and removing the remaining liquids (waste tank operations)

- enhancements and alternative system technologies for in situ analysis of tank waste, including tank vapor space analysis and in situ moisture and radiochemical analysis and their deployment systems (characterization)
- enhancements and alternative system technologies for retrieving tank waste, including enhanced end-effectors for the second-generation mechanical arm, nonleaking fluids (to avoid tank leaks during hydraulic sluicing), and feasibility studies for both alternative retrieval systems (retrieval)
- additional technologies for organic/ferrocyanide destruction, nitrate destruction, chemical recycle, inert separations, and additional capabilities for early pretreatment process development and deployment (pretreatment)
- evaluation of alternative LLW forms other than grout and glass (LLW)
- HWVP technology development (HLW).

Technology needs have been defined in detail for each of the TWRS program elements. Diagrams of the functional needs, functions, and supporting technologies to meet the NTS are contained in Appendix B. These diagrams were developed for the TWRS Integrated Technology Plan (DOE/RL 1993). The technologies presented in these diagrams are described (in order of HIPP functional need priority) in the following sections.

6.3.1 Partitioning Technologies

Technologies that should be considered for further development are listed in Table 6.3. Partitioning or pretreatment was ranked as the highest-priority functional need at the HIPP Functional Needs Prioritization Workshop. The purposes of pretreatment are to resolve tank safety issues and to separate tank wastes into high- and low-activity fractions that constitute acceptable feeds for the HLW and LLW immobilization processes. Pretreatment will be conducted in four phases:

- Phase 1: Tank Safety Issue Resolution - Destroy ferrocyanide and organic complexants in tanks
- Phase 2: Early Pretreatment - Provide additional tank space and reduce the concentration of radionuclides in the early grout feed to 10 CFR 61 Class A Limits (or better)

TABLE 6.3. High-Priority Technology Needs for Pretreatment

Function	Technology Development Activity
Organic/Ferrocyanide Destruction (Phase 1)	Technology evaluation and selection Test selected process
Radionuclide Removal (Phase 2) <ul style="list-style-type: none"> • Alkaline-side cesium • Removal of other radionuclides 	Ion exchange media selection for cesium removal Feasibility studies and process flowsheet development Early demonstration of CPUs
Organic Materials Destruction (Phase 2 and 3)	Technology evaluation and selection Testing of selected processes
Solid/Liquid Separation (Phase 3)	Gravity settling rate and efficiency in large tanks Process control
Radionuclide Removal (Phase 3) <ul style="list-style-type: none"> • Alkaline-side cesium • Alkaline-side TRU • Alkaline-side technetium • Alkaline-side strontium 	Ion exchange media selection for cesium removal Feasibility studies and process flowsheet development
Nitrate Destruction/Recycle (Phase 3)	Screen candidate processes Laboratory-scale feasibility studies Bench- and confirmation-scale pilot tests Flowsheet development Final specifications for plant design
Chemical Recycle (Phase 3)	No FY 1993 activities identified
Hazardous Materials Removal (Phase 3)	Establish adequacy of organic destruction to resolve tank safety issue Evaluate effect of pretreatment processes on organic content of LLW streams
(Enhancement) Aluminum and Sodium Removal (Phase 3)	Evaluate two candidate processes

TABLE 6.3. (contd)

Function	Technology Development Activity
Sludge Washing and Leaching (Phase 4)	<p>Determine washing efficiency</p> <p>Develop process control</p> <p>Evaluate blending enhancements that would be synergistic with selective leaching</p> <p>Complete blending study to examine benefits</p> <p>Update blending study to incorporate characterization and pretreatment data improvements</p> <p>Waste form composition range must be expanded for grout</p> <p>Identify and prioritize wastes that would benefit from leaching processes</p> <p>Conduct feasibility and/or confirmation studies on selected wastes with selective leaching</p>
Sludge Dissolution (Phase 4)	<p>Evaluate acidic and fusion dissolution methods for water-washed sludges</p> <p>Characterize mineral species in sludges to select dissolution procedure</p> <p>Develop modeling techniques for predicting dissolution behavior (to limit testing requirements)</p>
Radionuclide Removal <ul style="list-style-type: none"> • Acid-side TRU • Acid-side cesium • Acid-side strontium • Acid-side technetium 	<p>Screen candidate processes</p> <p>Laboratory-scale feasibility studies</p> <p>Bench- and confirmation-scale pilot tests</p> <p>Flowsheet development</p> <p>Final specifications for plant design</p>
Uranium Removal	Establish basis for removal
Iodine Removal	Conduct feasibility studies
Inerts Removal <ul style="list-style-type: none"> • Actinide/lanthanide • Barium/strontium 	<p>Establish basis for removal</p> <p>Conduct feasibility studies</p>
Recovery of Noble Metals (Phase 4 Enhancement)	No FY 1993 activities identified
Calcination and Leaching (Alternative)	<p>Complete systems study to further evaluate concept</p> <ul style="list-style-type: none"> • Alkaline-side cesium removal

TABLE 6.3. (contd)

Function	Technology Development Activity
Bulk Leaching (Alternative)	<ul style="list-style-type: none"> • Identify incentives for blending or bulk treatment processes • Complete feasibility studies on candidate bulk processes • Complete systems study to further evaluate concept • Alkaline-side cesium removal

Phase 3: Supernatant and Saltcake Treatment - Deploy full pretreatment capability for supernatants, sludge wash solutions, and dissolved saltcakes

Phase 4: Sludge Pretreatment - Decontaminate sludges to allow for disposal in the LLW product stream. Sludge treatment technologies are less developed than technologies required for decontamination of supernatants.

TWRS functions for each of these phases and bounding alternatives are defined in the TWRS Integrated Technology Plan (DOE/RL 1993) and are listed as follows:

- Organic Destruction (Phase 1)--Use near-term, moderately efficient process to breakdown organic compounds to reduce hydrogen-generating constituents.
- Ferrocyanide Destruction (Phase 1)--Investigate oxidation processes and hydrolysis to break ferrocyanide down into nonhazardous materials before waste disposal.
- Alkaline-Side Cs Removal (Phases 2 and 3)^(a)--Convert to harmless by-products using hydrothermal processing, steam reforming, ozonation, and calcination.
- Alkaline-Side Cs Removal (Phases 2 and 3)^(a)--Remove using well-known cation-exchange processes.

(a) These functions are required for the high-capacity vitrification approach. All functions are required for the extensive separations approach.

- Removal of Other Radionuclides (Phases 2 and 3)^(a)--
 - TRU: Remove from alkaline solutions (precipitation and sorption) and from acidified supernatants and saltcakes (e.g., solvent extraction).
 - Sr: Remove using precipitation or sorption processes.
 - Tc: Remove from alkaline solutions using strong base anion resins as well as other candidate processes.
- Organic Materials Destruction (Phase 2)^(a)--Destroy organic complexants to promote precipitation of previously complexed elements (e.g., TRU, ⁹⁰Sr) from alkaline solution.
- Nitrate Removal/Destruction (Phase 3)--Recover and reuse nitric acid from pretreatment processes.
- Chemical Recycle (Phase 3)--Recycle chemically large quantities of nonradioactive chemicals from wastes and processes.
- Hazardous Materials Removal (Phase 3)--Remove hazardous materials and treat RCRA heavy metals from the LLW feed stream, as might be necessary.
- Aluminum/Sodium Removal (Phase 3 Enhancement)--Remove from the supernatant before cesium removal to avoid fouling of ion-exchange resin.
- Solid/Liquid Separation (Phases 3 and 4)^(a)--Remove undissolved solids from the acids.
- Sludge Washing and Leaching (Phase 4)^(a)--Wash sludge in tank to remove water-soluble non-TRU compounds (e.g., cesium, sodium, potassium) by successive mixing with water. Blend or mix sludges with similar contents to provide feeds with better characteristics. Selectively leach to remove
 - radionuclides (e.g., cesium, technetium) or metals that are regulated in near-surface disposal processes
 - components that have a deleterious effect on waste glass formulation (e.g., phosphates, sulfates and chromates).
- Sludge Dissolution (Phase 4)--Dissolve in an acid (such as nitric acid).

(a) These functions are required for the high-capacity vitrification approach. All functions are required for the extensive separations approach.

- Radionuclide Removal (Acid Side) (Phase 4):
 - TRU, Sr: Remove radionuclides from dissolved sludges.
 - Cs: Remove especially from ferrocyanide tanks that may still contain 30% to 50% of the cesium after sludge washing.
 - Tc: Remove pertechnetate, a relatively mobile component in grout.
 - U: Recover uranium to improve the environmental acceptability of the grout.
 - I: Remove and isolate for disposal in some other waste form if sufficiently high levels of iodine are present.
- Inerts Removal (Phase 4)--Co-extract actinides/lanthanides in the TRU separation step. Co-extract nonradioactive barium with strontium.
- Recovery of Noble Metals (Phase 4 Enhancement)--Recover noble metals from the glass feed (sent to LLW for immobilization and disposal).
- Calcination and Leaching (Alternative Technology)--Calcinate and leach to destroy organics and nitrates and convert solid materials to their oxide states.
- Bulk Leaching (Alternative Technology)--Use bulk leaching to remove components from bulk solids that can be easily separated from the radionuclide-contaminated waste (e.g., aluminum, zirconium, iron).

6.3.2 Disposal Form Conversion Technologies

Disposal form conversion was ranked as the second highest-priority functional need. It is equivalent to the combination of the TWRS HLW immobilization and LLW immobilization and disposal program elements. Technology needs are listed in Tables 6.4 and 6.5.

The purpose of low-level radioactive waste immobilization and disposal is to immobilize and dispose of LLW either directly from stored tank waste or as a waste stream from pretreatment. The objectives are to develop and implement the grout LLW form to meet near-term needs and to develop an alternative LLW form, assumed to be a vitrified waste form using a high-capacity melter.

TABLE 6.4. High-Priority Technology Needs for Low-Level Radioactive Waste Immobilization and Disposal

Function	Technology Development Activity
Feed Tanks Characterization	Characterize candidate tanks and feed tank, with emphasis on analytical measurement sensitivity for organic materials
Formulation Development (for each tank)	Design blend of cementitious materials added to the waste Test on stimulants and waste samples
Quality Verification	Develop alternative nondestructive techniques to confirm quality of grout product and reduce costs
Performance Assessment	Evaluate the long-term behavior of the waste form and disposal facility, using flow and transport computer modeling
Glass Waste Form Development	Conduct testing to support waste form selection
Enhanced Characterization	Evaluate new methods of analyzing organic, inorganic, and radiochemical species Evaluate new methods of conducting waste sampling Evaluate capability to improve data management
Enhanced Process Formulation and Facilities	Establish formulation algorithms Establish acceptable formulation envelope Define technical bases for waste feed specifications controlled by formulation Define and develop methods of long-term durability Evaluate facility and process for capability to allow greater throughput and waste modification
Enhanced Quality Verification Methods	Evaluate in situ and in-line processes for sampling and analyzing process feed and product Evaluate control systems using real-time feedback of analyses to control product quality
Integrated Pretreatment Flowsheets	Evaluate LLW disposal in terms of performance objectives and provide guidance to TWRS Program
Enhanced Engineered Structures	Evaluate aggressive barrier systems Evaluate aggressive vault designs Test asphalt for material compatibility with RCRA requirements (9090 tests) Develop materials with an enhanced durability

TABLE 6.4. (contd)

Function	Technology Development Activity
Enhanced Performance Assessment Methodology	<p>Acquire and verify regional geological and hydrologic properties</p> <p>Acquire hydraulic properties of disposal system components including barriers, vaults, and waste form</p> <p>Evaluate field measurements relative to laboratory results</p> <p>Validate flow and transport model results</p>
Alternate Waste Form	Conduct testing to support waste form selection
Alternate Processes/Disposal Systems	Conduct testing to support LLW processes/disposal system concepts

The key functions for LLW immobilization and disposal under the high-capacity vitrification approach of the proposed NTS are similar to HLW immobilization. The key functions for LLW immobilization and disposal under the extensive separations approach, which retains grout as the LLW form, are indicated below.

- **Blending and Retrieval.** LLW is transferred from the tank farm to the LLW immobilization feed tank, where it is blended with other wastes and characterized to meet particular feed processing requirements.
- **Characterization.** This is a two-step process. Candidate waste material is sampled and analyzed in the tank farms to ensure that the feed will meet regulatory and technical criteria. Then, the waste is transferred to the LLW immobilization feed tank, where it is blended and sampled again for record purposes.
- **Waste Form Development.** The grout waste form is made by mixing the waste with a blend of cementitious materials including cement, fly ash, slag, and clay. The resulting slurry cures to a solid waste form. In this function, the blend is tailored to the waste to attain a grout that meets processing specifications and waste form criteria.

TABLE 6.5. High-Priority Technology Needs for High-Level Radioactive Waste Immobilization and Disposal

Function	Technology Development Activity
Receipt and Feed Preparation	Glass composition envelope definition Feed chemistry and/or rheology evaluation Radioactive process and/or product laboratory testing Feed characterization and processing assessment Enhanced feed preparation
Immobilization Process	Melter and waste formulation candidate selection Melter performance assessment Vitrification system testing Waste form qualification strategy
Process Control and Analytical Support	Process and/or product model development Analytical methods evaluation Enhanced process control and analytical methods
Waste Effluent Treatment	Equipment development Instrumentation and controls development Enhanced offgas and waste treatment
Packaging	Canister product qualification Large canister development
Alternative Immobilization Processes	Systems analysis studies for alternate waste forms Systems analysis studies for alternate immobilization processes
Alternative Packaging	Systems analysis studies for alternate waste packages

- **Waste Form Processing.** This function entails the processing of waste feed materials to form a product suitable for disposal. Dry materials blended specifically for the waste to be immobilized are mixed with the waste in a continuous process, and the resulting slurry is pumped to the disposal facility.
- **Transportation.** The product from the LLW immobilization facility is transported to the disposal vault. The slurry is pumped from a process surge tank through a pipeline to an underground vault.
- **Disposal.** The immobilized LLW is disposed of in near-surface vaults. The slurry cures in large (6000 m³ [1.6-Mgal]) underground vaults constructed of reinforced concrete. The vaults are designed to meet RCRA surface impoundment requirements and are covered by

several barriers which prevent physical intrusion, divert water and/or precipitation, and inhibit water vapor and contaminant diffusion.

The purpose of HLW immobilization is to convert the highly radioactive waste in Hanford tanks into a solid form suitable for interim onsite storage and ultimate disposal at an offsite geologic repository. This includes ensuring production of an acceptable waste form for disposal and demonstrating technology suitable for vitrification of all HLW and LLW in Hanford DSTs and SSTs. The proposed NTS for extensive separations is an extension of the current HWVP technology support program (2.4-tpd melter). The high-capacity vitrification system will be an adaptation of currently available melter system technologies and/or development of additional melter system technologies to meet capacity targets ranging from 10 to 100 tpd.

The key TWRS functions for HLW immobilization are as follows:

- Interim Storage and Characterization. This function provides the interface with the source of pretreated waste feed for processing.
- Receipt and Feed Preparation. This function prepares the feed for the immobilization process, including concentration, chemical additions and blending, reduction-oxidation adjustments, and frit formulation and addition.
- Immobilization Process. This function converts the waste to a stable form suitable for interim storage, transportation, and disposal. Processing involves changing the physical state of the waste to a stable, consolidated solid form.
- Process Control and Analytical Support. This function monitors and controls the process to ensure acceptable product composition by applying sampling plans and batching algorithms and includes methods of performing analyses on process samples.
- Waste Effluent Treatment. This function addresses gaseous, liquid, and potentially secondary solid waste effluent streams that result from the processes involved. Abatement and treatment technologies, as well as recycle of these streams, are included in this function.
- Packaging. This function packages the waste form into a container suitable for storage, handling, and transportation. Closure, sealing, and any necessary decontamination of the container are included in this function. Materials handling and transfer systems are also included.

- Interim Storage. This function stores waste containers on the Hanford Site before shipment to a geologic repository. The duration of the storage period affects the technical requirements and provisions that this function must provide.

There are approximately 1900 6.7-cm-diameter by 52-cm-long capsules that contain 160 MCi of ^{90}Sr and ^{137}Cs salts, doubly encapsulated in metal containers and stored in water basins. According to the 1981 ROD (53 FR 12449), ^{90}Sr and ^{137}Cs capsules will be packaged and disposed in a geologic repository. The plan to overpack the cesium and strontium capsules and ship them to the geologic repository may not meet the yet-to-be developed repository waste acceptance specifications, thereby requiring a different waste form.

6.3.3 In Situ Measurement

In situ measurement ranked as the third highest-priority functional need. This is equivalent to the following TWRS Characterization Program functions:

- Hot cell nondestructive assessments to rapidly scan core samples in a hot cell, allowing information to be obtained with a minimum of sample preparation
- In situ chemical and radiochemical measurement technologies to apply techniques that work well in the hot cell to the tank environment.

Technology needs are listed in Table 6.6.

6.3.4 Material Retrieval

Material retrieval was the fourth highest-priority functional need. The purpose of retrieval is to provide the necessary processes and equipment to remove the waste stored in the SSTs and DSTs, then transport the waste directly to treatment facilities or to interim DST storage. The technology development strategy is to maximize the use of existing equipment and facilities to reduce development costs and minimize schedule delays to the program. Technology needs are shown in Table 6.7. The primary and enabling functions associated with the retrieval of waste from the tanks are described below:

- Characterize Tank Waste. Visually examine for the presence of in-tank hardware (where possible) for structural integrity, and other characteristics that will affect retrieval.

TABLE 6.6. High-Priority Technology Needs for In Situ Measurement

Function	Technology Development Activity
In Situ Analysis: Physical	Acoustic wave guide
Laboratory Analysis: Nondestructive Analysis Hot Cell Scanning	Remote Raman spectroscopy Remote infrared/near infrared spectroscopy Gamma energy analysis core scanning Laser ablation/mass spectrometer
In Situ Analysis: Chemical	Remote Raman/fourier transform spectroscopy
In Situ Analysis: Radiochemical	Passive copper foil neutron activation with spectrometer Passive and induced gamma scanning Assays by CdTe detectors Field mobile screening laboratory

- Access Tank. Additional risers may be required.
- Mobilize Waste. Slurry with water, mix with a pump, suspend in an air stream, or agitate (e.g., some wastes may also require cutting or impacting to break them up for mobilization).
- Remove In-Tank Hardware. Cut and remove (or store in tank) components installed or disposed of in the tank (e.g., air lift circulators or thermocouple trees, other).
- Convey Waste. Convey to remove waste from the tank using hydraulic (e.g., pumps) or pneumatic methods. Remove in-tank hardware with mechanical elevators.
- Process Waste. Mix, slurry, delump, dissolve, or dilute waste to meet criteria for transporting it.
- Transport Waste. Transport waste from the tank site to the storage or treatment facility through double-encased pipe or other means of conveyance.

ENABLING FUNCTIONS

- Deploy System. Install, move, and remove retrieval equipment inside tank.

TABLE 6.7. High-Priority Technology Needs for Retrieval

Function	Technology Development Activity
Mobilize Waste: DST Mixer Pump - Scaled Experiments	<p>Conduct scaled experiments to determine effects on performance of the following:</p> <ul style="list-style-type: none"> • Pump power • Jet velocities • Number of pumps • Pump configuration <p>Determine correlations between 1/12- and 1/4-scale test facilities and DSTs</p>
Protect Tank: DST Mixer Pump - Scaled Experiments	<p>Complete structural analysis</p> <p>Perform erosion tests for expected metal loss from fluid jets</p> <p>Perform corrosion tests to support in-tank sludge washing</p>
Control Tank Environment: DST Mixer Pump - Numerical Simulations	Conduct aerosol generation tests
Monitor Process: DST Mixer Pump - Instrumentation Development	<p>Install and test effectiveness of laboratory-tested ultrasonic probe</p> <p>Identify alternative systems suitable for monitoring mobilization, solids settling, and slurry uniformity</p> <p>Develop and demonstrate cone penetrometer and shear vanes for evaluating slurry properties</p>
Mobilize Waste and Convey Waste: SST 1st Generation Long-Reach Arm - End Effector Development and Testing	<p>End effector development:</p> <ul style="list-style-type: none"> • Mechanical agitator with pneumatic conveyor • Scarifier with pneumatic conveyor
Control System: SST 1st Generation Long-Reach Arm Retrieval - Control System and Sensor Development	<p>Graphical real-time control</p> <p>Fault detection/error recovery</p> <p>Path planning</p> <p>Sensor data integration</p> <p>Real-time controls</p>
Deploy System: SST 1st Generation Long-Reach Arm - Base System Development	Complete testing for procurement specifications place procurement for cold system test
Mobilize Waste: SST Waste Simulant Development	Develop and validate waste simulants for major waste types
Waste Transport: SST/DST Full-Scale Pipe Tests and Flow Models	Full-scale pipe tests for Newtonian and non-Newtonian fluids. Develop computer codes for predicting flow characteristics
Mobilize Waste: DST Mixer Pump System Improvements	<p>Develop and test mixer pump nozzle design</p> <p>Develop and test special pump design to reduce tank heel</p>

TABLE 6.7. (contd)

Function	Technology Development Activity
Confine Waste: SST Hydraulic Sluicing Using Nonleaking Fluids	Develop, test, and demonstrate nonleaking fluids
Mobilize Waste: SST Second Generation Sluicing	Develop, test, and demonstrate limited or other sluicing methods and specialized sluicing nozzles
Control System: SST Second Generation Long-Reach Arm-Enhanced Control System and Sensor Development	Work space modeling Dynamic control
Mobilize Waste (saltcake) and Remove In-Tank Hardware: SST Second Generation Long-Reach Arm-Enhanced End Effectors	End effector development: <ul style="list-style-type: none">• Cutters with vision and sensing capabilities• Water cannon (or other fluid) with pneumatic conveyor Hydraulic jets with jet pump conveyor
Confine Waste: SST Barrier Development	System feasibility study for subsurface barriers Tank leak feasibility study
SST Mixer Pumps with Stop Leak Gel	Feasibility study
Dry Mining	Feasibility study
2nd Generation Alternative Technology	Feasibility study: <ul style="list-style-type: none">• SST mini-mixer• DST past practice• SST hydraulic mining• Other

- Control System. Control multiple retrieval functions during the retrieval operation.
- Confine Waste. Isolate waste from environment during retrieval using double-walled pipe for transport, double confinement in the structure at the surface above the tank, negative atmospheric pressure in the tank, exterior barriers around the tank, or a gel addition to the tank waste.
- Protect Tank. Protect tank against physical damage caused by overstressing, high temperatures, or chemical reactions associated with retrieval.
- Control Tank Environment. Tank atmosphere control during retrieval (e.g., ventilation, cooling).

- Monitor Process. Temperature, pressure, surface contours, obstructions, equipment locations, and waste consistency and uniformity are typical of the conditions that will be monitored. Visual and audio feedback for the operator will be an important part in the monitoring process.

6.3.5 Laboratory/Field Sampling, Analysis, and Testing

This ranked as the fifth highest-priority functional need for tank waste remediation. High-priority technology needs are summarized in Table 6.8. The functions associated with laboratory sampling and analysis of waste from underground storage tanks are defined below.

- Sample Acquisition. The activities and equipment required to obtain a representative portion of the solid, sludge, slurry, liquid, crust, and/or vapor for analysis.
- Sample Transportation. The methods, equipment, and procedures required to transfer TWRS samples to the analytical laboratories.
- Sample Preparation. The activities required to dissolve, dilute, and treat samples so that the required analytical measurements can be made. This includes activities to extrude core samples and homogenize samples to prepare them for additional analysis.
- Laboratory Analysis (chemical, radiochemical, physical and thermal). Measurements taken in an analytical or mobile laboratory using retrieved samples.
- Data Analysis and Integration. The process of interpreting data after the data are analyzed in the laboratory.
- Data Management. The activities required to track and archive samples; categorize and store analytical data; prepare data packages; and support reduction, manipulation, and efficient communication of data to the customers.

6.3.6 Low-Level Waste Packaging and Disposal

Initially, LLW will be disposed of in grout. In the longer term, LLW will be disposed of in grout or glass. An alternative being considered is to solidify the LLW as glass, which would be shipped offsite for disposal. Technology needs are included in Table 6.4.

TABLE 6.8. High-Priority Technology Needs for Laboratory Sampling and Analysis

Function	Technology Development Activity
Core Sample Acquisition	Hard saltcake sampling (rotary mode drilling truck)
Sample Preparation for Hard Saltcake, Semi-volatile, and Sample Dissolution	Hard saltcake homogenizer Semi-volatile sample preparation Normal paraffin hydrocarbon removal Microwave and acid digestion
Chemical and Radiochemical Laboratory Analysis	Noble metals/ ¹²⁹ I/radionuclides by inductively coupled plasma/mass spectroscopy Total carbon by combustion Chemical oxygen demand Ferrocyanide Total cyanide Mercury by cold vapor atomic absorption Complexants
Physical and Thermal Laboratory Analysis	Abrasivity Viscometer Thermal conductivity
In Situ Sampling and Deployment	Penetrometer delivery system Raman penetrometer probe Tank bottom sampler Mechanized/fluidized bed sampler Interstitial gas sampler

6.3.7 High-Level Waste Packaging, Storage, and Shipment

The glass canisters (or alternative HLW forms) will need to be remotely handled and temporarily stored onsite, but the plan is to eventually ship these canisters away from Hanford to the nation's high-level nuclear waste

repository. Cesium and strontium capsules returning from commercial facilities must be remotely handled onsite as well. Technology needs are included in Table 6.5.

6.3.8 In Situ Disposal

Disposal of SST waste in situ is also being considered for residual wastes left in tanks after retrieval. Technology development will likely be conducted as part of the ER Program because this program is responsible for tank closure. Because tank structures were not considered a high-priority problem, technology needs for disposal of tank structures were not discussed in the HIPP workshops.

6.3.9 Existing Storage Management

Existing storage management was the lowest-ranking functional need. It includes activities to ensure safe storage and interim stabilization of "watch list" tanks and to safely maintain and operate tank farm facilities. It is similar to the Waste Tank Safety and Operations Program. This functional need includes activities to mitigate or resolve the waste tank safety issues and system deficiencies as follows:

- Treat and Store Waste
 - Treat and transfer waste. Transfer new liquid waste into the tanks; add process materials as required.
 - Store waste. Perform day-to-day functions to operate tank support systems; monitor, characterize waste for process control, and identify safety issues to be resolved.
 - Optimize tank storage space. Oversee and control the existing storage space provided by tanks. This includes evaporation and waste segregation.
 - Maintain equipment, facilities, and infrastructure. Maintain equipment, facilities, and infrastructure supporting safe storage of tank waste; use administrative systems (such as job control); handle ad hoc restoration.
- Resolve Safety Issues
 - Evaluate and define safety issues. Establish the work to be done based on historical data, sampling and analysis,

synthetic waste studies, laboratory tests, monitoring data, mathematical modeling, and sensitivity analysis. Define safe conditions for operation, and decide on the appropriate path to resolve the safety issues.

- Implement safety issue resolution. Develop a safety issue corrective action plan that addresses out-of-tank requirements, analysis, redefinition of the safety envelope, procedure modification, or establishing control limits for resolution.
 - Mitigate safety condition. Develop a safety issue corrective action plan that addresses possible in-tank or interim out-of-tank treatment to control or eliminate the condition.
 - Verify safety issue closure. Administratively verify that a safety issue has been resolved, and complete the paperwork.
- Restore and Upgrade Facilities and Infrastructure
 - Restore equipment, facilities, and infrastructure. Return the equipment, facilities, and infrastructure to its original performance capabilities. Ensure that the originally intended performance is documented.
 - Upgrade equipment, facilities, and infrastructure. Improve the performance of the equipment, facilities, or infrastructure over the original design.

Technology development to support mitigation and resolution of waste tank safety issues and infrastructure problems focuses on implementing proven solutions so the overall risk to operations and maintenance personnel and the public is minimized. Safety problems receiving the highest scores (e.g., tanks with integrity problems, chemically reactive tanks, and high-heat tanks) are discussed below. Other types of tanks are not specifically discussed, because they did not receive high scores at the HIPP Problem Prioritization Workshop. Technology needs are shown in Table 6.9.

Tanks with Integrity Problems

This include all current and potential future leaking tanks. There are 68 known leakers. All 28 DSTs and 149 SSTs require integrity assessments, which also includes the potential hazard of a leak in the high-heat tank (Tank 241-C-106) that requires the addition of cooling water.

TABLE 6.9. High-Priority Technology Needs for Existing Storage Management

Function	Technology Development Activity
Corrosion Protection by Chemical Control	DST Corrosion Probes Waste chemistry adjustment
Leak Detection Methods	Instrument upgrades for surface-level measurements Detector for liquid observation wells Detector for dry wells, laterals, and pits
Data Acquisition and Management Tools	Software for temperature monitoring and control system Database for surveillance analysis computer system
Tank Structural Integrity Evaluation	Structural evaluations Analytical modeling Instrumentation for nondestructive annulus inspections Structural integrity assessments Tank 241-C-1-7 corrosion control
Evaluate and Define Flammable Gas Safety Issues	Synthetic waste studies Radiolytic/chemical mechanisms study Physical and numerical modeling Analytical methods for chelators
Evaluate and Define Ferrocyanide Safety Issues	Simulated waste studies Chemical reaction studies Laboratory studies of cesium uptake and procedures for ferrocyanides analysis Hot spot thermal modeling Vapor space gas modeling Continuous gas monitoring Infrared scanning system
Evaluate and Define Organic Material Safety Issues	Analytical for organic analysis methods development Laboratory tests Waste simulant studies Modeling
High Heat Tanks	Thermal Modeling (106-C)

TABLE 6.9. (contd)

Function	Technology Development Activity
Evaluate and Define Tank Vapors Safety Issues	Air dispersion plume modeling Vapor monitoring Portable gas monitoring laboratory
Mitigate Flammable Gas (safety condition)	In-tank mixing Ventilation upgrades
Mitigate Ferrocyanide (safety condition)	In situ tank moisture monitoring
Mitigate Tank Vapors (safety condition)	Tank vapor treatment system
Mitigate High Heat of Tanks (safety condition)	Heat removal/water level control system Heat extraction and cooling for C-106
Enhanced Waste Treatment and Transfer	SST waterline corrosion protection Enhanced SST stabilization
Enhanced Waste Storage	Hand-held data acquisition Spectral gamma probes Enhanced in-tank leak detection
Enhanced Optimization of Tank Storage Space	Enhanced waste volume projection system
Enhanced Mitigation of Safety Criticality Condition	Fissile material measurement Criticality monitoring
Flammable Gas	Sonic probe system Velocity density temperature tree
Emergency Response Waste Treatment and Transfer	Waste transfer truck
Dilute or Heat Waste to Mitigate Safety Condition	Waste dilution in Tank 241-SY-101 Waste heating in Tank 241-SY-101
Robotics Hot Testing	Robotics system hot testing and turnover to tank farm

Chemically Reactive Tanks

In situ stabilization and characterization of chemically reactive tanks ranked as the highest-priority subfunctional needs for existing storage management. Concerns for chemically reactive tanks include potential reactions that could result in one of the following hazards:

- generation, accumulation, and possible ignition of combustible mixtures of hydrogen and nitrous oxide

- potential explosion of ferrocyanides in waste tanks
- uncontrolled oxidation by nitrate or nitrite of high concentrations of mixed organic chemicals in tanks containing high-nitrate waste.

The current strategy is to stabilize the chemically reactive tanks until the TWRS Program is ready to pretreat the wastes for disposal form conversion.

6.4 COORDINATION WITH TANK WASTE REMEDIATION SYSTEM AND UNDERGROUND STORAGE TANK-INTEGRATED DEMONSTRATIONS

The HIPP S&T needs assessment builds on the TWRS integrated technology planning and EM-50 needs assessment activities in FY 1993, including the Underground Storage Tank-Integrated Demonstrations (UST-ID) activities for tanks. HIPP's unique role is to coordinate Hanford cleanup planning activities across all mission areas. The HIPP S&T needs assessment activity has been focused at a higher level of detail than either TWRS or UST-ID. In this way, it complements the roles of TWRS (detailed program planning) and UST-ID (detailed technology development planning), and is in the position to integrate the results of those activities with the planning results of other Hanford mission areas.

The UST-ID is designed to assemble and demonstrate the effectiveness of selected technology in correcting underground storage tank waste management and environmental problems. The UST-ID focuses on several DOE sites, including Hanford SSTs.

TWRS is tasked with ensuring that underground storage tank waste at Hanford is effectively and efficiently remediated. The TWRS Integrated Technology Plan (DOE/RL 1993) was established to ensure that the best technologies to do this job are identified, developed, demonstrated, tested, evaluated, and deployed, and that this is done in time to support an aggressive and cost-effective remediation schedule. To do this, the TWRS Integrated Technology Plan team adopted a multi-attribute methodology for prioritizing technology options. This methodology, which is quite similar to the HIPP S&T needs assessment methodology, relies largely on expert judgement. TWRS technology planning activities include three categories of systems: 1) a reference system for each program element, 2) enhancements to that reference system that

can be inserted into the system without altering it significantly, and 3) alternative systems that represent dramatically different alternatives to the reference system. Technology development will be required to support all three categories of systems.

After looking at the results in this section and comparing them with the results in Sections 7.0 through 11.0, it is clear that the TWRS program has been able to focus on developing comprehensive portfolios of S&T needs for tank waste remediation at a more detailed level than any of the HIPP workshop results. The TWRS program elements have 1) identified and narrowed their suites of remediation systems to be developed, 2) identified and prioritized their functional needs, and 3) identified and prioritized technologies to support their highest-priority functional needs. Implementing the TWRS methodology for integrated technology planning in the other mission areas would be useful, especially if needed technologies do not exist or there is a high risk of technical failure.

7.0 SOLID WASTE WORKSHOP RESULTS

7.1 PROBLEMS

The total scores for the 32 solid waste problems that were identified at the Problem Prioritization Workshop are shown in Table 7.1. These are the averages of the individual scores assigned to the problems by the workshop participants who did the scoring. Pre-1970 buried waste scored the highest (total score = 51), followed by spent fuel storage (46), pyrophorics (41), alkali metals (40), and drag-off waste (37). The normalized weights used for the 10 problem evaluation criteria are shown at the top of each column. These are the averages of the weights assigned to the criteria by the workshop participants.

The following assumptions were made by the workshop participants:

- 1) the problems were evaluated based on the disposal scenario for the 200 Areas;
- 2) the problems were evaluated "as is" without applying any technology (e.g., assuming no retrieval);
- 3) sanitary waste is nonradioactive, nonhazardous waste;
- 4) pre-1970 waste includes waste buried in the 100, 200, 300, and 400 Areas, as well as the old Hanford townsite;^(a)
- 5) some suspect plutonium waste in trenches will not be retrieved (both pre-1970 and post-1970);
- 6) there will be no big impacts on surface water or groundwater from buried waste;
- 7) there will be soil impacts within the next 10 years or more;
- and 8) there are regulatory problems with spent fuel storage, but no technology problems.

The S&T needs for the solid waste mission area cover the entire range of functions necessary to dispose of the waste (e.g., characterization, retrieval, treatment, and disposal), as well as the entire range of waste types (e.g., HLW, TRU, LLW, hazardous, mixed). In addition to newly generated or stored waste, a large portion of the solid waste to be disposed of is

(a) The HDW-EIS only identified one pre-1970 buried suspect TRU-contaminated solid waste site outside the 200-Area plateau.

TABLE 7.1. Solid Waste Problem Prioritization

		Normalized Weights									
		0.19	0.13	0.11	0.11	0.10	0.07	0.04	0.04	0.09	0.12
		Problem Criteria									
<u>Solid Waste Problems</u>	<u>Total Score</u>	<u>Health and Safety Short Term</u>	<u>Health and Safety Long Term</u>	<u>Health and Safety Future Gen.</u>	<u>Surface Water</u>	<u>Groundwater</u>	<u>Soil</u>	<u>Land Use</u>	<u>Cultural Concern</u>	<u>Public Concern</u>	<u>Regulatory Compliance</u>
TRU and TRU-Mixed											
Remote Handled											
Hazardous	34	16	23	28	0	23	87	100	40	60	50
Nonhazardous	29	9	12	12	0	17	87	100	40	60	50
Contact Handled											
Hazardous	31	16	18	12	0	13	97	100	40	60	50
Nonhazardous	29	8	13	10	0	13	97	100	40	60	50
Low-Level Mixed											
Remote Handled											
Class 1	32	6	8	6	0	13	93	100	30	50	100
Class 3	34	8	14	8	0	13	93	100	40	50	100
>Class 3	32	10	18	11	0	0	67	100	50	50	100
Contact Handled											
Class 1	18	7	8	6	0	13	80	100	40	25	10
Class 3	19	7	9	7	3	17	80	100	40	25	10
>Class 3	21	8	9	5	3	3	67	100	40	25	40
Solid Low-Level											
Remote Handled											
Class 1	18	7	7	5	0	13	80	100	40	25	10
Class 3	19	8	9	7	3	17	80	100	40	25	10
>Class 3	22	10	11	7	5	5	67	100	40	25	40

7.2

TABLE 7.1. (contd)

		Normalized Weights									
		0.19	0.13	0.11	0.11	0.10	0.07	0.04	0.04	0.09	0.12
		Problem Criteria									
Solid Waste Problems	Total Score	Health and Safety Short Term	Health and Safety Long Term	Health and Safety Future Gen.	Surface Water	Groundwater	Soil	Land Use	Cultural Concern	Public Concern	Regulatory Compliance
Contact Handled											
Class 1	18	7	8	6	0	13	80	100	40	25	10
Class 3	19	7	9	7	3	17	80	100	40	25	10
>Class 3	21	8	9	5	3	3	67	100	40	25	40
Nonradioactive Hazardous	10	7	8	4	10	20	55	5	0	5	0
Sanitary Waste	4	0	3	8	0	13	23	5	0	0	0
Offsite Waste	34	10	11	14	2	8	15	100	40	100	100
Special Case Waste											
Classified Waste	25	14	7	8	0	7	13	100	40	80	50
Munitions	35	28	21	19	0	0	13	100	30	80	100
Pyrophorics	41	48	29	23	0	0	13	100	40	80	100
Alkali Metals											
Material	40	44	21	16	0	13	47	100	20	60	100
Waste	40	44	21	16	0	13	47	100	20	60	100
Spent Fuel Storage	46	19	24	32	23	23	57	100	40	100	100
Drag-Off	37	22	16	21	2	15	70	100	40	50	100
Limbo Waste											
Pre-1970 Buried Waste	51	37	35	48	12	38	100	100	40	50	100
Production Reactor Graphite Core	21	13	10	10	3	8	28	100	40	50	30
D&C Waste (e.g., PFP)	22	11	8	6	3	8	25	100	40	50	50

TABLE 7.1. (contd)

		Normalized Weights									
		0.19	0.13	0.11	0.11	0.10	0.07	0.04	0.04	0.09	0.12
		Problem Criteria									
<u>Solid Waste Problems</u>	<u>Total Score</u>	<u>Health and Safety Short Term</u>	<u>Health and Safety Long Term</u>	<u>Health and Safety Future Gen.</u>	<u>Surface Water</u>	<u>Groundwater</u>	<u>Soil</u>	<u>Land Use</u>	<u>Cultural Concern</u>	<u>Public Concern</u>	<u>Regulatory Compliance</u>
HWVP Melters	26	18	19	15	7	7	18	100	40	50	50
Canyon Waste	34	17	21	18	7	13	28	100	40	50	100
Tunnel Waste	34	18	24	18	7	13	22	100	40	50	100

buried onsite. This solid waste mission area is also the recipient of solid waste from all other mission areas (e.g., building rubble from D&D, contaminated soil from ER).

The pre-1970 buried waste was ranked as the number one solid waste mission area problem primarily due to scores of 100 for soil impacts, land use, and regulatory compliance. This problem belongs in the ER mission area according to the Hanford WBS. However, the pre-1970 buried waste follows essentially the same disposal pathway as post-1970 buried waste (which belongs to the solid waste mission area). Thus, it is discussed in this solid waste section of this document rather than in the ER section. The other solid waste problems that are discussed below are special types of buried waste, and only those functions that needed to be handled differently from the "regular" buried solid waste functions were examined in the workshops.

Spent fuel storage was the number two solid waste mission area problem, mainly due to scores of 100 for land use, regulatory compliance, and public concern. The spent fuel is buried in trenches at Hanford, but the exact location of all the fuel rods is unknown. Most of the fuel rods are encased in schedule-80, 120-inch-long pipe, capped on both ends. This waste form is a special case of buried solid waste due to the extremely pyrophoric nature of the fuel rods, which will require careful handling and treatment.

Pyrophoric wastes were the third highest-priority problem, and alkali metals (both material and waste) tied for fourth place. These results are largely due to scores of 100 for land use and regulatory compliance. Both spent fuel and pyrophoric wastes are composed of highly reactive compounds that may ignite if exposed to air. Alkali metals are also highly reactive and may ignite if exposed to moisture.

Drag-off boxes were ranked as the fifth highest-priority problem due to scores of 100 for land use and regulatory compliance. Drag-off boxes are containers full of very "hot" wastes that were dragged by chains or cables attached to vehicles into trenches or pits and then buried. The contents vary from LLW to HLW to mixed waste. The exact location of all these boxes is not known. Also included in the drag-off waste problem category is waste contained in caissons, which are buried vaults, 10 to 12 ft high and 6 ft in

diameter, filled with paint buckets of very "hot" waste dropped in through a chute. Although waste volumes in caissons are low, the type of waste contained is a mix of TRU, fission products, and miscellaneous hot cell trash. Retrieval is planned for pre-1970 caisson wastes.

7.2 FUNCTIONAL NEEDS

Participants at the Solid Waste Functional Needs Structuring Workshop and the Solid Waste Functional Needs Prioritization Workshop identified and prioritized the functions and subfunctions needed to solve the highest-priority solid waste problems described above. The TLDs for the solid waste mission area were used to guide these discussions (see Appendix A). These TLDs were completed after all the workshops were held, and they represent a Hanford Site consensus on the most up-to-date set of functions, alternatives, and technologies applicable to the solid waste mission area.

To aid in understanding how the solid waste functions and subfunctions fit together, flowsheet representations, called functional needs diagrams (FNDs), were produced. The overview solid waste FND is shown in Figure 7.1. The 14 functional needs and their associated subfunctions are shown in the FNDs in Appendix B. The functions shown in the FND were arrived at by discussions and consensus in the two functional needs workshops. For the solid waste mission area, the 14 functions did not differ by problem (i.e., all the high-priority problems discussed above required the same set of functional needs for resolution).

The 14 functions and related subfunctions that are shown in Figure 7.1 are described below:

- Inventory information search. Activities associated with trying to determine what solid waste is buried where at Hanford, including the subfunctions of literature/records searches, Hanford worker interviews, and development/maintenance of an inventory database.
- Operations inventory management. Activities associated with managing the solid waste material onsite, both buried and stored waste, including the subfunctions of sampling for waste verification, development of heterogeneous material sampling methods, analysis of lab/field samples, and containment/interim stabilization of buried waste.

FIGURE 7.1. Overview of Solid Waste Functional Needs

- **Characterization.** Activities associated with determining the radionuclide, chemical, and physical properties of solid waste to determine how to retrieve and dispose of the waste, including the subfunctions of physical site surveys, in situ measurement/sampling, small-scale retrieval/sampling, methods for sampling heterogeneous materials, analysis of samples in the lab or field, and boundary/ flow modeling of specific solid waste sites.
- **Strategic decision modeling.** Activities associated with analytically determining the best way to retrieve, transport, treat, and dispose of the solid waste onsite, including the subfunctions of conducting risk assessments, performance assessments, and simulations, as well as developing the needed decision-support systems.
- **Solid waste retrieval.** Activities associated with physical removal of the solid waste from the Site for subsequent treatment, including the subfunctions of contact-handled waste removal methods and remotely handled waste removal methods.
- **Retrieved waste packaging and transport.** Activities associated with readying the solid waste for transportation and transporting the waste to onsite locations for treatment, including the subfunctions of size reduction for large masses, designing packages to meet treatment specifications, developing/obtaining shielded

packaging and transportation casks, and developing the capabilities to meet government transportation regulations.

- Sorting. Activities associated with separating the various components of the solid waste into physical, chemical, and radioactive categories as needed for treatment, including the subfunctions of sort/sample and sieve/size.
- Treatment. Activities associated with conversion of solid waste to a final disposal form in a central facility, including the subfunctions of partitioning/pretreatment and disposal form conversion.
- Storage and disposal. Activities associated with 1) interim storage of solid waste after treatment and before transportation to an offsite disposal location and 2) onsite disposal of some forms of solid waste, including the subfunctions of determining the transportation regulations to be met, developing casks, and obtaining/developing an automated visual inspection capability for the stored solid waste.
- Waste acceptance criteria generation. Activities associated with completion of all paperwork/tests to enable solid waste to be shipped offsite for disposal or disposed of onsite, including the subfunctions of ability/tools to develop onsite and offsite criteria, and performance assessments.
- In situ treatment. Activities associated with conversion of solid waste to a final disposal form onsite without retrieval and treatment at a central facility, including the subfunctions of mobility, toxicity, and volume reduction of the waste, containment of all emissions during treatment, special in situ characterization of the waste, and the use of biotechnology.
- Retrieval and disposal site closure. Activities associated with restoring the physical appearance of areas where solid waste has been retrieved or disposed of to a condition resembling the original appearance, including the subfunctions of barrier development, landscaping, stabilization, development of retrieval site backfill techniques, validation of waste form and barriers, and post-closure monitoring.

At the Functional Needs Prioritization Workshop, the 14 functions were prioritized for the following four problems: pre-1970 buried waste, drag-off boxes, caissons, and pyrophorics. The spent fuel and alkali metal problems were covered in the pyrophoric waste problem category. The functional needs prioritization criteria, as described in Section 4.2, included: the existence of technology development gaps, the urgency and timeliness of technologies to perform the functions, the potential for cost reduction, and the potential for

increased effectiveness of the function. General technology groups were discussed at the Functional Needs Prioritization Workshop, while detailed discussions of individual technologies were postponed until the Technology Prioritization Workshop.

The results of the functional needs prioritization for the pre-1970 buried waste problems are contained in Table 7.2. The normalized weights, which are the averages of all participants' weights, are shown at the top of Table 7.2. The highest-ranking functions, in order of importance (based on the total scores shown here in parentheses), for the pre-1970 buried waste problem were characterization (11), in situ treatment (10), solid waste retrieval (9), treatment (9), and waste acceptance criteria generation (9). Functional needs were also prioritized for the other three problems listed

TABLE 7.2. Solid Waste Functional Needs Prioritization

Functional Needs	Total Score	Normalized Weights			
		0.29	0.31	0.21	0.19
		Functional Needs Criteria			
		Gaps/Missing Technologies	Urgency/Timeliness	Cost Reduction Potential	Effective Increase Potential
Inventory Information Search	5	3	8	5	5
Operations Inventory Management	7	5	7	8	9
Characterization	11	11	11	11	12
Strategic Decision Modeling	7	5	8	7	8
Solid Waste Retrieval	9	11	8	9	7
Retrieved Waste Packaging and Transportation	6	7	7	6	4
Recycling	4	5	3	4	3
Retrieval Site Small-Scale Waste Treatment	8	9	7	8	7
Sorting	5	5	6	6	5
Treatment	9	10	8	9	7
Storage and Disposal	6	6	6	6	7
Waste Acceptance Criteria Generation	9	8	9	8	9
In Situ Treatment	10	11	8	9	11
Retrieval and Disposal Site Closure	4	4	3	4	5

above. For the drag-off boxes, the top-ranked functions were characterization (13), solid waste retrieval (13), treatment (10), and in situ treatment (10). For caissons, the top-ranked functions were treatment (14), solid waste retrieval (13), characterization (12), and storage and disposal (10). For pyrophorics, the top-ranked functions were characterization (13), treatment (12), solid waste retrieval (10), and retrieved waste packaging and transportation (10).

Looking across the four solid waste problems, the following three functions were ranked highly for all the problems: characterization, solid waste retrieval, and treatment. In addition, the in situ treatment function was ranked highly for two of the problems.

At the Functional Needs Prioritization Workshop, it was decided by the participants to focus on the top five functions for buried waste only. The other problems were seen as special cases of buried waste. These wastes (i.e., pyrophorics, drag-off boxes, caissons) have special needs in handling, characterization, and treatment, but the technologies needed to deal with the buried waste functions would be adapted on a case-by-case basis in order to handle many different types of waste. At this workshop, the subfunctions for the following five functional needs were ranked using the functional needs prioritization criteria and weights generated earlier: characterization, solid waste retrieval, treatment, waste acceptance criteria generation, and in situ treatment (see Table 7.3). The subfunctions were ranked within their own functional need area only, so their scores cannot be compared across functional needs.

For the characterization function, the in situ measurement and sampling subfunction scored the highest (24), and the heterogeneous material sampling methods scored the next highest (22). Both of these subfunctions scored higher on all five of the criteria than the other four subfunctions. For this reason, both of these subfunctions were examined further in the follow-on Technology Prioritization Workshop.

TABLE 7.3. Solid Waste Subfunctional Needs Prioritization Workshop

Functional Needs	Total Score	Normalized Weights			
		0.32	0.29	0.21	0.18
		Functional Needs Criteria			
		Gaps/Missing Technologies	Urgency/Timeliness	Cost Reduction Potential	Effective Increase Potential
Inventory Information Search	5	3	8	5	5
Operations Inventory Management	7	5	7	8	9
Characterization	11	11	11	11	12
Physical Site Surveys	15	15	17	13	14
In Situ Measurement/Sampling	24	24	22	25	23
Small-Scale Retrieval/Sampling	17	13	18	18	17
Heterogeneous Material Sampling Methods	22	24	19	23	24
Lab/Field Analysis	13	15	14	13	13
Boundary and Flow Modeling of Specific Sites	9	8	10	8	9
Strategic Decision Modeling	7	5	8	7	8
Solid Waste Retrieval	9	11	8	9	7
Contact Handled	39	37	43	37	38
Remote Handled	61	63	57	63	62
Retrieved Waste Packaging and Transport	6	7	7	6	4
Recycling	4	5	3	4	3
Retrieval Site Small-Scale Waste Treatment	8	9	7	8	7
Sorting	5	5	6	6	5
Treatment	9	10	8	9	7
Partitioning/Pretreatment	50	49	42	58	55
Disposal Form Conversion	50	51	58	42	45
Storage and Disposal	6	6	6	6	7
Waste Acceptance Criteria Generation	9	8	9	8	9
Ability and Tools to Develop Onsite Criteria	30	34	31	30	25
Ability and Tools to Develop Offsite Criteria	22	21	26	19	21
Performance Assessment	48	44	42	51	54
In Situ Treatment	10	11	8	9	11
Containment of Emissions	14	13	19	11	13
Mobility Reduction	18	19	17	17	19
Toxicity Reduction	19	19	18	18	22
Volume Reduction	12	10	12	15	12
Special In Situ Characterization	20	21	22	19	14
Biotechnology	18	18	12	21	20
Retrieval and Disposal Site Closure	4	4	3	4	5

For the solid waste retrieval function, the remotely handled material subfunction scored the highest on all five criteria as well as receiving the highest total score (61). Thus, this subfunction was examined further in the Technology Prioritization Workshop.

For the treatment function, the two subfunctions each scored the same overall (50). The partitioning/pretreatment subfunction scored significantly higher on cost reduction potential and increased effectiveness potential. The disposal form conversion subfunction scored significantly higher on contribution to the overall strategy/function and urgency/timeliness. Both subfunctions received similar scores on technology gaps. In the Technology Prioritization Workshop, both subfunctions were examined further.

After ranking the subfunctions of the waste acceptance criteria generation function, the workshop participants decided that this function had very few technology needs and more management needs. For this reason, the function was not examined further.

In discussions of the subfunction ranking results related to the in situ treatment function, it was decided that the subfunctions "mobility reduction" and "toxicity reduction" should be combined, as the technologies would be the same for both. The new subfunction "toxicity/mobility reduction" was examined further in the Technology Prioritization Workshop.

7.3 TECHNOLOGIES

Technologies applicable to the highest-ranking subfunctions were identified and prioritized in the Solid Waste Technology Prioritization Workshop. Technology experts from WHC and PNL and WHC problem-owners participated in this workshop. The functions and subfunctions for which technologies were prioritized include:

- characterization - in situ measurement/sampling and heterogeneous material sampling methods
- in situ treatment - toxicity/mobility reduction
- buried waste retrieval - remotely handled material
- treatment - partitioning/pretreatment and disposal form conversion.

The results of the technology prioritization are contained in Table 7.4. The technology prioritization criteria (described in Section 4.2) included the technology's importance to meeting the functional need; the cost-effectiveness of the technology; the timeliness/development risk of the technology; and the contribution of the technology to solving problems in other mission areas, functions, or subfunctions. The normalized weights, which are the averages of all participants' weights, are shown at the top of Table 7.4. The results of the technology prioritization are discussed below. It should be remembered that the problem focus for this technology prioritization was remediation of the pre-1970 buried waste at Hanford, although the workshop participants agreed that the technology needs also apply to post-1970 buried waste.

The highest-priority technology needs identified for in situ measurement/sampling (part of the characterization function), in order of priority, are nondestructive evaluation/nondestructive analysis (NDE/NDA) methods for both chemical and radioactive waste constituents, sensors for both radioactive and hazardous materials (nonbulk), bulk analysis and instrumentation, ground-penetrating radar, and package integrity analysis. The highest-ranking technology need, NDE/NDA methods, received the highest score of all these technologies on cost-effectiveness and timeliness/development risk. Sensors were the second highest-ranked technology need. They received a score of 100 for potential contribution to other Hanford cleanup needs, and they were ranked as the most important technology for meeting the characterization functional need for buried solid waste.

The technology needs identified for heterogeneous material sampling methods (also part of the characterization function) are real-time/on-line sensor instrumentation; a sound, statistical-based approach to minimize sampling; and a system-wide information system driven by an expert system. The highest-ranking technology need, real-time/on-line sensors, scored the highest of all these technologies on importance to meeting the characterization functional need and on cost-effectiveness. The second highest-ranked technology need for this subfunction, a sound statistical approach to minimize sampling, scored the highest on timeliness/development risk and contribution potential to other missions, functional needs, or problems.

TABLE 7.4. Results of the Solid Waste Technology Needs Prioritization

		Normalized Weights			
		0.32	0.52	0.16	
		Technology Needs Criteria			
Technology Needs	Total Score	Importance for Meeting Functional Needs	Cost-Effectiveness	Timeliness and Development Risk	Contribution to Other Missions or Functional Needs
Characterization					
In Situ Measurement/Sampling					
Sensors (radioactive and hazardous material, nonbulk)	64	83	83	58	100
Ground-Penetrating Radar	31	42	42	71	46
NDE/NDA Methods (chemical and radioactive)	66	80	88	73	92
Package Integrity Analysis	22	50	46	52	46
Bulk Analysis and Instrumentation	46	72	67	46	88
Heterogeneous Material Sampling Methods					
Sound Statistically Based Approach To Minimize Sampling	44	59	58	88	83
System-Wide Information System Driven by Expert System	33	55	75	58	63
Real-Time/On-Line Sensor Instrumentation	45	88	83	29	54
In Situ Treatment					
Toxicity/Mobility Reduction					
Dust Control Technologies	65	96	79	75	71
Soil Washing Technologies (covered in ER mission area)	37	60	55	50	70
Vitrification	51	79	73	58	73
Grout/Cementation	28	50	63	69	67
Encapsulation	24	50	50	65	58
Interim Stabilization Technologies	34	58	54	69	54
Buried Waste Retrieval					
Remotely Handled Material (not contact-handled remotely)					
Self-Contained Mobile Retrieval System (WORM)	5	26	33	23	27
Dust Control and Air Handling System	76	100	60	85	85
Robotics/Removal Equipment	68	92	83	63	71
Retrieval of Unstable/Reactive Chemical Waste	37	76	71	42	42

TABLE 7.4. (contd)

		Normalized Weights			
		0.32	0.52	0.16	
		Technology Needs Criteria			
Technology Needs	Total Score	Importance for Meeting Functional Needs	Cost-Effectiveness	Timeliness and Development Risk	Contribution to Other Missions or Functional Needs
Radioactive/Hazardous Materials Containment and Control	72	92	67	88	79
Treatment					
Partitioning/Pretreatment					
Sorting	81	100	75	96	63
Size Reduction Using Shredders, Torches, Shears, etc.	55	76	51	92	67
Decontamination Using Mechanical, Chemical, Aqueous Methods	47	63	63	75	75
Thermal Treatment Technologies	54	73	76	63	67
Disposal Form Conversion					
Vitrification	55	88	67	59	79
Stabilized Waste Forms	50	79	67	54	71
Ceramic Waste Forms	17	48	50	27	38
Metal Waste Forms	33	53	72	42	63

The technology needs identified for toxicity/mobility reduction (part of the in situ treatment function) are, in order of priority: dust control techniques, vitrification, soil washing technologies, interim stabilization techniques, grout/cementation, and encapsulation. The highest-ranking technology need, dust control techniques, scored the highest of all the technologies on three of the four criteria: importance for meeting the functional need, cost-effectiveness, and timeliness/development risk. The second highest-ranked technology need, vitrification, scored the highest on potential contribution to other mission areas, functional needs, or problems, and second highest on importance for meeting the in situ treatment functional need and on cost-effectiveness.

The technology needs identified for the remotely handled material subfunction (part of the buried waste retrieval function) are, in order of

priority: dust control and air-handling systems, radioactive/hazardous materials containment and control, robotics/removal equipment, retrieval of unstable/reactive chemical waste, and self-contained mobile retrieval systems. The highest-ranking technology need, dust control and air-handling systems, scored the highest of all the technologies on two of the four criteria: importance for meeting the functional need (score = 100) and contribution to other missions, functional needs, or problems. Radioactive/hazardous material containment and control, the second highest-priority technology need, scored the highest of all the technologies on timeliness/development risk. The third highest-priority technology need, robotics/removal equipment, scored higher than the other technologies on cost-effectiveness.

The technology needs identified for partitioning/pretreatment (part of the treatment function) are, in order of priority: sorting; size reduction with shredders, torches, and shears; thermal treatment techniques; and decontamination with mechanical, chemical, and aqueous methods. The highest-ranking technology need, sorting, scored the highest of all these technologies on two of the four criteria: importance for meeting the functional need (score = 100) and timeliness/development risk. The size-reduction technologies scored the second highest in this subfunction due to receiving the second-highest scores for the same two criteria. The third highest-ranked technology need, thermal treatment techniques, scored high due to having the highest score on cost-effectiveness in the partitioning/pretreatment subfunction.

The technology needs identified for disposal form conversion (part of the treatment function) are, in order of priority: vitrification, stabilized waste forms, metal waste forms, and ceramic waste forms. The highest-ranking technology need, vitrification, scored the highest of all these technologies on three of the four criteria: importance for meeting the functional need; timeliness/development risk; and contribution to other mission areas, functional needs, or problems. The second highest-priority technology need in this subfunction, stabilized waste forms, scored high due to having the second-highest scores on the same three criteria.

All of the technology needs discussed above are shown on the TLDs in Appendix A and also in flowsheet format in the FNDs in Appendix B. In summary, the top 10 solid waste technology needs (in priority order according to their overall scores shown in parentheses) are:

- Sorting (81) -- partitioning/pretreatment subfunction, treatment functional need.
- Dust control and air handling system (76) -- remotely handled material subfunction, buried waste retrieval functional need.
- Radioactive/hazardous materials containment and control (72) -- remotely handled material subfunction, buried waste retrieval functional need.
- Robotics/removal equipment (68) -- remotely handled material subfunction, buried waste retrieval functional need.
- NDE/NDA methods (66) -- in situ measurement/sampling subfunction, characterization functional need.
- Dust control techniques (65) -- toxicity/mobility reduction subfunction, in situ treatment functional need.
- Sensors (radioactive and hazardous materials, nonbulk) (64) -- in situ measurement/sampling subfunction, characterization functional need.
- Size reduction methods (55) -- partitioning/pretreatment subfunction, treatment functional need.
- Vitrification (55) -- disposal form conversion subfunction, treatment functional need.
- Thermal treatment techniques (54) -- partitioning/pretreatment subfunction, treatment functional need.

8.0 ENVIRONMENTAL RESTORATION WORKSHOP RESULTS

8.1 PROBLEMS

The average scores for the 23 problems that were identified at the ER Problem Prioritization Workshop are shown in Table 8.1. These are the averages of the individual scores assigned to the problems by the 15 participants who did the scoring. Cribs containing mixed waste scored the highest (total score = 36), followed closely by cribs containing HLW (total score = 34), groundwater in the 100 Areas (total score = 34), trenches and ponds containing mixed waste (total score = 33), and trenches and ponds containing HLW (total score = 31). The normalized weights used for the 10 prioritization criteria are shown at the top of each column. These are the averages of the weights assigned to the criteria by the 15 participants. The following assumptions were made by the workshop participants: 1) the problems were evaluated based on the disposal scenario in the 200 Areas and 2) the problems were evaluated "as is" without applying any technology.

The ER mission area includes cleanup of deliberate and accidental releases of hazardous and radioactive materials to the soils and groundwater at Hanford. Liquid discharges during almost 50 years to cribs and trenches, French drains, ponds, and the contaminated soils around and underneath tanks and processing plants are included in the ER mission area. Also included are soils and pipes under buried SSTs, any residual materials from other mission areas, and pre-1970 buried waste. Remediation of the areas where these past liquid discharges occurred is difficult to achieve because the contaminants have diffused into the environment from the discharge points. Therefore, concentrations are usually dilute and are often difficult to locate exactly.

The S&T needs for the ER mission area are extensive for in situ remediation options because of the wide range of materials involved, the lack of defined physical boundaries, the frequent difficulty of access due to depth, the dilution of contaminants in groundwater and/or soils, and the complexity of composition (e.g., mixed wastes, hazardous chemicals, radioactively contaminated materials). The large-scale remediation ER approach, relying

TABLE 8.1. Environmental Restoration Problem Prioritization

		Normalized Weights									
		0.17	0.15	0.12	0.12	0.10	0.09	0.06	0.02	0.07	0.09
		Problem Criteria									
ER Problems	Total Score	Health and Safety Short Term	Health and Safety Long Term	Health and Safety Future Gen.	Surface Water	Groundwater	Soil	Land Use	Cultural Concern	Public Concern	Regulatory Compliance
Surface Contamination											
Radioactive	20	3	0	0	25	12	41	88	53	40	19
Chemical	13	1	0	0	18	12	32	49	31	22	13
Tanks											
Single Shell	27	3	3	10	23	44	63	51	14	74	34
Petroleum	11	2	0	1	17	24	41	13	13	9	10
Burial Grounds											
Pre-1970 (any waste including plutonium)											
200 Areas	18	2	1	9	17	28	47	60	26	20	19
100 Areas	21	2	1	5	38	31	41	55	64	23	18
300 Area	19	2	1	8	32	30	43	50	45	21	18
1970-1985 (no TRU, 200 Areas only)	12	1	1	2	13	18	32	39	22	15	12
Post-1985 (no hazard, 200 Areas only)	10	3	0	2	10	14	22	28	21	13	12
Liquid Discharges											
Trenches and Ponds											
Mixed	33	2	2	2	36	57	82	57	34	64	66
Higher Level Radioactive	31	2	2	2	30	46	79	57	34	64	64

TABLE 8.1. (contd)

		Normalized Weights									
		0.17	0.15	0.12	0.12	0.10	0.09	0.06	0.02	0.07	0.09
		Problem Criteria									
ER Problems	Total Score	Health and Safety Short Term	Health and Safety Long Term	Health and Safety Future Gen.	Surface Water	Groundwater	Soil	Land Use	Cultural Concern	Public Concern	Regulatory Compliance
Cribs											
Mixed	36	2	2	3	32	65	100	59	35	64	74
Higher Level Radioactive	34	2	2	3	29	58	94	59	33	67	66
Groundwater											
600 Area	22	1	5	1	48	66	6	12	1	54	38
200 Areas	26	1	10	1	34	100	10	7	0	59	42
100 Areas	34	2	4	1	96	77	6	21	5	94	48
300 Area	26	2	3	1	66	69	3	17	4	67	44
Subsurface Piping											
200 Areas	10	0	0	1	8	17	45	23	17	9	9
100 Areas	12	0	0	0	19	20	34	29	46	9	9
300 Area	11	0	0	0	16	22	36	29	35	9	9
Facilities											
200 Areas	9	8	1	1	0	5	13	48	35	22	8
100 Areas	13	9	0	1	7	5	12	59	99	34	8
300 Area	11	5	0	1	8	6	12	55	53	31	9

heavily on the observational approach to characterization, excavation, and removal, minimizes these concerns for the 100 and 300 Areas. The ER problems of major importance include:

- About 285,000 cm of pre-1970 buried waste containing an estimated 300 kg of plutonium
- Many other past-practice sites that are incompletely characterized
- Between 580 and 920 metric tons of carbon tetrachloride spread over 18 km² to depths of 100 m
- Soils contaminated with nitrates, tritium, radionuclides, complexing agents, and solvents
- Residuals from other remedial actions, leaks from SSTs, and accidental spills.

Of the five highest-scoring ER problems, four relate to past liquid discharges to trenches, ponds, and cribs, and the fifth relates to groundwater pollution in the 100 Areas (as a result of plume movement from these discharges) and its potential to reach the Columbia River. Table 8.1 shows the complete matrix of ER problems, total scores, intermediate scores on each of the 10 criteria that were used in the prioritization process, and weights assigned to each criterion. The top five problems, their total scores from the problem matrix (shown in parentheses), and the three primary contributory factors to the scores (in order of highest to lowest), are:

1. Cribs containing mixed waste (36) - soil contamination, regulatory compliance, groundwater contamination
2. Cribs containing higher-level waste (34) - soil contamination, regulatory compliance, land use
3. Groundwater in the 100 Areas (34) - surface water contamination, regulatory compliance, groundwater contamination
4. Trenches and ponds containing mixed waste (33) - soil contamination, regulatory compliance, public concern
5. Trenches and ponds containing higher-level waste (31) - soil contamination, regulatory compliance, public concern.

These five problems are qualitatively similar and are defined and summarized together.

There are several types of cribs on the Site, including timber cribs, open pits, leach trenches, and the 100-N Area Crib. Some have immediate H&S impacts. Timber cribs are large wooden boxes in the ground that contain B-Plant wastes, reactor wastes, high-activity wastes, TRU-contaminated wastes, and heavy metals. The Z-9 Crib is a shallow pit in the ground (covered with a concrete barrier) containing TRU-contaminated waste, and it may also contain hazardous waste (e.g., cadmium). Leach trenches contain PUREX waste materials. At N Springs in the 100-N Area, there is a crib containing petroleum products and mixed fission products. Tanks with petroleum products have leaked in that vicinity, and workers used to burn off the organics at the site.

A decision must be made about which cribs will be retrieved and which will be left as is. The alternatives are to

- do nothing
- place a protective barrier over the crib
- retrieve the contents.

If a decision is made to retrieve, there are two alternatives: 1) contact-handled retrieval for the less serious wastes, or 2) remote-handled retrieval for the high-specific-activity wastes. There is a huge volume of contaminated soil and contaminated groundwater to be treated.

Past higher-level radioactive liquid discharges to trenches and ponds include wastes in all areas of the Hanford Site, but refer mainly to the 100 Areas (e.g., N-Reactor K-Basin ponds). (The term "higher-level radioactive" refers to high dose levels from potentially present TRU contamination).^(a) All the liquid discharge problems in the ER mission area are from past practice units; no current or future discharges are included in this mission area.

(a) Although not expected in the 100-Area trenches and ponds, it is possible that spent fuel elements or higher-activity sludges/soils could be found somewhere in the 100 Areas.

The groundwater problem in the 100 Areas (especially N Springs) is a major concern because of the proximity to the river and the possibility of a contaminant plume reaching the river in the near future. This problem can be alleviated in the short term by a barrier system, thus buying time for a more permanent solution.

8.2 FUNCTIONAL NEEDS

The primary functional needs for the five highest-priority ER problems that were defined by the workshop participants are shown in Figure 8.1. Details of each functional need are included in Appendix B. The associated technologies are listed in the ER mission area TLDs in Appendix A. Several assumptions were made in identifying these functional needs:

- Functional needs are based on the HIPP 1992 planning basis, which entails retrieval of wastes from the outer areas of the Site (e.g., the 100 and 300 Areas) and storage and/or disposal in the 200 Areas. No final decision has yet been made on the Hanford end-state to be pursued. This decision will have tremendous impacts on the remediation options selected.

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FIGURE 8.1. Overview of Environmental Restoration (ER) Functional Needs

- Ex situ technology options are preferred because the efficiency of contaminant removal/destruction can be more easily and accurately monitored. However, in situ options may be cheaper and easier to implement if this monitoring problem can be overcome.

Many of the identified functional needs are cross-cutting, especially the needs for contaminant characterization, location, sampling, and modeling of behavior in the environment. The ER functional needs (e.g., characterization, retrieval) are listed under "functions" on the TLDs.

Functions listed in the TLDs and the functional needs diagrams include a logical sequence of operations: inventory characterization (measurement and analysis); information and decision support; in situ treatment for soils and groundwater that will not be retrieved; retrieval, onsite transportation, and ex situ treatment for soils and groundwater that must be excavated or pumped and treated away from the source; and disposal and environmental monitoring. Each of these functions is associated with specific technology development needs for the ER mission area. These needs must be satisfied before the function can be accomplished in an effective manner. Some functions (e.g., onsite transportation) have few or no identified needs, while others (e.g., characterization) have critical and immediate needs which must be met before the function can be achieved.

The five highest-scoring ER problems were the subject of the Functional Needs Structuring Workshop, involving technical experts who identified and listed functional needs, without consideration of technology availability or stage of development. The TLDs for the ER mission area were used to guide the discussions. The list of technologies needed for problem resolution was amended and expanded in the TLDs as a result of these discussions.

The Functional Needs Prioritization Workshop, comprising WHC and PNL experts, was held to prioritize the functional needs and subfunctional needs. As described in Section 4.2, the functional needs prioritization criteria included evaluation of the existence of technology gaps, the urgency and timeliness of the function (whether a solution is needed now or in the future), the potential for cost reduction, and the potential for increasing the effectiveness of the function. The weighting factors for the criteria were similar, and were all in the range of 0.20 - 0.29. While general

technology groups were included in the functional needs prioritization exercise, detailed discussion of individual technologies was left to a later workshop (see Section 8.3).

Functional needs for the ER mission area were evaluated against the above criteria for contaminated soils (both the detailed and the observational approaches to characterization) and groundwater (detailed approach only). Results for contaminated soil functional needs by both approaches were very similar (see Tables 8.2 and 8.3). The greatest divergence was the need for laboratory analysis, which scored 13 for the detailed approach and 10 for the observational approach. This result is intuitively reasonable because a greater amount of analysis is needed, and sooner, for the detailed versus the observational approach.

Another result apparent from the total scores was that scores were generally higher (and, therefore, represented a greater need) on near-term functions than later ones. This represents the urgency/timeliness and strategy contributions, where, for example, characterization needs must be satisfied in the near term, while ultimate disposal needs can be met in a much longer time frame. This trend was apparent for almost all functions, for both the detailed and the observational approaches, and for both soil and groundwater. An exception to the trend was the slightly greater importance

TABLE 8.2. Environmental Restoration (Groundwater)
Functional Needs Prioritization

Functional Needs	Total Score	Normalized Weights			
		0.29	0.23	0.28	0.20
		Functional Needs Criteria			
		Gaps/Missing Technologies	Urgency/Timeliness	Cost Reduction Potential	Effective Increase Potential
In Situ/Field Measurement	26	24	25	27	26
Laboratory Analysis	11	7	14	9	12
Information and Decision Support Tools	8	8	8	7	13
In Situ Treatment (i.e., groundwater)	27	30	21	31	27
Material Retrieval	14	15	15	13	11
Ex Situ Treatment	14	18	17	12	10

TABLE 8.3. Environmental Restoration (Soil) Functional Needs Prioritization

Functional Needs	Total Score	Normalized Weights			
		0.29	0.23	0.28	0.20
		Functional Needs Criteria			
		Gaps/Missing Technologies	Urgency/Timeliness	Cost Reduction Potential	Effective Increase Potential
In Situ/Field Measurement	24	22	23	26	23
Laboratory Analysis	13	11	16	14	11
Information and Decision Support Tools	7	5	10	6	10
In Situ Pretreatment	12	13	12	13	10
Material Retrieval	11	9	10	12	14
Ex Situ Treatment	23	27	20	21	23
Packaging	3	6	3	1	1
Onsite Storage	3	3	3	3	3
Offsite Shipment	0	0	0	0	1
Onsite Disposal	4	5	4	4	5

(reflected in the scores) attributed to functional needs for ex situ treatment of contaminated soils (detailed and observational approaches = 23) and in situ treatment of groundwater (detailed approach = 27). The overall scores for in situ/field measurement were very similar (24, 26, and 22, respectively). After these two most critical and important ER functional needs (measurement and treatment), other functional needs were ranked a factor of two less in importance, and included laboratory analysis (11-13), retrieval (11-14), in situ treatment of soils (12-13), and ex situ treatment of groundwater (14). The need for information and decision-support tools ranked in the 7-8 range for both approaches and both media. All other functional needs scored below this range.

8.3 TECHNOLOGIES

The ER Technology Prioritization Workshop was held to prioritize technologies to meet the highest-priority functional needs and subfunctional needs. Each functional need (e.g., measurement, analysis, treatment) is

subdivided into technology-based subfunctional needs (e.g., chemical, physical, biological, radiological, thermal), with some modifications where such discipline-oriented subdivisions are inappropriate, such as computer modeling or barriers. In the two highest-priority functional needs, in situ/field measurement and treatment (which scored almost equally high), the workshop participants identified different technology development priorities for the two highest-priority problems: contaminated soils in cribs, trenches, and ponds; and groundwater remediation in the 100 Areas. The following is a discussion of the workshop assumptions and results.

8.3.1 Characterization

Characterization is needed to define the extent of ER problems because accurate surface area, depth, concentration, and composition of the contamination around and under the sites to be remediated are often unknown. Some remediation decisions cannot be made prior to characterization (e.g., due to LDRs).

Characterization includes two functional needs as defined by the workshop participants: in situ/field measurement and laboratory analysis (see Tables 8.4 and 8.5). The total scores for both soils (i.e., cribs, trenches, and ponds) and groundwater were higher for in situ/field measurement (24 for soils and 26 for groundwater) than for laboratory analysis (13 for soils and 11 for groundwater). Similarly, the subfunctional needs under in situ/field measurement (i.e., chemical, physical/geophysical, and radiological) generally received higher scores than the subfunctional needs under laboratory analysis (i.e., sampling and analysis, wet chemical analysis, spectrometry, radiometry, biological, and test method development). Although the urgency/timeliness criterion was an important contributory factor to these relatively high scores, the strategy contribution and cost-reduction potential criteria scores were even higher. The workshop participants, thus, saw the development of in situ/field measurement tools as the most effective way to meet ER cleanup goals.

TABLE 8.4. Environmental Restoration (Groundwater) Subfunctional Needs Prioritization

Functional Needs	Total Score	Normalized Weights			
		0.29	0.23	0.28	0.20
		Functional Needs Criteria			
		Gaps/Missing Technologies	Urgency/Timeliness	Cost Reduction Potential	Effective Increase Potential
In Situ/Field Measurement	26	24	25	27	26
Chemical	37	40	41	36	37
Physical/Geophysical	32	34	28	33	29
Radiological	31	26	32	31	34
Laboratory Analysis	11	7	14	9	12
Sampling and Analysis	25	22	29	27	17
Chemical-Wet Chemical Analysis	16	15	16	15	15
Physical-Spectrometry	9	10	6	9	11
Radiological-Radiometric/Counting	11	11	12	11	8
Biological	23	27	21	20	25
Test Methods Development	15	14	15	18	22
Information and Decision Support Tools	8	8	8	7	13
In Situ Treatment	27	30	15	13	11
Subsurface Manipulation	56	57	55	59	55
Treatment of Dense Non-aqueous Phase Liquids	44	43	45	41	45
Material Retrieval	14	15	15	13	11
Retrieval	52	48	52	57	53
Subsurface Barriers	48	52	48	43	47
Ex Situ Treatment (partitioning)	14	18	17	12	10

The greatest technology development needs for in situ/field measurement (for both soils and groundwater) are in the areas of sensors (total score = 57), process monitoring and control technologies (54), radiological measurement (47), and ion-specific electrodes (37) (see Table 8.6). Ion-specific electrodes can be considered as a subset of sensors, but are more developed commercially. Both types of instruments were considered to be chemical probes; together with soil gas analysis techniques (score 22), these chemical

TABLE 8.5. Environmental Restoration (Soil) Subfunctional Needs Prioritization

Functional Needs	Total Score	Normalized Weights			
		0.29	0.23	0.28	0.20
		Functional Needs Criteria			
		Gaps/Missing Technologies	Urgency/Timeliness	Cost Reduction Potential	Effective Increase Potential
In Situ/Field Measurement	24	22	23	26	23
Chemical	43	44	42	44	41
Physical/Geophysical	28	32	26	27	29
Radiological	29	24	32	29	30
Laboratory Analysis	13	11	16	14	11
Sampling and Analysis	34	21	29	42	39
Chemical-Wet Chemical Analysis	10	13	11	9	10
Physical-Spectrometry	9	10	10	8	10
Radiological-Radiometric/Counting	18	14	22	19	17
Biological	18	31	16	12	14
Test Method Development	11	11	13	10	10
Information and Decision Support Tools	7	5	10	6	10
In Situ Pretreatment	12	13	12	13	10
Chemical Pretreatment Stabilization (dust control)	60	57	60	67	60
Physical Pretreatment	40	43	40	33	40
Material Retrieval (soil)	11	9	10	12	14
Ex Situ Treatment	23	27	20	21	23
Soil Partitioning	58	57	57	65	56
Disposal Form Conversion	42	43	43	35	44
Packaging	3	6	3	1	1
Onsite Storage	3	3	3	3	3
Offsite Shipment	0	0	0	0	1
Onsite Disposal	4	5	4	4	5

methods scored higher as a group (43) for cribs, trenches, and ponds than did radiological technologies (29) or physical/geophysical techniques (28). For groundwater, chemical technology development needs were scored at 37, while

TABLE 8.6. Environmental Restoration Technology Needs Prioritization

Technology Needs	Total Score	Normalized Weights			
		0.37	0.37	0.26	
		Technology Needs Criteria			
		Importance for Meeting Functional Needs	Cost-Effectiveness	Timeliness and Development Risk	Contribution to Other Missions or Functional Needs
Soils Problem					
In Situ/Field Measurement					
Process Monitoring and Control Technologies	54	74	76	65	77
Chemical					
Ion-Specific Electrodes	37	52	71	73	84
Sensors	57	75	81	66	83
Soil Gas Analysis	22	40	54	70	33
Radiological Measurement	47	62	82	70	70
Physical/Geophysical					
Electrical Resistivity Technology	23	43	39	74	52
Infrared Thermal Imaging	17	34	36	71	52
Drilling	31	50	49	74	43
Fiber Optic Probe	34	53	69	69	64
Ground-Penetrating Radar	26	44	46	71	57
In Situ Treatment (soils)/Isolation					
Hanford Barrier	36	68	54	68	44
In Situ Vittrification	22	39	33	65	70
Vapor Extraction	16	24	46	74	50
Bioremediation	47	68	69	65	60
Soil Heating	26	45	56	56	43
Electrokinetics/Electroosmosis	21	49	54	47	40
In Situ Grouting	20	39	44	76	56
Material Retrieval					
Soil Fixant and Foam Technologies	29	53	42	62	43
Soil Retrieval					
Dust Control/Containment	30	48	54	65	50
Robotics Applications for Remote Handling	33	53	43	54	77

TABLE 8.6. (contd)

		Normalized Weights			
		0.37	0.37	0.26	
		Technology Needs Criteria			
Technology Needs	Total Score	Importance for Meeting Functional Needs	Cost-Effectiveness	Timeliness and Development Risk	Contribution to Other Missions or Functional Needs
Ex Situ Treatment					
Washing (chemical extraction)	34	55	52	69	39
Heat (thermal desorption)	18	30	55	76	38
Bioremediation	32	49	68	62	48
Electrokinetics/Electro-Osmosis	20	41	44	54	47
Grout	22	32	45	87	60
Ex Situ Vitrification	31	50	36	71	71
Groundwater Problem					
Subsurface Manipulation/Retrieval					
Chemical	28	55	52	49	28
Physical	19	40	40	60	25
Subsurface Barriers					
Grout	23	33	34	77	31
Cryogenic	18	32	32	60	29
Electrokinetic	12	29	19	60	33
Biological	20	41	43	48	33
Membrane	11	34	30	41	19
Ex Situ Treatment					
Precipitation	9	17	43	58	35
Membrane Separation (e.g., Reverse Osmosis)	29	52	43	73	34
Bioremediation	33	53	58	65	59
In Situ Treatment					
Chemical Treatment	35	67	65	39	35
Bioremediation	47	77	82	52	41
Technologies for Treatment of Dense Nonaqueous Phase Liquids	36	80	70	34	31

radiological and physical/geophysical technology developments were considered almost equally important (32 and 31, respectively).

Assumptions and comments made by the workshop participants in assigning these scores were mostly directed toward the importance of further developing physical/geophysical techniques (e.g., ground-penetrating radar, fiberoptic probes, infrared thermal imaging, and electrical resistivity technologies). If the spatial and analytical ranges of these techniques could be increased and improved, they could have a much greater impact. Conversely, soil vapor extraction was given a low score, since it was considered to be a developed technology with little or no need for further development. (This point was made for other technologies in all of the functions - some very important technologies received very low scores because they need little development).

Process monitoring and control technologies were not included in the earlier functional needs prioritization activity, but they were added as a separate subfunctional need by the Technology Prioritization Workshop participants. The need was emphasized for process monitoring and control technologies capable of handling the large numbers of operations involved in Site characterization. This new category received an overall score of 54, primarily due to high scores on cost-effectiveness and contribution to other mission areas, functional needs, or problems.

Under laboratory analysis, development of general sampling and analysis techniques scored higher (34 for soils and 25 for groundwater) than did the individual discipline areas (i.e., chemical, physical, radiological, biological), where scores ranged from 9-23. The S&T development needs for intrusive sampling techniques include:

- access techniques (e.g., drilling and sampling)
- real-time sampling and monitoring techniques (e.g., fiber optics)
- analytical work (mobile lab screening versus offsite analysis)
- retrieval for analysis.

Drilling techniques currently used at Hanford are 40 years old, and modern technology needs to be identified and applied. Existing sampling

techniques used for ER problems could be improved to expedite the remediation process and substantially reduce costs (e.g., samples obtained are frequently heterogeneous, nonrepresentative, and subject to changes in composition through handling, transportation, or exposure). Development of reliable and accurate sampling and monitoring techniques for ER problems is a universal and critical need, and includes new methodologies as well as development of on-location, rapid sample analysis methods, and methods for maintaining constant sample composition until analysis is complete.

Once samples have been obtained and analyzed, there is a need for better test methodology development tools (total scores = 11 for soils, and 15 for groundwater).

8.3.2 Information and Decision-Support Tools

Development of information-handling and decision-support tools ranked at the lower end of the range of technology development needs (total score = 7 for soils and 8 for groundwater). This category includes development of reliable models, risk analysis tools, predictive tools, and technology selection and evaluation tools (e.g., RAAS).

8.3.3 In Situ Pretreatment

There was agreement on in situ pretreatment scores between cribs, trenches, and ponds (i.e., contaminated soils) and groundwater in the 100 Areas. In the Functional Needs Prioritization Workshop, pretreatment of contaminated soils scored 12 for the detailed approach to characterization and 13 for the observational approach, while pretreatment of groundwater scored 11. The similarity between these scores reflects the 1992 planning basis, as well as the physical locations of the contaminated media. Cribs, trenches, and ponds are almost all in the 200 Areas; those that are not would be excavated and the retrieved material would be transported to the 200 Areas for treatment and disposal. Contaminated groundwater in the 100 Areas will be pumped to the 200 Areas for treatment and disposal. Pretreatment of soil as a preparative step prior to excavation is, thus, considered to be an important step in the mid-range of functional needs. In the Technology Prioritization Workshop, this category was renamed "in situ treatment (soils)/isolation" and

was expanded to include stabilization, dust control, and barriers. Technology development needs for soil isolation and in situ treatment as part of the 1992 planning basis (i.e., the 200-Area disposal strategy) included (scores in parentheses):

- Hanford barrier (36)
- soil heating (26)
- in situ vitrification (22)
- electrokinetics/electro-osmosis (21)
- in situ grouting (20)
- vapor extraction (16).

Again, the list reflects technology development needs. Technologies that are considered already highly developed (e.g., vapor extraction) tended to score low because they have few development needs; however, they may still be important for Hanford cleanup.

8.3.4 In Situ Treatment of Groundwater

In situ treatment of groundwater was determined to be the highest-priority functional need for groundwater (total score = 27). This reflects the fact that if the estimated billions of gallons of contaminated groundwater can be treated in place or at least permanently isolated from the Columbia River, major savings would result in cost, time, and safety compared to the ex situ treatment option of pumping the groundwater to the 200 Areas for treatment. Also reflected is the fact that major technology development needs will be necessary. Of the two subfunctional needs, 1) subsurface manipulation and 2) treatment of dense, nonaqueous phase liquids (DNAPLs), the former received the second highest total score (56). Technology development needs associated with these subfunctions scored relatively low, however, compared to the more immediate needs in the characterization functions. Technology development needs and their scores were as follows:

- bioremediation (47)
- technologies for treatment of DNAPLs (36)
- chemical treatment (35).

8.3.5 Material Retrieval

Retrieval of contaminated soils in cribs, trenches, and ponds and of groundwater in the 100 Areas scored in the 11-14 range and was, therefore, considered of relatively low importance. However, retrieval represents a group of needs requiring new S&T development and is more complex than it at first appears. For high-activity contaminated soils, potential technology needs identified for retrieval included robotics applications for sorting and handling radioactive materials, dust control/containment, and soil fixants and foams for stabilization. The relative scores were

- robotics applications for remote handling (33)
- technologies for dust control (containment) (30)
- soil fixants and foams for stabilization (29).

For groundwater retrieval, the technology needs include chemical and physical subsurface manipulations and subsurface barriers. For groundwater, the technology needs and scores for retrieval were

- subsurface manipulations - chemical technologies (28)
- subsurface manipulations - physical technologies (19)
- subsurface barriers - grout (23), biological (20), cryogenic (18), electrokinetic (12), and membrane (11).

The need for development of remote- versus contact-handled mechanical systems comes from the presence in some cribs of TRU-contaminated waste and/or highly radioactive waste. Specialized mechanical systems for retrieval may be needed to minimize worker exposure and contaminant dispersion through airborne dust and gas release. Development of robotic "smart" retrieval equipment is an identified technology development need.

Reusable metal filters represent one technology development option to contain the dust (and contaminants) from excavation and retrieval activities,

and to reduce the used filter waste volume. Alternatively, dust control can be achieved through chemical foams and fixants applied to the matrix surface. Information about the best foams and fixants is scanty for this application, as is knowledge of foam/fixant behavior in, and effects on, grout immobilization mixtures.

8.3.6 Ex Situ Treatment

For contaminated soils, ex situ treatment was considered to be the second most important functional need, scoring 23 for both the detailed and the observational approaches. For groundwater, ex situ treatment scored only 14 (whereas in situ treatment of groundwater scored 27). The subfunctional need for partitioning (contaminant separation) scored 58 for soils and 56 for groundwater. The subfunctional need for disposal form conversion received a score of 42 for soils and 40 for groundwater. Partitioning was, therefore, the most important subfunctional need requiring technology development.

The treatment of retrieved contaminated soils from cribs, trenches, and ponds includes a number of S&T needs (scores in parentheses):

- soil washing and chemical extraction (34)
- bioremediation (32)
- ex situ vitrification (31)
- grouting (22)
- electrokinetics/electroosmosis (20)
- heat (thermal desorption) (18).

Technology needs (and scores) for ex situ treatment of groundwater included: bioremediation (33), membrane separation (including reverse osmosis) (29), and precipitation (9). The first two needs received mid-range scores, reflecting the need for additional development of these processes.

8.3.7 Packaging, Shipment, Storage, and Disposal

The Functional Needs Structuring Workshop participants did not consider packaging, shipment, storage, and disposal to have many technology development needs (the highest score in these categories was 4 for onsite disposal of

contaminated soils), and these functions were not considered in either the Functional Needs Prioritization Workshop or the Technology Prioritization Workshop. In general, S&T needs for disposal of wastes, contaminant concentrates, and treated matrices depend on the disposal option chosen. For wastes removed from sites and treated using one or more of the technologies listed above, options for disposal form conversion include:

- return of the treated solid matrix (soil) to an excavated site as backfill without further treatment
- immobilization of the treated solid matrix in grout, glass, or other solid, stable waste form for offsite transportation (e.g., to a licensed TRU waste repository) or for the 200 Areas
- destruction of the contaminant concentrates (if organic) by thermal, chemical, electrochemical, or biological methods
- immobilization of the contaminant concentrates (if inorganic) in grout, glass, or other stable form for offsite transportation or transportation to the 200 Areas.

No S&T needs were identified for the packaging, storage, shipment, or disposal functional needs categories. Shipment includes options for waste transport by rail, truck, or conveyors, or as a slurry.

8.4 COMPARISON WITH ENVIRONMENTAL RESTORATION BASELINE TECHNOLOGY PLAN

Comparison of the Sitewide S&T priorities presented in this document with those obtained by others in more focused, program-specific plans is a useful exercise and provides a reality check of our results. In particular, it is especially valuable to compare our results with the Environmental Restoration Baseline Technology Plan (Field 1992), since it contains evaluations of available technologies for the ER mission at Hanford, as well as selected technology improvement activities that would be desirable to fill gaps in available technologies. In general terms, the plan lists the same critical needs (prioritized as "high," "medium," or "low") as the HSSSTP. A brief comparison of the results in this baseline plan and our HSSSTP results follows for the major ER technology needs areas, which are characterization and treatment.

8.4.1 Characterization

Characterization technology development needs in the high-priority category presented in the Environmental Restoration Baseline Technology Plan include instruments for surface and down-hole in situ sampling and monitoring and laboratory analysis. Calibration and field-testing of instruments with improved resolution and sensitivity is considered high-priority, as are improved methods for surface and down-hole geophysical surveys. Techniques for in situ sampling of groundwater and the vadose zone in soils, and air contaminant monitoring are also high-priority technology development needs identified in the baseline plan. These development needs for new instruments (e.g., X-ray fluorescence), drilling methods (e.g., sonic drilling, instrumented cone penetrometers), and mobile laboratory analysis closely parallel the technology development needs identified in this HSSSTP.

Development of chemical sensors for in situ/field measurement in soils received a technology need score of 57 in the HIPP evaluation (see Table 5.4), and process monitoring and control technology for in situ/field measurement in soils received a score of 54. These technology needs were ranked 15 and 23, respectively, out of 150 nontank technology development needs across Hanford mission areas. Radiological in situ/field measurement scored 47 and was ranked 31 overall. Table 8.7, which is reproduced from the Environmental Restoration Baseline Technology Plan, lists the ER Program's characterization and sensing technology development priorities. For a detailed discussion of how these needs were identified, refer to the baseline document.

8.4.2 Treatment

Potential baseline remediation technologies assessed in the Environmental Restoration Baseline Technology Plan are listed in Table 8.8. These are quite similar to the technology development needs identified in the Hanford Environmental Restoration Program Roadmap Addendum (DOE/RL 1992b) but are more technology-specific. The roadmap document lists technology development needs for the Hanford Site as:

- real-time detectors and field-portable analytical instruments
- foam and fixant dust-suppression techniques

TABLE 8.7. Baseline Investigation Technologies and Examples of Improvements

Type of Investigation	Baseline Technologies	Examples of Potential Improvements	Priority for Improvement	Improvement Activities ^(a)
Radiation surveys	Portable beta/gamma detectors Ultrasonic ranging and data system Road monitors	Aerial surveys in open areas	Low priority	OTD ^(b)
Surface sampling (soil, water, structures)	Intrusive sampling techniques followed by laboratory analysis	Calibrate and field test instruments for screening samples and in situ monitoring	High priority	X-Ray fluorescence Mobile laboratory
Surface geo-physical surveys	Ground-penetrating radar Electromagnetic induction Seismic surveys Magnetic surveys	Improve instrument resolution Enhance data interpretation	Medium priority	OTD ^(b)
Down-hole geo-physical surveys	Gross gamma-ray logging Spectral gamma-ray logging	Gamma-gamma Neutron-neutron Neutron activation	High priority	OTD ^(b)
Air monitoring	Air monitors and particulate sampling	Increase instrument sensitivity, more investigations	High priority	CCl ₄ expedited response action, OTD ^(b)
Ecological investigation	Plant/animal surveys Vegetation sampling Lab analysis	Screening instruments	Medium priority	OTD ^(b)
Drilling	Cable-tool drills	Sonic drill ODEX rotary drill Angle/horizontal drilling	Medium priority	Sonic drilling, OTD ^(b) (VOC-Arid ID Site)
Aquifer testing	Well draw-down tests Slug tests	Technologies to minimize water volumes generated	Medium priority	None, interference slug testing is being investigated
Groundwater monitoring	Pump wells, obtain samples, and send to laboratory for analysis	In situ sampling	High priority	None
Soil-gas monitoring	Insert sample tubes, draw samples, send to laboratory	In situ soil-gas sampling Increased depth of soil-gas samples	Medium priority	Cone penetrometer tests, OTD ^(b) (VOC-Arid ID Site)

TABLE 8.7. (contd)

Type of Investigation	Baseline Technologies	Examples of Potential Improvements	Priority for Improvement	Improvement Activities ^(a)
Vadose zone sampling	Drill boreholes, split spoon or other sampling technique, send samples to lab	Reduce need for boreholes, and intrusive sampling by using down-hole geophysical techniques, cone-penetrating testing, and/or screening instruments	High priority	OTD ^(b) Mobile Laboratory
Pipeline investigations	Locate breaches or leaks in underground pipelines using helium injection and detection	Remote application of thermal infrared sensors, corrosion logging	Medium priority	OTD ^(b)
(a) All types of investigations are in progress and are projected to continue at the Hanford Site for up to 10 years.				
(b) Being addressed by one or more OTD activities listed in Section 12.0.				

- remote control equipment
- improved soil-washing technology
- improved in situ vitrification technology for increased melt depth
- improved in situ biological and chemical groundwater remediation
- enhanced groundwater contaminant extraction methods
- development of the Hanford isolation barrier.

The ER Baseline Technology Plan lists field screening instrumentation, soil washing, in situ groundwater treatment technologies, and the Hanford isolation barrier as high-priority development needs; and soil fixant (binders), remote control equipment, and ISV development as medium-priority needs. The HIPP prioritized list of treatment technology development needs includes radiological in situ/field measurement (score 47, rank 31); bio-remediation of contaminated soils and groundwater (score 47 each, rank 32-33); treatment of dense, nonaqueous, phase liquids (DNAPLs) (score 36, rank 57); in situ chemical treatment of groundwater (score 35, rank 58); and ex situ vitrification (score 31, rank 80).

TABLE 8.8. Potential Baseline Remediation Technologies

Technology	Development or Testing Needed	Priority and Schedule	Hanford ER Program Planning/Activities Funded in FY 1992
Field Screening Instrumentation for Radiation, Chemical, Physical, Criticality Detection	Engineering/Science: Calibration testing and/or design of real-time and mobile laboratory screening instruments	High priority, 0-15 years ^(a)	100-B/C Demonstration
Binders, Encapsulants and/or Polymers for Dust Control	Engineering/Science: Test/develop for more effective dust suppression, and to replace structural containment	Medium priority, 4-15 years ^(b)	100-B/C Demonstration
Remote Controlled Excavator and Other Automated Equipment	Engineering: Enhance/modify equipment to reduce potential exposure levels to workers. Remote control excavators are being developed by major construction equipment companies	Medium priority, 4-15 years ^(b)	100-B/C Demonstration
Physical Separation/Soil Washing	Engineering: Treatability tests on Hanford soils to reduce waste volumes; may include selection of reagents	High priority, 2-15 years ^(c)	300-FF-1
In Situ Vitrification	Science/Engineering: Increase depth for potential use in 200 Areas and develop for compactible waste stabilization and burial grounds	Medium priority, 4-15 years	None current, ER funding planned for FY 1994
Incinerator/Melter or Ex Situ Vitrification	Science/Engineering: Investigate and test as potential alternatives to compaction and disposal	Medium priority, 4-15 years	None current, ER funding for 100-Area treatability tests planned for FY 1993
In Situ Groundwater Treatment Technologies Such as Chemical Injection or Bioremediation	Science: Research and testing for isolated groundwater contaminants and potential sitewide groundwater remediation, if required	High priority, 6-15 years ^(d)	
Hanford Isolation Barrier	Engineering/Science: Build a prototype barrier and instrument for performance tests. Continue performance studies	High priority, 4-15 years ^(b)	
<p>(a) Currently needed for investigations and EPA. While it is assumed that remediation will continue for 20 years or more, any new developments should be implementable within 15 years.</p> <p>(b) These are potential improvements identified in support of the 100-B/C demonstration.</p> <p>(c) An interim response measure is scheduled to begin in the 300-FF-1 operable unit in 2 years.</p> <p>(d) Assuming groundwater remediation will continue for 20 years, it must begin within 6 years to be completed by year 2018, as required by the Tri-Party Agreement.</p>			

Although the HIPP technology needs are the same as those identified in both the Environmental Restoration Baseline Technology Plan and the Roadmap document, the priority order is somewhat different in each document. This order reflects factors such as urgency of technology development need, H&S issues surrounding the problems to be remediated, and status of technology development, which were considered in the HIPP methodology but not in the other two documents. In addition, the roadmap document lists one high-priority technology need that is not identified as such in either the HSSSTP or the baseline plan: the need for improved contaminant extraction methods for groundwater remediation, because the technology in use (air sparging) is not efficient.

9.0 DECONTAMINATION AND DECOMMISSIONING WORKSHOP RESULTS

9.1 PROBLEMS

A prioritized listing of the 18 D&D problems identified in the D&D Problem Prioritization Workshop and their average scores are shown in Table 9.1. The scores are the averages of the individual scores assigned by the 15 workshop participants. The irradiated fuel storage facilities (e.g., the K-Basins) scored the highest (total score = 41), followed by the plutonium process non-canyon facilities (e.g., 233-S, total score = 35), and small waste tanks (total score = 29). The normalized weights used for the 10 problem prioritization criteria are shown at the top of each column. Workshop participants broke into three working groups and developed consensus scores for all 18 problems for their assigned criteria. Each of the problems was evaluated assuming none of the facilities would undergo D&D. That is, each facility's risk was estimated assuming that it would be left "as is."

Table 9.1 shows the complete matrix of D&D problems, total scores, individual criteria scores, and the weights assigned each criterion. The top three problems, their total scores, and the primary contributing criteria for the scores are:

- Irradiated Fuel Storage Facilities (41) -- groundwater contamination, future generations' health and safety (H&S) risks
- Plutonium Process Non-Canyon Facilities (35) -- future generations' H&S risks, short-term H&S risks, long-term H&S risks
- Small Waste Tanks (29) -- future generations' H&S risks, soil contamination, groundwater contamination

The irradiated fuel storage facilities (e.g., K-Basins) ranked as the worst potential D&D problem due to the high risk of future H&S impacts and significant long-term risk to the groundwater. Plutonium process (non-canyon) facilities also ranked high because of potential H&S risks. The plutonium facilities ranked high for future generations' risks and medium for both short-term and long-term H&S risks. Small waste tanks, such as the plutonium sludge tanks behind Z-Plant, showed medium H&S risks as well as medium soil and groundwater contamination risks.

TABLE 9.1. Decontamination and Decommissioning Problem Prioritization

		Normalized Weights									
		0.19	0.16	0.13	0.12	0.11	0.07	0.03	0.03	0.07	0.10
		Waste Group Consensus Ratings									
D&D Problems	Total Score	Health and Safety Short Term	Health and Safety Long Term	Health and Safety Future Gen.	Surface Water	Groundwater	Soil	Land Use	Cultural Concern	Public Concern	Regulatory Compliance
Reactors and Support Facilities											
Defueled Core Structures	9	0	0	0	0	1	0	100	50	50	10
Effluent Treatment Systems	13	0	0	0	3	12	35	90	80	35	10
Ancillary Structures/Buildings	6	0	0	0	0	1	1	80	50	20	10
FFTF	6	0	0	0	0	2	2	50	30	30	10
Irradiated Fuel Storage Facilities	41	20	20	80	45	85	35	50	50	35	10
Pu Process (non-canyon) Facilities	35	50	50	100	0	3	18	15	15	38	4
PUREX Tunnel	8	5	5	10	0	4	7	15	20	35	4
Canyon Facilities	6	0	0	5	1	5	8	15	20	38	4
U Process Facilities	4	0	0	2	1	4	7	15	20	15	4
Other Facilities											
Small Waste Tanks	29	30	30	50	5	45	48	5	5	15	20
Laboratories	5	0	0	15	3	4	4	5	5	15	4
Hot Cell Facilities	9	5	5	15	0	1	2	40	10	32	15
Contaminated Equipment	1	0	0	0	0	1	3	1	10	5	4
Special-Case Waste											
Research Fuels (NM)	1	0	0	0	0	0	0	5	1	12	4
Class C (NM)	1	0	0	0	0	0	0	5	1	10	4
Radioactive Glass in B Cell (NM)	2	0	0	0	0	0	0	5	1	20	4

TABLE 9.1. (contd)

		Normalized Weights									
		0.19	0.16	0.13	0.12	0.11	0.07	0.03	0.03	0.07	0.10
		Waste Group Consensus Ratings									
<u>D&D Problems</u>	<u>Total Score</u>	<u>Health and Safety Short Term</u>	<u>Health and Safety Long Term</u>	<u>Health and Safety Future Gen.</u>	<u>Surface Water</u>	<u>Groundwater</u>	<u>Soil</u>	<u>Land Use</u>	<u>Cultural Concern</u>	<u>Public Concern</u>	<u>Regulatory Compliance</u>
Underground Lines and Piping	10	0	0	0	5	25	35	15	20	20	15
Fuel Fabrication Facilities	23	20	20	100	0	2	4	40	10	25	4

Workshop participants were asked to focus on the two highest-priority D&D problems in order to structure and prioritize functional needs in two follow-on workshops, and to identify and prioritize applicable technologies in a fourth workshop. The TLDs were used to guide discussions in the follow-up workshops. The D&D TLDs (see Appendix A) have been updated to reflect the results of the workshops.

The cleanup scenario assumed for the D&D mission area is as follows:

- Retrieval of all 100- and 300-Area facilities (irradiated fuel storage facilities), with onsite treatment and disposal in the 200 Areas.
- Minimal cleanup of facilities in the 200 Areas (plutonium Process non-canyon facilities), with continued surveillance and maintenance.

The results of the D&D Functional Needs Structuring and Prioritization Workshops and the D&D Technology Prioritization Workshop are presented in the following two sections.

9.2 FUNCTIONAL NEEDS

The functions to perform D&D at the Hanford Site are shown in the functional needs diagrams (see Figure 9.1 for an overview and Appendix B for details). The functions are existing storage management, characterization (in situ and ex situ), in situ pretreatment, material retrieval, treatment (only in situ considered since the solid waste mission area would handle ex situ treatment), onsite transportation, and retrieval site closure. Storage, which is another function required in the flow from facilities to final disposal, was also assumed to be a solid waste mission area function. Definitions of each of the functions considered in the D&D workshops follow:

- Existing Storage Management. Activities associated with managing stored materials, reducing the spread of existing environmental contamination to new areas, or reducing the increase of contaminant concentration in contaminated areas.
- Characterization. Activities associated with identification of the radionuclide, chemical, and physical properties of materials necessary to determine the disposition of the Site inventory.

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FIGURE 9.1. Overview of Decontamination and Decommissioning (D&D) Functional Needs

- **In Situ Pretreatment.** Activities associated with physical or chemical form conversion required to facilitate retrieval of material.
- **Material Retrieval.** Activities associated with physical removal of inventories from the site environment for subsequent disposition processing.
- **In Situ Treatment.** Activities associated with conversion of inventory materials to a final disposal form without retrieval and processing in a central facility.
- **Onsite Transportation.** Activities associated with transporting inventory materials to onsite locations for processing and/or disposition.
- **Retrieval Site Closure.** Activities associated with restoring the physical appearance of areas where contamination has been retrieved to a condition resembling the original appearance before facility construction activities.

Each of the D&D functions is associated with specific technology development needs. Unlike some of the other Hanford mission areas, the D&D mission area requires no technology development to enable D&D activities to progress. However, a number of new technologies could significantly improve how D&D is currently performed. Technology development could: 1) reduce the quantity of waste generated by current D&D techniques, 2) speed up D&D, 3) reduce the cost of D&D, or 4) reduce personnel risk. In most cases,

improved technologies are needed before a function can be performed in a cost-effective manner. Some of the functions were determined to have no current technology development needs, while others offer opportunities for many potential improvements.

Although the workshop participants stated that no new technologies are needed to physically complete the D&D work at Hanford, they agreed that it is unlikely that adequate funding will be available to finish the job with existing technologies. If cost-effective D&D technologies can be developed, more facilities will be able to undergo D&D operations sooner, and at a lower cost.

Secondary waste generation is a critical issue for the D&D mission area. Current D&D techniques generate large amounts of secondary waste. New D&D techniques should be developed that incorporate onsite recycling of metal and concrete. The Site should be proactive in identifying and implementing waste minimization approaches to clean up activities whenever possible. In the working definition used by EPA, the waste minimization hierarchy consists of 1) source reduction, 2) recycling, 3) treatment, and 4) disposal, in declining order of preference. Source reduction is defined as any activity that reduces the volume, quantity, or toxicity of a waste stream using inplant process technology. Recycling includes use and reuse, or regeneration and reuse, of a material so that it does not become a waste. Treatment and disposal of waste streams are considered to be the least desirable approach.

Two workshops were held to define and prioritize D&D functional needs. "Functional needs" are the D&D functions where improvement (e.g., in performance, waste generation, safety, cost) would be most beneficial to the overall D&D performance.

The Functional Needs Structuring and Prioritization Workshops were composed of WHC and PNL D&D experts. The overview functional needs diagram (Figure 9.1) was used as the baseline for discussion. Functional needs prioritization criteria included the existence of technology development gaps, the urgency and timeliness of technologies to perform the function, the potential for cost reduction, and the potential for increased effectiveness.

General technology groups were discussed in the functional needs prioritization, while detailed discussion on individual technologies was left to the Technology Prioritization Workshop.

Each of the D&D functional needs was evaluated for the two highest-priority problems: spent fuel storage facilities and plutonium process non-canyon facilities. The detailed results, including scores for each functional need against each of the five criteria as well as total scores, are contained in Table 9.2. The normalized weights (i.e., the average of all participants weights) are shown at the top of the table.

Characterization was ranked as the highest-priority functional need for D&D, with a score of 28 out of a possible 100 points. Participants noted that characterization is needed for all decommissioning and is needed throughout the D&D process. Improvements in characterization would be realized throughout the D&D process and in other mission areas. In situ pretreatment followed close behind characterization with a score of 25, and in situ treatment received a score of 21. Characterization ranked relatively high for all four of the evaluation criteria. Although in situ pretreatment ranked higher in the missing technologies and timeliness criteria, these two criteria had been

TABLE 9.2. Decontamination and Decommissioning Functional Needs

Functional Needs	Total Score	Normalized Weights			
		0.17	0.20	0.32	0.31
		Functional Needs Criteria			
		Gaps/Missing Technologies	Urgency/Timeliness	Cost Reduction Potential	Effective Increase Potential
Existing Storage Management	5	6	4	5	4
Characterization	28	24	29	31	28
In Situ Pretreatment	25	33	36	19	29
Material Retrieval from Facility	14	11	12	15	13
In Situ Treatment (waste form conversion)	21	18	13	21	20
Offsite Transportation	2	1	1	4	1
Retrieval Site Closure	6	6	4	5	5

weighted low due to the mission area's existing capability to perform D&D. In situ treatment scores were rather uniform across the criteria, with generally lower scores than either characterization or in situ pretreatment.

The other four D&D functions (existing storage management, material retrieval, transportation, and site closure) all ranked low on all criteria. These four functions are usually thought of as ancillary functions which are well understood and can be performed adequately with current technology.

9.3 TECHNOLOGIES

Technologies applicable to the highest-ranking functional needs were identified and prioritized in the D&D Technology Prioritization Workshop. D&D technology experts from WHC, PNL, and Kaiser Engineers Hanford (KEH) participated. The highest-priority functional needs (characterization and in situ pretreatment) were subdivided into subfunctions, and technologies were identified for each of the subfunctions. The technologies were then ranked using four criteria: the technology's importance to meeting the functional need; cost-effectiveness; timeliness; and contribution to other mission areas, functions, or subfunctions.

9.3.1 Characterization

Characterization can be either intrusive or nonintrusive. Most characterization is done intrusively in the D&D area. Core samples are generally extracted from a material and the sample is then sent to a laboratory for analysis. The process is long and time-consuming. Characterization was noted as having the highest potential for payback of all the D&D functions because characterization must be done for all D&D problems, and during all the other D&D functions (e.g., characterization is needed during pretreatment to ensure that acceptable dose rates are maintained).

Participants stated that the nonintrusive characterization subfunction is where a large breakthrough is possible, but at higher risks than improving intrusive characterization techniques. When asked what the participants would

fund given limited funding, they noted that they would put most of their money on intrusive technologies, but also fund some small amount of nonintrusive technology development.

Eight technologies were identified for D&D characterization needs:

Intrusive technologies

- remote sampling technologies
- rapid radiological field analysis
- rapid physical field analysis
- rapid hazardous field analysis.

Nonintrusive technologies

- rapid radiological field detection instruments
- rapid physical field detection instruments
- rapid hazardous field detection instruments
- scanner with robotic interface.

Table 9.3 contains the rankings of the eight characterization technologies for the plutonium process (non-canyon) and the spent fuel storage facilities combined. The nonintrusive, rapid hazardous field detection instruments ranked the highest priority of all the technologies identified in the workshop, with a total score of 43. The second highest-priority characterization technology is intrusive rapid hazardous field analysis, with a score of 37.

The prioritized results for the characterization function do not match the intuition of the participants to put most of the money on intrusive technologies. However, the results do reflect the participants' belief that the nonintrusive technologies are where higher cost-effectiveness may be realized.

TABLE 9.3. Decontamination and Decommissioning Technology Needs Prioritization

Technology Needs	Total Score	Normalized Weights			
		0.57		0.30	0.13
		Technology Needs Criteria			
		Importance for Meeting Functional Needs	Cost-Effectiveness	Timeliness and Development Risk	Contribution to Other Missions or Functional Needs
Characterization					
Intrusive					
Remote Sampling Technologies	31	54	58	54	71
Rapid Field Analysis					
Radioactive	29	46	62	56	82
Physical	18	33	52	54	81
Hazardous	37	53	74	48	87
Nonintrusive					
Rapid Field Detection Instruments					
Radioactive	33	56	66	37	86
Physical	22	43	57	36	85
Hazardous	43	66	77	29	90
Scanner with Robotic Interface	30	56	58	39	72
In Situ Pretreatment					
Immobilization					
Fixatives and Foams	25	47	44	66	63
Isolation	13	32	30	53	59
Decontamination					
Remote Mechanical Devices	24	41	50	68	79
Abrasives	22	35	46	67	66
Thermal	17	31	41	56	67
Removable Coatings	26	39	49	70	66
High-Intensity Radiant Energy					
Remote Laser Decontamination	39	55	61	49	58
Liquid-Phase Decontamination					
Aqueous					
Water Jet	34	48	64	80	75
Foams and Gels	32	49	54	70	70
Electro-Chemical					
CEPOD	41	57	62	64	69

TABLE 9.3. (contd)

Normalized Weights					
Technology Needs Criteria					
Technology Needs	Total Score	Importance for Meeting Functional Needs	Cost-Effectiveness	Timeliness and Development Risk	Contribution to Other Missions or Functional Needs
Electro Polishing	22	36	48	74	55
Chelating Agents	17	32	38	74	62
Gas or Vapor Phase Decontamination	38	61	64	45	69
Dismantle Components					
Thermal Dismantling					
Metal	16	31	27	79	68
Concrete	14	29	26	66	52
Physical Dismantling					
Metal	18	32	33	89	71
Concrete	19	32	39	89	71
Noncontamination Imbedding Sectioning Technologies					
Liquid Metal Embrittlement	24	51	44	44	66
Nonthermal Dismantling	31	59	48	53	64
Size Reduction Methods	26	44	56	69	67
Recycle					
Metal	42	61	56	65	70
Concrete	32	53	45	63	68

9.3.2 In Situ Pretreatment

In Situ Pretreatment was subdivided into five subfunctional needs: immobilization, isolation, decontamination, dismantling, and recycling. The following technologies were identified for the in situ pretreatment subfunctional needs:

Immobilization technologies

- fixatives and foams

Isolation technologies (not subdivided)

Decontamination

- remote mechanical devices
- abrasives
- thermal decontamination
- removable coatings
- remote laser decontamination
- water jets
- foams and gels
- CEPOD
- electro-polishing
- chelating agents
- gas- or vapor-phase decontamination

Dismantling

- metal thermal dismantling
- concrete thermal dismantling
- metal physical dismantling
- concrete physical dismantling
- liquid metal embrittlement
- nonthermal dismantling
- size reduction methods

Recycling

- metal recycling
- concrete recycling.

The scores that were given to the 22 pretreatment technologies listed above are shown in Table 9.3. Metal recycling received the highest total score (42) of the 22 in situ pretreatment technologies, and was only one point behind the highest-scoring D&D technology, rapid hazardous field detection (43), which is part of characterization. CEPOD, remote laser decontamination,

gas- or vapor-phase decontamination, water jets, foams and gels, and concrete recycling technologies followed closely behind remote laser decontamination.

In summary, the top 10 D&D technology needs and their respective scores, functions, and subfunctions are (in order of priority):

- Rapid hazardous field detection instruments (43) -- nonintrusive characterization
- Metal recycling (42) -- in situ pretreatment, recycling
- CEPOD (41) -- in situ pretreatment, electrochemical decontamination
- Remote laser decontamination (39) -- in situ pretreatment, high-intensity radiant energy decontamination
- Gas- or vapor-phase decontamination (38) -- in situ pretreatment, decontamination
- Rapid hazardous field analysis (37) -- intrusive characterization
- Water jet (34) -- in situ pretreatment, liquid-phase decontamination
- Rapid radioactive field detection (33) -- nonintrusive characterization
- Foams and gels (32) -- in situ pretreatment, liquid-phase decontamination
- Concrete recycling (32) -- in situ pretreatment, recycling.

10.0 NUCLEAR MATERIALS WORKSHOP RESULTS

10.1 PROBLEMS

The average scores for the 17 problems that were identified at the Nuclear Materials Problem Prioritization Workshop are shown in Tables 10.1 and 10.2. Table 10.1 contains the problem rankings based on a short-term evaluation of the problems (i.e., based on the current Hanford missions), while Table 10.2 contains the same list of problems evaluated from a long-term perspective (e.g., with consideration of potential future Site missions related to plutonium-238 and weapons returns to Hanford). The problems that the participants considered to be important in the long term are much more speculative than those that are considered to be important now. Therefore, we focused on the short-term rankings for the remainder of the workshops and for this section.

The scores shown in Table 10.1 are the averages of the individual scores assigned to the problems by the 11 participants who did the scoring. The problem of disposition of irradiated fuel currently stored in the K-Basins scored the highest (41) in the nuclear materials mission area, and was the ninth highest-priority problem for the entire Hanford Site. Residual holdup of radioactive material in facilities to be decommissioned scored the same (34) as stabilization of nonshippable mixed hazardous/radioactive liquid solutions (34).

The normalized weights used for the 10 prioritization criteria are shown at the top of each column in Table 10.1. These are the averages of the weights assigned to the criteria by the workshop participants.

The following assumptions were made by the workshop participants:

- 1) the problems were evaluated based on the disposal scenario for the 200 Areas (1992 planning basis);
- 2) the problems were evaluated "as is" without applying any technology;
- 3) the capability exists at Hanford to ship irradiated fuel materials onsite but not offsite, and to ship uranium both onsite and offsite.

TABLE 10.1. Nuclear Materials (Short-Term) Problem Prioritization

Nuclear Materials Problems (Short Term)	Priority Score	Normalized Weights										
		0.16	0.13	0.08	0.12	0.11	0.06	0.03	0.04	0.09	0.10	0.10
		Problem Criteria										
		Health and Safety Short Term	Health and Safety Long Term	Health and Safety Future Gen.	Surface Water	Groundwater	Soil	Land Use	Cultural Concern	Public Concern	Regulatory Compliance	Safe Guards
Special Nuclear Materials												
Future Mission Materials												
Pu-238	10	1	2	2	0	0	0	0	0	0	0	100
Weapons Returns	20	1	2	100	0	0	0	25	25	0	0	100
Residual Holdup (Terminal Clean-out)	34	10	3	0	0	35	45	0	0	75	100	100
Shipable (stable)	26	0	0	0	0	0	0	0	0	75	100	100
Nonshipable (needs stabilization)												
Mixed Hazardous												
Liquid Solutions	34	6	2	0	0	35	50	0	0	75	100	100
Sludges	26	6	2	0	0	0	0	0	0	65	100	100
Soils	26	6	2	0	0	0	0	0	0	65	100	100
Radioactive Solids	25	6	2	0	0	0	0	0	0	50	100	100
Uranium (cold)												
Material from Other Sites	8	1	1	0	0	0	0	0	0	35	50	0
Metallic	7	1	1	0	0	0	0	0	0	25	50	0
Oxides	6	1	1	0	0	0	0	0	0	5	50	0
Cesium Chloride and Strontium Fluoride Capsules	9	1	2	0	0	25	40	0	0	15	25	0

TABLE 10.1. (contd)

		Normalized Weights										
		0.16	0.13	0.08	0.12	0.11	0.06	0.03	0.04	0.09	0.10	0.10
		Problem Criteria										
Nuclear Materials Problems (Short Term)	Priority Score	Health and Safety Short Term	Health and Safety Long Term	Health and Safety Future Gen.	Surface Water	Groundwater	Soil	Land Use	Cultural Concern	Public Concern	Regulatory Compliance	Safe Guards
Irradiated Fuel												
Short-Term Fuel (PUREX, T Plant)												
Sodium Bonded	27	5	5	0	0	100	95	0	0	35	30	30
Nonsodium Bonded	26	4	4	0	0	100	95	0	0	25	30	30
Long-Term Pools (K-Basins)	41	4	10	0	100	100	75	25	25	50	30	30
Dry Storage	9	4	4	0	0	0	0	0	0	25	30	30
FFTF Fuels	9	4	4	0	0	0	0	25	25	10	30	30
Miscellaneous Research Fuels	17	4	4	0	0	75	25	0	0	10	30	30

TABLE 10.2. Nuclear Materials (Long-Term) Problem Prioritization

		Normalized Weights										
		0.16	0.13	0.08	0.12	0.11	0.06	0.03	0.04	0.09	0.10	0.10
		Problem Criteria										
Nuclear Materials Problems (long term)	Total Score	Health and Safety Short Term	Health and Safety Long Term	Health and Safety Future Term	Surface Water	Groundwater	Soil	Land Use	Cultural Concern	Public Concern	Regulatory Compliance	Safe Guards
Special Nuclear Materials												
Future Mission Materials												
Pu-238	28	1	2	2	0	5	20	0	0	75	100	100
Weapons Returns	40	1	2	100	0	5	20	25	25	100	100	100
Residual Holdup (TCO)	28	10	3	0	0	0	0	0	0	75	100	100
Shipable (stable)	26	0	0	0	0	0	-	0	0	75	100	100
Nonshipable (needs stabilization)												
Mixed Hazardous												
Liquid Solutions	27	6	2	0	0	0	0	0	0	75	100	100
Sludges	26	6	2	0	0	0	0	0	0	65	100	100
Solids	26	6	2	0	0	0	0	0	0	65	100	100
Radioactive Solids	25	6	2	0	0	0	0	0	0	50	100	100
Uranium (cold)												
Material from Other Sites	9	1	1	0	0	0	15	0	0	35	50	0
Metallic	7	1	1	0	0	0	0	0	0	25	50	0
Oxides	6	1	1	0	0	0	15	0	0	5	50	0
Cesium Chloride and Strontium Fluoride Capsules	4	1	2	0	0	0	5	0	0	15	25	0

TABLE 10.2. (contd)

		Normalized Weights										
		0.16	0.13	0.08	0.12	0.11	0.06	0.03	0.04	0.09	0.10	0.10
		Problem Criteria										
Nuclear Materials Problems (long term)	Total Score	Health and Safety Short Term	Health and Safety Long Term	Health and Safety Future Term	Surface Water	Groundwater	Soil	Land Use	Cultural Concern	Public Concern	Regulatory Compliance	Safe Guards
Irradiated Fuels												
Short-Term Fuel (PUREX, T Plant)												
Sodium Bonded	10	5	5	0	0	0	0	0	0	35	30	30
Nonsodium Bonded	9	4	4	0	0	0	0	0	0	25	30	30
Long-Term Pools (K-Basins)	14	4	10	0	0	0	0	25	25	50	30	30
Dry Storage	9	4	4	0	0	0	0	0	0	25	30	30
FFTF Fuels	9	4	4	0	0	0	0	25	25	10	30	30
Miscellaneous Research Fuels	8	4	4	0	0	0	0	0	0	10	30	30

The S&T needs are relatively well-known for the nuclear materials mission area and are mostly limited to equipment design verification and process improvements. Pending nontechnical decisions regarding the ultimate storage and disposal of nuclear materials will affect some of the technology options chosen. None of the high-priority technology needs identified in this mission area involves the large quantities of uranium or SNM at Hanford. Technology for processing and disposing of these materials already exists.

In addition, technology exists for dealing with the irradiated fuel at Hanford. (This is also true of the cesium/strontium capsules which, in the past, were included in the nuclear materials mission area, but which have now been included as part of the tank waste remediation system mission area.) Problems are arising (and will worsen with time) because of the extended storage period of the fuel in a physically unstable form pending decisions about 1) whether it will be reprocessed, 2) the final form in which it will be transferred to its ultimate disposal site, and 3) where disposal will occur. Once these decisions are made, acting upon them presents few technical problems. A brief discussion of the major nuclear material problems is given below, followed by results of the workshops held to structure and prioritize functional needs and technology needs.

10.1.1 100-K Area Irradiated Fuel Storage Pools

Storage of irradiated fuel in the K-Basins is a problem because the fuel is stored at less than optimum conditions and must eventually be retrieved. If the basins develop a leak, there will be leakage of radioactive material to the environment. Retrieval of the irradiated fuel, conversion to a stable form, and packaging for long-term storage (either at Yucca Mountain, Nevada or at a Hanford monitored retrievable storage [MRS] facility) all involve mature technologies.

The primary near-term S&T need is packaging of all N-Reactor fuel into closed containers to provide a primary boundary between damaged fuel elements and storage pool water. Packaging will include the injection of a corrosion inhibitor into the containers to counter fuel corrosion processes. An additional need was identified that is associated with shipping irradiated fuel

onsite. That is, if existing shipping equipment (i.e., rail cars and shipping casks) is deemed to be unsatisfactory, then additional cask development work may be required.

If a reprocessing option is chosen for the irradiated fuel, technology required for this is already mature. The alternatives are a chemical deacid option that has been demonstrated at PUREX or a chop/leach option that has been demonstrated at West Valley. In the stabilization/treatment area, a primary science need is for laboratory research into methods of oxidizing the irradiated fuel, assuming that the reprocessing option will not be chosen. Stabilization through oxidation will support intermediate dry storage, which is commercially available. If an MRS facility at Hanford is decided upon, irradiated fuel could be co-located with high-activity materials from other programs.

10.1.2 Residual Holdup in Buildings

Residual holdup of radioactive and possibly hazardous chemical materials in buildings is a problem of terminal clean-out (TCO) prior to decommissioning. The problem exists primarily in PUREX, PFP, 308 Building, 333 Building, and N-Reactor. Radioactive dust particles and possibly hazardous organic and inorganic substances need to be removed from surfaces to which they have adhered over years of operation. The primary need is for characterization and quantification of the material in a nonhazardous, nondestructive fashion. Some techniques exist for doing this, but there is a science need for developing more advanced, safer, cheaper, and more rapid characterization equipment (instruments and probes). Once the quantities and the compositions of the materials have been determined, collection and treatment techniques can be specified.

10.1.3 Plutonium Nitrate Solutions, Sludges, and Solids in Tanks and Gloveboxes

PFP and PUREX are operable facilities in a prior stage to TCO. PFP contains residual plutonium nitrate solutions (1500 L of 30-100 g/L concentration) as well as radioactive sludges and solids which must be stabilized before final disposition. The solutions, plus some solids and sludges, are

3 of 5

stored mainly in tanks (and also some gloveboxes) at the solvent extraction facilities inside PFP and PUREX. They must be converted to a solid oxide form prior to final disposition. Stabilization (liquid-solid conversion and conversion to oxide form) involves mature technologies. Additional processing may be required to remove impurities in the plutonium solutions. Packaging and long-term storage issues are dependent on the final disposal option for the materials. There were no significant new S&T needs identified for this problem.

10.1.4 Short-Term Irradiated Fuel Disposal

Disposal of irradiated fuel from PUREX and T-Plant is not a short-term technical problem. Developed techniques already exist for doing this. Rather, it is a management decision as to which technical option for disposal will be used.

10.2 FUNCTIONAL NEEDS

Functions listed in the TLDs (see Appendix A) and the functional needs diagrams (see Figures 10.1 and 10.2 for overviews and Appendix B for details) include a logical sequence of operations applicable to the nuclear materials mission area. The irradiated fuel disposition functions include: existing inventory management, onsite transportation, partitioning, disposal form conversion, packaging, onsite storage, and offsite shipment (see Figure 10.1). The SNM disposition functions include: existing inventory management, retrieval and recovery, partitioning, disposal form conversion, packaging, onsite storage, and offsite shipment (see Figure 10.2). Most (but not all) of these nuclear material functions are associated with specific technology development needs. Technology development needs must be satisfied before a function can be accomplished in an effective manner. Some functions in the nuclear materials mission area (e.g., offsite shipment) have few or no identified needs, while others (e.g., disposal form conversion) have critical and immediate needs that must be met before the function can be achieved.

A workshop comprising WHC and PNL experts was held to prioritize the nuclear material functional needs and subfunctional needs. As described in

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FIGURE 10.1. Overview of Irradiation Fuel Functional Needs

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FIGURE 10.2. Overview of Special Nuclear Materials Functional Needs

Section 4.2, the functional needs prioritization criteria included: existence of technology gaps, the urgency and timeliness of the function (whether a solution is needed now or in the future), the potential for cost reduction, and the potential for increasing the effectiveness of the function. While general technology groups were included in the functional need prioritization exercise, detailed discussion of individual technologies was left to a later workshop.

Functional needs for the nuclear materials mission were evaluated separately for irradiated fuel in the K-Basins and for SNM (including residual

holdup and nonshippable, unstable, mixed hazardous liquid solutions), using the above criteria. (Stored uranium was not considered, as it has no significant functional needs requiring new technology development, and cesium/strontium capsules were not considered as they are no longer part of the nuclear materials mission area). A complete list of functional needs priority scores is presented in Table 10.3.

TABLE 10.3. Nuclear Materials Functional Needs Prioritization

Irradiated Fuel Problem					
Normalized Weights					
0.22 0.40 0.21 0.17					
Functional Needs Criteria					
Functional Needs	Total Score	Gaps/Missing Technologies	Urgency/Timeliness	Cost Reduction Potential	Effective Increase Potential
Existing Inventory Management	27	15	23	23	25
Onsite Transportation	2	1	2	5	3
Partitioning (unrestricted use only)	12	14	8	13	14
Disposal Form Conversion	27	31	25	26	24
Packaging	18	20	22	14	16
Onsite Storage	13	19	20	18	17
Offsite Shipment	0	1	1	1	2

Special Nuclear Materials Problem					
Normalized Weights					
0.28 0.31 0.23 0.18					
Functional Needs Criteria					
Functional Needs	Total Score	Gaps/Missing Technologies	Urgency/Timeliness	Cost Reduction Potential	Effective Increase Potential
Existing Inventory Management	22	26	27	13	15
Retrieval and Recovery of Residual Holdup	32	25	32	37	37
Partitioning	19	18	14	22	15
Disposition Form Conversion	10	11	8	11	15
Packaging	9	8	10	10	11
Onsite Storage	7	10	9	7	6
Offsite Shipment	1	1	0	1	1

The highest-priority functional needs identified for irradiated fuel in the K-Basins were for existing inventory management and disposal form conversion (scores tied at 27), because this fuel is currently stored in water pools and must be retrieved and converted to a stable, disposable form in the future. Packaging of the irradiated fuel scored 18, and onsite storage scored 13. No other significant functional needs were identified for irradiated fuel in the K-Basins.

For SNM, retrieval and recovery of residual holdup received the highest overall score (32). This is a technical problem with significant effects on other mission areas (especially D&D), and with significant worker health risks. Existing inventory management received a score of 22, and partitioning received a score of 19. All other nuclear material functional needs received much lower scores compared to the pressing need for retrieval and recovery of residual holdup.

10.3 TECHNOLOGIES

Additional workshops were held to prioritize subfunctional needs and technology needs. Each functional need (e.g., existing inventory management) is subdivided into technology-based subfunctional needs, with some modifications where discipline-oriented subdivisions are inappropriate (e.g., encapsulation or barriers). The workshop participants prioritized technology needs for the highest-priority functional needs for the irradiated fuel and SNM problems. (Stabilization of mixed hazardous liquid solutions was included with the SNM problem for this exercise.) The following is a discussion of the workshop assumptions and results as shown in Table 10.4.

10.3.1 Irradiated Fuel

The highest-priority S&T need for irradiated fuel in the K-Basins was for development of techniques to assess the safety aspects of storing metal fuel in dry storage conditions once it has been removed from the pools (score = 44). These laboratory/engineering technology evaluations are needed to support extended storage and stabilization of the irradiated fuel (i.e., evaluate the nature and rate of metal fuel reactions in alternative storage

TABLE 10.4. Nuclear Materials Technology Needs Prioritization

		Normalized Weights			
		0.42	0.33	0.25	
		Technology Needs Criteria			
Technology Needs	Total Score	Importance for Meeting Functional Needs	Cost-Effectiveness	Timeliness and Development Risk	Contribution to Other Missions or Functional Needs
IRRADIATED FUEL PROBLEM					
Existing Inventory Management					
Interim Storage Form Conversion					
Sodium Removal by Water Reaction (FFTF only)	0	0	67	100	3
Mechanical Size Reduction/Oxidation for Metal Fuel (alt. oxidants) Including Offgas Treatment for High-Temperature Spent Fuel Treatment	31	58	60	58	29
Interim Storage Systems					
Enhanced Current Storage					
Barriers/Liners for Existing Water Filled Basins	23	36	55	62	60
Encapsulate N Fuel	10	18	58	85	19
Consolidation Racking	13	22	52	85	28
New Dry Storage					
Encapsulation for Dry Storage	21	40	61	65	42
Inventory Characterization (laboratory/engineer studies)					
Metal Fuel Safety in Dry Interim Storage Systems	44	73	72	53	21
Basin Sludge Removal					
Commercial Vacuum Transfer and Solidification as Applied to Metal Fuels	12	19	53	81	49
Sludge Disposition Characteristics	17	35	53	66	15
Disposal Form Conversion					
Mechanical Size Reduction/Oxidation for Metal Fuel (alt. oxidants) Including Offgas Treatment for High-Temperature Spent Fuel Treatment	29	55	54	67	21

TABLE 10.4. (contd)

Technology Needs	Total Score	Normalized Weights			
		0.42	0.33	0.25	
		Technology Needs Criteria			
		Importance for Meeting Functional Needs	Cost-Effectiveness	Timeliness and Development Risk	Contribution to Other Missions or Functional Needs
Shear/Dissolve/Vitrify in High Fissile Content Vitrification Process	25	53	46	50	35
Alternate Waste Form Technologies	18	43	36	43	34
SPECIAL NUCLEAR MATERIAL PROBLEM					
Existing Inventory Management					
Interim Material Stabilization/Storage of Liquid Solutions	45	56	71	74	80
Monitoring/Characterization					
Remote Inventory System for Exposure Reduction	53	70	68	67	84
Nondestructive Characterization	33	50	53	54	73
Sampling/Chemical Analyses	29	47	46	61	84
Repackaging					
Long-Term Storage Package	43	56	69	71	79
Retrieval and Recovery of Residual Holdup					
Ductwork Remediation (downstream of HEPA filters)	42	70	56	58	67
Assessment					
Portable Nondestructive analysis/nondestructive evaluation Systems	32	52	59	48	80

systems over long time periods to identify potential safety issues). Irradiated fuels stored in water basins are known to slowly degrade with time. The technology evaluations do not by themselves represent a classical technology development need, since new technologies are not envisioned to be required to resolve potential safety issues. However, the work represents development of basic chemistry data that are needed to identify if, or when, potential safety issues could arise with the current metal fuel storage configuration and to

assess the ability of available alternatives to mitigate an issue. The data are not available at this time to quantify the magnitude of a potential safety issue, nor to predict the urgency required to modify the metal fuel storage configuration. The results of the technology evaluations may lead to technology development recommendations in the future.

Mechanical size reduction technology, development of alternative oxidants for metal fuels, and an effective off-gas treatment system for high-temperature processing of spent fuel were evaluated together as the second highest-priority need (listed under interim storage form conversion in Table 10.4) for the irradiated fuel (score = 31). This same technology need category (i.e., mechanical size reduction, alternative oxidants, and off-gas treatment) was also evaluated for disposal form conversion (score = 29).

Technology development for shearing, dissolving, or vitrifying in a high-fissile content process for disposal form conversion scored next highest (25). These technology needs all relate to the anticipated removal, interim storage, conversion to a disposal form, and ultimate disposal of the irradiated fuel in vitrified form. The next highest-priority technology needs relate to extended storage of the fuel, either remaining in the K-Basins with some enhancements to the existing storage system or in a dry storage form. Development of barriers/liners for the existing water-filled basins received a score of 23, while encapsulation technology for dry storage scored 21. Finally, development of alternative waste form technologies scored 18, and removal of sludge from the storage basins scored 17. The scores for all other identified technology needs were relatively low.

10.3.2 Special Nuclear Material

The highest-priority technology need in the SNM problem area was for development of a remote inventory system to replace the current manual system (score = 53). This would significantly impact worker health and safety by reducing radiation dose to inventory workers. This problem was not even identified in earlier workshops, which illustrates the value of the iterative process in flushing out items which may have been overlooked.

The stabilization and storage of mixed hazardous liquid plutonium nitrate solutions received a score of 45 and was, thus, considered quite important. Next in importance was the need for repackaging SNM into a ship-pable form for long-term storage/disposal (score = 43). Retrieval and recovery of residual holdup, which was the highest-priority functional need for SNM, slipped to fourth place for technology needs, with a score of 42. The remaining technology needs all received mid-level scores as follows: non-destructive characterization of SNM (33), portable NDA/NDE systems development (32), and sampling and chemical analysis technology (29).

11.0 LIQUID EFFLUENTS WORKSHOP RESULTS

11.1 PROBLEMS

The Problem Prioritization Workshop was held with Hanford problem-owners from WHC and technologists from both PNL and WHC to determine the major problems in the liquid effluents mission area. The following assumptions were made by the workshop participants: 1) the problems were evaluated based on the disposal scenario for the 200 Areas, 2) the problems were evaluated "as is" without applying any technology, 3) the effluent treatment facility will generate a dry solid mixed waste that will be sent to the solid waste mission area treatment facilities for disposal, and 4) the leachate from the grout vaults' leachate collection system will be transferred to the liquid effluent treatment facility.^(a)

Table 11.1 contains a listing of the six liquid effluents mission area problems, as identified at the workshop, and their priority scores. These scores are the averages of the individual scores assigned by the workshop participants. The normalized weights used for the 10 problem prioritization criteria are shown at the top of each column in Table 11.1. The criteria are described in Section 4.2. The top three problems identified in this mission area workshop are:

- contaminated groundwater
- mixed/LDR waste
- low-level waste.

Each of these problems is discussed below.

11.1.1 Contaminated Groundwater

Contamination of the groundwater on the Hanford Site has occurred due to the past practice of discharging liquid effluents to the soil column. Thirty-three liquid effluent streams from existing Hanford facilities have been

(a) The Liquid Effluents Program now states that leachate from the grout vaults will likely go back into the grout system and not go to the effluent treatment facility.

TABLE 11.1. Liquid Effluent Problem Prioritization

		Normalized Weights									
		0.19	0.13	0.11	0.11	0.10	0.07	0.04	0.04	0.09	0.12
		Problem Criteria									
Liquid Effluent Problems	Total Score	Health and Safety Short Term	Health and Safety Long Term	Health and Safety Future Gen.	Surface Water	Groundwater	Soil	Land Use	Cultural Concern	Public Concern	Regulatory Compliance
Sanitary Waste	4	0	0	0	0	10	10	2	0	0	20
Mixed/LDR	49	2	2	2	80	100	100	20	0	100	100
Low-Level Waste	46	10	10	1	30	100	100	40	0	90	100
Spent Fuel Storage Waste	15	1	1	0	5	0	0	0	0	20	100
Contaminated Groundwater	50	10	10	10	30	100	100	100	0	100	100
Nonradioactive Waste	14	0	0	0	0	0	0	0	0	20	100

identified for which action is required. Some of the streams are targeted for elimination, others are targeted only for source control/flow reduction (including closed-loop recycling), while the remaining streams will be subject to end-of-pipe treatment. These various waste stream management alternatives reflect the best available technology/all known and reasonable technology (BAT/AKART) approach to waste management, in keeping with both federal and Washington State regulations. As the primary method of treatment, the past practice of discharging liquid effluents to the soil column will be discontinued at Hanford. However, due to their high volumes and low contaminant concentrations, monitoring and treatment of these streams may present significant technical challenges.

Some of the 33 streams, most notably those discharged to cribs and ponds in the 200 Areas, have already resulted in groundwater contamination. In other cases, significant contamination of the vadose zone has occurred, and any additional discharges to the soil would lead to contaminant mobilization and subsequent groundwater contamination. Periodic sampling and continuous in-line monitoring are important for both pre-cleanup characterization of the effluent streams and post-cleanup compliance assurance and environmental monitoring of the wastewater. Streams will be treated to remove suspended solids, organics, heavy metals, and other hazardous inorganic contaminants, as well as radionuclides contributing to alpha, beta, and gamma activity. Post BAT/AKART effluents that meet regulatory requirements will be discharged to a permitted site, such as the Treated Effluent Disposal Facility in the 200 Areas.

Although contaminated groundwater is an ER mission area problem, the Liquid Effluents Problem Prioritization Workshop participants included it in their problem list for completeness. It was ranked as the highest-priority liquid effluent problem due to receiving scores of 100 on the following problem prioritization criteria: groundwater contamination, soil contamination, land use, public concern, and regulatory compliance. Further discussion of this problem is presented in Section 8.0.

11.1.2 Liquid Effluent Containing Mixed/Land Disposal Restriction (LDR) Waste

This liquid effluent stream containing mixed/LDR waste is the process condensate from the 242-A Evaporator, which contains both radioactive and

hazardous chemical constituents. It was ranked as the second highest-priority liquid effluent problem, receiving scores of 100 on the following criteria: groundwater contamination, soil contamination, public concern, and regulatory compliance.

The stream, which has been designated a federally listed waste and a state dangerous waste, is subject to LDRs due to the hazardous nature and concentration of its constituents. LDRs are regulations adopted by EPA that restrict certain wastes from management in land disposal units such as landfills or surface impoundments (see 40 CFR 268). Because LDRs were written primarily to regulate single-contaminant streams, it is more difficult to treat the multiple-contaminant effluent stream from the 242-A Evaporator to meet the LDR requirements. Care must be exercised at the pre-cleanup inventory, treatment, and post-cleanup monitoring stages to ensure that LDR levels are met for all constituents. The radioactive constituents include cesium, strontium, and tritium fission products. Hazardous chemical components include NH_3 (up to 9000 ppm), butanol, acetone, and MIBK. A facility to treat this waste stream is scheduled for start-up in December 1994.^(a)

11.1.3 Liquid Effluents Containing Low-Level Waste

The majority of the 33 identified liquid effluent streams that require treatment contain low levels of radioactivity. This was the third highest-priority liquid effluent problem due to receiving scores of 100 on the following criteria: groundwater contamination, soil contamination, and regulatory compliance. Most of these waste streams are steam condensate, cooling water, or laboratory wastewater. In the 200 Areas alone, there were 2.5 billion gallons of this type of waste generated in 1991. These waste streams are below hazardous concentration limits but above groundwater protection standards.

The radioactive constituents include tritium (which is largely untreatable at the low concentrations encountered) and radionuclides emitting alpha,

(a) The Liquid Effluents Program will continue to evaluate existing and emerging tritium treatment technologies for future application at the Effluent Treatment Facility.

beta, and gamma activity. The inability to detect the low concentration levels of individual radionuclides in high-volume streams makes it difficult to predict whether they exceed regulatory discharge limits before and/or after treatment. In some cases, the estimated regulatory levels of these contaminants are below current detection capabilities. In many instances, technology is not available for the desired in-line monitoring of these streams. Thus, pre-cleanup and post-cleanup inventory of these streams is problematic and may require extensive technology development efforts. In addition, many of these streams contain mixed organic and nonradioactive heavy metal contaminants. Therefore, treatment must address radionuclide removal, hazardous organics removal or degradation, and inorganics (particularly heavy metals) mitigation. Low concentrations increase the difficulty of these multiple tasks.

The current strategy to treat the LLW streams is to employ source control and treatment at the facility that generates the liquid effluent stream. Nineteen of the 33 streams will be treated or stopped by June 1995; the other 14 will be treated or stopped by 1997.

11.2 FUNCTIONAL NEEDS

Subsequent liquid effluent workshops involving WHC and PNL personnel determined the critical functional needs and subfunctional needs to resolve the problems described above. The TLD for the liquid effluents mission area was developed by consensus after the workshops were completed (see Appendix A). It represents the most up-to-date set of functions, alternatives, and technologies to remediate the liquid effluent problems at Hanford.

To aid in understanding how these functions fit together, a flowsheet representation of the liquid effluent functions was produced (see Figure 11.1 for the overall FND, and Appendix B for details of the subfunctions and applicable technologies). The eight functional needs shown in the FND for the liquid effluents mission area do not differ by problem. That is, all of the major problems discussed above have the same functional needs required to solve them.

FIGURE 11.1. Overview of Liquid Effluents Functional Needs

The eight functional needs, their definitions, and the associated subfunctional needs are as follows:

- **Waste Characterization.** Activities associated with managing the liquid effluents onsite, which includes proper characterization of all waste streams before treatment, including the subfunctional needs of sampling and continuous in-line monitoring.
- **Generation.** Activities associated with reducing the amount of liquid effluents generated at the source, including the subfunctional needs of waste minimization and recycle/reuse.
- **Onsite transportation.** Activities associated with transporting liquid effluents to an onsite location for treatment, including the subfunctional needs of collection pipes, tank trucks, and rail tank cars.
- **Interim storage.** Activities associated with the interim storage of liquid effluents prior to onsite treatment, including the subfunctional needs of double-lined leachate collection, double-shell tanks, and aboveground single-shell tanks.
- **Treatment.** Activities associated with conversion of liquid effluents to final disposal waste forms, including the subfunctional needs of partitioning/pretreatment and secondary waste treatment.
- **Storage.** Activities associated with both interim and long-term storage of liquid effluents after treatment and before final

disposal, including the subfunctional needs of double-lined leachate collection, double-shell tanks, and aboveground single-shell tanks.

- Disposal. Activities associated with onsite disposal of treated effluents and secondary waste, including release of treated water to the environment and sending the solid secondary waste to the solid waste mission area facilities for disposal.
- Environmental monitoring. Activities associated with monitoring the environment after release of treated water, both with onsite wells and river sampling, including the subfunctional needs of sampling and continuous in-line monitoring.

At the Liquid Effluents Functional Needs Prioritization Workshop, some of the functional needs were prioritized. Only four of them were seen as being important: waste characterization, generation, treatment, and environmental monitoring. The functional needs prioritization criteria, as described in Section 4.2, included: the existence of technology development gaps, the urgency and timeliness of technologies to perform the functions, the potential for cost reduction, and the potential for improving the effectiveness of the function. General technology groups were discussed during the functional needs prioritization activity, while detailed discussion of individual technologies was left until the Technology Prioritization Workshop.

The results of the Functional Needs Prioritization Workshop for the liquid effluents mission area are contained in Table 11.2. The criteria weights are shown at the top of the table. The highest-ranked functional need, waste characterization, received a total score of 28 due to receiving the highest score of all the functional needs on effectiveness improvement potential, and a score of 100 on cost-reduction potential. The generation and treatment functional needs each received the same score (26), and both had scores of 100 on cost-reduction potential. The fourth functional need, environmental monitoring, received a score of 20 and was not considered further in the Technology Prioritization Workshop.

TABLE 11.2. Liquid Effluents Functional Needs Prioritization

Functional Needs	Total Score	Normalized Weights			
		0.20	0.08	0.40	0.32
		Functional Needs Criteria			
		Gaps/Missing Technologies	Urgency/Timeliness	Cost Reduction Potential	Effective Increase Potential
Waste Characterization	28	16	3	40	26
Generation	26	16	4	40	19
Onsite Transportation					
Interim Storage ^(a)					
Treatment	26	16	4	40	19
Storage ^(a)					
Disposal ^(a)					
Environmental Monitoring	20	10	2	33	13

(a) These Functions were not ranked as they were deemed of little or no importance to the liquid effluents mission area personnel.

11.3 TECHNOLOGIES

Technologies applicable to the highest-ranking functions/subfunctions were identified and prioritized in the Liquid Effluents Technology Prioritization Workshop. The functions and subfunctions for which technologies were prioritized included:

- waste characterization - sampling and continuous in-line monitoring
- generation - waste minimization and recycle/reuse
- treatment - partitioning/pretreatment and secondary waste treatment.

The results of the technology prioritization are contained in Table 11.3. The technology prioritization criteria (described in Section 4.2) included: cost-effectiveness; timeliness/development risk; and the contribution of the technology to solving problems in other mission areas, functions, or subfunctions. The normalized weights, which are the averages of all participants' weights, are shown at the top Table 11.3. The results of the technology prioritization are discussed below by functional needs area.

TABLE 11.3. Liquid Effluents Technology Needs Prioritization

		Normalized Weights			
		0.33	0.25	0.42	
		Technology Needs Criteria			
Technology Needs	Total Score	Importance for Meeting Functional Needs	Cost-Effectiveness	Timeliness and Development Risk	Contribution to Other Mission or Functional Needs
Waste Characterization					
Sampling					
Time Composite	2	4	10	87	63
Flow Composite	2	4	10	87	63
Grab Sample	2	4	40	87	63
Continuous In-line Monitoring					
Radiological					
Alpha	54	83	73	28	80
Beta	54	83	73	28	80
Gamma	38	57	67	43	80
Chemical					
Inorganic	54	83	70	33	80
Organic	70	100	93	23	80
Generation					
Waste Minimization	67	87	90	67	73
Recycle/Reuse	71	90	93	70	73
Treatment					
Partitioning/Pretreatment					
Physical					
Filtration	73	90	87	60	90
Air Stripping	2	7	34	64	10
Adsorption	38	50	90	60	73
Reverse Osmosis	56	78	62	83	73
Supported Liquid Membrane	18	47	37	37	43
Freeze Drying	31	57	47	47	67
Perevaporation	23	45	45	55	55
Tritium Removal via Membrane	57	87	63	40	83
Chemical					
Precipitation	10	27	30	63	27
Ion-Exchange	69	80	87	73	93
Coagulation/Filtration	11	30	33	63	23

TABLE 11.3. (contd)

		Normalized Weights			
		0.33	0.25	0.42	
Technology Needs Criteria					
Technology Needs	Total Score	Importance for Meeting Functional Needs	Cost-Effectiveness	Timeliness and Development Risk	Contribution to Other Mission or Functional Needs
UV Oxidation	69	93	70	80	73
Chemical Oxidation	50	80	63	60	63
Chelation	33	47	60	70	77
Electrodialysis	38	67	67	70	43
Electrolytically Regenerated IX	41	67	80	73	40
Supercritical H ₂ O Oxidation	15	35	37	20	63
Biological					
Biopolymers	18	37	33	37	67
Microorganisms	33	57	60	50	60
Secondary Waste Treatment					
Solidification/Stabilization					
Grout	8	15	50	50	60
Freeze Drying	43	60	73	67	73
Filter Press	40	60	60	63	73
Polymerization	55	77	70	53	83
Glass	23	43	43	23	77
Destruction					
Incineration	6	13	20	50	63

Technology needs for the waste characterization functional need area were focussed on the need for continuous in-line monitoring of radiological and chemical waste stream constituents. The monitoring of organic chemicals (score = 70) was ranked the highest technology need in this functional area. Continuous monitoring of both alpha and beta radiation in the liquid waste streams received a score of 54, along with monitoring of inorganic chemicals. The need for a continuous in-line monitor of organics in a waste stream ranked

the highest due to its score of 100 on importance for meeting the characterization functional need and a score of 93 on the cost-effectiveness criterion. These two scores were higher than the scores for any of the other characterization technology needs.

Technology needs for the generation functional need area were split between the needs of the waste minimization and recycle/reuse subfunctions. The technology needs for the recycle/reuse subfunction were ranked slightly higher on three of the four criteria, for a total score of 71. The waste minimization subfunction technology needs received a total score of 67.

Technology needs identified for partitioning/pretreatment (part of the treatment function) were divided into three groups. Those technologies that used physical methods of partitioning in order of priority are filtration, tritium removal via membrane, reverse osmosis, adsorption, freeze drying, pervaporation, supported liquid membrane, and air stripping. Those technologies that used chemical means of partitioning are, in order of priority: ion exchange, UV oxidation, chemical oxidation, electrolytically regenerated ion exchange, electrodialysis, chelation, supercritical water oxidation, coagulation/filtration, and precipitation. Those technologies that use biological agents for partitioning are, in order of priority: microorganisms and biopolymers.

The highest-ranking technology, filtration, scored a 90 on two criteria: the importance for meeting the functional need and the contribution to other mission areas or functional needs. Both ion-exchange and UV oxidation received total scores of 69. Ion-exchange had the highest score (93) of all these subfunction technologies for the contribution to other mission areas or functional needs criterion. UV oxidation had the highest score (93) of all these subfunction technologies for the importance for meeting the functional need criterion.

The six technology needs for secondary waste treatment (part of the treatment function) were divided into two groups: solidification and destruction technologies. The six technologies are, in order of priority and with the group in parenthesis: polymerization (solidification/stabilization), freeze drying (solidification), filter press (solidification), glass

(solidification/stabilization), grout (solidification/stabilization), and incineration (destruction). The highest-ranking technology need, polymerization, scored the highest of all these technologies on two of the four criteria: importance for meeting the functional need (77) and contribution to other mission areas or functional needs (83). The freeze-drying technologies scored the second highest in this subfunction due to receiving the highest scores on the following criteria: cost-effectiveness (73) and timeliness/development risk (67).

All of the technology needs discussed above are shown on the TLDs in Appendix A and also in flowsheet format in the FNDs in Appendix B. In summary, the top liquid effluent technology needs (in priority order according to their overall scores shown in parenthesis) are:

- Filtration (73) -- partitioning/pretreatment subfunction, treatment functional need
- Recycle/reuse of waste water (71) -- generation functional need
- Characterization of organics (70) -- continuous in-line monitoring subfunction, waste characterization functional need
- Ion exchange (69) -- partitioning/pretreatment subfunction, treatment functional need
- UV oxidation (69) -- partitioning/pretreatment subfunction, treatment functional need
- Waste minimization/source reduction (67) -- generation functional need
- Tritium removal via membrane (57) -- partitioning/pretreatment subfunction, treatment functional need
- Reverse osmosis (56) -- partitioning/pretreatment subfunction, treatment functional need
- Polymerization (55) -- secondary waste treatment subfunction, treatment functional need
- Monitoring of alpha radiation (54) -- continuous in-line monitoring subfunction, waste characterization functional need

- Monitoring of beta radiation (54) -- continuous in-line monitoring subfunction, waste characterization functional need
- Characterization of inorganics (54) -- continuous in-line monitoring subfunction, waste characterization functional need.

12.0 HANFORD TECHNOLOGY NEEDS CROSSWALKS

This section summarizes our progress in linking Hanford's technology needs to 1) EM-50 technology development activities, 2) technology development efforts funded by other federal agencies and other countries, and 3) basic scientific research to develop a better understanding of key Site cleanup problems (via the Environmental and Molecular Sciences Laboratory [EMSL]).

12.1 LINKING HANFORD'S NEEDS TO EM-50 TECHNOLOGY DEVELOPMENT ACTIVITIES

This section describes EM-50's technology development strategy, the preliminary results of our Hanford technology needs crosswalk effort (i.e., linking Hanford's needs to EM-50 technology development activities), and a more in-depth analysis of the crosswalk results for the ER mission area.

12.1.1 EM-50 Technology Development Strategy

The EM-50 programmatic implementation strategy is founded on the concept of integrated demonstrations (IDs) and integrated programs (IPs) (DOE/RL 1991a). An ID is "a cost-effective mechanism that assembles a group of related and synergistic technologies," including performance evaluation, and relating to "a single environmental restoration or waste management issue or function." IPs, such as robotics and analytical laboratory management, are cross-cutting technical disciplines supporting several IDs. Currently, two IDs are assigned to the Hanford Site for lead coordination: 1) underground storage tank stabilization and remediation, and 2) cleanup of volatile organic compounds (VOCs) in soils and groundwater at arid sites. The Arid Site ID is currently focused on an expedited response action to remediate the carbon tetrachloride plume in the 200-West Area. In addition, the Buried Waste ID being conducted at the Idaho National Engineering Laboratory is very relevant to Hanford's needs. The list of current IDs and IPs is shown in Table 12.1. All of the IDs and IPs support national needs, not just the needs of the host sites.

In essence, the purpose of the IDs is to demonstrate, test, and evaluate new technologies for all phases of cleanup. Technical support groups (TSGs) have been organized for each ID to provide input for needs identification,

TABLE 12.1. Currently Funded EM-50 Integrated Demonstrations/Programs

	Integrated Demonstration	Integrated Program
Soils and Groundwater Cleanup		
Volatile Organic Compounds in Nonarid Soils	X	
Volatile Organic Compounds in Arid Soils	X	
Mixed Waste Landfill	X	
Plutonium in Soils	X	
Uranium in Soils	X	
In Situ Vittrification		
Dynamic Stripping		
Characterization, Monitoring, and Sensor Technology		X
In Situ Remediation Technology Development		X
Analytical Laboratory Management		X
Waste Retrieval and Processing		
Buried Waste	X	
Underground Storage Tanks	X	
Robotics	X	
D&D of Concrete and Metals	X	
Efficient Separations and Processing		X
Hazardous and Mixed Waste Destruction		X
Rocky Flats FFC1 Compliance		
Supercritical Water Oxidation		
Waste Minimization and Avoidance		
Environmentally Conscious Manufacturing	X	
DOE/Air Force Memoranda of Agreement		
Waste Component Recycle, Treatment, Disposal	X	

technology selection, test plan development, and systems engineering. Results of the HIPP S&T needs assessment process will be shared with the TSGs to support their recommendations for technologies that will best meet Hanford's needs.

In addition to sharing results with the TSGs, the HIPP S&T Needs Team will work with Hanford staff who are leading the technology integration activities for several of the IDs. For example, the technology integration task will be alerted to promising candidate technologies that are identified in the course of the HIPP S&T needs assessment process. In some cases, preliminary performance and cost assessments may be jointly undertaken by HIPP and one of the IDs if such cooperation makes sense.

12.1.2 Hanford Technology Needs Crosswalk Results

The results of the FY 1992 S&T needs assessment workshops that are presented in this version of the HSSSTP were used as the basis for developing technology development needs/responses crosswalks for the Hanford Site. Tables 12.2 through 12.8 contain the preliminary results of the technology needs crosswalk for each mission area as follows:

- Table 12.2 - Tanks
- Table 12.3 - Solid Waste
- Table 12.4 - Environmental Restoration
- Table 12.5 - D&D
- Table 12.6 - Irradiated Fuel
- Table 12.7 - Special Nuclear Materials
- Table 12.8 - Liquid Effluents.

The column on the far left of each table contains a prioritized list of technology needs and the functional needs and subfunctional needs with which they are associated. For example, in the D&D mission area (Table 12.5), under the characterization function, there are subfunctional needs for both intrusive and nonintrusive technologies. Under the intrusive subfunctional need, there are needs for remote sampling technologies and rapid field analysis. Under rapid field analysis, there are needs for hazardous, radioactive, and physical analysis techniques. The other three columns of each table provide information about technology development activities that are currently being funded by EM-50. This information was obtained from the EM-50 FY 1992 and FY 1993 TTPs.

TABLE 12.2. Technology Needs Crosswalk for Hanford Tank Waste Remediation System

Technology Needs	Technical Task Plan Number/Title		Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
PARTITIONING	RL 321206	Waste Separations Testbed Requirements (FY92)	D.A. Kurath, PNL (509-376-6752)	Identify permitted test facilities for waste separation technology development
Organic/Ferrocyanide Destruction (phases 1, 2, and 3) • Technology evaluation and selection • Testing of selected process	AL 221201	Destruction of Organics by Steam Reforming (FY92)	J.L. Sprung, SNLA	Test synthetic process on Hanford wastes
	HQ 032005	Organics Destruction	Not listed	
	AL 111201	Supercritical Water Oxidation (FY92)	S. Beulow, LANL (843-1178)	Develop skid-mounted organic destruction process
Alkaline Side Removal of Radionuclides (phases 2 and 3) • Ion exchange media selection for alkaline-side cesium removal • Feasibility studies and process flowsheet development - Alkaline-side TRU removal - Alkaline-side technetium removal - Alkaline-side strontium removal • Early demonstration of compact processing units (CPUs)	RL 321203	Continuous Cesium Recovery (FY92)	J.B. Duncan, PNL (509-376-0467); L.K. Holton, PNL (509-376-5954); D.A. Nelson, PNL	Investigate feasibility of ion exchange (IX) membranes, facilitated transport membranes, and other options to replace current biotechnology processes
	CH 201201/ CH 232001	TRUEX Model Validation	G.F. Vandergrift, ANL (708-972-4513)	TRUEX database Generic TRUEX model TRUEX centrifugal contractor
	RL 332011	Tank Waste Processing Analysis	E.G. Baker, PNL (509-376-1494)	Engineering and design requirements for clean option Options for deployment of distributed processes
	SR 132002	Cesium Extraction Testing	J. Bibler, WSRC (803-725-5276)	Develop resorcinol/ formaldehyde IX resin for CPUs
	RL 321221/ RL 321331	Cesium Removal Using CPUs	W.G. Richmond, PNL (509-376-8195)	Develop IX CPU to treat undiluted cesium waste from underground storage tank

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title		Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Nitrate Destruction/Recycle (phase 3) <ul style="list-style-type: none"> • Screen candidate processes • Laboratory-scale feasibility studies • Bench- and confirmation-scale pilot tests • Flowsheet development • Final specifications for plant design 	ID 121204	Biological Destruction of Plutonium Nitrates	G.F. Andrews, EG&G Idaho (208-526-0174)	Biological destruction of nitrate salts buried as waste Develop, design, and construct laboratory-scale biodenitrification unit
	OR 111203	Radioactive Sodium Nitrate Waste Treatment	A.J. Mattus, ORNL (615- 576-1795)	Test process for denitration of aqueous waste Benchtop and small-scale plant testing
Chemical Recycle (phase 3)				
<ul style="list-style-type: none"> • No FY 1993 activities identified 				
Hazardous Materials Removal (phase 3) <ul style="list-style-type: none"> • Establish adequacy of organic destruction to resolve tank safety issue • Evaluate effect of pretreatment processes on organic content of LLW streams 				
Aluminum and Sodium Removal (phase 3 Enhancement) <ul style="list-style-type: none"> • Evaluate two candidate processes 				
Solid/Liquid Separation (phases 3 and 4) <ul style="list-style-type: none"> • Gravity settling rate and efficiency in large tanks • Process control 				
Sludge Washing and Leaching (phase 4) <ul style="list-style-type: none"> • Determine washing efficiency • Develop process control • Conduct blending studies • Expand grout waste form composition range • Identify candidate wastes • Conduct feasibility studies 	OR 132008	Comprehensive Sludge/Supernate Development, Test- ing, and Evaluation	C.P. McGinnis, ORNL (615-576-6895)	Develop comprehensive sludge proces- sing flowsheet using actual tank wastes produced in a hot cell including washing, dissolution, par- titioning, and conversion of TRU to disposable solids

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Sludge Dissolution (phase 4) • Evaluate acidic and fusion dissolution methods • Characterize mineral species in sludges • Develop modeling techniques for predicting dissolution behavior	RL 321216 Processing of HLW Sludge		
Acid-Side Radionuclide Removal (TRU, Cesium, Strontium, Technetium) (phase 4) • Screen candidate processes • Laboratory-scale feasibility studies • Bench- and confirmation-scale pilot tests • Flowsheet development • Final specifications for plant design	AL 121217 Removal of TRU from Waste Using Sequestering Agents		
	CH 211202 Combined TRUEX/SREX Extraction/Recovery Process	E. Phillip Horowitz, ANL (708-972-3653)	Develop and test solvent extraction recovery process to selectively partition uranium, TRU, strontium-90, and technetium-99 from dissolved sludge
Selective Component Removal (phase 4) • Screen candidate processes - Uranium removal - Iodine removal - Inerts removal (e.g., actinide/lanthanide, barium/strontium) - Recovery of noble metals (enhancement)	RL 321701 High Capacity Selective Sequestering Agents	D. Wester, PNL (509-376-4522)	Develop and test selective solid extractants for cesium, strontium, chromium, silver, and noble metals in participation with industry
	RL 321204 Innovative Chemical Separations and Treatment Methods for Nuclear Waste Disposal	D. Wester, PNL (509-376-4522)	Monitor research sponsored by DOE Basic Energy Sciences Develop options to separate cesium, strontium, and TRU from acidified and basic HLW

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
	AL 121217 Sequestering Agents for Removal of TRU from Radioactive Waste	G. Jarvinsen, LANL (505-665-0822); B.S. Jorgensen, LANL (505-667-3619); W.S. Midkiff, LANL (505-667-7391); B.F. Smith, LANL (505-667-2391); P.H. Smith, LANL (505-667-1604)	Polymer-supported ligands to remove actinides (plutonium and americium) from wastewater at RFP
	AL 121203 Magnetic Separation for Actinide Segregation (FY 1992)	C. Prenger, LANL; L. Avens, LANL (843-2320)	Test OGMS/HGMS on surrogate wastes to remove plutonium, uranium, and americium from the wastes
	RL 421204/ RL 321215/ RL 411205 Advanced Separations Technology	J.J. Holmes, WHC (509-376-1406); J.A. Hunter, WHC (509-376-2356)	Computer model to simulate total waste treatment system Integration with system engineering studies Advanced separation technologies screening
Calcination and Leaching (alternative) • Complete systems study to further evaluate concept • Alkaline-side cesium removal	RL 421216 Calcination/Dissolution Process Development	S.A. Colby, WHC (509-376-8676)	Test plasma arc calciner at Westinghouse Science and Technology Center
Bulk Leaching (alternative) • Identify incentives for blending or bulk treatment processes • Complete feasibility and system studies • Alkaline-side cesium removal			

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
LLW IMMOBILIZATION AND DISPOSAL			
Characterization <ul style="list-style-type: none"> • Characterize candidate tanks, feed tank, with emphasis on organic materials • New methods for analyzing organic, inorganic, and radiochemical species • New methods of conducting waste sampling 			
Grout Waste Form Development <ul style="list-style-type: none"> • Design blend of cementitious materials added to waste • Test formulation on stimulants and waste samples 	RL 321217	Base Technology Development for Waste Disposal	
Glass Waste Form Development <ul style="list-style-type: none"> • Testing to support waste form selection 			
Waste Form Processing and Facilities <ul style="list-style-type: none"> • Formulation algorithms • Acceptable formulation envelope • Waste feed specifications • Long-term durability • Facility and process for greater throughput and waste modification 			
Waste Form Quality Verification Methods <ul style="list-style-type: none"> • Alternative nondestructive techniques to confirm quality of grout product and reduce costs • In situ and in-line processes for sampling and analyzing process feed and product • Control systems using real-time feedback of analyses to control product quality 			

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title		Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Alternative Waste Form Development • Testing to support waste form selection	CH 321201	Polyethylene Encapsulation of Low-Level SST Wastes	P. Kalb, BNL (516-282-7644)	Test radiation and thermal effects on integrity, durability, and leachability of waste form test specimens
	RL 421205	Alternative Waste Forms for Disposal of Underground Storage Tanks (UST)	J.A. Hunter, WHC (509-376-2356)	Develop and test alternative LLW, HLW, and TRU waste forms
Disposal Facility • Flow and transport computer modeling of long-term behavior of waste form and disposal facility • Aggressive barrier systems • Aggressive vault designs • Test asphalt for material compatibility with RCRA requirements (9090 tests) • Development of materials with an enhanced durability	RL 411201/ RL 301205	Permanent Isolation Surface Barrier Prototype System	L. Cadwell, PNL (509-376-5659); G. Gee, PNL (509-376-8424)	Design, test, and construct a waste isolation barrier Conduct accelerated aging tests and analog studies to verify performance
Disposal Facility Performance Assessment • Verify regional geological and hydrologic properties • Acquire hydraulic properties of disposal system components including barriers, vaults, and waste form • Field measurements to validate flow and transport model results	See above			
Alternate Processes/Disposal Systems • Concept Testing				

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
HLW IMMOBILIZATION AND DISPOSAL			
Receipt and Feed Preparation <ul style="list-style-type: none"> • Glass composition envelope definition • Feed chemistry and/or rheology evaluation • Radioactive process and/or product laboratory testing • Feed characterization and processing assessment • Enhanced feed preparation 			
Immobilization Process <ul style="list-style-type: none"> • Melter and waste formulation candidate selection • Melter performance assessment • Vitrification system testing • Waste form qualification (WFQ) strategy 	RF 101204 Joule Glass Melter Demonstration for TRU waste		
	SR 123301 International Melters for Vitrification of TRU and Low-Level Mixed Waste (LLMW)	D.F. Bickford, WSRC (803-725-3737)	Transfer German melter technology to United States Determine glass composition and melter redox state
Process Control and Analytical Support <ul style="list-style-type: none"> • Process and/or product model development • Analytical methods evaluation • Enhanced process control and analytical methods 			
Waste Effluent Treatment <ul style="list-style-type: none"> • Equipment development • Instrumentation and controls development • Enhanced offgas and waste treatment 			
Packaging <ul style="list-style-type: none"> • Canister product qualification • Large canister development 			

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Alternative Immobilization Processes <ul style="list-style-type: none"> • Systems analysis studies for alternate waste forms • Systems analysis studies for alternate immobilization processes 			
Alternative Packaging <ul style="list-style-type: none"> • Systems analysis studies for alternate waste packages 			
RETRIEVAL			
DST Mixer Pump: Scaled Experiments <ul style="list-style-type: none"> • Conduct scaled experiments to determine effects on performance of the following: <ul style="list-style-type: none"> - Pump power - Jet velocities - Number of pumps - Pump configuration - Determine correlations between 1/12- and 1/4-scale test facilities and DST 	RL 421202 UST Retrieval, Transport, and Storage Concepts (FY 1992)	J. Womack, WHC (509-376-5357)	Guidance for retrieval and transport system development for nonrobotic concepts
	AL 221203/ SF 221202 Nonrobotic UST Retrieval, Transport, and Storage Technology (FY 1992)	D. Engi, SNL; D. Ruffner, LLNL	Nonrobotic retrieval concepts Conceptual design with cost estimates
DST Mixer Pump: Scaled Experiments <ul style="list-style-type: none"> • Complete structural analysis • Perform erosion tests for expected metal loss from fluid jets • Perform corrosion tests to support in-tank sludge washing 			
DST Mixer Pump: Numerical Simulations <ul style="list-style-type: none"> • Conduct aerosol generation tests 			

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
DST Mixer Pump: Instrumentation Development to Monitor Process <ul style="list-style-type: none"> • Install and test effectiveness of laboratory-tested ultrasonic probe • Identify alternative systems suitable for monitoring mobilization, solids settling, and slurry uniformity • Develop and demonstrate cone penetrometer and shear vanes for evaluating slurry properties 			
SST First Generation Long-Reach Arm (LRA): End Effector Development and Testing <ul style="list-style-type: none"> • Mechanical agitator with pneumatic conveyor • Scarifier with pneumatic conveyor 	RL 421201 Waste Dislodging and Conveyance	D.M. Burgess, WHC (509-376-5245)	Purchase air conveyance system Issue functions and requirements for soft waste end effector Define bounding conditions for systems specification Develop soft waste end effector Specify conveyance for in-tank hardware
	SF 221205/ SF 221204 Waste Dislodging and Conveyance	G. Armatrout, LLNL	Identify, select, develop, and test candidate waste dislodging concepts Support physical waste characterization
	RL 332003 Multifunctional Scarifier/Conveyor: Design and Development of a Multifunction Scarifier End Effector with an Integral Conveyance System	J.A. Bamberger, PNL (509-375-3898)	Modify scarifier available from Quest Integrated, Inc. for in-tank environment Develop design requirements for scarifier

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
SST First Generation LRA Retrieval: Control System and Sensor Development <ul style="list-style-type: none"> • Graphical real-time control • Fault detection/error recovery • Path planning • Sensor data integration • Real-time controls 	RL 313202 Robotics UST (FY 1992)	D.W. Bennett, PNL (509-375-2159)	Sensing for tele-operated manipulators Remote imaging methods Dynamic control Technical support for computing and controls
	OR113203/ OR132001 LRA - Control System	W.R. Hamel, ORNL (615-574-6814)	Whole-arm obstacle avoidance Long-reach manipulator research and development (R&D) Sensor data interpretation
	AL 213210/ AL 213204 Robotics	D. Berry, SNL (505-844-0234); R.W. Harrigan, SNL (505-844-3004)	Whole-arm collision avoidance Generic intelligent system controller (GISC) Automated path planning Error recovery
	AL 232002 Computer Interface/End Effector	D. Berry, SNL (505-844-0234)	Interface with SNL GISC Transfer and application to long-reach manipulator
	ID 132002/ AL 232001 LRA Computer Interface	S. Thunborg, SNL (505-844-3733)	Human computer interface System supervisory control using GISC
SST First Generation LRA: Base System Development <ul style="list-style-type: none"> • Complete testing for procurement specifications • Place procurement for cold system test 	RL 432001 LRA Systems Coordination and Definition	D.M. Burgess, WHC (509-376-9325)	System reviews and studies to establish baseline concept Coordination with Robotics Integrated Program

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
12.14	RL 413203 Robotics	D.M. Burgess, WHC (509-376-9325)	Robotics testbed Industry involvement Basis for performance specifications
	ID 132001 LRA-Maintenance and Decontamination	T. Nash, WINCO (208-526-8880)	Develop and demonstrate remote maintenance and decontamination
	RL 332004 LRA-Kinematics	D. Bennett, PNL (509-375-2159)	Prepare dynamic and kinematic guidance leading to selection of a LRA
	SF 213204 Robotics UST	S. Couture, LLNL (510-422-1594); P. Densley, LLNL (510-422-3304)	Integrate waste dislodging tools with UST Robotics testbed Wireless data transmission system for end effector tracking and positioning
SST Waste Simulant Development • Develop and validate waste simulants for major waste types	RL 321205 Define and Prepare Waste Tank Simulants	M.R. Elmore, PNL (509-376-4309)	Develop waste simulant formulations to mimic physical and chemical characteristics of UST waste (FY 1992) Develop simulant requirements for end effector DT&E
SST/DST Waste Transport • Full-scale pipe tests for Newtonian and non-Newtonian fluids • Develop computer codes for predicting flow characteristics	OR 111202 Fluid Dynamic Demonstrations for Waste Retrieval and Treatment	E.L. Youngblood, ORNL (615-574-6814)	Develop and test sludge mixing, handling, and transport methods Sludge handling technical exchange Industry survey
DST Mixer Pump System Improvements • Develop and test mixer pump nozzle design • Develop and test special pump design to reduce tank heel			

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title		Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
SST Hydraulic Sluicing Using Nonleaking Fluids • Develop, test, and demonstrate nonleaking fluids				
SST Second-Generation Sluicing • Develop, test, and demonstrate limited or other sluicing methods and specialized sluicing nozzles	AL 232003	Excavation and Retrieval of UST Wastes by Waterjets--Confined Sluicing End Effector	D.A. Summers, SNL (314-341-4311)	Develop confined sluicing end effector that can be maneuvered by robotic arm within the tank Examine waste removal, water recovery, damage to tank walls, and vertical slurry transport properties
SST Second-Generation LRA: Enhanced Control System and Sensor Development • Work space modeling • Dynamic control	RL 332004	LRA - Kinematics	M.S. Evans, PNL (509-375-2143)	Kinematic/dynamic performance prediction System evaluation and integration
SST Second-Generation LRA: Enhanced End Effectors • Cutters with vision and sensing capabilities • Water cannon (or other fluid) with pneumatic conveyor • Hydraulic jets with jet pump conveyor	AL 221205	Waste Dislodging and Conveyance	R. Harrigon, SNL	Baseline technology for conveyance system Evaluate shears, waterjet cutting, and small commercial tools
	RL 332006	Hydraulics Technology	M.R. Powell, PNL (509-376-2334)	Data objectives for testing hydraulic transport components
	AL 221205/ SF 221205		S. Thunborg, SNL (505-844-3733) S. Couture, LLNL (510-532-4100)	In-tank hardware end effector Shear cutters and abrasive water jet with sensors Hydraulic impact end effector Rubble-forming equipment

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
SST Barrier Development • Mobilize waste (salt cake) System feasibility study for subsurface barriers • Tank leak feasibility study	RL 421210 Interim Confinement Barrier for UST	S.J. Phillips, WHC (509-376-1720)	Interim barriers using thermal treatment or injection of polymers into the soil
SST Mixer Pumps with Stop Leak Gel • Feasibility Study			
Dry Mining • Feasibility study	RL 411206 Application of Mining Technology to the USTs (FY 1992)	R.R. Silva, WHC (509-372-0206)	Scope defined by user
Second-Generation Alternative Technology • Feasibility study: - SST mini-mixer - DST past practice - SST hydraulic mining - Other			
LABORATORY SAMPLING AND ANALYSIS			
Sample Acquisition • Hard salt cake homogenizer • Semivolatile sample preparation • NPH removal • Microwave and acid digestion			
Laboratory Analysis: Chemical and Radiochemical • Total carbon by combustion • Chemical oxygen demand • Ferrocyanide • Total cyanide • Mercury by CVAA • Complexants			
Laboratory Analysis: Physical and Thermal • Abrasivity • Viscometer • Thermal conductivity			

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
	RL 332001 Early Deployment System for Remote Characterization	D. Bennett, PNL (509-375-2159)	Investigate, design, and procure components for remote characterization Insertion of sensor package that can assay waste tank contents and perform nonintrusive mapping using laser range finder
Sample Acquisition • In situ sampling and deployment • Penetrometer delivery system • Raman penetrometer • Tank bottom sampler • Mechanized/fluidized bed sampler • Interstitial gas sampler	RL 401203 Light-Duty Utility Arm (LDUA)	J.A. Yount, WHC (509-376-3284)	Design and demonstrate LDUA Prepare LDUA testbed
	RL 332002 LDUA: Sampling End Effector	D. Bennett, PNL (509-375-2159)	Sampling end effector for the LDUA
	RL 421203 Cone Penetrometer Demonstration (FY 1992)	T. Cameron, WHC (509-373-3177)	Demonstrate cone penetrometer for in-tank deployment
	SR 132001 Early Deployment System: Deployment Device	F.M. Heckendorn (803-725-5207)	Report on SRS retrieval technologies Develop robotic system to deploy sensor packages to surface of the waste
	SR 132003 Fiber Optic Near Infrared Spectrometer	P. O'Rourke, WHC (803-725-2173)	Develop fiber optic probe to measure moisture content of ferrocyanide-containing wastes
IN SITU ANALYSIS	RL 421211 Instruments for In Situ Characterization of USTs (FY 1992)	G.V. Delisle, WHC (509-376-1866)	Develop instrument platform to support field and in situ data acquisition
In Situ Analysis: Physical • Acoustic wave guide	CH 11201 Physical Characterization of USTs (FY 1992)	P. Jeong, Ames (515-294-8428)	Ultrasonic technique development Field trials

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Laboratory Analysis: NDA Hot Cell Scanning <ul style="list-style-type: none"> • Remote Raman spectroscopy • Remote infrared/near infrared spectroscopy • Gamma energy analysis core scanning • Laser ablation/mass spectrometer 	SF 213202 Microinstrumentation Application for Laboratory Automation		Development of data analysis approaches Basis of automated laboratory
	SR 132003 Fiber Optic Near Infrared Spectrometer	P. O'Rourke, WHC (803-725-2173)	Develop fiber optic probe to measure moisture content of ferrocyanide-containing wastes
	RL 411206 Ferrocyanide Detection Using Laser Raman Scattering	W. Winkelman, WHC; S. Mech, WHC (509-376-3339)	Develop and test laser Raman methods for detecting ferrocyanides in Hanford UST wastes
	SF 211203/ SF 211201 Advanced Fiber Optic Spectroscopy for Inorganics	M. Angel, and T. Kulp, LLNL (509-543-7839)	Develop and demonstrate integrated fiber optic measurement system
In Situ Analysis: Chemical <ul style="list-style-type: none"> • Remote Raman/fourier transform spectroscopy 	RL 421206 Surface Characterization and Mapping of Tank Waste Using Fourier Transformed Infrared (FTIR) (FY 1992)	S. Mech, WHC (509-376-8858)	Modify Jet Propulsion Laboratory methods and equipment
	RL 421211 Instruments for In Situ Characterization of USTs (FY 1992)	G.V. DeLisle, WHC (509-376-1866)	Develop instrument platform to support field and in situ data acquisition
In Situ Analysis: <ul style="list-style-type: none"> • Radiochemical • Passive copper foil neutron activation with penetrometer • Passive and induced gamma scanning • Assays by CdTe detectors 			

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Field Mobile Screening Laboratory	RL 421211 Characterization Field Support System for In-Situ Characterization of Tank Waste	S.J. Eberlein, WHC (509-376-5029)	Develop instrument and control trailer to support instruments and sensors placed inside tank
	RL 313202 Robotics - Buried Waste/Noninvasive Physical Techniques	D. Bennett, PNL (509-375-2159)	Low Signature Vehicle to deliver multiple integrated sensors to waste site
EXISTING STORAGE MANAGEMENT			
Waste Treatment and Transfer: Corrosion Protection by Chemical Control <ul style="list-style-type: none"> DST corrosion probes Waste chemistry adjustment 			
Waste Storage: Leak Detection Methods <ul style="list-style-type: none"> Instrument upgrades for surface-level measurements Detector for liquid observation wells Detector for dry wells, laterals, and pits Software for temperature monitoring and control system Database for surveillance analysis computer system 			
Waste Storage: Tank Structural Integrity evaluations <ul style="list-style-type: none"> Structural evaluations Analytical modeling Instrumentation for nondestructive annulus inspections Structural integrity assessments Tank 241-C-106 corrosion control 	RL 332001 LDUA Laser Range Finder	F.M. Heckendorn, WSRC (803-725-5207)	Develop remote viewing technology to provide images and real-time monitoring of tank interior conditions
	RL 401203 LDUA	B.A. Carteret, WHC (509-376-8680)	LDUA Remotely operated, mobile system to deploy end effectors for tank inspection

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
	ID 413202 Robotics	L. Martinson, WINCO (208-526-4045); B.L. Griebenow, WINCO (208- 526-0389)	NDE for tank integrity evaluation
Evaluate and Define Safety Issues: Flammable Gas • Synthetic waste studies - Radiolytic/chemical mechanisms study • Physical and numerical modeling • Analytical methods for chelators			
Evaluate and Define Safety Issues: Ferrocyanide • Simulated waste studies • Chemical reaction studies • Laboratory studies - Cesium uptake - Procedures for ferrocyanide analysis • Hot spot thermal modeling • Vapor space gas modeling • Continuous gas monitoring • Infrared scanning system			
Evaluate and Define Safety Issues: Organic Materials • Organic analysis methods development • Laboratory tests • Waste simulant studies • Modeling			
Evaluate and Define Safety Issues: High Heat Tanks • Thermal modeling (106-C)			
Evaluate and Define Safety Issues: Tank Vapors • Air dispersion plume modeling • Vapor monitoring • Portable gas monitoring laboratory			

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Mitigate Safety Condition: Flammable Gas <ul style="list-style-type: none"> • In-tank mixing • Ventilation upgrades 			
Mitigate Safety Condition: Ferrocyanide <ul style="list-style-type: none"> • In situ tank moisture monitoring 			
Mitigate Safety Condition: Tank Vapor <ul style="list-style-type: none"> • Tank vapor treatment system 			
Mitigate Safety Condition: High-Heat Tanks <ul style="list-style-type: none"> • Heat removal/water level control system • Heat extraction and cooling for C-106 			
(Enhancement) Waste Treatment and Transfer <ul style="list-style-type: none"> • SST waterline corrosion protection • Enhanced SST stabilization 			
(Enhancement) Waste Storage <ul style="list-style-type: none"> • Hand-held data acquisition • Spectral gamma probes • Enhanced in-tank leak detection 			
(Enhancement) Optimize Tank Storage Space <ul style="list-style-type: none"> • Enhanced waste volume projection system 			
(Enhancement) Mitigate Safety Condition: Criticality <ul style="list-style-type: none"> • Fissile material measurement • Criticality monitoring 			
Mitigate Safety Condition: Flammable Gas <ul style="list-style-type: none"> • Sonic probe system • Velocity density temperature tree 			

TABLE 12.2. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Waste Treatment and Transfer <ul style="list-style-type: none"> • Emergency response • Waste transfer truck 			
Mitigate Safety Condition <ul style="list-style-type: none"> • Waste dilution in tank 241-SY-101 • Waste heating in tank 241-SY-101 			
Waste Storage <ul style="list-style-type: none"> • Robotics system hot testing and turnover to tank farm 			

TABLE 12.3. Technology Needs Crosswalk for Hanford Solid Waste

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application	
CHARACTERIZATION				
In Situ Measurement/Sampling				
NDE/NDA Methods for Radioactivity and Hazardous Chemicals	AL 111104	Noninvasive Site Characterization-Phase 1: Program Plan for Integrating Space, Airborne, and Surface Methods	E. Van Eeckhout (505-667-1916)	Preliminary site characterization to minimize and optimally locate borehole penetrations
	AL 921101	Neutron Activation Logging System for the Mixed Waste Landfill ID	D.C. George (303-248-6699)	In situ measurement of metals of interest particularly chromium
	ID 121213	Field Demonstration and Characterization Technologies	K.M. Kostelnik (208-526-9642)	Demonstrate characterization technologies that support monitoring, retrieval, and post retrieval
	AL 921102	Integrated Geophysics Program for Nonintrusive Characterization of Mixed Waste Landfill Sites	J.C. Hasbrouck (303-248-6714)	Burial site characterization - locate pit boundaries, characterize pit contents, and detect contaminant plumes
	CH 101104	Onsite Infrared Analyzers for Complex Inorganic/Organic Mixtures	D.P. Baldwin (515-294-2069)	Analyzers for gas, liquid, and solid contamination site samples; real-time analysis during remediation
	SF 213205	Remote Characterization System	J.L. Pence (510-423-1173)	Characterization, excavation, and retrieval of buried waste
	CH 121201	NDE/NDA Peer Review		
	ID 001201	Nonintrusive Sensing of Environmentally Important Objects and Species	J.R. Duray	Site characterization using broadband electromagnetics for in situ detection, especially fissile elements

TABLE 12.3. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Nonbulk Sensors for Radioactivity and Hazardous Chemicals	AL 111104 Noninvasive Site Characterization, Phase 1: Plan for Integrating Space, Airborne, and Surface Methods	Ed Van Eeckhout (505- 667-1916)	Preliminary site characterization to minimize and optimally locate borehole penetrations
	AL 921101 Neutron Activation Logging System for Mixed Waste Landfill ID. In Situ Meas- urement of Metals of Interest	D.C. George (303-248- 6699)	In situ measurement of metals of interest, particularly chromium
	OR 923201 Robotics - Buried Waste	D.L. Jacoboski (513-738- 8986)	Remote and precise excavation for demo planning and remote excavation of soils
	RL 313203 Robotics - Buried Waste (PNL)	D.W. Bennett (509-375- 2159)	Mapping of buried waste, improved object sensing, and mapping techniques
	CH 101104 Onsite Infrared Analyzers for Com- plex Inorganic/ Organic Mixtures	D.P. Baldwin (515-294- 2069)	Analyzers for gas, liquid, and solid contamination site samples; real- time analysis during remediation
	ID 001201 Nonintrusive Sensing of Environmentally Important Objects and Species	J.R. Duray	Site characterization using broad- band electromagnetics for in situ detection, especially fissile elements
	SF 213205 Remote Characteri- zation System	J.L. Pence	Assessment of buried waste sites, unattended sampling, and chemical/ radiological analysis
	ID 413201 Robotics - Buried Waste (INEL)		
	NV 001102 Remote Sensing Systems Development and Applications	L. Balick	Development and evaluation of sensor systems and remote sensing technologies

TABLE 12.3. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
	NV 021701 Associated Particle Imaging	P. Hurley	Noninvasive container characterization, chemical composition, 3-D images
	OR 113202 Robotics - Buried Waste (ORNL)	B.S. Richardson (615-576-6820)	Robotics technology for subsurface characterization and remote excavation of buried waste
Bulk Analysis and Instrumentation	AL 111104 Noninvasive Site Characterization, Phase 1: Plan for Integrating Space, Airborne, and Surface Methods	E. Van Eeckhout (505-667-1916)	Preliminary site characterization to minimize and optimally locate borehole penetrations
	AL 221118 High-Resolution Infrared Imaging for Locating Buried Waste, Containers, and Subsurface Voids	R. Knowlton (505-844-5777)	Thermographic imaging techniques for locating buried waste and subsurface voids
	AL 921102 Integrated Geophysics Program for Nonintrusive Characterization of Mixed Waste Landfill Sites	J.C. Hasbrouck (303-248-6714)	Burial site characterization - locate pit boundaries, characterize pit contents, and detect contaminant plumes
	OR 113202 Robotics - Buried Waste (ORNL)	B.S. Richardson (615-576-6820)	Robotics technology for subsurface characterization and remote excavation of buried waste
	RL 321210 Advanced Mixed Waste Assay System: A Technique for NDA of Waste Drums for Radionuclide and TRU Levels	R.J. Arthur (509-376-0405)	Summarize current status of barrel-scanning technology

TABLE 12.3. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Ground-Penetrating Radar	AL 111104 Noninvasive Site Characterization. Phase 1: Plan for Integrating Space, Airborne, and Surface Methods	E. Van Eeckhout (505-667-1916)	Preliminary site characterization to minimize and optimally locate borehole penetrations
	ID 121213 Field Demonstration and Characterization Technologies	K.M. Kostelnik (208-526-9642)	Demonstrate characterization technologies that support monitoring, retrieval, and post retrieval
	RL 313203 Robotics - Buried Waste (PNL)	D.W. Bennett (509-375-2159)	Mapping of buried waste, improved object sensing and mapping techniques
Package Integrity Analysis			
Heterogeneous Material Sampling Methods			
Real-Time/On-Line Sensors	OR 021201 Linac-Based Characterization of Remote Handled (RH) TRU Waste	F.J. Schultz (615-576-6870)	Description of linear accelerator-based waste characterization system for RH and contact handled (CH) TRU
	RL 321210 Advanced Mixed Waste Assay System: A Technique for NDA of Waste Drums for Radionuclide and TRU Levels	R.J. Arthur (509-376-0405)	Summarize current status of barrel-scanning technology
Sound Statistically Based Approach to Minimize Sampling	AL 221107 Characterization System for Metal Contamination in Arid Soils	J.C. Stormont (505-845-9347)	Characterization and plume definition for metals and mixed waste burial sites
	CH 221103 SEAMIST Applications for Heavy Metal and Mixed Waste Characterization	M.D. Erickson (708-972-7772)	Remediation of mixed waste sites containing heavy metals and complex organic contaminants

TABLE 12.3. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
System-Wide Information System Driven by Expert Systems	CH 221103 SEAMIST Applications for Heavy Metal and Mixed Waste Characterization	M.D. Erickson (708-972-7772)	Remediation of mixed waste sites containing heavy metals and complex organic contaminants
IN SITU TREATMENT			
Toxicity and Mobility			
Dust-Control Technologies			
Vitrification	ID 121201 ISV Demonstration	S.K. Merrill (208-526-8735)	ISV Demonstration Program for the Subsurface Disposal Area acid pit at INEL
	OR 101201 In Situ Vitrification Remedial Action Technology	G.K. Jacobs (615-576-0567)	ISV applications at Oak Ridge National Laboratory
	RL 311201 Buried Waste In Situ Vitrification Project	J. Luey (509-376-5740)	ISV application for buried TRU and mixed waste
Soil-Washing Technologies			
Interim Stabilization Technologies	AL 123302 LLW/Mixed Waste Landfill Cover, Stabilization and Liner Design	J.W. Nyhan (505-667-3331)	Demonstrate pilot-scale landfill cover, in situ stabilization/isolation, and liner systems
	CH 321101 In Situ Containment and Stabilization of Buried Waste	L.E. Kukacka (516-282-3065)	In situ stabilization of contaminated soils and installation of subsurface barriers
	RL 411201 Permanent Isolation Surface Barrier System - Prototype Design	N.R. Wing (509-376-6806)	Development of isolation barriers
	RL 423301 LLW/Mixed Waste Landfill Cover, Stabilization, and Liner Design	S.J. Phillips (509-376-1720)	Demonstrate pilot-scale landfill covers and in situ stabilization systems

TABLE 12.3. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Grout/Cementation	CH 321101 In Situ Containment and Stabilization of Buried Waste	L E. Kukacka (516-282-3065)	In situ stabilization of contaminated soils and installation of subsurface barriers
Encapsulation			
BURIED WASTE RETRIEVAL			
Remote-Handled Material			
Dust-Control and Air-Handling System	AL 021201 Methods and Technical Basis for Monitoring, Evaluating, and Mitigating Airborne Hazards from Buried Waste Retrieval Operations	F.J. Schultz (615-576-6870)	Description of linear accelerator based waste characterization system for RH and CH TRU
	ID 121206 Retrieval Support Contamination Control Technologies		
Radioactive and Hazardous Chemicals Containment and Control	ID 121203 Cryogenic Retrieval	G.G. Loomis (208-526-9802)	Cryogenic retrieval demonstration for TRU-contaminated pits and trenches
	ID 121206 Retrieval Support Contamination Control Technologies		
	SR 101201 TRU Waste Treatment Methodology		
Robotics/Removal Equipment	AL 013202 Robotics - Buried Waste: Supports OTD Robotic Tech Dev't Plan	P. Eicker	Remote characterization and effective handling of buried waste
	OR 923201 Robotics - Buried Waste	D.L. Jacoboski (513-738-8986)	Remote and precise excavation for demo planning, remote excavation of soils

TABLE 12.3. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
	ID 413201 Robotics - Buried Waste (INEL)	B. S. Richardson (615-576-6820)	Robotics technology for subsurface characterization and remote excavation of buried waste
	OR 113202 Robotics - Buried Waste (ORNL)		
Retrieval of Unstable or Reactive Chemical Waste	ID 121203 Cryogenic Retrieval	G. G. Loomis (208-526-9802)	Cryogenic retrieval demonstration for TRU contaminated pits and trenches
Self-Contained Mobile Retrieval System (WORM)			
TREATMENT			
Partitioning/Pretreatment			
Sorting	AL 213205 Robotics Waste Facility Operations; supports OTO TO Plan	P. Eicker	Robotic and automation technologies for waste facility operations, handling, sorting, inspection
	SF 223203 Waste Facilities Operations Waste Sorting Technology	M. Holliday (510-423-0509)	Evaluate robotics technologies for characterizing and repackaging radioactive, hazardous, and mixed waste
	OR 113205 Robotics Waste Facility Operations (ORNL)		
Size Reduction Using Shredders, Shears, etc.	ID 413201 Robotics - Buried Waste (INEL)		
	ID 413204 Robotics - Waste Facilities Operations		
	SR 113201 SR Robotics Support - Waste Facilities Operations	C. R. Ward (803-725-5891)	Automated drum inspection and handling, remote size reduction

TABLE 12.3. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Thermal Treatment Technologies	ID 121207 Thermal Processing Methods Evaluation		
	ID 001203 Buried/Stored TRU Plasma Treatment Process	D. Battleson	Fixed hearth arc plasma technology for processing specialty and other metals
	RL 401204 Treatment Technology for TRU Waste	B. Place (509-376-5016)	Technologies for processing TRU, emphasis on pretreatment
	PE 021202 Butte Plasma Arc Furnace		
	RF 101205 Incineration Alternatives for Combustible Waste	C.M. Brown (303-966-5277)	Thermal treatment technologies for solid and liquid LLW
	SF 221210 Actinide Volatilities: Evaluation and Control of Uranium, Plutonium, and Americium Volatilities in Mixed Waste Oxidation Processes	O.H. Krikorian (510-422-8076)	Treatment of offgas from incineration of actinides, plutonium and uranium
	RF 111202 Thermal Treatment Process Unit	P.M. Williams (303-966-4495)	Thermal treatment of mixed waste, halogens, high-efficiency particulate air (HEPA) filters, lead gloves, PCBs
	RL 321211 Graphite DC Arc Plasma and Glass Melter TSR	J.E. Surma (509-376-4905)	Treatment of contaminated solids such as soils, sludges, etc., as well as liquid and gaseous streams
Mechanical, Chemical, or Aqueous Decontamination Methods	RF 121204 Surface Organic Contaminant Removal		
	SF 211206 Integrated Plutonium Hydriding, Dehydriding, and Casting		

TABLE 12.3. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Disposal Form Conversion			
Vitrification	CH 221203 Minimum Additive Waste Solid/ Vitrification		
	RL 321212 Vitrification of TRU Mixed Waste	C.C. Chapman (509-376- 0016)	Sizing and specifications of a melter and feeding system for metals and combustibles
	ID 121207 Thermal Processing Methods Evaluation		
	ID 001203 Buried/Stored TRU Plasma Treatment Process	D. Battleson	Fixed hearth arc plasma technology for processing specialty and other metals
	SR 123301 International Program-Melters for Vitrification of TRU and LLMW		
Stabilized Waste Forms	ID 121207 Thermal Processing Methods Evaluation		
	RF 101202 Solidification Development for Sludges, Salts, and Ash		
	RF 111203 Polymer Solidifica- tion Development	A.M. Faucette (303-966- 6420)	Solidification of secondary waste streams, ash, miscellaneous waste, organic destruction
	RL 401204 Treatment Technology for TRU Waste	B. Place (509-376-5016)	Technologies for processing TRU, emphasis on pretreatment
	SR 101102 Hazardous and Mixed Waste Treatment Technology Development		

TABLE 12.3. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
	ID 001203 Buried/Stored TRU Plasma Treatment Process	D. Battleson	Fixed hearth arc plasma technology for processing specialty and other metals
	RF 101205 Incineration Alter- natives for Combus- tible Waste	C.M. Brown (303-966- 5277)	Thermal treatment technologies for solid and liquid LLMW
	RF 111204 Nitric Acid Recycle/ Nitrate Destruction		
	SF 221207 Mediated Electro- chemical Oxidation and UV Oxidation as Incineration Alter- natives for Rocky Flats	Z. Chiba (510-273-7878)	Treatment for LLMW combustibles, solid and liquid streams
Metal Waste Forms			
Ceramic Waste Forms	RL 321211 Graphite DC Arc Plasma and Glass Melter TSR	J.E. Surma (509-376- 4905)	Treatment of contaminated solids such as soils, sludges, etc., as well as liquid and gaseous streams

TABLE 12.4. Technology Needs Crosswalk for Hanford Environmental Restoration

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
IN SITU/FIELD MEASUREMENT			
Process Monitoring and Control Technologies	AL 113204 Robotics Lab Automation (LANL)	A.J. Beugelsdijk (505-845-6101)	Laboratory automation, Standard Analysis Method, develop EPA Soxhlet extraction and ultrasonication tests
	AL 121101 Groundwater and Cost Analysis Modeling, Savannah River Site Integrated Demonstration (SRS ID)	N.D. Rosenberg (505-665-0183)	Savannah River ID/groundwater modeling, cost-effectiveness analysis
	AL 121102 Modeling of Bioremediation Experiments at SRS ID	P. Saxman (505-845-6101)	Savannah River ID/bioremediation experiment modeling
	AL 213203 Robotics Lab Automation	P. Eicker (505-844-5827)	Automated analytical lab/modular automation for sample handling
	AL 213204 Robotics Cross Cutting and Advanced Technology	P. Eicker (505-844-5827)	Robotics development, generic applications
	AL 223302 EnviroTRADE Information System	M.W. Harrington (505-844-4221); C.P. Harlan (505-844-8164)	EnviroTRADE relational database development
	AL 223303 EnviroTRADE Relational Database Development	M.W. Harrington (505-844-4221); C.P. Harlan (505-844-8164)	EnviroTRADE relational database development
	CH 023101 Procedure Development for Environmental Sampling and Analysis Operations	S.M. Blacker (703-360-9378)	Quality assurance methods development/setup
	ID 001201 Nonintrusive Sensing of Environmentally Important Objects and Species	J.R. Duray (303-248-6702)	Nonintrusive (magnetic gradient) sensing of important objects for buried waste integrated demonstration (BWID)

TABLE 12.4. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
12.34	ID 121213 Field Demonstration and Characterization Technologies	K. Kostelnik (208-526-9642)	Field demonstration, radar/magnetic anomaly mapping of buried waste for BWID
	NV 001102 Remote Sensing Systems Development/Applications	L. Balick (208-575-8603)	Survey of existing airborne remote sensor technology
	OR 113101 Assessment of Mature Environmental Field Screening Methods		Assessment of mature environmental field screening methods
	OR 113203 3RAC Robotics Advanced Technology (ORNL)	W.R. Hamel (615-574-5691)	VLSI-based sensor for obstacle avoidance, robot long-reach manipulator arm development
	RL 311106 Development, Testing, and Evaluation (DT&E) Characterization and Monitoring Technology	R. Schalla (509-376-5064)	VOC Arid ID sensor/access system/protocol/end-user interface
	RL 313205 Robotics Cross-Cutting and Advanced Technology (PNL)	D.W. Bennett (509-375-2159)	VLSI-based sensor for robot arm obstacle avoidance
	RL 321105 R&D Characterization and Monitoring Technologies	S.C. Slate (509-375-3903)	Supercritical fluid extraction/vadose zone characterization centrifuge
	SR 121102 Integrated Demonstration for Cleanup of Organics in Soils and at Nonarid Sites: Characterization and Monitoring	C.A. Eddy (803-725-2418)	ID for cleanup of organics in soils/nonarid sites: characterization; horizontal well bioremediation; in situ radiofrequency (RF) heating
Sensors	AL 201101 Groundwater Flow Sensor/Seismic Imaging	S. Ballard and G. Elbring (505-844-6293)	Savannah River ID/cross-hole seismic imaging/groundwater flow analysis
	AL 221104 PAWS Down-Hole Liquid/Vapor Phase	G. Frye (505-844-0787)	Acoustic-wave sensors for down-hole VOC real-time monitoring

TABLE 12.4. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
12.35	AL 221206 Field Screening Laboratory System	E.R. Lindgren (505-844-3820 and W.B. Cox (505-844-6820)	X-Ray fluorescence field screening of metals/VOCs
	AL 921101 Neutron Activation Logging System for the Mixed Waste Landfill Integrated Demonstration	D.C. George (303-248-6699)	Development of neutron activation logging tool mixed waste landfill ID, in situ analysis of metals
	CH 101101 Mobile Inductively Coupled Plasma Optical Emission Spectrometer	A.P. D'Silva (515-294-9317)	ICP-OES instrument for direct analysis of uranium, plutonium, thorium in soils using laser ablation
	CH 101103 Improvements in Inductively Coupled Plasma Mass Spectrometry	R.S. Houk (515-294-9462/3887)	Field-portable ICP-mass spectrometer for direct elemental and isotopic soil analysis
	CH 101104 Onsite Infrared Analyzers for Complex Inorganic/Organic Mixtures	D.P. Baldwin (515-294-2069); J.F. McClelland (515-294-7948); and R.W. Jones (515-294-9636)	Field use real-time IR instruments for analysis of mixtures
	CH 311101 Passive Groundwater Sampler for Integrated Demonstration	E. Kaplan (516-282-2007)	Passive multilayer groundwater sampling system demonstration
	ID 121110 In Situ SIMS Analysis: Development and Evaluation of a Transportable Ion Trap SIMS Instrument for the Direct Analysis of Low Volatile Organic Compounds	J.E. Delmore (208-526-2820)	Develop compact in situ secondary ion mass spectrometer for field use, analysis of low-volatile organics

TABLE 12.4. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
12.36	OR 101101 In Situ Fiberoptic Derivative Ultra-violet Absorption Spectroscopic (DUVAS) Monitoring of Aromatic Contaminants	J.W. Haas (615-574-4042)	In situ fiberoptic UV monitor for organics in groundwater
	OR 101102 3CAB Characterization Sites Field Analytical Methods	M.R. Guerin; M.B. Wise (615-574-4862)	Direct sampling mass spectrometry development for VOCs in water and soil with the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA)
	OR 101106 3CAE Integrated Demonstration Protocol Project - Multisorbent Sampler	R.A. Jenkins (615-576-8594)	Savannah River ID/multisorbent-multitrap arrayed downhole sampler
	OR 111101 3BAC Integrated Demonstration of Trichloroethylene (TCE) Degradation	A.V. Palumbo (615-576-8002)	Probe development for TCE bioremediation
	OR 111105 3CAA Characterization Sites Field Analytical Methods - R&D	M.R. Guerin; M.B. Wise (615-574-4862)	Direct-sampling mass spectrometry development for VOCs with USATHAMA (see above)
	OR 121101 3CAD Spectroelectrochemical Sensors for DOE Site Characterization	J.W. Haas (615-574-4042)	Fiberoptic spectroelectrochemical probes/subsurface organics
	OR 121103 3CAF DSITMS Real-Time Monitor Deployment Test	M.B. Wise; M.R. Guerin (615-574-4862)	Direct sampling ion-trap mass spectrometer development for organics in air, water, soil
	OR 121104 Colloidal Borescope	T.A. Cronk; P.M. Kearn (615-576-6265)	Colloidal borescope to determine groundwater flow velocity by advective transport of colloids

TABLE 12.4. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
12.37	RL 321102 Biomolecular Probe Analysis: Bioremediation Organisms	F.J. Brockman (509-375-3903)	VOC nonarid ID/determination of microorganism response to bioremediation activity
	RL 321112 Onsite Analysis of Metals in Soils and Using ASV	K.S. Olsen (509-376-4114)	Absorptive stripping voltammetry, Sandia landfill soil, analysis of chromium, lead, cadmium, copper, nickel, zinc, cobalt
	RL 321114 Detection of High-Z Metals Detection and Quantification of High-Z Metals at the SNL Mixed Waste Landfill by X-Ray Fluorescence	C.L. Shepard (509-375-3675)	Use of Scitek Corp. X-ray fluorescence instrument, Sandia landfill soil in situ characterization
	SF 213202 Microinstrumentation Application to Laboratory Automation		Development of microsensors
	SF 213203 Robotic Cross-Cutting and Advanced Technologies	S. Couture (510-423-4100); J. Folta (510-423-5881); and H. Martz (510-423-4269)	Microelectronic chemical environmental sensors for robotics
Ion-Specific Electrodes			
Soil Gas Analysis			
Radiological Measurements	NV 021701 Associated Particle Imaging	P. Hurley (805-681-2472)	Associated particle imaging/neutron activation sensors
	RL 321103 Mapping of Radionuclides: In Situ Mapping of Radionuclides in Subsurface and Surface Soil	R.W. Perkins (509-376-0204); D.E. Robertson (509-376-5664); and R.L. Brodzinski (509-376-3529)	In situ (radiometric) mapping of uranium in soil using directional gamma-ray spectrometry; alpha-beta-gamma real-time surface monitor development, demonstration, and use at Fernald

TABLE 12.4. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
	RL 321109 RL Sample Support to the Plutonium in Soil ID	R.J. Serne (509-375-3903)	Collection of 1 to 10 tons of soil from Hanford for use in the plutonium in soils ID for physical separations
	RL 321113 Sandia Landfill: In Situ Determination of Radionuclide and Metal	R.L. Brodzinski (509-376-3529)	Gamma-ray spectrometer and x-ray fluorescence sensor for radionuclides/metals determination in landfill
Fiber Optic Probe	OR 101101 DUVAS Probe Demonstration/ Aromatic Organics in Groundwater	J. Evans (509-376-0934)	DUVAS probe demonstration/aromatic organics in groundwater
	RL 311102 Fiber Optic Probe: Fiber Optic Probe for TCE in Soil and Groundwater at VOC-Nonarid Integrated Demonstration	S.M. Angel (510-543-0375)	TCE-selective chemical optrode (Fiberchem, Inc) development/test
	SF 201203 Advanced Fiber Optic Sensors	S.M. Angel (510-543-0375)	Development of several types of advanced fiber optic sensors
	SF 211102 In Situ Detection of Organics, Demo Support	F.P. Milanovich (510-422-6838)	LLNL fiber optic sensor development and testing/in situ organics, coordinated U.S. Army fiber optics
	SF 211103 In Situ Detection of Organics, Phase IV	S.M. Angel (510-543-0375) and K. Langry (510-543-2043)	Fiber optic sensor development, indicator chemistry for organics in groundwater
	SF 211107 Advanced Fiber Optic Sensors	S.M. Angel (510-543-0375)	LLNL advanced fiberoptic sensor system general development
	SF 221101 Fiber Optic Sensor and Analysis for the Integrated Demonstration for Cleanup of Soils and Groundwater in Nonarid Sites	F.P. Milanovich (510-422-6838)	LLNL TCE fiberoptic sensor for non-arid site organics, evaluation

TABLE 12.4. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
	SF 221104 Development of Fiber Optic Sensors for CHCl_3 and CCl_4 for the Arid-Site Demo	S.M. Angel (510-543-0375) and K. Langry (510-543-2043)	VOC arid fiberoptic probe for chlorinated organics
	SF 223301 Remote Sensors for Organics, Toxic Metals, and Actinides	R. Silva (510-543-1977); R. Russo (415-486-4258); and W. Hoppes (510-422-0158)	LLNL/Germany fiber optic probe/ groundwater colloids analysis, using laser-based photothermal absorption spectroscopy
Drilling	AL 221103 Utility Industry Directional Drilling	R.P. Wemple (505-844-2230)	Adaptation of existing utility industry directional drilling technology for sensor placement
	AL 221116 Hybrid Directional Boring and Horizontal Logging	R.P. Wemple (505-844-2230)	Hybrid directional boring and horizontal logging coop. research with Ditch-Witch
	CH 221103 SEAMIST Applications for Heavy Metal and Mixed Waste Characterization	M.D. Erickson (708-972-7772) and C. Keller (505-983-6698)	Application of pneumatic membrane emplacement system for heavy metal and mixed waste characterization
	RL 421103 Arid Site Drilling Technology Development	G.W. McLellan (509-376-2260)	Directional drilling demonstration/ 200W Area Hanford
	RL 421203 Cone Penetrometer Demonstration	J.W. Cammann (509-376-8506) and D.R. Myers (509-376-1723)	Cone penetrometer demonstration/ in situ SST and soil
	SF 121105 Directional Drilling Status and DOE Applications	G.A. Cooper	Survey of directional drilling status and DOE applications for SRS ID directional drilling
	SR 121101 SRS ID Demonstration: Directional Drilling	D.S. Kaback (803-725-5190) and M.E. Denham (803-725-9714)	Testing and evaluation of several directional drilling technologies

TABLE 12.4. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Ground-Penetrating Radar	AL 221123 Cross Borehole Electromagnetic Imaging of Chemical and Mixed Waste Landfills	D.J. Borns; G.A. Newman; and L.C. Bartel (505-844-7333)	Cross-borehole radar/continuous wave imaging/mixed waste landfill
	RL 313203 Robotics - Buried Waste (PNL)	D.W. Bennett (509-375-2159)	Subsurface mapping ground-penetrating radar remotely operated vehicle
Electrical Resistivity Technologies	CH 221101 DNAPL Investigation at SRS Integrated Demonstration	M.D. Ericksen (708- 252-7772)	Cone penetrometer, shear wave seismic survey, Raman spectroscopy, depth-discrete sampling for DNAPLs
	OR 113202 SRAB Robotics - Buried Waste (ORNL)	B.S. Richardson (615-576-6820)	Adaptation of excavator for remote use and subsurface characterization vehicle development
	SF 221102 VOCs in Nonarid Soils Monitoring Task: Underground Imaging	A.L. Ramirez (510-423-5053)	Savannah River ID underground 3D electrical resistivity tomographic imaging
Infrared Thermal Imaging			
IN SITU SOIL TREATMENT/ISOLATION			
Bioremediation	OR 101108 Demonstration of Co-Metabolic Techniques	S.E. Herbes (615- 574-7336)	VOC co-metabolism in situ bioremediation with methane-utilizing microorganisms
	OR 121102 TCE/Perchloroethylene (PCE) Vegetation Demonstration	B.T. Walton N.T. Edwards (615-574-7839)	Use of vegetation to stimulate microbial degradation of chlorinated hydrocarbons
	OR 121110 Bioremediation of PCB Contamination	T.L. Donaldson (615-574-2210)	Ex situ bioremediation of PCBs. CRADA with General Electric

TABLE 12.4. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
	RL 311104 Treatment Technologies	T.M. Brouns (509-376-7855); W.O. Heath (509-376-0554); J.N. Petersen (509-335-1003); D.J. Johnstone (509-335-3177); R.L. Crawford (208-855-6580); and D. Cohn (617-253-5524)	R&D for in situ soil treatment/ bioremediation; six-phase soil heating; tunable hydrid plasma for off-gas treatment at PNL
Hanford Barrier	RL 301205 Surface Barrier Technology Development of Permanent Isolation Barriers for Underground Storage Tank Sites	G.W. Gee (509-376-8424); L.L. Cadwell (509-376-5659); and N.R. Wing (509-376-6806)	Development of permanent isolation barriers for UST sites with WHC (TTP # RL 411201)
	RL 411201 Permanent Isolation Surface Barrier System - Prototype Design	N.R. Wing (509-376-6806) and G.W. Gee (509-376-8428)	Permanent isolation surface barrier system -prototype design (collaborative effort with WHC)
	RL 421210 Interim Subsurface Confinement Barrier for USTs	S.J. Phillips (509- 376-1720)	Demonstrate candidate interim subsurface confinement barrier for USTs
	RL 421212 Monolith Confine Radioactive Waste Management Committee (RWMC): Monolithic Confinement of RWMC-Contaminated Geologic Media	S.J. Phillips (509- 376-1720)	INEL-RWMC. demonstrate monolithic entombment materials for in situ treatment of fractured rock and interbed media
Soil Heating	RL 311104 Treatment Technologies	T.M. Brouns (509-376-7855); W.O. Heath (509-376-0554); J.N. Petersen (509-335-1003); D.J. Johnstone (509-335-3177); R.L. Crawford (208-855-6580); and D. Cohn (617-253-5524)	R&D for in situ treatment/ bioremediation/six-phase soil heating

TABLE 12.4. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
In Situ Vitrification (ISV)	CH 221203 Minimum Additive Waste Stabilization Program	R.F. Gimpel (708-774-6112)	Combination of waste streams for minimum additive waste solids/ ex situ vitrification
	ID 111202 In Situ Vitrification R&D/SDA Acid Pit	R.K. Farnsworth (208-526-6986)	Site-specific R&D for ISV demonstration at INEL Subsurface Disposal Area (SDA) acid pit
	ID 121201 ISV Demonstration	S.K. Merrill (208-526-8735)	ISV demonstration/INEL BWID soil treatment at SDA acid pit
	OR 101201 In Situ Vitrification Remedial Action Technology/ORNL	G.K. Jacobs (615-576-0567) and B.P. Spalding (615-576-0567)	Evaluation of results from pilot-scale radioactive seepage trench ISV demonstration
	RL 301202 116-B-6A Crib ISV Demonstration Project	C.H. Kindle (509-376-5904)	Site characterization study and treatability test of ISV at 116-B-6A Crib site
Electrokinetics/Electroosmosis	OR 221102 In Situ Remediation by Electrokinetics	R. Swatzell (615-435-3126)	Evaluation of in situ remediation by electrokinetics
In Situ Grouting	AL 223309 Characterization and Sealing of Contaminated Sites from Horizontal Boreholes	A. DuCharme (505-844-5571)	Identify technical advances in Germany in horizontal drilling, borehole stabilization, contaminant sampling, and polymer seals formulation and injection
	RL 321217 UST Base Technology Development for Waste Disposal	C. Voss (206-883-0777)	
Vapor Extraction	AL 221121 Thermal Enhanced Vapor Extraction System	J.M. Phelan (505-845-9892)	Chemical Waste Landfill, Pit 3, combination of in situ heating, vacuum extraction, offgas treatment
MATERIAL RETRIEVAL			
Soil Fixant and Foam Technologies			
Soil Retrieval			

TABLE 12.4. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Robotics Applications for Remote Handling	AL 213203 Robotics - Contaminant Analysis Automation	R.W. Harrigan (505-844-3004)	Development of modular automation technologies for characterization of EPA standard methods
	AL 213204 Robotics Cross-Cutting and Advanced Technology	D. Horschel (505-845-9836)	General development, robotics laboratory automation technology
	OR 923201 Robotics - Buried Waste	D.L. Jacoboski (513-738-8986)	Development of robotic excavator for accurate buried waste/remote excavation
Dust Control/Containment			
Chemical Methods for Groundwater Subsurface Manipulation/Retrieval			
Physical Methods for Groundwater Subsurface Manipulation/Retrieval	RL 401202 BWID Retrieval Demonstration	G.G. Loomis (208-526-9802) and B. M. Wilding (208-526-8160)	Demonstration of remote excavator retrieval of simulated radioactive waste using ground freezing
Subsurface Barriers			
Grout	RL 401202 In Situ Stabilization Fluidized-Bed Zeolite System	S.J. Phillips (509-376-1720)	Fluidized-bed zeolite slurry fixation of subsurface in situ
Biological	SR 101101 TCE Biodegradation Demonstration	T.C. Hazen (803-952-7517)	Vegetation enhancement of microbial TCE biodegradation; large-scale continuous flow bioreactor
	SR 121106 SRS Integrated Demo: Bioremediation Tasks	T.C. Hazen (803-952-7517)	Full-scale multi-laboratory SRS ID remediation tasks/in situ bioremediation with methane injection
Cryogenic			
Electrokinetic			
Membrane			

TABLE 12.4. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
EX SITU TREATMENT OF SOILS			
Washing (chemical extraction)	AL 121121 Selective Extraction/Leaching	R.R. Ryan (505-667-6045)	Development of novel chelators for soil leaching (uranium/plutonium chemical treatment)
	NV 001101 Plutonium (Pu) Contaminated Soil Cleanup Demonstration	H.F. Kerschner (702-295-0536)	Plutonium-contaminated soil cleanup demonstration - generic
	NV 011104 Physical Methods for Soil Decontamination	H.F. Kerschner (702-295-0536)	Soil treatability test facility to demonstrate physical methods for soil decontamination
	PE 021101 Soil Treatment System/Jig and Cyclone Technologies/NTS		Soil treatment system/jig and cyclone technologies/NTS
	SR 121105 Soil Contaminant Extraction/Leaching	L.O. Dworjanyn (803-725-3515)	Fernald - uranium removal from soil/generic
Bioremediation	ID 121102 Soil Bioreactor Studies	G.F. Andrews (208-526-0174)	Assessment of bioremediation of Savannah River site soils and groundwater by indigenous bacteria
	ID 121103 Bioprocessing Technologies for Uranium-Contaminated Soils	A.E. Torma (208-526-8472)	Microbial uranium precipitation by redox reactions; solubilization by microbially generated chemicals
	ID 121204 Biological Destruction of Nitrates	G.F. Andrews (208-526-0174)	INEL buried waste nitrate bioremediation
	OR 121102 Vegetation to Remove TCE Soil Contamination		
Ex Situ Vittrification	RL 321211 Graphite DC Arc Plasma and Glass Melter	J.E. Surma (509-376-4905)	Graphite torch DC arc plasma and glass melter with Electro-Pyrolysis, Inc., BWID

TABLE 12.4. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Grout			
Electrokinetics/Electroosmosis	AL 124102 Magnetic separation CRADA		Magnetic separation CRADA, uranium, Transuranics in soils
	ID 121211 Ice Electrode	D.F. Glenn (208-526-1265)	Heavy metals removal from liquids and soils using an ice-coated electrode and Isotron's Electrosorb proc.
	RL 301204 CEPD: Catalyzed Electrochemical Oxidation Treatment of TRU-Contaminated and Hazardous Waste	E.J. Wheelwright (509-376-3441)	CEPD treatment of TRU-contaminated and hazardous waste; not funded
Heat (thermal desorption)			
Bioremediation	SR 121108 Bioremoval of Heavy Metals from Aqueous Solutions	E.W. Wilde (803-725-5212); R.J. Mehlhorn (415-486-5068)	Use of algae for biosorption of heavy metals from aqueous solutions
Membrane Separation (e.g., reverse osmosis)	CH 221301 Groundwater Decontamination of VOCs	G.F. Vandegrift (708-972-4513) and J.C. Hutter (708-972-6497)	Joint DOE/USAF program, membrane-assisted solvent extraction and membrane-assisted distillation strip.
	OR 121110 Bioremediation of PCB Contamination		PCB bioremediation in soils
	OR 123301 3BAF Removal of Uranium by Biosorption - Germany	B.D. Faison (615-576-0484)	Removal of uranium from German mill tailings wastewater by biosorption
	SF 201101 In Situ Microbial Filters	R.B. Knapp	In situ methanotropic bacteria to form a "curtain" microbial filter in soil column
	SF 201701 Method to Remove Chloroform and TCE from Groundwater and Wastewater	K. Langry (415-543-2043)	Hollow-fiber polyethylene-based filter system to remove chloroform and TCE from groundwater and wastewater directly

TABLE 12.4. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Precipitation			
IN SITU TREATMENT OF GROUNDWATER			
Bioremediation	OR 101104 Bioremediation of Groundwater	S. E. Herbes (615-574-7336)	Evaluation of existing systems for chlorinated hydrocarbon bioremediation of groundwater
	OR 111101 SRS ID of TCE degradation		SRS ID of TCE degradation (no abstract)
	OR 123302 In situ destruction of VOCs - an American-German Collaboration	R. L. Siegrist (615-574-7286)	ORNL/University Karlsruhe collaboration, in situ soil liquid circulation system and bioremediation of VOCs
Technologies for Treatment of DNAPLs			
Chemical Treatment	SF 211104 Dynamic Underground Stripping Demonstration Project	R. Aines (415-422-7184)	Combined cyclic steam injection with electrical heating and vacuum extraction of gasoline from soils in situ

TABLE 12.5. Technology Needs Crosswalk for Hanford Decontamination and Decommissioning

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
CHARACTERIZATION	CH 101103 Improvements in Inductively Coupled Plasma-Mass Spectrometry (ICP-MS)	R. Houk (515-294-9462/3887)	Improve precision and accuracy of ICP-MS for monitoring stable and radioactive elements
	SF 201203 Advanced Fiber Optics Sensors	No. Found	
	AL 201303 Online Monitoring of VOCs for Waste Minimization (application to recycle)	G. Frye (505-844-0787)	Development/demonstration and fielding of portable acoustic wave sensor system
	RL 421206 Surface Characterization	Not Found	
	RL 421208 Characterization System Study	Not Found	
	NV 001102 Remote Sensing Systems Development and Applications	L. Balick	Evaluation of existing and development of new remote sensing technologies
	OR 101103 Real-Time Monitoring for Organics	M.B. Wise (615-574-4867)	Development of high-sensitivity mass spectrometer-based technologies for real-time monitoring of hazardous organic compounds in air and process streams
	OR 121101 Spectroelectrochemical Sensors for Site Characterization	J.W. Haas (615-574-5042)	Develop new, cost-saving spectroelectrochemical technologies for in situ detection of subsurface contaminants
	OR 121103 DSITMS Real-Time Monitoring Deployment Test	M.B. Wise (615-574-4862)	Expedite the testing and deployment of advanced monitoring and field technologies based on DSITMS

TABLE 12.5. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
12.48	OR 121201 Rapid and Cost-Effective Luminescence Spot Test for Screening PCBs	T. Vo-Dinh (615-574-6249)	Evaluate and test a cost-effective and rapid screening technology and fabricate a portable monitor for PCBs
	AL 221102 PAWS Offgas	Not Found	PAWS is for CCl ₄ only
	OR 101102 Characterization Sites Field Analytical Methods - Demo	M.R. Guerin (615-574-4862)	Demonstrate rapid laboratory and field methods based on Direct sampling mass spectrometry for analysis of water and soil
	OR 111105 Characterization Sites Field Analytical Methods - R&D	M.R. Guerin (615-574-4862)	See OR 101102
	SF 221103 Advanced Fiber Optic Spectroscopy for Inorganic Contaminants	Not Found	
	ID 121213 BWID Field Demonstration and Characterization Technologies	K. Kostelnik (208-526-9642)	Demonstrate characterization technologies that support retrieval, monitoring during retrieval, and post-retrieval characterization for sorting and processing (BWID)
	RL 321103 In Situ Mapping of Radionuclides in Subsurface and Surface Soil	R.W. Perkins (509-376-5664)	Develop and demonstrate technology for the measurement of uranium in subsurface and surface soils
	RL 321112 Strippable Voltammetry: Onsite Analysis of Metals in Soils using ASV	K. Olsen (509-376-4114)	Develop and test the effectiveness of using absorptive stripping voltammetry on soils/sediments
	RL 321113 In Situ Determination of Radionuclide and Metal Concentrations at a Landfill	R.L. Brodzinski (509-376-3529)	Design and fabricate in situ sensor capable of measuring radioactive and stable metal contaminants in and around landfill

TABLE 12.5. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
12.49	RL 321114 Detection and Quantification of High Z Metals at the SNL Mixed Waste Landfill by X-Ray Fluorescence	C.L. Shepard (509-375-3675)	Employ x-ray fluorescence to the in situ characterization of soil for heavy metals
	AL 113101 Research and Special Studies A: Field Screening	C. Liebman (505-664-6789)	Identify DOE field measurement needs, assess field screening technologies, develop methods and analytic procedures
	ID 021204 TRU/Hazardous Waste Characterization Technical Evaluation	Not Found	
	OR 021201 LINCA-Based NDA/NDE of RH TRU Waste	F.J. Schultz (615-576-6870)	Describe a linear accelerator-based waste characterization system for remote-handled and difficult-to-certify contact-handled transuranic wastes
Intrusive			
Remote Sampling Technologies	SF 213203 Robotic Cross Cutting and Advanced Technologies	S. Couture (510-423-4100)	Develop sensor systems and robotics to be used for environmental characterization and monitoring technologies
	AL 223201 Robotics - D&D	R.W. Harrigan (505-844-3004)	Develop prototype robotics system to remove and bag asbestos on straight pipes
	SR 123201 SR Robotics - D&D	C.R. Ward (803-725-5891)	Develop mobile floor characterization system
	OR 113206 Robotics - D&D	W.R. Hamel (615-574-5691)	Coordinate other robotics D&D programs
	RL 323201 Robotics for D&D	M. Dodson (509-375-2039)	Develop improved robotics-based methodologies for D&D (dismantling, mobile support)

TABLE 12.5. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
12.50	OR 323201 Robotics Support, D&D	Not Found	
	SF 223203 Waste Facilities Operations Waste Sorting Technology	M. Holliday (510-423- 0509)	Develop, demonstrate, and test robotics technologies for waste facilities for storing, character- izing, and/or repackaging radioac- tive, hazardous, or mixed wastes
	SF 213206 Robotics Waste Minimization	Not Found	
	AL 221117 Nonintrusive Characterization	Not Found	
	AL 111104 Noninvasive Site Characterization, Phase I	E. Van Eeckhout (505- 667-1916)	Plan? - for noninvasive methods for preliminary site characterization
	SF 121101 Seismic Characterization	E. Majer (510-486-6709)	Test the use of high-resolution seismic imaging in the mixed waste landfill ID to locate and determine extent of contaminant sources and define local geology
	RL 421206 Surface Characterization/Map ping of Tank Waste Using Fourier Transform Infrared Spectroscopy	W.D. Ledgett (509-376- 4520)	Provide means to identify, enhance, and transfer remote materials char- acterization technologies for use in tank waste characterization
	AL 213201 Robotics Storage Tanks - West	D. Horschel (505-845- 9836)	Develop prototype intelligent robot system control technology
	AL 213202 Robotics - Buried Waste	D. Horschel (505-845- 9836)	Develop robotic and automation technologies
	AL 213205 Robotics Waste Facilities Operations	D. Horschel (505-845- 9836)	Develop robotic and automation

TABLE 12.5. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
	ID 423201 Robotics - D&D (see remote mechanical devices)	Not Found	
Rapid Field Analysis	AL 221208 Field Screening Laboratory System	Not Found	
	ID 121212 Radiological and Hazardous Materials Measurement System	T.J. Roney (208-526-9712)	Develop technology status report
	CH 101010 Mobile Inductively Coupled Plasma Optical Emission	Not Found	
Hazardous	SF 221101 Fiber Optic Sensor	F.P. Milanovich (510-422-6838)	Field demonstrate fiber optic sensor technology applicable to liquid and gas phase only
	OR 111105 Characterization Sites Field Analytical Methods - R&D	M.R. Guerin (615-574-4862)	See OR 101102
	AL 221206 Field Screening Laboratory System for the MWLFID	E. Lindgren (505-844-3820)	Provide field screening laboratory system capable of fast turnaround, high quality, metals and VOC analyses
	CH 101104 Field Deployable VOC Analyzer: Onsite, Real-Time VOC Analyzer Systems for Air, Soil and Water	J. McClelland (515-294-7948)	Develop field-deployable analyzer systems for gaseous, solid and liquid environmental samples
	ID 121110 In Situ SIMS Analysis	J.E. Dillmore (208-526-2820)	Develop a laboratory-based, transportable instrument combining secondary ion mass spectrometry technology with an ion trap mass spectrometry to analyze low- or nonvolatile organic compounds
	CH 111203 Characterization and Sensor Technology Integrated Program		

TABLE 12.5. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Radioactive			
Physical			
Nonintrusive			
Rapid Field Detection Instruments	CH 101101 Mobile Inductively Coupled Plasma Atomic Emission Spectrometer	A. D'Silva (515-294-9317)	Uses inductively coupled plasma (ICP) atomic emission spectrometry for detection of over 70 elements and laser ablation for direct analysis of solids to produce aerosols for the ICP spectrometer
Hazardous	SF 223203 Waste Facilities Operations Waste Sorting Technology	M. Holliday (510-423-0509)	Develop, demonstrate, and test robotics technologies for waste facilities for storing, characterizing, and/or repackaging radioactive, hazardous, or mixed wastes
	CH 121202 Paper Study on Inductively Coupled Plasma	Not Found	
	CR 121101 Spectroelectrochemical Sensors for Site Characterization	J.W. Haas (615-574-5042)	Develop new, cost-saving spectroelectrochemical technologies for in situ detection of subsurface contaminants
	CH 101104 Field Deployable VOC Analyzer: Onsite, Real-Time VOC Analyzer Systems for Air, Soil and Water	J. McClelland (515-294-7948)	Develop field-deployable analyzer systems for gaseous, solid and liquid environmental samples
Radioactive	CH 121202	Not Found	
Physical	ID 001201 Nonintrusive Sensing of Environmentally Important Objects and Species	J.R. Duray (303-248-6702)	Develop improved system for nonintrusive characterization using a tensor magnetic gradiometer and adapt broadband electromagnetics techniques for 3-D site characterization, etc.

TABLE 12.5. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Scanner with Robotic Interface	SF 223203 Waste Facilities Operations Waste Sorting Technology	M. Holliday (510-423-0509)	Develop, demonstrate, and test robotics technologies for waste facilities for storing, characterizing, and/or repackaging radioactive, hazardous, or mixed wastes
IN SITU PRETREATMENT			
Immobilization			
Fixatives and Foams			
Isolation	RL 423301 LLW/MW Landfill Cover Stabilization Liner	Not Found	
Decontamination	RF 121204 Surface Organic Contamination Removal	Not Found	
	OR 121110 Bioremediation of PCB Contamination	T.L. Donaldson (615-574-2210)	Evaluate specialized cultures for biodegradation of PCBs
	OR 123301 Removal of Uranium by Biosorption - Germany	B.D. Faison (615-576-0484)	Develop biosorption technology for the removal of uranium and other metals from uranium mill tailings wastewater (water only?)
	OR 221102 In Situ Remediation by Electrokinetics	R. Swatzell (615-435-3126)	Evaluate the applicability and technical feasibility of electrokinetic capabilities for remediation of contaminated soils and groundwater
	OR 911104 Uranium Soils Integrated Demonstration Management	K.R. Nuher (513-738-6677)	Demonstrate and evaluate a system of technologies for the removal of uranium from soils
	RL 321204 Innovative Chemical Separation/Treatment	D. Wester (509-376-4522)	Identify, develop, and test new solid-based chemical separations/treatment options for radioactive and hazardous wastes

TABLE 12.5. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
	RL 411205 Advanced Separation Technologies	Not Found	
	OR 111104 D&D ID Planning	R.D. Bundy (615-576-0192)	Define and oversee RDDT&E needed to support DOE-wide D&D obligations
	ID 101101 Chlorinated Solvent Substitution Program	A.A. Chavez (208-583-7834)	Assist in replacement of toxic halogenated solvents
	OR 921109 Secondary Waste Treatment Soils	Not Found	
Removable Coatings			
Remote Mechanical Devices	AL 213201 Robotics Storage Tanks - West	D. Horschel (505-845-9836)	Develop prototype intelligent robot system control technology
	AL 213202 Robotics - Buried Waste	D. Horschel (505-845-9836)	Develop robotic and automation technologies
	AL 213205 Robotics Waste Facilities Operations	D. Horschel (505-845-9836)	Develop robotic and automation technologies
	SF 213203 Robotic Cross Cutting and Advanced Technologies	S. Couture (510-423-4100)	Develop sensor systems and robotics to be used for environmental characterization and monitoring
	AL 223201 Robotics - D&D	R.W. Harrigan (505-844-3004)	Develop prototype robotics system to remove and bag asbestos on straight pipes
	SR 123201 SR Robotics - D&D	C.R. Ward (803-725-5891)	Develop a mobile floor characterization system
	OR 113206 Robotics - D&D	W.R. Hamel (615-574-5691)	Coordinate other robotics D&D programs
	RL 323201 Robotics for D&D	M. Dodson (509-375-2039)	Develop improved robotics-based methodologies for D&D (dismantling, mobile support)

TABLE 12.5. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
12.55	OR 323201 Robotics Support, D&D	Not Found	
	SF 223203 Waste Facilities Operations Waste Sorting Technology	M. Holliday (510-423- 0509)	Develop, demonstrate, and test robotics technologies for waste facilities for storing, characteriz- ing, and/or repackaging radioactive, hazardous, or mixed wastes
	SF 213206 Robotics Waste Minimization	Not Found	
	ID 423201 Robotics - D&D	Not Found	
	ID 413201 Robotics - Buried Waste	L.M. Martinson	Develop a low signature vehicle (LSV), demonstrate remote emplace- ment of sensors, enhance remote size reduction capabilities, and apply remotely operated excavators to BW retrieval
	OR 113202 Robotics - Buried Waste	B.S. Richardson (615- 576-6820)	Develop and demonstrate robotics technology for subsurface charac- terization and remote excavation of buried waste
	RL 413202 Robotics - Buried Waste	Not Found	
	RL 313203 Robotics - Buried Waste	D. Bennett (509-375- 2159)	Develop a LSV to be used to deliver multiple integrated sensors to a buried waste site
	SF 213205 Robotics - Buried Waste	J. Pence (510-423-1173)	Looks like the management program for the "Robotics Buried Waste" Programs
	OR 113201 Robotics, UST	B.L. Burks (615-576- 7350)	Develop and demonstrate robotics technology for characterization and remediation of underground storage tanks

TABLE 12.5. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
12.56	OR 913201 Robotics Program UST - East Projects	D.L. Jacoboski (513-738-8986)	Lead the robotics UST efforts to provide technology support for FEMP silo surface characterization, waste removal and tank D&D needs, etc.
	RL 313202 Robotics UST	D. Bennett (509-375-2159)	Initiate and implement force-based control algorithms for very large manipulators, integrate kinematic tracking camera, and develop remote imaging methods
	SF 213204 Robotics UST	S. Couture (510-422-1594)	Define requirements of wireless in-tank communications and investigate independent tool point tracking concepts
	RL 413203 Cone Penetrometer Demonstration	D. Burgess (509-376-5245)	This is the coordinating program for the "Robotics UST" programs
	OR 113203 Robotics Advanced Technologies	W.R. Hamel (615-574-5691)	Technology development in whole-arm obstacle avoidance, long-reach manipulation R&D and sensor data interpretation
	RL 313205 Robotics Cross Cutting and Advanced Technology	Not Listed	Improve characterization sensing methods and increase productivity of teleoperated manipulator operations via advanced servo controls.
	RL 421203 Cone Penetrometer Demonstration	J.W. Cammann (509-376-8506)	Develop and demonstrate enhanced cone penetrometer techniques for performing in situ characterization of SST waste and the in situ soil characterization of SST leaks
	RF 121105 Directional drilling Status and DOE Applications	Not Found	
	SF 221204 Robotic Mole Development for Toxic Waste Site Inspection	Not Found	

TABLE 12.5. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
	SF 223201 Robotics - D&D	G. Armantrout	Support in identifying specific applications for robotics in D&D
	RL 423201 Robotics - D&D	J. Yount (509-376-3284)	Contribute to preliminary conceptual design of an integrated D&D mobile robot support system, etc.
	SF 213203 Robotics Cross Cutting and Advanced Technologies	S. Couture (510-423-4100)	Develop sensor systems and robotics to be used for characterization and monitoring
Abrasives			
Thermal			
High-Intensity Radiant Energy	OR 101204 Microwave Concrete Decontamination System (also remote)	R. Grubb (615-574-1781)	Demonstrate decontamination of concrete surfaces using microwave technology.
Remote Laser Decontamination	CH 101120 Laser Decontamination and Recycle of Metals (See Recycle Metals)	Not Found	
Liquid-Phase Decontamination	OR 111102 Liquid-Phase Decontamination of Gas Diffusion Equipment	R.L. Fellows (615-576-5632)	Develop decontamination processes for nickel, aluminum, steel, stainless steel, copper and copper alloys
Aqueous			
Water Jet			
Foams and Gels			
Electrochemical			
CEPOD	RL 321203 Continuous Cesium Recover	J.B. Duncan (509-376-0467)	Provide continuous ion exchange technology for the recovery of Cs-137 from liquid waste streams (This does not sound like CEPOD)
Electropolishing			
Chelating Agents			

TABLE 12.5. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Gas-Phase or Vapor-Phase Decontamination			
Dismantle Components			
Thermal Dismantling			
Metal			
Concrete			
Physical Dismantling			
Concrete			
Nonthermal Dismantling			
Liquid Metal Embrittlement			
Size-Reduction Methods			
Other Decontamination			
Contamination Control	AL 121210 Real-Time Monitoring During Retrieval	D. Moore (505-667-1989)	Evaluate status of retrieval support and contamination control technology
Recycle	SR 113201 SRS Robotics Waste Facility Operations	C.R. Ward (803-725-5891)	Develop remote inspection and survey system for stored waste drums, test bed for remote drum opening and emptying, and telerobot improvements
	OR 221103 D&D/Recycle Projects ID Coordination	Not Found	
	OR 221104 Recycle of Contaminated Materials and Equipment	Not Found	
Metal	CH 111201 Laser Decontamination and Recycle of Metals	Not Found	
	OR 111102 See Liquid-Phase Decontamination		

TABLE 12.5. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
	CH 111204 Laser Decontamina- tion and Recycle of Metals	M.C. Edelson (515-294- 4987)	Investigate use of lasers to decon- tamine metals with no solvents, avoids exposure of equipment and can be performed remotely
	SF 201202 Cleanable Steel HEPA Filters	W. Bergman	Develop a cleanable steel high- efficiency particulate filter
	CH 101120 See Remote Laser Decontamination		
Concrete			

TABLE 12.6. Technology Needs Crosswalk for Hanford Irradiated Fuel

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
EXISTING INVENTORY MANAGEMENT			
Interim Storage Form Conversion			
Mechanical Size Reduction/Oxidation for Metal Fuel (alternative oxidants) Including Offgas Treatment for High- Temperature Spent Fuel Treatment	TD 413204 Robotics - Waste Facilities Operation		
	SF 211205 Plutonium Oxide Reduction Through Electrowinning		
Interim Storage Systems			
Enhanced Current Storage			
Barriers/Liners for Existing Water- Filled Basins			
Consolidation Racking			
Encapsulation of N-Reactor Fuel			
New Dry Storage			
Inventory Characterization (laboratory and engineering studies) to Determine Metal Fuel Safety in Dry Interim Storage Systems			
Encapsulation for Dry Storage			
Basin Sludge Removal			
Sludge Disposition Characteristics			
Commercial Vacuum Transfer and Solidification as Applied to Metal Fuels	CH 221203 Minimum Additive Waste Stabilization Program	R.F. Gimpel	Bench-scale demo of vitrification and ion exchange for LLMW sludges, soil, etc., with few additives
DISPOSAL CONVERSION			

TABLE 12.6. (contd)

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
Mechanical Size Reduction/Oxidation for Metal Fuel (alternative oxidants) Including Offgas Treatment for High-Temperature Spent Fuel Treatment	ID 413204 Robotics - Waste Facilities Operation		
	SF 211205 Plutonium Oxide Reduction Through Electrowinning		
Shear/Dissolve/Vitrify in High-Fissile-Content Vitrification Process	CH 221203 Minimum Additive Waste Stabilization Program	R.F. Gimpel	Bench-scale demo of vitrification and ion exchange for LLMW sludges, soil, etc., with few additives
Alternate Waste Form Technologies	SF 211205 Plutonium Oxide Reduction Through Electrowinning		
	SF 211206 Reduced Plutonium Oxide, Dehydrid- and Casting		

TABLE 12.7. Technology Needs Crosswalk for Special Nuclear Materials

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
EXISTING INVENTORY MANAGEMENT			
Interim Material Stabilization/Storage of Liquid Solutions	RL 301204 Catalyzed Electro- chemical Oxidation Treatment of TRU- Contaminated and Hazardous Waste	E. Wheelwright (509-376- 3441)	CEPOD in standby until funded; can be used for Plutonium Finishing Plant waste and other residues
Monitoring/Characterization			
Remote Inventory System for Exposure Reduction	ID 413204 Robotics - Waste Facilities Operations (INEL)		
	OR 113205 Robotics - Waste Facilities Operations (ORNL)	W.R. Hamel (615-574-5691)	Robotics Integrated Program, develop waste inspection robot
Nondestructive Characterization	NV 021701 Associated Particle Imaging	P. Hurley (805-681-2472)	Develop nonintrusive method to detect material compositions and geometries inside sealed containers
Sampling/Chemical Analyses			
Repackaging			
Long-Term Storage Package			
RETRIEVAL AND RECOVERY OF RESIDUAL HOLD-UP			
Ductwork Remediation (downstream of HEPA filters)			
Assessment			
Portable NDA/NDE Systems			

TABLE 12.8. Technology Needs Crosswalk for Hanford Liquid Effluents

Technology Needs	Technical Task Plan Number/Title	Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
PRE-CLEANUP INVENTORY MANAGEMENT			
Continuous In-Line Monitoring			
Radiological	OR 113204 Contaminant Analysis Automation-Data Interpretation Module	L.N. Klatt (574-6588)	Develop specifications for data modules from commercial sector, measure alpha and beta in water samples
Chemical (inorganic and organic)	AL 201303 On-Line Monitoring of Volatile Organics for Waste Minimization	G. Frye (505-844-0787)	Develop single sensor system to detect VOCs in effluent discharge
	SF 223301 Remote Sensors for Organics, Toxic Metals, and Actinides	R. Silva	Collaboration effort with Germany to develop field instruments to measure TRU, metals, and organics
TREATMENT			
Partitioning/Pretreatment			
Physical	SR 101102 Hazardous and Mixed Waste Treatment Technology Development		
Chemical	RF 101205 Incineration Alternatives for Combustible Waste	R.W. Tyler (303-916-5927)	Develop oxidation methods for LLMW combustibles, solids and aqueous streams
Biological	OR 123301 Removal of Uranium by Biosorption--Germany	B.D. Faison (615-576-0484)	Develop biosorption technology to remove uranium in continuous operation
	RF 101205 Incineration Alternatives for Combustible Waste	R.W. Tyler (303-916-5927)	Develop oxidation methods for LLMW combustibles, solids, and aqueous streams; no biological methods being examined now

TABLE 12.8. (contd)

Technology Needs	Technical Task Plan Number/Title		Principal Investigator Name/Telephone Number	Technical Task Plan Scope/Application
	SR 121108	Bioremoval of Heavy Metals from Aqueous Solutions	E. Wilde (803-725-5212)	Bioremoval processes for heavy metal waste in aqueous solutions
Secondary Waste Treatment				
Polymerization	RF 111203	Polymer Solidifica- tion Development	A.M. Faucette (303-966- 6420)	Polymer encapsulation for nitrate salts; pilot-scale tests in FY93 on mixed waste salts
	SR 101102	Hazardous and Mixed Waste Treatment Technology Development		
Freeze Drying				

We plan to expand this crosswalk effort to include activities funded by other federal agencies as well as the private sector (see the ER mission area example in Section 12.2). This expansion would provide important information regarding which scientific research needs are currently being met or partially met by DOE/OER, and which technology development and deployment needs are being addressed by EPA, DoD, and/or industry. Once the expanded work is finished and the crosswalk tables are completed, the tables will provide a clear indication of the existence of technology gaps. This information can then be used to construct a first cut at the HTPP and develop recommendations for funding high-priority scientific research, technology development, and technology improvement activities, as described in Section 13.0.

In addition to completing these crosswalk tables, another near-term goal is to facilitate interactions between Hanford problem owners (e.g., program managers and engineers who are working on remediation of Hanford Site waste problems funded by either EM-30 or EM-40) and the technology developers (i.e., the EM-50-funded scientists and engineers who are developing innovative technologies through IDs or IPs).

Completion of the crosswalk tables will require the joint efforts of Site operations staff, current users of mature technologies new to Hanford, developers of new technologies, staff involved with international programs, and technology transfer staff who are searching industry for solutions. Once candidate solutions are identified, it will be necessary to communicate the solutions to the program managers and engineers who are working on the specific ER/WM problems. In many cases, extensive interactions over potentially long time periods will be needed to transfer the know-how behind a new technology to staff tasked with day-to-day operations. A number of mechanisms for information exchange methods and follow-up can be envisioned:

- Initial Information Exchange Meetings. Several types of meetings can be set up to introduce users to new technologies. Bi-weekly or monthly meetings can be set up with small groups of local technologists and users to discuss options to solve specific problems. Larger meetings can be set up with expert groups, such as staff working on IDs and IPs, to discuss multiple technologies available for large Site problems. Site users can also attend national meetings such as the EM-40 Technical Information Exchange Meetings to discover technologies that are being used elsewhere. A function could be set up onsite to review work plans and related documents

that recommend technology options for a given problem, to ensure that all available, applicable technologies are considered.

- Information Packages. Information will be collected in a number of forms, including Technical Task Plans used by EM-50, printouts from technology databases such as the EPA's ATTIC system, technical reports, and vendor literature. This information will be disseminated to users directly responsible for a problem.
- Technology Adoption Activities. Identifying a technology that is a potential solution to a Site problem is only the first of several steps needed before it can be adopted for actual use. In many cases, the current form of the technology is inappropriate for direct use. The user must work directly with the technology supplier to identify aspects that must be modified or demonstrated before the technology can be used. For a technology that is under development, the user can provide direction to the development effort or participate jointly in the development. The users may also have to work together with the suppliers to develop cost information, work with regulators and the public to gain acceptance, or establish mechanisms to supply the technologies in the quantities needed. Mechanisms will need to be established to allow these detailed interactions to take place.

12.1.3 Analysis of Environmental Restoration Crosswalk Results

Tables 12.4 and 12.9 provide a comparison of Hanford-specific ER problems and EM-50's Complex-wide R&D activities. The table shows a significant number of gaps where the necessary technology is not currently being developed. In some cases, this technology is being developed by other DOE offices, other U.S. agencies, U.S. industry, or foreign industry. An initial method to highlight areas where technology development gaps exist is to compare the highest-ranked problems with the number of TTPs funded in that area (see Table 12.9 for the ER mission area). For example, the ER mission area's top need (sensors for in situ field measurement) is supported by 22 TTPs.

However, beyond the top ER need, there is not a good correlation between the priority of an ER technology development need and the number of funded TTPs to address that need. The number of TTPs drops off rapidly after the first two needs (i.e., 22, 17, 4, 4, 3, 0....), which appear to be over funded for Hanford's purposes. The fourth- and fifth-priority ER needs (i.e., ion-specific electrodes for in situ field measurement and in situ treatment of DNAPLs in groundwater) have no TTPs to address them. On the other hand, the

TABLE 12.9. Comparison of Hanford Environmental Restoration Mission Area Needs and FY 1992 Technical Task Plans

Score	Technology Need	Number of Funded Technical Task Plans
57	In Situ Field Measurement - Sensors	22
54	In Situ Field Measurement - Process Monitoring and Control Technologies	17
47	In Situ Field Measurement - Radiological	4
47	In Situ Soil Treatment/Isolation - Bioremediation	4
47	In Situ Treatment of Groundwater - Bioremediation	3
37	In Situ Field Measurement - Ion-Specific Electrodes	0
36	In Situ Soil Treatment/Isolation - Hanford Barrier	4
36	In Situ Treatment of Groundwater - DNAPL Treatment	0
35	In Situ Treatment of Groundwater - Chemical	1
34	In Situ Field Measurement - Fiber Optic Probe	9
34	Ex Situ Treatment of Soils - Washing (Chemical Extraction)	5
33	Material Retrieval - Robotics Applications for Remote Handling	3
33	Ex Situ Treatment of Groundwater - Bioremediation	1
32	Ex Situ Treatment of Soils - Bioremediation	4
31	In Situ Field Measurement - Drilling	7
31	Ex Situ Treatment of Soils - Ex Situ Vittrification	1
30	Material Retrieval - Dust Control/Containment	0
29	Material Retrieval - Soil Fixant and Foam Technology	0
29	Ex Situ Treatment of Groundwater - Membrane Separation	5
28	Material Retrieval - Chemical methods for Groundwater Subsurface Manipulation/Retrieval	0
26	In Situ Field Measurement - Ground-Penetrating Radar	2
26	In Situ Soil Treatment/Isolation - Soil Heating	1
23	In Situ Field Measurement - Electricity Resistivity Technology	3
22	In Situ Field Measurement - Soil Gas Analysis	0
22	In Situ Soil Treatment/Isolation - In Situ Vittrification	5
22	Ex Situ Treatment of Soils - Grout	1
21	In Situ Soil Treatment/Isolation - Electrokinetics and Electro-osmosis	1

TABLE 12.9. (contd)

Score	Technology Need	Number of Funded Technical Task Plans
20	In Situ Soil Treatment/Isolation - In Situ Grouting	2
20	Ex Situ Treatment of Soils - Electrokinetics/Osmosis	3
20	Ex Situ Treatment of Soils - Thermal Desorption	0
19	Material Retrieval - Physical Methods for Groundwater Subsurface Manipulation/Retrieval	1
17	In Situ Field Measurement - Infrared Thermal Imaging	0
16	In Situ Soil Treatment/Isolation - Vapor Extraction	1
<21	In Situ Field Measurement - Chemical (Mass Spectrometry) - Magnetic	1
		1
	Contaminant Concentrate Treatment (low priority)	11
	Contaminant Concentrate Monitoring (low priority)	2
	Ex Situ Treatment of Soils - Contaminant Concentrate Metals Recovery	1
	Ex Situ Treatment of Soils - Magnetic Plutonium Recovery	1
	Ex Situ Treatment of Soils - Electron Beam Destruction	2

secondary treatment of recovered soil or groundwater offgas VOCs, either from the gas stream or from carbon adsorbate, has 11 funded TTPs. This seems excessive since this technology area was not identified as a significant need in the HIPP workshops, and there is commercially available technology.

EM-50-funded technology development to support Complex cleanup is intended to push the state of the art, as defined by what is commercially available, and be directed in order of technology development need priority as defined by the HSSSTP and similar needs assessment at other sites. This intent is not always the case, and a closer collaboration between the problem owners with the technology development needs and the technology developers with the means to satisfy those needs should be made a high priority. In this way, DOE can avoid duplication of already existing technology and prevent development of solutions which are inadequate, misdirected, or for which there are no needs.

Closer examination of the TTPs in the two most important ER needs areas (sensors and process monitoring and control technologies for in situ field measurement) indicates that many of the TTPs do not support the development of new instruments, decision support methodologies, data management, or other critical items. Instead, they support surveys, assessments, and databases.

There are no TTPs supporting priority #4, 5, 11, 12, 13, 16, 18, and 20 ER needs. These should be urgently addressed in the future, as some of them may be needed to meet Tri-Party Agreement (TPA) milestones for which there are no currently available technologies. For example, needs #3, 5, and 6 combined (in situ treatment of groundwater) are associated with a total of only 4 TTPs, yet the Hanford Environmental Restoration Program Roadmap Addendum (DOE/RL 1992b) lists in situ groundwater remediation as a high-priority need, because no technologies are currently available to meet TPA milestones for groundwater remediation. In particular, the location, treatment, and/or removal of DNAPLs is now recognized as a major technical problem requiring novel solutions.

Hopefully, this initial crosswalk exercise in the ER mission area will make technology developers and technology users aware of each others' capabilities and needs so they can better coordinate their activities to achieve the overall mission goals.

12.2 LINKING HANFORD'S NEEDS TO OTHER TECHNOLOGY DEVELOPMENT EFFORTS

A logical next step in the sequence of prioritizing Site problems and technology needs is to identify technologies being developed by other federal agencies. Technology needs not being addressed by these other agencies would be high-priority candidates for EM-50 support. Technology being developed by other agencies is assumed to be available for purchase/use.

This section briefly describes an example of preliminary efforts to link Hanford's S&T needs in the ER mission area to technology development activities funded by other federal agencies as well as other countries. This linkage effort will continue during FY 1993 and FY 1994 for the other Hanford mission areas.

12.2.1 Other DOE Technology Development Activities

At the request of EM-40, Chem-Nuclear Geotech Corporation (Geotech) performed a crosswalk of cleanup problems for the entire DOE Complex (site by site) and TTPs supported by EM-50 (Geotech 1991). Problems were identified by interviews and surveys of technical experts at each site. Problems identified as high-priority for the Hanford Site are listed below and summarized in a memo with attached tables (Wojtasek 1991):

- groundwater in the 100 Areas
- surface soils in the 100 Areas
- cribs/drains in the 200 Areas
- groundwater in the 200 Areas
- ponds/trenches/cribs in the 300 Area
- surface soil in the 300 Area.

The Geotech crosswalk report (Chem-Nuclear Geotech 1993) builds on their needs assessment report by comparing Complex-wide needs with funded TTPs. An initial set of TTPs was selected by EM-50 staff as being relevant to the ER mission area (about 320 of over 800 TTPs were selected). These TTPs were evaluated by Geotech as a function of technology needs, with technology gaps being noted. This information is now available on a database for individual users to identify those TTPs relevant to their particular problems. Problem areas identified for the Geotech survey by WHC and PNL experts match closely with those identified as primary problems through the HSSSTP methodology.

A new Technology Search Program is being supported by Dr. Lawnie Taylor (EM-43) to identify needed technologies that are already available through domestic or foreign industry. Identified technologies have been technically reviewed for potential value and collected in a database, which currently contains over 500 technologies/processes in six different characterization and treatment areas. A decision on deployment of the database has not been made as of this date, but it is available through the Project Manager (Dr. Dale Pflug, Argonne National Laboratory, 708-252-6682). A connection to the Geotech needs assessment could be made to allow problem owners to identify both EM-50 and industrial sources for needed technologies.

A Remedial Action Contacts Directory is available (Knox et al. 1992) for use by problem owners seeking information from others with similar problems.

The directory lists contact names, affiliations, and other data for almost 3300 ER/remedial action staff at radioactively contaminated sites. This activity was also supported by EM-40.

Individual DOE facilities are in the process of developing their own crosswalks (e.g., DOE/AL 1992) and reports on technology development activities (e.g., ORNL 1993). The IDs and IPs also issue their own technology development information (e.g., Ames 1993). Although Hanford Site problem owners with technology development needs will find useful information and contacts in these types of documents, as many similar problems occur across the Complex, there is a need for coordinated technology identification, deployment, and implementation activities. There is an excess of information with no easily accessible central point source, so most of the information goes undiscovered and unused. This is a major information-sharing problem within DOE and its contractors, which, unless rectified, will lead to duplication of effort, wasted time, and wasted money.

12.2.2 Environmental Protection Agency Technology Development Activities

Of the other U.S. Government agencies involved in ER activities, EPA is the most involved in technology development. However, EPA also has information flow/management problems similar to DOE's. Each EPA laboratory supports its own programs with little or no central coordination, and a listing of all of EPA's ER-related R&D activities proved unobtainable (although it may exist somewhere). The most useful and readily obtainable sources for developing treatment technologies are published through the EPA Technology Innovation Office (EPA 1992a) and the Office of Research and Development Superfund "SITE" (Superfund Innovative Technology Evaluation) Programs (EPA 1992b). Three other reports from a coordinating group (FRTR 1991a, 1991b, 1991c) list EPA sources (mostly those given above) almost entirely. Also, EPA supports R&D primarily to evaluate and test industrial processes rather than to develop them, and most of these processes are treatment technologies rather than characterization technologies.

12.2.3 Department of Defense Technology Development Activities

The Department of Defense (DoD) mostly solicits vendors to contract for site-specific cleanup work, although it collaborates with other agencies

(notably DOE) in joint demonstration projects. Each site appears to act independently, and no centralized source of DoD cleanup technology information could be found. However, there are many independent literature reports of cleanup activities at DoD sites, mostly written by contractors, presented at conferences and symposia, and available through the open literature. It is likely that there is a great deal of applicable DoD technology, for example in the sensor development area (originally for chemical agent detection), which has not yet been made available for use in an environmental cleanup context. The DoD is also in the process of beginning to develop its cleanup strategy (White and Fow 1990). There is a need for a survey of DoD technology for application to the ER mission area.

12.2.4 International Technology Development Activities

Other countries and organizations share the overall environmental restoration problems of the United States, and it makes sense to access and apply technologies developed and proven abroad where feasible. Through collaboration with DOE, environmental cleanup problems and solutions in the radioactive waste area are just beginning to emerge from the former Soviet Union. However, hazardous materials, munitions, petroleum, chlorinated hydrocarbons, toxic heavy metals, and most other forms of pollution have been investigated and remediated in Europe and elsewhere. There are many applicable technologies that could be used directly in the United States with considerable time and cost savings relative to independent development here.

Access to these technologies can be obtained through the international component of the EM-40-funded Technology Search Program discussed above, which lists mostly foreign industrial sources, individual foreign government agencies equivalent to our EPA, and multinational organizations such as the Commission for the European Community (CEC). One of the most active of these multinational organizations is the North American Treaty Organization (NATO), which is currently supporting a number of research activities.

12.3 LINKING HANFORD'S NEEDS TO BASIC SCIENTIFIC RESEARCH AT HANFORD: THE ENVIRONMENTAL AND MOLECULAR SCIENCES LABORATORY

The Environmental and Molecular Sciences Laboratory (EMSL) is designed to satisfy the fundamental research needs at Hanford. The new knowledge and concepts about chemical, physical, and biological phenomena resulting from research performed in the EMSL facility will form the basis for technically sound, economical solutions to environmental problems. Because of the time required to move new scientific knowledge into accepted procedures and practices, construction of the EMSL must proceed as expeditiously as possible.

Considerable effort has been expended to strengthen the roles that EMSL will play in the Hanford cleanup mission. The goals of this effort were to 1) frame a comprehensive definition of the technological gaps that could impede Hanford cleanup, and 2) describe the roles that basic and applied research will play in filling these gaps. The mission and capabilities of the EMSL facility are described below, along with the research capabilities of PNL's Molecular Science Research Center (MSRC), which will be housed in the EMSL facility and will be responsible for managing research programs in support of Hanford cleanup.

12.3.1 Mission of the Environmental and Molecular Sciences Laboratory

EMSL's prime mission is to provide the scientific capability needed to develop new and improved technologies to support cleanup of the Hanford Site. The Office of Energy Research (OER) has been assigned program management and funding responsibilities for EMSL. Research capabilities in EMSL will support work in areas such as soil and groundwater remediation, analytical characterization, advanced processing, and health effects, and provide a synergistic framework under which programmatic funding from EM and OER can be focused on solutions to key Hanford cleanup problems.

12.3.2 Capabilities of the Environmental and Molecular Sciences Laboratory

EMSL's capabilities will enable research that will increase our understanding of complex environmental systems and lead to the development of new technologies that will reduce costs, increase effectiveness, and decrease uncertainty. EMSL will provide the tools needed to perform cutting-edge research (i.e., state-of-the-art equipment, laboratories, and computers) in a

central location. This arrangement will provide scientists with integrated, comprehensive capabilities for rapid, focused problem-solving at the molecular level.

EMSL will serve to focus the attention of the scientific research community on Hanford's environmental restoration and waste management problems. Multi-disciplinary programs in chemistry, materials science, chemical sensor development, condensed-matter physics, advanced chemical processing, and molecular and structural biology will provide a comprehensive understanding of molecular-level phenomena. This understanding will aid technologists in developing innovative new technologies for solving some of the most pressing cleanup problems at Hanford.

A number of major research capabilities will be housed in EMSL, including the following:

- A suite of materials laboratories will be dedicated to the development of 1) new chemical sensors for monitoring the exposure of workers to toxic gases, monitoring the transport of contaminants in soil and groundwater, and controlling critical waste treatment processes; 2) advanced materials for use in new separation membranes and waste containment barriers; and 3) advanced chemical processing techniques to improve the effectiveness of waste separation operations and to reduce the amount of toxic chemicals needed to treat waste.
- A mass spectrometry capability with new instrumentation will provide a dramatic extension of the ability to investigate the structure of large molecules and the capability to analyze complex mixtures with ultra-high sensitivity. Included among the mass spectrometers is an advanced Fourier Transform Ion Cyclotron Resonance Mass Spectrometer (FT-ICRMS), facilitating effective high-resolution mass spectrometry measurements on large biomolecules. Several types of mass spectrometers, ionization techniques, data acquisition, and post-processing techniques will be available.
- A molecular science computing capability will be available that includes a high-performance computer based on massively parallel architecture for production computing, experimental computer(s) for research in alternative computer architectures, and high-performance graphics work stations for closely coupling visualization technology with high-performance computing.
- A computer hardware and network infrastructure will be available that includes a data management system, distributed computing, electronic communications, and laboratory automation, allowing

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modeling, data acquisition, and data analysis of complex environmental systems and problems. These computer capabilities will be linked with the high-performance computers in the molecular science computing facility and the graphics and visualization laboratories, as well as all staff offices. Software to take full advantage of this hardware is being developed as part of the MSRC research programs in computing and information sciences and theory, modeling, and simulation.

- An ultrahigh-field nuclear magnetic resonance (NMR) capability is planned that will allow structure/function studies of molecules up to 40,000 daltons in size, along with equipment for isotopic labeling, deoxyribonucleic acid (DNA) and protein sequencing, and analysis and molecular synthesis required for bioremediation and health effects studies.
- A capability will be available to study chemical clusters. This capability includes an extensive array of spectroscopic and surface analysis tools and a diversity of very intense cluster sources for studying and modeling subsurface contaminant transport.

Many of these capabilities do not currently exist and will be developed as part of the EMSL project.

12.3.3 Molecular Science Research Center

The MSRC is the line management organization at PNL responsible for developing the EMSL facility. MSRC staff will be housed in the EMSL and will use the unique capabilities of the new facility for projects relevant to the Hanford cleanup mission.

DOE has made a commitment to restore and protect the environment at Hanford. To accomplish this mission, a comprehensive S&T program that directly links basic research to applied research and technology development must be undertaken. Such a program will lead to the development of technologies that can be effectively used in the cleanup efforts. Research undertaken in MSRC focuses on advancing the understanding of the molecular sciences and applying this advanced understanding to a broad spectrum of Hanford cleanup needs. Such needs-driven research programs aim at increasing our understanding of complex systems and feature basic and applied research that is multi-disciplinary, involving chemical, biological, materials, and computational sciences.

Theory, Modeling, and Simulation

Theoretical and computational molecular science will play a critical role in developing molecular-level descriptions of chemical, physical, and biological processes in natural and contaminated systems. Theory provides the conceptual framework for the analysis and interpretation of experimental data. Modeling and simulation provide quantitative information that may be expensive or difficult to obtain in the laboratory. Modeling molecular processes in the environment requires a fundamental understanding of molecules and their interactions in isolation (gas phase) and in liquids, on surfaces, and at interfaces (condensed phase). Research in the Theory, Modeling, and Simulation Program also involves developing state-of-the-art methods for studying important molecular-level problems. The program includes three distinct activities:

- molecular theory and modeling, which focuses on rigorous theoretical and computational studies of elementary molecular processes in solutions and includes studies of solvation and reactions in aqueous solution, the mineral-water interface, and the glass-water interface
- materials theory and modeling, which focuses on the surface structure and chemistry of natural materials and includes studies of the structure of metal oxide surfaces (e.g., MgO, ZnO, and SnO₂) and of minerals (e.g., quartz and clays, such as kaolinite)
- biomolecular modeling and simulation, which focuses on the structure and chemistry of the complex biomolecular systems found in the environment and includes studies of the structure and function of enzymes involved in the detoxification of environmental contaminants.

Chemical Structure and Dynamics

To provide a sound technical basis for Hanford cleanup activities, research in the Chemical Structure and Dynamics Program responds to the need for a fundamental molecular-level understanding of chemistry at environmental interfaces. Such research has direct applications to advanced processing (especially separations techniques and soil washing); contaminant transport modeling in soils and groundwater; sensor development and other advanced analytical instrumentation for characterization, quantification, and monitoring; bioremediation; and health effects. The research is built around the

established relationship between structure and function (reaction dynamics), which is the underpinning of molecular science. The structural studies are key to the direct comparison with theory. Real-time dynamics measurements of atomic/molecular motions during chemical reactions provide for a molecular-level description of reaction dynamics.

Computing and Information Sciences

The Computing and Information Sciences Program has two missions. The first mission is to develop the advanced computing infrastructure needed for research in the EMSL. The second mission is to conduct applied research and development in computing and information sciences. These missions directly support the theoretical and computational research programs critical in developing molecular-level descriptions of the chemical, physical, and biological processes that occur in the Hanford environment.

The research and technology development elements of the program are aimed at providing technical solutions to problems defined by the theoretical and experimental research programs, including Hanford cleanup problems. For example, software engineering tools are needed to support molecular science software development, particularly in the areas of the graphical user interface and visualization, parallel methods for computational chemistry, and data storage systems that provide easy access to pertinent scientific data. There also will be substantial emphasis on laboratory automation, including instrument control and data acquisition technologies, and laboratory data management. The software tools and technologies developed will be available for use by research programs that are focused on Hanford cleanup problems.

Macromolecular Structure and Dynamics

The focus of the Macromolecular Structure and Dynamics Program is on determining biomolecular structure/function relationships for processes that control the transport and biological transformation of contaminants and the health effects resulting from exposure to toxic substances and radiation. Leading-edge NMR and mass spectrometry systems are being developed to address several key Hanford cleanup problem areas. Research in these problem areas will include the following: 1) structural analysis of genetically engineered enzyme systems for bioremediation, 2) characterization of chemical speciation

and reactivity in complex waste mixtures, 3) analysis of contaminant diffusion and fluid flow profiles in heterogeneous media such as soil, and 4) analysis of radiogenic and chemical damage to critical biological macromolecules such as DNA.

Materials and Interfaces

The Materials and Interfaces Program will generate information to support 1) the design and synthesis of advanced materials for the analysis and separation of mixed chemical waste, 2) the long-term storage of concentrated hazardous materials, and 3) the development of chemical sensors for environmental monitoring of a wide variety of organic and inorganic species and for use in process control to enhance waste minimization efforts. Supporting this program will be facilities and instrumentation used to synthesize novel materials; study their structural, mechanical, electronic, and chemical properties; and fabricate prototype sensors for full testing.

The interactions of various artificial and natural materials with their environments play a critical role in containing, transporting, monitoring, and stabilizing hazardous waste. The need for materials research relative to environmental restoration is significant and covers a broad range of materials science. A detailed understanding of guest-host interaction will allow for the rational design of the next generation of efficient chemical sensors. These sensors are important for monitoring hazardous waste processing, transport, and storage and for post-remediation monitoring of sites. This research will also contribute to waste storage solutions. Hazardous waste must be contained or encapsulated in materials that react very slowly with the environment. These containment materials must be further protected by barrier materials that must react with the environment in a predictable manner. Molecular-level studies of reactions with containment materials will form the basis for predictions of the long-term stability of these materials and the rational design of new materials with special properties to meet the demands of long-term storage of hazardous materials.

The spread of contaminants in the atmosphere or groundwater is strongly influenced by interactions with oxides, minerals, or other accessible materials. An ongoing task of the Materials and Interfaces Program is an

integrated experimental and theoretical effort to provide an increased understanding of mineral and oxide surface structures and their interaction with contaminants, and to generate improved contaminant transport models. In this task, molecular-scale research on single-crystal surfaces is propagated through several steps, from studies of water and contaminant interactions on single-crystal surfaces to measurement of contaminant chemistry in colloidal suspensions. Integration of the resulting information will enable development and refinement of predictive models of contaminant behavior in the mixed, solid, multi-solute, and subsurface environments.

Environmental Dynamics and Simulation

The Environmental Dynamics and Simulation Program is designed to provide a bridge between fundamental research into the molecular-scale properties of materials and the applied research required for the Hanford cleanup effort. The focus of these research activities is on interfacial processes, such as reactions of dissolved inorganic and organic contaminants with mineral surfaces, selective extraction of radionuclides from waste streams, and transport of solutes across membranes. Applications of this research will be targeted at bioremediation (and other forms of in situ and ex situ remediation), subsurface transport phenomena, characterization and monitoring technologies, and predictive tools. The facilities required for directed research to support the development of cleanup technologies include the following: 1) controlled-atmosphere environmental chambers; 2) spectroscopic systems for molecular-scale characterization of contaminants, surfaces, and reaction mechanisms; 3) analytical systems for quantification of contaminants and reaction products; 4) thermochemical and kinetic systems for macroscopic and mechanistic characterization of contaminant-soil interactions; and 5) graphics and computational hardware/software for the simulation of chemical reactions and transport processes. The location of these capabilities adjacent to other unique instruments in EMSL will enhance the effectiveness of the research efforts.

During 1992, research began on the interactions between organic ligands and metals. Naturally occurring organic ligands play an important role in soil/pore water equilibria. These ligands influence the weathering of soils and the mobility of metals. The stabilities of a limited number of metal

chelate complexes have been determined experimentally, and semi-empirical schemes have been developed to predict the stabilities of certain classes of complexes. The goal of this work is to develop a quantitative understanding of the relationship between structure and reactivity of organic ligand/metal complexes. This work is currently being extended to include organic ligands that have the potential to selectively extract radionuclides from waste streams.

Advanced Processing Research

Process science and engineering are critical competencies required to address problems of national significance in waste management and minimization and in environmental remediation. The EMSL Advanced Processing Research Program is designed to provide the resources for developing scientific ideas into concepts and processes to solve these problems. It is part of a broad program in advanced process development that is ongoing at PNL. This EMSL program has three primary goals: 1) to understand how to implement existing technology and scientific understanding in waste cleanup processes; 2) to identify technology gaps; and 3) to focus EMSL and other research activities in materials, characterization, modeling, and process science and engineering to address the issues discussed above. A prevailing goal of this program is to speed up the technology development cycle to deliver timely solutions to nationally significant problems.

Core technical capabilities for the EMSL Advanced Processing Research Program include colloid chemistry, fluid dynamics, catalysis, chemical and surface analysis, reaction chemistry, and process control. These core capabilities will be applied to problems such as the separation of radionuclides from the wastes stored in tanks at Hanford, the destruction of carbon tetrachloride in contaminated soils, and conversion of hazardous organic materials and nitrates in mixed waste to more benign materials.

12.3.4 Examples of Hanford Site-Specific Problem Areas Addressed by EMSL

The following are examples of Hanford site-specific problem areas that will be served by the research capabilities in the Environmental and Molecular Sciences Laboratory.

Advanced Processing of Chemical Wastes

Environmental cleanup efforts at Hanford and other DOE sites will involve a broad spectrum of hazardous wastes that often are mixed with radioactive isotopes. These wastes include radioactive sludge and liquids in waste storage tanks and contaminated facilities, soils, and groundwater. Cleanup of these wastes represents one of the most significant processing challenges facing the nation. New technologies are required for separating, converting, and destroying these wastes and contaminants. The central issue in developing these technologies is an understanding of how complex chemical mixtures interact with other materials in natural environments and in treatment-process environments. These same issues are also of concern to the industrial sector in designing manufacturing processes that do not degrade the environment.

Catalytic Waste Destruction

The nation is faced with the immense task of treating and managing highly toxic by-products and wastes that have resulted from past commercial and defense-related nuclear material production activities. These by-products and wastes include complex mixtures of organic and inorganic chemicals and, in some cases, radioactive materials. Carcinogenic chlorinated hydrocarbons are one of the most significant contaminants in soils and groundwater surrounding DOE and DOD facilities. For example, during past operations at the Hanford Site, the disposal of an estimated 1000 metric tons of carbon tetrachloride mixed with significant amounts of radioactive materials (plutonium, strontium, technetium, and other transuranic elements) has resulted in widespread contamination of the dry soil zone and a plume of contaminated groundwater that extends over approximately 12 km². These contaminants must be completely isolated and/or destroyed.

Incineration, one of the most commonly proposed methods of handling hazardous waste, can create significant secondary environmental problems. For example, dioxanes have been found to be produced during the incineration of chlorinated hydrocarbons. Properly designed, heterogeneous catalytic oxidation or incineration processes combined with catalysis can eliminate such problems. Successful, effective treatment of the complex and diverse wastes at DOE sites will require new process technologies. The development of these

new technologies, in turn, requires a sophisticated process science program with the ability to design and test new catalytic materials and facilitate their full implementation into waste processing systems. As the wastes are identified and characterized, catalysts that are compatible with both the waste and the chosen treatment process stream must be identified. To accomplish this level of compatibility, new catalysts must be created by rational design rather than the currently used trial-and-error process, which is very time intensive. Rational design of an effective catalyst requires research that leads to an understanding of the catalytic reaction mechanism(s) and the design and synthesis of complex composite materials. This research must include the disciplines of surface and materials chemistry and molecular and materials modeling. With its new level of computational tools, facilities for synthesizing catalytic materials, and advanced instruments for measuring catalytic reaction mechanisms, the EMSL is specifically designed to support this research effort.

Tank Waste Processing

Current baseline scenarios for the disposal of toxic waste at Hanford and other DOE sites will result in enormous volumes of materials that must be stored and monitored for hundreds of years at tremendous cost to the taxpayer. For example, our estimates indicate that treatment of high-level radioactive mixed waste stored in tanks at Hanford will result in the production of over 15,000 glass logs at a cost of over \$650,000 per log. Additional enormous costs will be incurred during the long-term storage that will be required for these logs. New processing concepts, such as distributed processing versus the classical centralized facility model, offer tremendous hope for increased efficiency and reduced costs, but these concepts require advanced technologies.

The development of more efficient chemical processes for separating the high- and low-level fractions of Hanford's complex wastes is a critical element of the new technologies that will be used to reduce the volume of waste to be treated and stored. This effort requires 1) a detailed understanding of the complex chemistry involved in the separations processes and 2) development of active separation materials. The key components in these new chemical separation processes are materials that function as active separations media

in severe environments. The extensive Advanced Processing Research Program will use the equipment and capabilities in the EMSL to develop molecular-level details of the chemical processes and to tailor the physical and chemical properties of new separations materials.

13.0 CONCLUSIONS AND RECOMMENDATIONS

This section contains conclusions and recommendations regarding:

- what existing technologies require additional R&D to become feasible alternatives to the existing Hanford baseline technologies
- what new technologies should be developed to address Hanford's environmental restoration and waste management missions
- what scientific research should be funded to address phenomena for which there is an incomplete understanding that is hampering cleanup technology development efforts at Hanford.

The S&T needs assessment workshop results described in Sections 6.0 through 11.0 form the foundation for the technology development needs crosswalk activity described in Section 12.0. The crosswalk activity has resulted in the identification of technology development gaps in some of the highest-priority functional needs areas to address the highest-priority problems on the Site. Recommendations for a comprehensive Hanford S&T Program to address these gaps are documented in this section.

This section provides an overview of the issues that must be considered during the process of developing recommendations for S&T activities which are promising enough to merit risking an R&D investment. It includes a series of questions to be answered while reviewing R&D proposals for technology improvement activities, technology development activities, and scientific research activities. Finally, it provides a first cut at recommendations for technology improvement, technology development, and scientific research activities that should be funded to address Hanford's most critical needs.

13.1 TECHNOLOGY IMPROVEMENT NEEDS

Technology improvement is defined as an incremental advance or modification of a commercially available technology to meet specific Site needs (e.g., adding radiation-monitoring equipment, up- or down-sizing equipment, making equipment mobile). The distinction between technology improvement and

technology development is sometimes difficult to discern. However, in this document, technology improvement is assumed to be a near-term activity requiring little technical risk. Prioritized nontank technology improvement needs across mission areas are shown in Table 3.1.

Under the technology improvement category, there are two options: technologies that are ready for insertion into the Site technical baseline, and technologies that are ready for demonstration, testing, and evaluation. Both types of technologies would be available now, but the former would have already been demonstrated, while the latter would not. Before a technology can be designated a Hanford baseline technology, it will most likely have to be demonstrated on and adapted to this Site. Thus, one question to consider for such a technology is who manages and funds the adaptation activities.

A technology that has already been demonstrated at Hanford will have to meet or exceed a series of technology acceptance criteria (e.g., cheaper, faster, better, and safer than the current baseline). The first step is to develop a list of these criteria. The second step is to evaluate the ability of the technology to meet the criteria. Finally, if the technology meets all the criteria, there needs to be a procedure to get the appropriate decision-makers to replace the current baseline technology with the new technology. This step will require extensive interactions between problem owners, technologists, regulators, DOE program managers, and the public to ensure that all of these stakeholder groups understand and support the change.

13.1.1 Tanks

This section provides technology improvement recommendations for the TWRS Program.

- Partitioning: Improved alkaline-side radionuclide and solid/liquid separation methods are needed for supernatant and salt cake treatment and sludge pretreatment. Improvements needed include process control capabilities and increased gravity settling rate and efficiency in large tanks. Sludge washing and leaching processes must be tested to determine efficiencies, develop process flowsheets, and develop process controls. New technology may be needed if testing shows that existing processes are ineffective.

TABLE 13.1. Prioritized Nontank Technology Improvement Needs Across Hanford Mission Areas

Mission Area (Problem)	Functional Need: Technology Improvement Need	Technology Need Scores	
		t	p·f·t
LE	Treatment: filtration	75	930
LE	Pre-cleanup inventory management: continuous in-line monitoring for organics	71	1132
LE	Treatment: ion exchange	71	879
LE	Generative: waste minimization (source reduction)	69	1018
LE	Treatment: reverse osmosis	56	713
SW	Treatment (partitioning/pretreatment): size reduction with shredders, torches, shears, etc.	55	252
SW	Treatment (disposal form conversion): vitrification	55	252
SW	Treatment (partitioning/pretreatment): thermal treatment technologies	54	248
SW	In situ treatment (toxicity/mobility reduction): vitrification	51	260
ER (TCP)	In situ/field measurement of soils: radiological measurement	47	406
NM (SNM)	Existing inventory management: interim stabilization/storage of liquid solutions	45	337
SW	Characterization (heterogeneous material sampling methods): sound statistical-based approach to minimize sampling	44	247
NM (SNM)	Existing SNM inventory management: repackaging for long-term storage	43	322
LE	Treatment: filter press	43	510
D&D	In situ pretreatment (recycle): metal	42	431
D&D	In situ pretreatment (liquid-phase decontamination): electrochemical - CEPOD	41	420
D&D	In situ pretreatment (high-intensity radiant energy decontamination): remote laser decontamination	39	400
ER (TCP)	In situ/field measurement of soils (chemical): ion-specific electrodes	37	320
D&D	In situ pretreatment (liquid-phase decontamination): aqueous/water jets	34	349
SW	Treatment (disposal form conversion): metal waste forms	33	151
D&D	In situ pretreatment (recycle): concrete	32	328
ER (TCP)	In situ/field measurement of soils (physical/geophysical): drilling	31	268

TABLE 13.1. (contd)

Mission Area (Problem)	Functional Need: Technology Improvement Need	Technology Need Scores	
		t	p.f.t
ER (TCP)	Soil retrieval: dust control/containment	30	119
NM (SNM)	Existing SNM inventory management (monitoring/characterization): sampling/chemical analyses	29	217
ER (TCP)	Soil retrieval: soil fixant and foam technologies	29	115
ER (TCP)	In situ/field measurement of soils (physical/ geophysical): ground-penetrating radar	26	225
NM (IF)	Irradiated fuel disposal form conversion: shear/dissolve/vitrify in high-fissile-content Vitrification Process	25	277
D&D	In situ pretreatment (decontamination): remote mechanical devices	24	246
D&D	In situ pretreatment (dismantle components): noncontamination imbedding sectioning technologies - liquid metal embrittlement	24	246
NM (IF)	Existing irradiated fuel inventory management (interim storage systems): enhanced current storage - barriers/liners for existing water-filled basins	23	255
ER (TCP)	In situ/field measurement of soils (physical/geophysical): electrical resistivity technologies	23	199
D&D	In situ pretreatment (decontamination): abrasives	22	226
D&D	In situ pretreatment (liquid-phase decontamination): electro-polishing	22	226
ER (TCP)	Ex situ treatment of soils: grout	22	182
ER (TCP)	In situ treatment/isolation of soils: in situ grouting	20	86
D&D	In situ pretreatment (dismantle components): physical dismantling - concrete	19	195
D&D	In situ pretreatment (dismantle components): physical dismantling - metal	18	185
D&D	In situ pretreatment (decontamination): thermal	17	174
ER (TCP)	In situ/field measurement of soils (physical/geophysical): infrared thermal imaging	17	147
D&D	In situ pretreatment (dismantle components): thermal dismantling - metal	16	164
D&D	In situ pretreatment (dismantle components): thermal dismantling - concrete	14	144
NM (IF)	Existing irradiated fuel inventory management (interim storage systems): enhanced current storage - consolidation racking	13	144

TABLE 13.1. (contd)

Mission Area (Problem)	Functional Need: Technology Improvement Need	Technology Need Scores	
		t	p-f-t
NM (IF)	Existing irradiated fuel inventory management (burn, sludge removal): commercial vacuum transfer and solubilization as applied to metal fuels	12	132
NM (IF)	Existing irradiated fuel inventory management (interim storage systems): enhanced current storage - encapsulation of N-fuel	10	111
ER (GW)	Ex situ treatment of groundwater: precipitation	9	43
Key: DNAPL = dense nonaqueous phase liquid f = functional need score GW = groundwater IF = irradiated fuel LE = liquid effluents (problem focus = immediate discharge of liquid effluents) NM = nuclear materials p = problem score SNM = special nuclear materials SW = solid waste (problem focus = buried waste) t = technology need score TCP = contaminated soils in trenches, ditches, and ponds			

- LLW Immobilization and Disposal: Cementitious grout is the preferred LLW form, but there are still concerns about the stability when a wide range of waste stream compositions are considered. Waste formulations must be optimized to accept a greater range of waste feed specifications. The design of the disposal facility must be optimized for greater throughput and improved waste processing.
- HLW Immobilization and Disposal: The receipt and feed preparation processes should be evaluated to allow selection of melters and glass formulations.
- Retrieval: Scaled experiments are required to evaluate and improve the effectiveness of DST mixer pump technology. Supporting systems are needed to evaluate and monitor mobilization, solids settling, and slurry uniformity during DST mixer pump operation. Base system procurement specifications are needed for the DST first generation LRA.
- Laboratory Sampling and Analysis: Sample acquisition methods for hard salt cake and semivolatiles must be improved. Laboratory analysis methods must be tested and validated for complexants.

ferrocyanide, and mercury. Improvements are needed in data management tools for tank waste characterization data.

- Existing Storage Management: Methods are needed to monitor and protect tanks against corrosion using chemicals and corrosion-protection probes. Instruments and sensors need to be installed in liquid observation wells, laterals, dry wells, and pits to improve leak detection. Mitigation measures need to be demonstrated for watchlist tanks. Mitigation measures for flammable gas tanks include sonic probes, in-tank mixing, ventilation system upgrades, waste dilution (101-SY), and waste heating (101-SY). Heat removal and water-level control systems should be tested in high-heat tanks.
- Packaging: A large waste canister must be developed and qualified.

13.1.2 Solid Waste

This section provides technology improvement recommendations for the solid waste mission area.

- Treatment: The highest-priority technology improvement need for the treatment function is for size reduction of waste with shredders or shears. Three TTPs currently address development of size reduction technologies. Other technology improvement needs are thermal treatment technologies, including vitrification for disposal form conversion and in situ treatment. TTPs have been funded by EM-50 for all of these needs except disposal form conversion for metal waste forms.
- Characterization: Two TTPs were funded to address development of sound, statistical methods for analysis of data provided through in situ measurement and sampling.

13.1.3 Environmental Restoration

This section provides technology improvement recommendations for the ER mission area.

- Characterization: Technology improvement would be beneficial in all areas of characterization, since most of the instruments and sensors currently being used are generic and were not designed for Hanford-specific needs. More robust instruments capable of more rapid and reproducible measurements are needed. This is particularly true of ion-specific electrodes, which tend to be delicate and difficult to use in the field.

Radiological instruments are already field-portable and robust, since they were developed for mining and exploration. In the physical/geophysical area, instrumentation tends to be bulky.

Smaller, more accurate instruments for down-hole or surface physical measurements would be advantageous (e.g., for ground-penetrating radar, infrared thermal imaging, and electrical resistivity measurements). These are classed as technology improvements because they do not change the basic function of existing instruments. Faster and cheaper drilling technology is urgently needed for deployment of down-hole instruments and sampling.

- In Situ Treatment (soils): The only technology improvement need is for in situ grouting, where techniques for more accurate placement of grout barriers and measurement of the location of emplaced barriers need additional improvement.
- Material Retrieval: The major technology improvement need is for demonstration of dust-control technology and selection of the best of many commercially available dust suppressants, foams, and fixants.
- Ex Situ Treatment: Technology in all of the priority areas is commercially available and requires demonstration at the Hanford Site (except for ex situ grouting, which is fully demonstrated.) Any technology improvements required would be based on the results of the demonstrations, and would be modifications to the processes based on the characteristics of Hanford soils.
- Subsurface Manipulation/Retrieval (groundwater): In the retrieval area, improved pumping techniques should receive priority.
- Ex Situ Treatment (groundwater): Improved precipitation techniques for dissolved or suspended iron should be developed, as this is necessary to prevent membrane clogging during separations. Conversely, improved membrane materials which are less likely to clog but which still separate contaminants efficiently should be developed, as this would reduce the cost of added pre-treatment chemicals.
- In Situ Treatment (groundwater): There are no technologies available for in situ treatment of groundwater (as opposed to soil), especially for treatment of DNAPLs, so we need to focus on technology development and science needs in this area.

13.1.4 Decontamination and Decommissioning

This section provides technology improvement recommendations for the D&D mission area.

- Characterization: Technology improvements were identified for all areas of characterization.

Radiological instruments being used for D&D are generic and not developed specifically for Hanford D&D needs. More discriminating and rapid systems capable of reproducible results are needed in the field for D&D because current methods are nondiscriminating (e.g., counters only tell radiation is present, not that there is a hot spot on a specific pip. and relatively slow (e.g., counters must be placed in the environment to be tested, left for a time, then removed to be read). Radioactive detection must be real-time with rapid communication, and must be discriminatory to both the ions present and the location of the ions.

No ongoing research was identified in this area. There may be technologies available to meet the D&D radiological characterization needs at Hanford, but integration and testing would be required as a minimum to determine their applicability. If current technologies cannot provide the remote, in situ, real-time capability needed, then improvements to current technologies will be needed.

- In Site Pretreatment: Several technology improvement needs were identified for pretreatment in the areas of decontamination and recycle. The decontamination technology improvement needs were identified as CEPOD (an electrochemical liquid-phase decontamination technique), remote laser decontamination, and water jets. The recycle technology improvements identified were for both metal recycling and concrete recycling.

The improvements identified for CEPOD are in minimizing the secondary waste, providing a mobile capability, and permitting CEPOD as a mobile treatment. There is one ongoing project for CEPOD, but the needs identified for Hanford D&D are not being addressed in that project. Therefore, additional R&D is indicated for CEPOD.

Technology improvements identified for the remote laser decontamination are increased speed (to compare with sandblasting), improved collection systems for removed materials and gases, and the capability to detect when contamination removal is complete. This technology would also be improved if the technology could be automated to move to a new section once decontamination is removed from an area or if the technology could be applied to nonflat surfaces such as valves or cylinders.

Most of the ongoing work on lasers is for metal recycling capabilities. Although applicable to the metal recycling issue, the work appears to have little applicability to the laser decontamination needs defined for the decontamination at the Hanford Site. Therefore, development will be required for all the improvements identified for remote laser decontamination.

The water jet technology is currently used in decontamination, and no ongoing research was found for the water jet. The identified improvement is the addition of a real-time detection capability for use on the reuse water. This improvement to the water jet technology is really a characterization need which is addressed in Section 13.2.4.

Like the water jet technology, both metal recycling and concrete recycling have identified needs in characterization, which are covered in Section 13.2.4. Other technology improvements identified for both metal and concrete recycling are better containment of contamination, better separation of materials, improved ability to decontaminate for both radiological and hazardous contamination, and improved volume reduction. Only metal recycling has any ongoing work, which is the laser decontamination of metals. Therefore, research is indicated for all the improvements identified in the recycling area.

13.1.5 Nuclear Materials

This section provides technology improvement recommendations for the nuclear materials mission area.

Irradiated Fuels Problem Area

- Disposal Form Conversion: The highest-ranking technology improvement need for irradiated fuel is the process for shearing, dissolving, and vitrifying the fuel elements. Although the technology exists, it needs to be demonstrated with Hanford's needs in mind. There is an EM-50 project underway that is examining ways to make the vitrification process cheaper and amenable to more waste forms.
- Existing Inventory Management: Three technology improvement needs relate to improving the existing interim storage system. The first is the need for barriers or lines in the basins to halt any leaks. The second is the need for consolidation ranking of the fuel elements to provide more space. The third need, related to the second need, is to encapsulate the N-Reactor fuel.

Special Nuclear Materials Problem Area

- Existing Inventory Management: All of the technology improvement needs for the SNM problem area are in the inventory management function. The most pressing need is to stabilize and store the mixed hazardous liquid plutonium nitrate solutions. The processing and storage techniques need to be improved to safely and cost effectively dispose of these solutions. There is also a need to repackage SNM into a shippable form for long-term storage and

ultimately disposal. The need for sampling and chemical analysis of the SNM throughout the Site is also a technology improvement need. This is needed before any retrieval or processing of the SNM can take place.

13.1.6 Liquid Effluents

This section provides technology improvement recommendations for the liquid effluents mission area.

- Treatment: Four of the top six technology improvement needs are in the partitioning/pretreatment area of the treatment function. These four are filtration, ion exchange, reverse osmosis, and filter presses. The major improvements needed are the ability to cost-effectively remove from very dilute and large waste streams a number of hazardous and radioactive constituents. All of these technologies are commercially available today but may need significant improvements to be effectively used at Hanford.
- Waste Characterization: There is a technology improvement need for continuous in-line monitoring of organics. Monitoring the dilute level of the waste stream organics is the primary improvement needed at Hanford.
- Generation: Waste minimization incorporation into the operation of the Hanford Site will require minimal technology improvements as developments but will require a change in operating philosophy, attitudes, and behavior. This change has the potential to be one of the largest payoffs in the long term at Hanford.

13.2 TECHNOLOGY DEVELOPMENT NEEDS

Under the technology development category, there are two possibilities: technologies exist that are currently under development and need more R&D, or no technologies currently exist to meet the need. In the case of technologies that are already being developed, a technology need signifies an extension of the state-of-the-art technology to different boundary conditions (e.g., greater depth, sensitivity, speed, range). There are three key questions to be asked when considering whether or not to fund a technology development activity:

1. Is the technology likely to be ready when needed?
2. Does it offer substantial benefits over the existing baseline technology?

3. Who should fund its continued development?

In a case where no technologies currently exist to do the job, there are four questions to be asked:

1. Is there a good technology development idea to fund?
2. Can the technology be ready when needed?
3. Does it offer substantial benefits over other technologies that are being developed or proposed?
4. Who should fund its development?

Many of these questions will be difficult to answer. In particular, quantitative comparisons of the costs, benefits, and Site-wide impacts of all important technology options must be made using a systems analysis approach prior to making funding decisions. Prioritized nontank technology development needs across mission areas are shown in Table 3.2.

13.2.1 Tanks

Technology development recommendations for tanks are summarized below.

- Partitioning: Technologies must be developed for acid-side removal of TRU, technetium, and strontium. Organic/ferrocyanide destruction technologies are needed as soon as possible for tank safety issue resolution and early pretreatment as well as for supernatant/salt cake treatment. There is no technology available for removing iodine or bulk nitrate/nitrite from HLW. Technologies for aluminum and sodium removal technologies are needed for supernatant and salt cake treatment. Alternative pretreatment technologies for waste using calcination and bulk leaching must be further evaluated.
- LLW Immobilization and Disposal: LLW materials with enhanced durability are needed. Nondestructive measurement techniques are needed to confirm quality of grout products and reduce costs. This includes in situ and in-line process-monitoring equipment for sampling and analyzing process feed and product. Evaluation needs to continue of alternative LLW forms, aggressive vault designs, and aggressive barrier concepts.
- HLW Immobilization and Disposal: Process control and analytical measurement methods are needed to support plant operations. Waste effluent and offgas treatment equipment, instrumentation, and controls must be developed. System studies are needed to evaluate alternative immobilization processes and alternative waste packages.

**TABLE 13.2. Prioritized Hanford Technology Improvement Needs
Across Hanford Mission Areas**

Mission Area (Problem)	Functional Need: Technology Development Need	Technology Need Scores	
		t	p-f-t
SW	Treatment (partitioning/pre-treatment): sorting	81	372
SW	Buried waste retrieval (remotely handled material): dust control and air handling system	76	349
LE	Generation: recycle/reuse of waste water	73	1078
SW	Buried waste retrieval (remotely handled material): Radioactive/hazardous materials containment and control	72	330
LE	Treatment: ultraviolet oxidation	71	879
SW	Buried waste retrieval (remotely handled material): robotics/removal equipment	68	312
SW	Groundwater characterization (in situ measurement/sampling): NDE/NDA methods (chemical and radioactive)	66	370
SW	In situ treatment (toxicity/mobility reduction): dust control technologies	65	332
SW	Characterization (in situ measurement/sampling): sensors (radioactive and hazardous materials, non-bulk)	64	359
ER (ICP)	In situ/field measurement of soils (chemical): sensors	57	492
LE	Pre-cleanup inventory management: continuous in-line monitoring for alpha radiation	56	873
LE	Treatment: polymerization	55	701
ER (ICP)	In situ/field measurement of soils: process monitoring and control technologies	54	467
LE	Pre-cleanup inventory management: continuous in-line monitoring for organics	54	873
NM (SRM)	Existing inventory management (monitoring/ characterization): remote inventory system for exposure reduction	53	396
LE	Treatment: chemical oxidation	52	637
LE	Treatment: freeze drying (secondary waste treatment)	49	548
SW	Treatment (partitioning/pre-treatment): decontamination with mechanical, chemical, and aqueous methods	47	216
ER (ICP)	In situ treatment/remediation of soils: bioremediation	47	203
ER (GW)	In situ treatment of groundwater: bioremediation	47	431
SW	Characterization (heterogeneous material sampling methods): remote/in situ sensor instrumentation	45	252
ER	Pre-cleanup inventory management: rapid field detection and monitoring methods: chemical	43	494

TABLE 13.2. (contd)

Mission Area (Problem)	Functional Need: Technology Development Need	Technology Need Scores	
		t	p·f·t
LE	Treatment: electrolytically regenerated ion exchange	43	522
NM (SNM)	Retrieval and recovery of residual holdup: ductwork remediation (downstream of HEPA filters)	42	457
LE	Treatment: freeze drying (chemical pretreatment)	40	395
LE	Treatment: electrodialysis	39	484
D&D	In situ pretreatment: gas- or vapor-phase decontamination	38	390
SW	In situ treatment (toxicity/mobility reduction): soil washing technologies	37	189
SW	Buried waste retrieval (remotely handled material): retrieval of unstable/reactive chemical waste	37	170
D&D	Characterization (intrusive): rapid field analysis - hazardous	37	425
LE	Treatment: adsorption	37	484
ER (TCP)	In situ treatment/isolation of soils: Hanford barrier	36	156
ER (GW)	In situ treatment of groundwater: chemical treatment	35	321
LE	Treatment: chelation	35	420
LE	Treatment: microorganisms	34	420
SW	In situ treatment (toxicity/mobility reduction): interim stabilization technologies	34	173
ER (TCP)	Ex situ treatment of soils: washing (chemical extraction)	34	282
SW	Characterization (heterogeneous material sampling methods): integrated information system driven by expert systems	33	185
D&D	Characterization (nonintrusive): rapid field detection instruments - radioactive	33	379
NM (SNM)	Existing SNM inventory management (monitoring/characterization): nondestructive characterization	33	247
ER (TCP)	Soil retrieval: robotics applications for remote handling	33	131
ER (GW)	Ex situ treatment of groundwater: bioremediation	33	157
ER (TCP)	Ex situ treatment of soils: bioremediation	32	265
SW	Characterization (in situ measurement/sampling): ground-penetrating radar	31	174
D&D	Characterization (intrusive): remote sampling technologies	31	356

TABLE 13.2. (contd)

Mission Area (Problem)	Functional Need: Technology Development Need	Technology Need Scores	
		t	p·f·t
NM (IF)	Existing irradiated fuel inventory management (interim storage form conversion): mechanical size reduction/oxidation for metal fuel (alternative oxidants)	31	343
D&D	In situ pretreatment (dismantle components): noncontamination imbedding sectioning technologies - nonthermal dismantling	31	318
ER (TCP)	Ex situ treatment of soils: ex situ vitrification	31	257
D&D	Characterization (nonintrusive): scanner with robotic interface	31	344
ER (TCP)	Soil retrieval: dust control/containment	30	119
D&D	Characterization (intrusive): rapid field analysis - radioactive	29	333
NM (IF)	Irradiated fuel disposal form conversion: mechanical size reduction/oxidation for metal fuel (alternative oxidants), including offgas treatment for high-temperature spent fuel treatment	29	321
ER (GW)	Ex situ treatment of groundwater: membrane separations (e.g., reverse osmosis)	29	138
SW	In situ treatment (toxicity/mobility reduction): grout/cementation	28	143
ER (GW)	Subsurface manipulation/retrieval of groundwater: chemical	28	133
D&D	In situ pretreatment (decontamination): removable coatings	26	267
D&D	In situ pretreatment (dismantle components): size reduction methods	26	267
ER (TCP)	In situ treatment/isolation of soils: soil heating	26	112
LE	Treatment: pervaporation	25	293
LE	Treatment: glass	25	293
SW	In situ treatment (toxicity/mobility reduction): encapsulation	24	122
ER (GW)	Subsurface manipulation/retrieval of groundwater (subsurface barriers): grout	23	109
D&D	Characterization (nonintrusive): rapid field detection instruments - physical	22	253
ER (TCP)	In situ/field measurement of soils (chemical): soil gas analysis	22	190
ER (TCP)	In situ treatment/isolation of soils: in situ vitrification	22	95
LE	Treatment: supported liquid membrane	22	229

TABLE 13.2. (contd)

Mission Area (Problem)	Functional Need: Technology Development Need	Technology Need Scores	
		t	p·f·t
NM (IF)	Existing irradiated fuel inventory management (interim storage systems): new dry storage - encapsulation for dry storage	21	232
ER (TCP)	In situ treatment/isolation of soils: electrokinetics/electro-osmosis	21	91
ER (TCP)	Ex situ treatment of soils: electrokinetics/electro-osmosis	20	166
LE	Treatment: biopolymers	20	229
ER (GW)	Subsurface manipulation/retrieval of groundwater: physical	19	90
D&D	Characterization (intrusive): rapid field analysis - physical	18	207
NM (IF)	Irradiated fuel disposal form conversion: alternate waste form technologies	18	199
ER (TCP)	Ex situ treatment of soils: heat (thermal desorption)	18	149
ER (GW)	Subsurface manipulation/retrieval of groundwater (subsurface barriers): cryogenic	18	86
SW	Treatment (disposal form conversion): ceramic waste forms	17	78
NM (IF)	Existing irradiated fuel inventory management (basin sludge removal): sludge disposition characteristics	17	188
LE	Treatment: supercritical water oxidation	17	191
ER (TCP)	In situ treatment/isolation of soils: vapor extraction	16	69
D&D	In situ pretreatment: isolation	13	133
LE	Treatment: coagulation/filtration	13	140
LE	Treatment: precipitation	11	127
LE	Treatment: grout	10	102
LE	Treatment: incineration	6	76
SW	Buried waste retrieval (remotely handled material): self-contained mobile retrieval system (WORM)	5	23
LE	Treatment: air stripping	3	25
LE	Pre-cleanup inventory management: time composite sampling	2	32
LE	Pre-Cleanup inventory management: flow composite sampling	2	32
LE	Pre-cleanup inventory management: grab sample	2	32

TABLE 13.2. (contd)

Mission Area (Problem)	Functional Need: Technology Development Need	Technology Need Scores	
		t	p·f·t
NM (IF)	Existing irradiated fuel inventory management (interim storage form conversion): sodium removal by water reaction (FFTF only)	0	0
Key: DNAPL = dense nonaqueous phase liquid f = functional need score GW = groundwater IF = irradiated fuel LE = liquid effluents (problem focus = mixed/land disposal restricted effluents) NM = nuclear materials p = problem score SNM = special nuclear materials SW = solid waste (problem focus = buried waste) t = technology need score TCP = contaminated soils in trenches, cribs, and ponds			

- In Situ Measurement: An NDA hot cell scanning system must be developed that utilizes remote Raman spectroscopy, remote infrared/near infrared spectroscopy, gamma energy analysis core scanning, and laser ablation/mass spectrometry. Technology validated in the hot cell must be adapted for in situ deployment. Several in situ radiochemical analysis methods must be demonstrated, including passive copper foil neutron activation with penetrometer, passive and induced gamma scanning, and assays with Cd/Te detectors.
- Retrieval: Much of the technology development required for the LRA, LRA control systems, and end effectors is being conducted by EM-50. The use of mixer pumps with stop-leak gel should be studied for SSTs. SST hydraulic sluicing methods must be developed and tested. Full-scale pipe tests and computer codes are needed for predicting flow characteristics for Newtonian and non-Newtonian fluids. SST second-generation sluicing methods must be developed, tested, and demonstrated, including limited or other sluicing methods and specialized sluicing nozzles. Subsurface barrier technology is needed to control tank leaks during sluicing.
- Laboratory Sampling and Analysis: In situ sampling and deployment methods are needed. Specific needs include a Raman penetrometer probe and a penetrometer delivery system.
- Existing Storage Management: Most of the technology needs for existing storage management can be met with existing technology.

Some areas that may require technology development include instrumentation for nondestructive annulus inspection; analytical methods for detecting organics and chelators; and technology for in situ moisture, vapor, and criticality monitoring.

13.2.2 Solid Waste

This section provides technology development recommendations for the solid waste mission area.

- Treatment: Sorting, under the partitioning/pretreatment subfunction, was the highest-priority technology need for the solid waste mission area. Three TTPs were identified that address sorting. Another high-priority technology need identified under the partitioning/pretreatment subfunction is mechanical, chemical, or aqueous decontamination of waste streams.

Under the disposal form conversion subfunction, the use of ceramic waste forms was identified as an important technology development need.

- Characterization: All technology development needs under the characterization function are for the development of in situ measurement and sampling capabilities. The highest-priority characterization need is for NDE/NDA methods. Eight TTPs were identified that address this technology need. Other technology development needs include nonbulk sensors for radionuclides and hazardous chemicals, real-time/on-line sensors, ground-penetrating radar, and development of a system-wide expert system.
- In Situ Treatment: Technology development needs for in situ treatment fall under the toxicity and mobility reduction subfunction. The development of dust control technologies was ranked highest under in situ treatment needs. Two TTPs were funded to address this problem. The remaining technology needs for in situ treatment are soil washing technologies, interim stabilization, grout/cementation, and encapsulation. No TTPs were identified that address soil washing or in situ encapsulation.
- Retrieval: All technology development needs under the retrieval function deal with the retrieval of remote-handled material. As with in situ treatment, the highest-priority technology need under retrieval is for dust control technologies. Two TTPs currently address development of dust control technologies for retrieval. Containment and control of radionuclides/hazardous chemicals and robotic removal of waste are also identified as technology development needs.

13.2.3 Environmental Restoration

This section provides technology development recommendations for the ER mission area.

- Characterization: There is a great need for development of a Site-wide decision support system to meet the process monitoring and control technology need. Such a system would provide a central data source for all Hanford engineers and scientists involved in cleanup activities. It would include sample and characterization data for each operable unit, a system for selecting remediation technology trains (e.g., Re-Opt), descriptions of technologies and their vendors, and ongoing data storage and visualization capabilities as cleanup progresses.

One of the functions of such a system would be the ability to "walk through" a proposed Hanford cleanup on the computer, using results obtained elsewhere, and identify problems in advance. It would also provide a central communications tool whereby engineers at one operable unit could select technologies already in use at another, and obtain direct and timely information on the efficiency of cleanup being achieved, avoiding costly mistakes and duplication of effort. An additional benefit, if the system is maintained and updated, is that developing technology would be included, so that technologies selected would always be state-of-the-art and not obsolete.

Technology development needs in the chemical sensors area consist mainly of the development of sensors for chemicals currently not specifically detectable. A recent development of immunological- or enzyme-based chemical detection systems for PCBs and other hazardous organics may offer a cheap, fast alternative to mass spectrometry and should be examined for use at Hanford.

Further development is recommended of instrumented cone penetrometers and similar devices to enhance the speed of drilling without dust and residues and to provide real-time down-hole analytical capability.

There is a need for technology development in the characterization area for real-time monitoring of the progress of all the in situ remediation technologies listed. One of the major impediments to utilization of in situ technologies is the inability to measure progress and end-state results (e.g., the final concentration of contaminants left in the soil).

- In Situ Treatment/Isolation (soils): Technology development activity is ongoing in all in situ soil treatment areas (Hanford barrier, ISV, vapor extraction, bioremediation, soil heating, electrokinetics/electro-osmosis, and in situ grouting). However,

major effort should be expended in developing the electrokinetics and electro-osmosis techniques as these have the ability to remove both organics in solution and contaminant metals and radionuclides from soil simultaneously.

- Material Retrieval: Development of automated remote handling (robot) systems for contaminated (and radioactive) soil retrieval should be actively pursued because of H&S reasons. Both robotic manipulation and the continuous monitoring capabilities should be developed.
- Ex Situ Treatment (soils): Commercially available technology exists for all of the ex situ soil treatment technology needs, but there are Hanford-specific technology development needs. These include the need for more efficient soil washing systems (e.g., additives, surfactants), demonstration of an effective electrokinetic system in dry soil, and the need for greater melt depth and consistency with ISV.
- Subsurface Manipulation/Retrieval (groundwater): Both cryogenic and grout barriers have been developed for retention of soils, but there are different problems with groundwater, such as grout setting in a wet environment and maintenance of a cryogenic barrier in the presence of water, which will tend to cause melting. Both represent technology development needs. For the other technologies listed under this heading (electrokinetic, biological, and membrane barriers), the technology is less well known, and development is listed as a science need.
- Ex Situ Treatment (groundwater): Technology development is recommended for some of the innovative membrane separation systems currently being investigated, such as chromium separation using liquid membranes or ionic membranes, which may be more effective than reverse osmosis at recovering contaminant metal ions from groundwater.
- In Situ Treatment (groundwater): The most pressing technology development area is for additional enhancement of in situ bioremediation treatment systems, together with monitoring of their effectiveness.

13.2.4 Decontamination and Decommissioning

This section provides technology development recommendations for the D&D mission area.

- Characterization: Much of the ongoing research in characterization may be applicable to D&D, but integration and testing, as a minimum, would be required to determine applicability at the Hanford Site. Policies may also require modification to allow for the use

of in field instrumentation results in characterizing a site; in monitoring a site; in determining the "cleanliness" of a site; and in segregating wastes for packaging, treatment, and recycle.

Characterization is performed throughout the D&D process; however, most characterization deals with radioactive contamination in a gross manner and either does not deal with hazardous contamination at all or involves detailed laboratory work. Much research is ongoing in the characterization field, but most appears generic and may not be applicable to Hanford D&D needs.

- Detection and Analysis Capabilities: Rapid hazardous field detection capabilities currently do not exist for most hazardous constituents and require technology development to meet the needs of Hanford D&D. There is much research being done to improve hazardous sensors, but not directly for D&D applications. Integration and field testing would be required as well as possible further improvements and development to ensure that Hanford needs are met.

Rapid hazardous field analysis capabilities are needed to identify RCRA-listed constituents to RCRA limits. Research is being done to improve hazardous field analysis capabilities. A real-time metals and VOCs analyzer is being developed for analysis of air, soil, and water samples. A fiber optic sensor and analysis capability is being developed for liquid and gas samples. However, no other research was identified for the many hazardous constituents that may be present in facilities to be decontaminated and decommissioned. Since this capability does not exist, it will have to be developed.

- Remote Sampling: The needs identified for remote sampling technologies are a combination of technology improvement and technology development needs. Remote sampling should be useable on various structures and materials, able to detect the presence of contamination in order to determine what areas should be sampled, able to track and sample locations in three dimensions, and able to travel various distances and fit through small holes in contaminated areas. Many ongoing robotic development programs are applicable to the remote sampling needs identified for Hanford D&D. However, much of the development is being performed for applications other than D&D sampling. As a minimum, integration and testing would be required to determine the applicability of the various robotics and sensor systems to the remote sampling needs. Further development or improvements may also be required.
- Continuous Feed System Capabilities: A need for the ability to detect on a continuous feed system was identified for metal and concrete recycling. The technology should be sensitive enough (e.g., micro curies of alpha contamination) to weed out nonrecyclable materials. There is one ongoing program applicable to recycling and detection. However, it is doubtful the program

involves continuous feed capabilities. Therefore, development is needed to provide this capability.

13.2.5 Nuclear Materials

This section provides technology development recommendations for the nuclear materials mission area.

Irradiated Fuels Problem Area

- Existing Inventory Management: The highest-priority technology need was for mechanical size reduction technology, development of alternative oxidants for metal fuels, and an effective offgas treatment system for high-temperature processing of spent fuel. This same need also ranked high in the disposal form conversion function evaluation. There is some research underway on alternative oxidants and the use of robotics in waste facilities but nothing specific to the Hanford needs. Another technology need was for encapsulation of fuel elements to allow for dry storage. This technology would meet an interim storage system need.

Special Nuclear Materials Problem Area

- Existing Inventory Management: The highest scoring technology need in the nuclear materials mission area was for the development of a remote inventory system for the reduction of worker exposure to radiation. This system is needed to monitor the inventory of stored SNM for security reasons and is now done manually which leads to worker exposure in the process. The EM-50 robotics work may be useful in meeting this need. Another technology development need identified in this area was the need for nondestructive characterization of SNM.
- Retrieval and Recovery: The remediation of ductwork downstream of the HEPA filters was seen as an important technology development need. This need may be seen as part of the D&D mission area, but there may be a need for robotics or remote technology to recover any SNM in the ductwork before D&D takes place.

13.2.6 Liquid Effluents

This section provides technology development recommendations for the liquid effluents mission area.

- Generation: The highest ranking technology development need was the recycle/reuse of waste water. The major impediment to recycle/reuse of the water is the build-up of tritium in the water. Some method is needed to partition or remove the tritium from the recycle stream.
- Treatment: The technology development needs for partitioning/pretreatment include the following: UV oxidation, chemical oxidation, freeze drying, electrolytically regenerated ion-exchange, adsorption, electrodialyses, micro-organisms, and chelation. These technologies are not in a commercially viable mode now for use at Hanford and would require a development effort to be cost-effective at this time. Polymerization was a highly ranked technology development need for secondary waste treatment.
- Waste Characterization: There were two technology development needs identified for continuous in-line monitoring: alpha radiation and inorganic chemicals monitoring. The need to monitor trace elements of inorganic chemicals and low levels of alpha radiation in a huge volume of continuously moving liquid will require technology development before effective methods are ready for implementation at Hanford.

13.3 SCIENCE NEEDS

Significant challenges to successful completion of the Hanford cleanup mission are posed by problems for which there is an incomplete understanding of the basic phenomena that cause these problems. In many cases, it is desirable to invest resources in promising scientific research that could lead to the development of innovative technological solutions to Hanford's most serious problems. However, research is not warranted in every case. Near-term visible progress on the Site cleanup mission is a pressing goal. Thus, carefully thought-out decisions are needed regarding exactly which scientific research proposals will be successful, what the impacts on the Site would be if they were successful, and ultimately, which ones should be funded and by whom.

First, a theory must exist that would be possible to prove or disprove as a result of the research. Second, there must be enough time to do the research, which will not be the case where there are imminent worker or public health and safety impacts, or where we are in danger of missing a TPA milestone. Third, there must be the promise of a substantial payoff in terms

of new technology development if the research is successful. Finally, there is the question of who would be willing to fund the research.

In this document, science needs are defined as development of entirely new technology, instruments, or methods to perform functions currently beyond the state of the art, such as real-time, three-dimensional, nonintrusive radioisotope mapping by concentration, isotope, and location. Prioritized nontank science needs across mission areas are shown in Table 3.3.

13.3.1 Tanks

This section provides science recommendations for meeting TWRS needs. These recommendations include areas where a better fundamental understanding of underlying phenomena is important and areas where no technology currently exists. Since the focus of TWRS integrated technology planning was technology development rather than science, this list is probably incomplete.

- Partitioning: Modeling techniques are needed for predicting the behaviors of sludge during dissolution and separations processes. Such models might make it possible to develop new sludge separations schemes.
- LLW Immobilization and Disposal: Flow and transport computer models are needed to predict the long-term behavior of the LLW form and disposal facility. Regional and hydrogeological conditions must be incorporated into the models, and the models must be verified by field tests.
- Retrieval: Computer models are needed to simulate aerosol generation in the tank environment during retrieval.
- Existing Storage Management: Activities needed to evaluate and define safety issues for flammable gas include synthetic waste studies, radiolytic/chemical mechanisms studies, and physical and numerical modeling. Resolution of the ferrocyanide issue requires laboratory chemical reaction studies, hot spot thermal modeling, and vapor space gas modeling. Modeling is required to resolve the organic tank safety issues. Air dispersion plume modeling is required to define the tank vapor safety issue.

13.3.2 Solid Waste

This section provides science recommendations for the solid waste mission area.

TABLE 13.3. Prioritized Nontank Science Needs Across Hanford Mission Areas

Mission Area (Problem)	Functional Need: Science Need	Technology Need Scores	
		t	p·f·t
LE	Treatment: tritium removal via membrane	60	726
ER (TCP)	In situ/field measurement of soils (chemical): sensors	57	492
LE	Pre-cleanup inventory management: continuous in-line monitoring for beta radiation	56	873
SW	Treatment (disposal form conversion): stabilized waste forms	50	230
ER (TCP)	In situ treatment/isolation of soils: bioremediation	47	203
SW	Characterization (in situ measurement/sampling): bulk analysis and instrumentation	46	258
NM (IF)	Existing inventory management (interim storage systems): inventory characterization (laboratory/engineering studies) - metal fuel safety in new dry storage	44	487
LE	Pre-cleanup inventory management: continuous in-line monitoring for gamma radiation	38	614
ER (GW)	In situ treatment of groundwater: technologies for treatment of DNAPLs	36	330
ER (TCP)	In situ/field measurement of soils (physical/geophysical): fiber optic probe	34	294
NM (SNM)	Retrieval and recovery of residual holdup: assessment of portable NDA/NDE systems	32	348
D&D	In situ pretreatment (liquid-phase decontamination): foams and gels	32	328
D&D	In situ pretreatment (dismantle components): noncontamination imbedding sectioning technologies - nonthermal dismantling	31	318
D&D	Characterization (nonintrusive): scanner with robotic interface	31	344
ER (TCP)	In situ treatment/isolation of soils: soil heating	26	112
D&D	In situ pretreatment (immobilization): fixatives and foams	25	256
SW	Characterization (in situ measurement/sampling): package integrity analysis	22	123
ER (TCP)	In situ treatment/isolation of soils: electrokinetics/electro-osmosis	21	91
ER (GW)	Subsurface manipulation/retrieval of groundwater (subsurface barriers): biological	20	95
D&D	In situ pretreatment (liquid-phase decontamination): chelating agents	17	174

TABLE 13.3. (contd)

Mission Area (Problem)	Functional Need: Science Need	Technology Need Scores	
		t	p·f·t
ER (GW)	Subsurface manipulation/retrieval of groundwater (subsurface barriers): electrokinetic	12	57
ER (GW)	Subsurface manipulation/retrieval of groundwater (subsurface barriers): membrane	11	52
Key: DNAPL = dense nonaqueous phase liquid f = functional need score GW = groundwater IF = irradiated fuel LE = liquid effluents (problem focus = mixed/land disposal restricted effluents) NM = nuclear materials p = problem score SNM = special nuclear materials SW = solid waste (problem focus = buried waste) t = technology need score TCP = contaminated soils in trenches, cribs, and ponds			

- Treatment: Development of methods and technologies to create stabilized waste forms that meet long-term disposal criteria was identified as the highest-priority science need for the solid waste mission area. Nine TTPs are currently funded to address this technology need.
- Characterization: Bulk analysis of waste in situ and the ability to determine package integrity in situ were classified as science needs under characterization. Five TTPs currently address in situ bulk analysis of waste, and one TTP was identified that addresses package integrity.

13.3.3 Environmental Restoration

This section provides science recommendations for the ER mission area, which represent areas where no good technology currently exists, but one is needed.

- Characterization: New chemical sensors are needed that are fast, cheap, accurate, sensitive, and that record multiple species independently but simultaneously (e.g., for heavy metal contamination in soil).

Physical/geophysical methods that will provide a three-dimensional map of the locations and concentrations of radionuclides, chemical plumes, and heavy metals in soil from surface-based measurements represent a major science need. Such instruments would eliminate the need for much of the drilling on the Site. An example is prompt gamma-emission neutron activation spectroscopy for uranium in soil; however, this technology is currently depth- and sensitivity-limited.

Development is needed of fiber-optic probes that have higher sensitivity and a greater range of analytical measurements, especially for organics in soil.

- In Situ Treatment/Isolation (soils): New methods for at-depth placement of materials need to be developed. This is a general problem. In soil heating, electrokinetics, and bioremediation, there is a need for exact placement of electrodes or nutrient supply injection points. "Concentration gradients" of electrons or nutrients disperse from these injection points to cause localized overheating or oversupply near the injection point. In bioremediation, this can cause overgrowth of the organisms, followed by plugging of the soil pores. In electric soil heating, it can cause localized boiling of water. The problem can be reduced by closer placement of injection points or electrodes, but this increases drilling costs. Better methods are urgently needed.
- Subsurface Manipulation/Retrieval (groundwater): There are currently no fully developed technologies for underground manipulation of groundwater. Development of electrokinetic "fences," biological barriers (such as in situ bacterial polysaccharide walls), and in situ biomembranes (for destruction of organics in water passing through) all represent new science opportunities. If available, they could fill a major technology void for which no currently effective technology exists (i.e., subsurface groundwater control and treatment).
- In Situ Treatment (groundwater): There are no effective methods to locate or recover DNAPLs for ex situ treatment and no methods for in situ treatment of DNAPLs. Techniques for finding, destroying, or recovering DNAPLs represent a major science need at Hanford in view of the large portion of the carbon tetrachloride plume that may exist in DNAPL form.

13.3.4 Decontamination and Decommissioning

This section presents science recommendations for the D&D mission area.

- Characterization: Characterization needs have been described in both Sections 13.1.4 and 13.2.4 as improvement and development needs. However, some hazardous constituents may require scientific breakthroughs before development or improvements can be performed.

- Generation: The only other science need defined for D&D was for foams and gels. Foams and gels are technologies that generate mixed waste. A method is needed that generates no mixed waste. Such a technology could be drastically different than the technologies currently used for foams and gels and, therefore, may require scientific research.

13.3.5 Nuclear Materials

This section presents science recommendations for the nuclear materials mission area.

Irradiated Fuels Problem Area

- Existing Inventory Management: The highest-priority need in the irradiated fuels problem area was for development of laboratory techniques to assess the safety aspects of storing metal fuel in dry storage conditions once the fuel is removed from the current storage fuels. Not enough is known about such stored fuel to safely allow for dry storage of the fuel at this time.

Special Nuclear Materials Problem Area

- Retrieval and Recovery of Residual Holdup: A portable NDA/NDE system was seen as a science need to support the assessment and characterization of SNM during the retrieval/recovery process. This system would have to be flexible enough to detect minute quantities of SNM in a large variety of building settings.

13.3.6 Liquid Effluents

This section presents science recommendations for the liquid effluents mission area.

- Treatment: Removal of tritium via membrane was seen as a partitioning/pretreatment need. At the present time, there is no economical way to separate tritium from regular water. If such a method could be developed, there would be many applications, both throughout the Hanford Site and at other contaminated sites around the world.
- Waste Characterization: The continuous in-line monitoring of both beta and gamma radiation is seen as a need both prior to treatment and also to allow the disposal or discharge of treated water. As with other characterization needs for liquid effluents, part of the problem is the dilute nature of the large volume of water to be monitored.

14.0 BUILDING THE HANFORD TECHNOLOGY PROGRAM PLAN

To successfully implement the Hanford cleanup, DOE (in conjunction with regulatory agencies) must choose the best available technology for each of the Site's environmental cleanup problems, which differ widely in nature. During the cleanup period (30 years or more), available technologies will improve due to technological progress, and a forward-looking approach to technology selection is needed to avoid application of obsolete and less cost-effective techniques.

For each of the Hanford problem areas, there exists a class of technologies and processes considered "the best available" by the environmental restoration/waste management (ER/WM) technical community. Obviously there is wide variation and much disagreement among experts, but a general consensus exists as to which are the best available technologies and processes at the present time. For example, remediation of carbon tetrachloride-contaminated soil is almost always performed by soil vapor extraction methods, although in situ bioremediation is a developing technology with promise.

As part of the FY 1992 S&T needs assessment workshops, participants were asked to identify potential technology solutions for the highest-priority problems. In the future, the S&T Needs Team may identify additional technologies based on literature reviews and interviews with experts. For each technology identified, information must be obtained about its performance, cost, environmental impacts, risks, safety, development status, public acceptability, and regulatory compliance.

In future years, the S&T Needs Team will also develop technology acceptance criteria to evaluate which technologies are best suited for insertion into the technical baseline. These criteria should include a designated percentage improvement over the technical baseline technologies in such areas as performance, cost, and safety. Alternative technologies must be able to demonstrate sufficient promise over the current baseline to be recommended for R&D funding. A key issue that must be resolved is how to compare a potentially high-risk, unproven technology with an accepted baseline technology. Regulatory and institutional constraints to new technology applications are discussed in Appendix E.

Consistent with the philosophy of having waste cleanup needs drive scientific research and technology development, the Hanford approach to understanding where new technologies are needed is to:

- prioritize cleanup problems and technology needs
- assess the status of existing technology to support environmental restoration and waste management needs
- focus S&T development efforts on key technology gaps
- build an integrated, needs-driven Hanford Technology Program Plan (HTPP).

The HTPP will include the integrated set of S&T needs and performance requirements for scientific research, technology development, demonstration, testing, and deployment activities associated with solving Hanford's top environmental cleanup problems. This set includes: 1) basic research needs (DOE/OER activities), 2) applied technology development needs (EM-50 activities), and 3) adaptation, demonstration, and deployment of more mature or proven technologies (EM-30 and EM-40 activities).

The HTPP will encompass an integrated S&T development planning and decision-making process across all Hanford mission areas and the data to support Sitewide decisions about S&T needs and performance requirements. The plan will include the Site's strategic development goals, mission-specific baselines/options, overall and mission-specific technology life-cycle descriptions, and a top-down set of technology data requirements for each mission area (as identified by the problem owners in those mission areas). The HTPP will also include a description of how Hanford's S&T Program will be performed (including deliverables, cost, schedule, facility requirements, and equipment needs) and criteria for inserting new technologies into the baseline programs.

Using results from the HSSSTP, the HTPP will provide the integration of Hanford's technology planning efforts and decisions from the lowest, most-detailed mission area cleanup strategies to the highest, Hanford-wide cleanup strategies. It will help minimize work duplication, technology omission, and science/technology development guidance conflicts. The HTPP will be an integral part of the Hanford Integrated Planning Process (HIPP), which

establishes a tiered set of technical planning documents based on DOE/HQ guidance: the Hanford Strategic Plan, the Hanford Mission Plan, the multi-year program plans, and the fiscal-year work plans (see Figure 14.1). The goal of HIPP is to develop plans for accomplishing the cleanup mission that are technically sound, acceptable to stakeholders, and realistically achievable. Thus, HIPP provides the process (linking Hanford goals to specific work activities) by which the Hanford S&T Program will be developed.

The Hanford Mission Plan (HMP) provides the integrated planning basis for all Hanford cleanup programs (see Figure 14.2). The HMP will contain an analysis of cross-program, Site-wide implications of all S&T needs identified by the Hanford programs and submitted in their Multi-Year Program Plans. The full set of mission-specific and cross-cutting S&T needs will be captured under the HTPP, as well as Hanford's systems engineering needs.

The HTPP will be a "living document" and will be routinely updated as needs are identified and technologies are brought on-line. For example, there would be continued updating of the mission area baselines, alternative strategies, technology requirements, the HTPP planning process, and the S&T activities integrated into the Site's and EM-50's Integrated Demonstrations and Integrated Programs. External participation, review, and calls for new technology development proposals would continue as needed. Work proposals received from national laboratories, industry, and universities will be evaluated against the mission-specified requirements.

FIGURE 14.1. Simplified Hierarchy of Hanford Site Planning Documents (DOE/RL 1992a)

FIGURE 14.2. Hanford Integrated Planning Process

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APPENDIX A

TECHNOLOGY LOGIC DIAGRAMS

APPENDIX A

TECHNOLOGY LOGIC DIAGRAMS

A.1 TANKS

WASTE TANK OPERA

PROBLEM

1. TANK WASTE
 - A. SINGLE-SHELL TANK WASTE
 - SALT CAKE (NON-TRU)
 - SLUDGE (TRU)
 - INTERSTITIAL AND FREE LIQUIDS
 - B. DOUBLE-SHELL TANK WASTE
 - NCRW
 - DSTCC
 - PFP WASTE
 - NCAW
 - DSS/DSSF
 - NEWLY GENERATED LIQUID WASTE

MATERIAL STRATEGY

RETRIEVE, PROCESS, STORE, SHIP TANK WASTE
FOR 200 AREA AND/OR OFFSITE DISPOSAL

FUNCTIONS

PRE CLEANUP INVENTORY MANAGEMENT
•EXISTING STORAGE MANAGEMENT

SORTING/CHARACTERIZATION

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IONS AND DISPOSAL SHEET 1 OF 5

ALTERNATIVES

TECHNOLOGY

STATUS

KING TANKS	<p>WASTE TREATMENT AND TRANSFER</p> <ul style="list-style-type: none"> CORROSION PROTECTION BY CHEMICAL CONTROL DST CORROSION PROBES SST WATER LINE CORROSION PROTECTION ENHANCED SST STABILIZATION EMERGENCY RESPONSE <p>WASTE STORAGE</p> <ul style="list-style-type: none"> LEAK DETECTION METHODS TANK STRUCTURAL INTEGRITY EVALUATIONS HAND-HELD DATA ACQUISITION SPECTRAL GAMMA PROBES ENHANCED IN-TANK LEAK DETECTION OPTIMIZE TANK STORAGE SPACE ENHANCED WASTE VOLUME PROJECTION SYSTEM 	
MICALLY REACTIVE TANKS	<p>EVALUATE AND DEFINE SAFETY ISSUES (FLAMMABLE GAS, ORGANICS, FERROCYANIDE)</p> <ul style="list-style-type: none"> WASTE STUDIES, MODELING AND MONITORING MITIGATE SAFETY CONDITION (FLAMMABLE GAS) INTANK MIXING VENTILATION UPGRADES DILUTE WASTE HEAT WASTE SONIC PROBE VELOCITY DENSITY TEMPERATURE TREE MITIGATE SAFETY CONDITION (FERROCYANIDE) IN SITU MOISTURE MONITORING <p>WASTE STORAGE</p> <ul style="list-style-type: none"> DATA ACQUISITION AND MANAGEMENT TOOLS 	
HEAT TANKS	<p>EVALUATE AND DEFINE SAFETY ISSUES</p> <ul style="list-style-type: none"> THERMAL MODELING MITIGATE SAFETY CONDITION HEAT REMOVAL/WATER LEVEL CONTROL SYSTEM HEAT EXTRACTION/COOLING FOR C-106 	
K VAPORS	<p>EVALUATE AND DEFINE SAFETY ISSUES</p> <ul style="list-style-type: none"> AIR DISPERSION PLUME MODELING VAPOR MONITORING PORTABLE GAS MONITORING LABORATORY MITIGATE SAFETY CONDITION TANK VAPOR TREATMENT SYSTEM 	
TICALITY	<p>MITIGATE SAFETY CONDITION</p> <ul style="list-style-type: none"> FISSILE MATERIAL MANAGEMENT CRITICALITY MONITORING 	
ORATORY	<p>SAMPLE ACQUISITION</p> <ul style="list-style-type: none"> HARD SALT CAKE SAMPLING PENETROMETER DELIVERY SYSTEM RAMAN PENETROMETER PROBE TANK BOTTOM SAMPLER MECHANIZED/FLUIDIZED BED SAMPLER INTERSTITIAL GAS SAMPLER <p>SAMPLE PREPARATION</p> <ul style="list-style-type: none"> HARD SALT CAKE HOMOGENIZER SEMI-VOLATILE SAMPLE PREPARATION REMOVAL OF NORMAL PARAFFIN HYDROCARBONS MICROWAVE AND ACID DIGESTION <p>CHEMICAL AND RADIOCHEMICAL ANALYSIS</p> <ul style="list-style-type: none"> NOBLE METALS/¹²⁹I/RADIONUCLIDES BY ICP/MS TOTAL CARBON BY COMBUSTION CHEMICAL OXYGEN DEMAND FERROCYANIDE TOTAL CYANIDE MERCURY BY CYAA COMPLEXANTS <p>PHYSICAL AND THERMAL ANALYSIS</p> <ul style="list-style-type: none"> ABRASIVITY VISCOMETER THERMAL CONDUCTIVITY 	
SITU	<p>PHYSICAL ANALYSIS</p> <ul style="list-style-type: none"> ACOUSTIC WAVE GUIDE NDA HOT CELL SCANNING REMOTE RAMAN SPECTROSCOPY REMOTE INFRARED/NEAR-INFRARED SPECTROSCOPY GAMMA ENERGY ANALYSIS CORE SCANNING LASER ABLATION/MASS SPECTROMETER <p>CHEMICAL ANALYSIS</p> <ul style="list-style-type: none"> REMOTE RAMAN/FOURIER TRANSFORM SPECTROSCOPY <p>RADIO CHEMICAL ANALYSIS</p> <ul style="list-style-type: none"> PASSIVE COPPER FOIL NEUTRON ACTIVATION W/PENETROMETER PASSIVE AND INDUCED GAMMA SCANNING ASSAYS BY CdTe DETECTORS 	
D	MOBILE LABORATORY	

CONTINUED ON DRAWING DCLTW2AA SHEET-2

DCLTW2A/CEW/6-14-93-12

WASTE TANK OPERA

PROBLEM

MATERIAL STRATEGY

FUNCTIONS

1. TANK WASTE
 - A. SINGLE-SHELL TANK WASTE
 - SALT CAKE (NON-TNU)
 - SLUDGE (TRU)
 - INTERSTITIAL AND FREE LIQUIDS
 - B. DOUBLE-SHELL TANK WASTE
 - NCNW
 - DSIC
 - PTP WASTE
 - NCW
 - DSX/DSS
 - NEWLY GENERATED LIQUID WASTE

RETRIEVAL, PROCESS, STORE, SHIP TANK WASTE
FOR 200 AREA AND/OR OFFSITE DISPOSAL

RETRIEVAL

ALTERNATIVES	TECHNOLOGY	STATUS
DST MIXER PUMP	CONDUCT SCALED EXPERIMENTS <ul style="list-style-type: none"> • DETERMINE CORRELATIONS BETWEEN SCALED TESTS AND DST • COMPLETE STRUCTURAL ANALYSIS • PERFORM EROSION TESTS FOR EXPECTED METAL LOSS FROM FLUID JETS • PERFORM CORROSION TESTS TO SUPPORT IN-TANK SLUDGE WASHING CONTROL TANK ENVIRONMENT <ul style="list-style-type: none"> • SIMULATE AEROSOL GENERATION MONITOR PROCESS <ul style="list-style-type: none"> • INSTALL AND TEST EFFECTIVENESS OF LABORATORY-TESTED ULTRASONIC PROBE • IDENTIFY ALTERNATIVE SYSTEMS TO MONITOR MOBILIZATION, SOLIDS SETTLING, AND SLURRY UNIFORMITY • DEVELOP AND DEMONSTRATE CONE PENETROMETER AND SHEAR VANCES FOR EVALUATING SLURRY PROPERTIES DST MIXER PUMP SYSTEM IMPROVEMENTS <ul style="list-style-type: none"> • DEVELOP AND TEST MIXER PUMP NOZZLE DESIGN • DEVELOP AND TEST SPECIAL PUMP DESIGN TO REDUCE TANK HEEL 	
ST MIXER PUMPS WITH STOP LEAK GEL	FEASIBILITY STUDY	
ST HYDRAULIC SLUICING USING NONLEAKING FLUIDS	DEVELOP, TEST, AND DEMONSTRATE NONLEAKING FLUIDS	
ST WASTE SIMULANT DEVELOPMENT	DEVELOP AND VALIDATE WASTE SIMULANTS FOR MAJOR WASTE TYPES	
TRANSPORT SST/DST WASTES	FULL-SCALE PIPE TESTS FOR NEWTONIAN AND NON-NEWTONIAN FLUIDS	
ST SECOND GENERATION SLUICING	DEVELOP COMPUTER CODES FOR PREDICTING FLOW CHARACTERISTICS	
ST FIRST GENERATION LONG-REACH ARM	DEVELOP, TEST, AND DEMONSTRATE LIMITED OR OTHER SLUICING METHODS AND SPECIALIZED SLUICING NOZZLES	
	END EFFECTOR DEVELOPMENT <ul style="list-style-type: none"> • MECHANICAL AGITATOR W/PNEUMATIC CONVEYOR • SCARIFIER W/PNEUMATIC CONVEYOR CONTROL SYSTEM AND SENSOR DEVELOPMENT <ul style="list-style-type: none"> • GRAPHIC REAL-TIME CONTROL • FAULT DETECTION/ERROR RECOVERY • PATH PLANNING • SENSOR DATA INTEGRATION • REAL-TIME CONTROLS BASE SYSTEM PROCUREMENT SPECIFICATIONS	
ST SECOND GENERATION LONG-REACH ARM	CONTROL SYSTEM <ul style="list-style-type: none"> • WORK SPACE MODELING • DYNAMIC MODELING END EFFECTOR DEVELOPMENT <ul style="list-style-type: none"> • CUTTERS W/VISION AND SENSING CAPABILITIES • WATER CANNON (OR OTHER FLUID) W/PNEUMATIC CONVEYOR • HYDRAULIC JETS W/JET PUMP CONVEYOR 	
ST BARRIER DEVELOPMENT	SYSTEM FEASIBILITY STUDY FOR SUBSURFACE BARRIERS	
SECOND GENERATION ALTERNATIVE TECHNOLOGIES	TANK LEAK FEASIBILITY STUDY <ul style="list-style-type: none"> • FEASIBILITY STUDY • DRY MINING • SST MINI-MIXER • DST PAST PRACTICE • SST HYDRAULIC MINING • OTHER 	

WASTE TANK OPERAT

PROBLEM

MATERIAL STRATEGY

FUNCTIONS

1. TANK WASTE
 - A. SINGLE-SHELL TANK WASTE
 - SALT CAKE (NON-TRU)
 - SLUDGE (TRU)
 - INTERSTITIAL AND FREE LIQUIDS
 - B. DOUBLE-SHELL TANK WASTE
 - MCRW
 - DSTCC
 - PTP WASTE
 - MCAW
 - DSS/DSSF
 - NEWLY GENERATED LIQUID WASTE

RETRIEVE, PROCESS, STORE, SHIP TANK WASTE FOR 200 AREA AND/OR OFFSITE DISPOSAL

ONSITE TRANSPORTATION

INTERIM STORAGE

• RETRIEVED MATERIAL INTERIM STORAGE

TREATMENT

• PARTITIONING

SLS
SOL
LIO

NOM
DOU
CAR

PHA
PHA
(SL)

PHA
CAR

PHA
CAR
(SL)
PHA

ALT

ALTERNATIVES

TECHNOLOGY

STATUS

TY ——— PIPELINES
 98 ——— CONTAINER/CASK
 108 ——— CONTAINER/CASK

LE-SHELL TANKS
 S/PAD

2 1 (TANK SAFETY ISSUE RESOLUTION)

ORGANIC/FEROXYANIDE DESTRUCTION

- TECHNOLOGY EVALUATION AND SELECTION
- TESTING OF SELECTED PROCESS

2 2 (EARLY PRETREATMENT) AND PHASE 3
 (RNATANT AND SALT CAKE TREATMENT)

RADIONUCLIDE REMOVAL

- ION EXCHANGE MEDIA SELECTION FOR
 - ALKALINE-SIDE CESIUM REMOVAL
- FEASIBILITY STUDIES AND PROCESS FLOWSHEET DEVELOPMENT FOR
 - ALKALINE-SIDE TRU REMOVAL
 - ALKALINE-SIDE TECHNETIUM REMOVAL
 - ALKALINE-SIDE STRONTIUM REMOVAL
- EARLY DEMONSTRATION OF CPUe

ORGANIC MATERIALS DESTRUCTION

- TECHNOLOGY EVALUATION AND SELECTION
- TESTING OR SELECTED PROCESS
- NITRATE DESTRUCTION/RECYCLE
- SCREEN CANDIDATE PROCESSES
- LABORATORY-SCALE FEASIBILITY STUDIES
- BENCH- AND CONFIRMATION-SCALE PILOT TESTS
- FLOWSHEET DEVELOPMENT
- FINAL SPECIFICATIONS FOR PLANT DESIGN
- CHEMICAL RECYCLE
 - NO FY 1993 ACTIVITIES IDENTIFIED
- MEMBRANE SEPARATION
 - ESTABLISH ADEQUACY OF ORGANIC DESTRUCTION TO RESOLVE TANK SAFETY ISSUE
- EVALUATE EFFECT OF PRETREATMENT PROCESSES ON ORG. NIC CONTENT OF LLW STREAMS
- ALUMINUM /NO SODIUM REMOVAL (ENHANCEMENT)

2 3 (SUPERNATANT AND SALT
 TREATMENT)

SOLID/LIQUID SEPARATION

- EVALUATE TWO CANDIDATE PROCESSES

2 3 (SUPERNATANT AND SALT
 TREATMENT) AND PHASE 4
 (DOE PRETREATMENT)

2 4 (SLUDGE PRETREATMENT)

SLUDGE WASHING AND LEACHING

- DETERMINE WASHING EFFICIENCY
- DEVELOP PROCESS CONTROL
- CONDUCT BLENDING STUDIES
- EXPAND GROUT WASTE FORM COMPOSITION RANGE
- IDENTIFY CANDIDATE WASTES
- CONDUCT FEASIBILITY STUDIES
- SLUDGE DISSOLUTION
 - EVALUATE ACIDIC AND FUSION DISSOLUTION METHODS
 - CHARACTERIZE MINERAL SPECIES IN SLUDGE
 - DEVELOP MODELING TECHNIQUES FOR PREDICTING DISSOLUTION BEHAVIOR
- ACID-SIDE RADIONUCLIDE REMOVAL (TRU, Cs, Sr, To)
 - SCREEN CANDIDATE PROCESSES
 - LABORATORY-SCALE FEASIBILITY STUDIES
 - BENCH- AND CONFIRMATION-SCALE PILOT TESTS
 - FLOWSHEET DEVELOPMENT
 - FINAL SPECIFICATIONS FOR PLANT DESIGN
- SELECTIVE COMPONENT REMOVAL
 - SCREEN CANDIDATE PROCESSES
 - URANIUM REMOVAL
 - IODINE REMOVAL
 - INERTS REMOVAL (e.g., ACTINIDE/LANTHANIDE, BARIUM/STRONTIUM)
 - RECOVERY OF NOBLE METALS (PHASE 4 ENHANCEMENT)

ALTERNATIVES

CALCINATION AND LEACHING

- COMPLETE SYSTEMS STUDY TO FURTHER EVALUATE CONCEPT
- ALKALINE-SIDE CESIUM REMOVAL
- BULK LEACHING
 - IDENTIFY INCENTIVES FOR BLENDING OR BULK TREATMENT PROCESSES
 - COMPLETE FEASIBILITY AND SYSTEM STUDIES
 - ALKALINE-SIDE CESIUM REMOVAL

WASTE TANK OPERAT

PROBLEM

1. TANK WASTE
 - A. SINGLE-SHELL TANK WASTE
 - SALT CAKE (MON-TRU)
 - SLUDGE (TRU)
 - INTERSTITIAL AND FREE LIQUIDS
 - B. DOUBLE-SHELL TANK WASTE
 - NCRW
 - DSTCC
 - PPF WASTE
 - NCAW
 - DSS/DSSF
 - NEWLY GENERATED LIQUID WASTE

MATERIAL STRATEGY

RETRIEVE, PROCESS, STORE, SHIP TANK WASTE
FOR 200 AREA AND/OR OFFSITE DISPOSAL

FUNCTIONS

•DISPOSAL FORM CONVERSION

LLW DIS
•CHA

•GRC

•GLA

•WAL

•WAL

•ALT
HLW DIS
•REC

•IMM

•PRO

•WAL

•PAQ

•ALT

•ALT

CESIUM I
•OVED

STORAGE

- INTERIM STORAGE
- LONG-TERM STORAGE
- REMOTE-HANDLING SYSTEM

DISPOSAL

- OFFSITE TRANSPORTATION
- OFFSITE STORAGE/BURIAL

OFFSITE

•OEC

OFFSITE

•RAI

•OEC

•ON-SITE DISPOSAL FACILITY

ON-SITE I

•DIS

•DIS

•ALT

- DISPOSAL FACILITY CLOSURE
- ENVIRONMENTAL MONITORING

ALTERNATIVES

TECHNOLOGY

STATUS

WASTE TANK OPERA

PROBLEM

1. TANK RESIDUALS
 - A. SINGLE-SHELL TANK WASTE
 - B. DOUBLE-SHELL TANK WASTE

MATERIAL STRATEGY

IN SITU TREATMENT OF TANK RESIDUALS
FOR ONSITE DISPOSAL

FUNCTIONS

- TREATMENT
- IN SITU TREATMENT OF TANK RESIDUALS
- DISPOSAL
- DISPOSAL SITE CLOSURE
 - ENVIRONMENTAL MONITORING

IONS AND DISPOSAL SHEET 5 OF 5

CONTINUED FROM DRAWING DCLTW4A SHEET-4

ALTERNATIVES

TECHNOLOGY

STATUS

SITU VITRIFICATION
MOBILIZE AND DOME/VOID FILL
IE

MOBILIZE AND DOME/VOID FILL
P/COVER
WDSCAPE
IFACE BARRIER

DCLTWSA/CEW/5-10-03-5

A.2 SOLID WASTE

SOLID WASTE OPER

PROBLEM

1. BURIED SOLID WASTE
 - A. TRANSURANIC & TRANSURANIC MIXED
 - B. LOW-LEVEL MIXED SOLID WASTE
 - C. LOW-LEVEL SOLID WASTE
 - D. NONRADIOACTIVE HAZARDOUS SOLID WASTE
 - E. NONRADIOACTIVE NONHAZARDOUS SOLID WASTE

MATERIAL STRATEGY

RETRIEVE, PROCESS, STORE, SHIP WASTE
FOR 200 AREA AND/OR OFFSITE DISPOSAL

FUNCTIONS

PRECLEANUP INVENTORY MANAGEMENT

• INVENTORY INFORMATION SEARCH

• OPERATIONS INVENTORY MANAGEMENT

• CHARACTERIZATION

• STRATEGIC DECISION MODELING

GENERATION (RETRIEVAL)

• SOLID WASTE RETRIEVAL

ACTIONS AND DISPOSAL SHEET 1 OF 4

ALTERNATIVES	TECHNOLOGY	STATUS
LITERATURE/RECORDS SEARCHES		
WORKER INTERVIEWS/INFERENCE TECHNIQUES		
DEVELOPMENT OF DATABASES		
SAMPLING FOR VERIFICATION		
HETEROGENEOUS MATERIAL SAMPLING METHODS		
LAB/FIELD SAMPLE ANALYSIS		
CONTAINMENT/INTERIM STABILIZATION		
IN SITU MEASUREMENT/SAMPLING	<ul style="list-style-type: none"> BOTH RH & CH METHODS CONTAINER INTEGRITY NDE/NDT METHODS 	
PHYSICAL SITE SURVEYS	<ul style="list-style-type: none"> AERIAL SURVEYS GROUND-PENETRATING RADAR NEW GROUND-PENETRATING PROBES 	
LAB/FIELD ANALYSIS	<ul style="list-style-type: none"> ASSAY ANALYSIS MOBILE LABS PHYSICAL/CHEMICAL METHODS 	
HETEROGENEOUS MATERIAL SAMPLING METHODS	<ul style="list-style-type: none"> STATISTICAL-BASED APPROACH SYSTEM-WIDE INFO SYSTEM REAL-TIME/ON-LINE SENSOR INSTRUMENTATION 	
BOUNDARY & FLOW MODELING OF SPECIFIC SITES	<ul style="list-style-type: none"> EXTENT OF CONTAMINANT SPREAD SUBSURFACE MATERIAL MAPPING 	
WALL-SCALE RETRIEVAL SAMPLING		
DECISION SUPPORT SYSTEMS		
RISK ASSESSMENT		
PERFORMANCE ASSESSMENT		
EMULSION		
CONTACT HANDLED	<ul style="list-style-type: none"> PACKAGE INTEGRITY ANALYSIS RAD/HAZ. MATERIAL CONTAINMENT/CONTROL LARGE/SMALL REMOVAL EQUIPMENT RETRIEVE UNSTABLE/REACTIVE CHEMICAL WASTE OPERATIONAL MONITORING FOR WORKER SAFETY CHARACTERIZATION AFTER RETRIEVAL NDE/NDT ROBOTICS/REMOVAL EQUIPMENT 	
REMOTE HANDLED	<ul style="list-style-type: none"> PACKAGE INTEGRITY ANALYSIS RAD/HAZ. CONTAINMENT/CONTROL ROBOTICS/REMOVAL EQUIPMENT RETRIEVE UNSTABLE/REACTIVE CHEMICAL WASTE OPERATIONAL MONITORING FOR WORKER SAFETY CHARACTERIZATION AFTER RETRIEVAL 	

SOLID WASTE OPERA

PROBLEM

1. BURIED SOLID WASTE
 - A. TRANSURANIC & TRANSURANIC MIXED
 - B. LOW-LEVEL MIXED SOLID WASTE
 - C. LOW-LEVEL SOLID WASTE
 - D. NONRADIOACTIVE HAZARDOUS SOLID WASTE
 - E. NONRADIOACTIVE NONHAZARDOUS SOLID WASTE

MATERIAL STRATEGY

RETRIEVE, PROCESS, STORE, SHIP WASTE
FOR 200 AREA AND/OR OFFSITE DISPOSAL

FUNCTIONS

ALTERNATIVES

TECHNOLOGY

STATUS

REDUCTION FOR LARGE MASSES
AGE DESIGN TO MEET
MENT CRITERIA
ABLE PACKAGES/CASKS
ILITIES TO MEET GOV'T. REGULATIONS
DED PACKAGING
WASHING
TIONATION
TAMINATION
FICATION
MENT DISPOSAL

S/AGGREGATE FOR CONCRETE
LS
ITY/TOOLS TO DEVELOP ONSITE CRITERIA
ITY/TOOLS TO DEVELOP OFFSITE CRITERIA
ORMANCE ASSESSMENT

LIANCE WITH TRANSPORTATION REGULATIONS
DEVELOPMENT
MATED VISUAL INSPECTION CAPABILITY
IER DEVELOPMENT
SCAPING
ILIZATION TECHNIQUES
FILL TECHNIQUES FOR RETRIEVAL SITE
DATION OF WASTE FORM & BARRIERS
CLOSURE MONITORING

SOLID WASTE OPERA

PROBLEM

1. BURIED SOLID WASTE
 - A. TRANSURANIC & TRANSURANIC MIXED
 - B. LOW-LEVEL MIXED SOLID WASTE
 - C. LOW-LEVEL SOLID WASTE
 - D. NONRADIOACTIVE HAZARDOUS SOLID WASTE
 - E. NONRADIOACTIVE NONHAZARDOUS SOLID WASTE

MATERIAL STRATEGY

IN SITU TREATMENT OF WASTE
FOR ONSITE DISPOSAL

FUNCTIONS

PRE CLEANUP INVENTORY MANAGEMENT

• INVENTORY INFORMATION SEARCH

• OPERATIONS INVENTORY MANAGEMENT

• CHARACTERIZATION

• STRATEGIC DECISION MODELING

TREATMENT

• INSITU TREATMENT

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IONS AND DISPOSAL SHEET 3 OF 4

CONTINUED FROM DRAWING DCL17A SHEET-2

ALTERNATIVES TECHNOLOGY STATUS

RATURE/RECORDS SEARCHES

CKER INTERVIEWS/INFERENCE TECHNIQUES

ELOPMENT OF DATABASES

PLING FOR VERIFICATION

EROGENEOUS MATERIAL
PLING METHODS

/FIELD SAMPLE ANALYSIS

TAINMENT/INTERIM
BILIZATION

ITU MEASUREMENT/SAMPLING ———— BOTH RH & CH METHODS
——— CONTAINER INTEGRITY
——— NDE/NDA METHODS

ICAL SITE SURVEYS ———— AERIAL SURVEYS
——— GROUND-PENETRATING RADAR
——— NEW GROUND-PENETRATING PROBES

'FIELD ANALYSIS ———— ASSAY ANALYSIS
——— MOBILE LABS
——— PHYSICAL/CHEMICAL METHODS

EROGENEOUS MATERIAL
PLING METHODS ———— STATISTICAL-BASED APPROACH
——— SYSTEM-WIDE INFO SYSTEM
——— REAL-TIME/ON-LINE SENSOR INSTRUMENTATION

NDARY & FLOW MODELING ———— EXTENT OF CONTAMINANT SPREAD
SPECIFIC SITES ———— SUBSURFACE MATERIAL MAPPING

L-SCALE RETRIEVAL SAMPLING

SION SUPPORT SYSTEMS

K ASSESSMENT

ORMANCE ASSESSMENT

PLATION

ILITY REDUCTION ———— ENCAPSULATION
——— GROUTING
——— SOLIDIFICATION
——— POLYMERIZATION
CITY REDUCTION ———— CHEMICAL TREATMENT
——— VITRIFICATION
——— PHOTOLYTIC OXIDATION
UME REDUCTION ———— SOIL-HEATING METHODS
——— GAS/VAPOR EXTRACTION
——— ELECTROKINETIC SEPARATION

NTAINMENT OF EMISSIONS

ICIAL IN SITU CHARACTERIZATION

TECHNOLOGY

CONTINUED ON DRAWING DCL35A SHEET 4

DCL12A/CEW/8-27-82-8

SOLID WASTE OPERA

PROBLEM

1. BURIED SOLID WASTE
 - A. TRANSURANIC & TRANSURANIC MIXED
 - B. LOW-LEVEL MIXED SOLID WASTE
 - C. LOW-LEVEL SOLID WASTE
 - D. NONRADIOACTIVE HAZARDOUS SOLID WASTE
 - E. NONRADIOACTIVE NONHAZARDOUS SOLID WASTE

MATERIAL STRATEGY

IN SITU TREATMENT OF WASTE
FOR ONSITE DISPOSAL

FUNCTIONS

WASTE SITE CLOSURE

BA
LA
ST
BA
VA
PC

TIONS AND DISPOSAL SHEET 4 OF 4

CONTINUED FROM DRAWING DCL12A SHEET 3

ALTERNATIVES

TECHNOLOGY

STATUS

RIER DEVELOPMENT
 IDSCAPING
 IBLIZATION TECHNIQUES
 KFULL TECHNIQUES
 IDATION OF WASTE FORM & BARRIERS
 ICLOSURE MONITORING

DCLSSA/CEW/8-10-93-4

A.3 ENVIRONMENTAL RESTORATION

ENVIRONMENT

PROBLEM

1. CONTAMINATED ENVIRONMENTAL MEDIA
 - A. SOIL
 - B. GROUNDWATER

MATERIAL STRATEGY

RETRIEVE, PROCESS, STORE, SHIP WASTE FOR 200 AREA DISPOSAL

FUNCTIONS

PRECLEANUP INVENTORY MANAGEMENT

CHARACTERIZATION

•IN SITU FIELD MEASUREMENT

CHEM
PHYS
RAD
MOB

•LABORATORY ANALYSIS

CHEM
PHYS
RAD
BIO
TEST
SAM
AUT

INFORMATION AND DECISION SUPPORT TOOLS

•INFORMATION HANDLING

IN
LAB
DAT

IN SITU TREATMENT

•SOILS/ISOLATION

HAR
IN
VAR
BIO
SOI
ELE
IN

•GROUNDWATER

SUB

•IN SITU PRE-TREATMENT

CHEM
PHYS

MATERIAL RETRIEVAL

•SOIL FIXANT, AND FOAM TECHNOLOGIES

•SOIL

DUS
ROE
EXC

•GROUNDWATER

SUB
CHE
PHY

•SUBSURFACE BARRIERS

CRY
ORG
ELE
BIO
ME

ONSITE TRANSPORTATION

•RETRIEVED MATERIAL

SOI
ORG

RESTORATION SHEET 1 OF 2

ALTERNATIVES

TECHNOLOGIES

STATUS

ICAL ----- ION-SPECIFIC ELECTRODES
 ----- SENSORS
 ----- SOIL-GAS ANALYSIS

ICAL/GEOPHYSICAL ----- ELECTRICAL RESISTIVITY TECHNOLOGY
 ----- INFRARED THERMAL IMAGING
 ----- DRILLING
 ----- FIBER OPTIC PROBE
 ----- GROUND/PENETRATING RADAR

OLOGICAL MEASUREMENT

LABORATORY ----- PROCESS MONITORING AND CONTROL

ICAL ----- WET CHEMICAL ANALYSIS
 ICAL ----- SPECTROMETRY
 OLOGICAL
 DIGITAL
 METHODOLOGY DEVELOPMENT ----- VISUAL DATA DISPLAY
 ----- STANDARDS DEVELOPMENT
 ----- MOBILE LABORATORY

LE PROTOCOL/FIELD STANDARDS
 MATED SAMPLE PREPARATION

ITU MEASUREMENT
 RATORY ANALYSIS ----- MOBILE LABORATORY
 ----- REMOTE LABORATORY

REDUCTION ----- PERFORMANCE ASSESSMENT
 ----- RISK ASSESSMENT/MANAGEMENT
 ----- DECISION SUPPORT SYSTEMS
 ----- TECHNICAL EVALUATION SYSTEMS

FORD BARRIER

SITU VITRIFICATION
 DR EXTRACTION
 REMEDIATION
 HEATING
 TROMKINETICS/ELECTROOSMOSIS
 SITU GROUTING

SURFACE MANIPULATION ----- CHEMICAL TREATMENT
 ----- BIOREMEDIATION
 ----- TREATMENT OF DNAPLs

ICAL PRETREATMENT/STABILIZATION ----- DUST CONTROL

ICAL PRETREATMENT ----- VAPOR EXTRACTION
 ----- THERMAL

CONTROL/CONTAINMENT

OTICS APPLICATIONS FOR REMOTE HANDLING
 AVATE (MECHANICAL/HYDRAULIC)

SURFACE MANIPULATION/RETRIEVAL
 IICAL
 IICAL
 OGEMIC
 JT
 TROMKINETIC
 LOGICAL
 BRAHE

----- DRUMS/TRUCK
 ----- BULK/RAIL
 ----- CONVEYORS
 ----- SLURRY PIPELINE

INDWATER ----- TANK TRUCK
 ----- RAIL TANK CAR
 ----- PIPE LINE

CONTINUED ON DRAWING DCL188 SHEET-2

DCL148/CEW/6-16-93-10

AL RESTORATION SHEET 2 OF 2

ALTERNATIVES TECHNOLOGIES STATUS

A.4 DECONTAMINATION AND DECOMMISSIONING

DECONTAMINATION AND

PROBLEM

1. CONTAMINATED FACILITIES AND STRUCTURES
 - A. REACTORS AND SUPPORT FACILITIES
 - DEFUELED CORE STRUCTURES
 - EFFLUENT TREATMENT SYSTEMS
 - ANCILLARY STRUCTURES/BUILDINGS
 - FFTF
 - IRRADIATED FUEL STORAGE FACILITIES
 - B. Pu PROCESS FACILITIES (NON-CANYON)
 - C. PUREX TUNNELS
 - D. CANYON FACILITIES
 - E. U PROCESS FACILITIES
 - F. HOT CELL FACILITIES
 - G. FUEL FABRICATION FACILITIES
 - H. OTHER FACILITIES
 - SMALL WASTE TANKS
 - LABORATORIES
 - I. UNDERGROUND LINES AND PIPING

MATERIAL STRATEGY

RETRIEVE, PROCESS, STORE, AND SHIP WASTE
FOR 200 AREA AND/OR OFFSITE DISPOSAL
(FACILITIES OUTSIDE 200 AREA)

FUNCTIONS

PRECLEANUP INVENTORY
MANAGEMENT
• EXISTING STORAGE MANAGEMENT

• CHARACTERIZATION

DEA

CON
AS

NO
ON

NO

IT

STATUS

DCLDD1A/CEW/6-10-93-8

PROBLEM	MATERIAL STRATEGY	DECONTAMINATION AND FUNCTIONS
1. CONTAMINATED FACILITIES AND STRUCTURES A. REACTORS AND SUPPORT FACILITIES • DEFUELED CORE STRUCTURES • EFFLUENT TREATMENT SYSTEMS • ANCILLARY STRUCTURES/BUILDINGS • FFTF • IRRADIATED FUEL STORAGE FACILITIES B. PU PROCESS FACILITIES (NON-CANYON) C. PUREX TUNNELS D. CANYON FACILITIES E. U PROCESS FACILITIES F. HOT CELL FACILITIES G. FUEL FABRICATION FACILITIES H. OTHER FACILITIES • SMALL WASTE TANKS • LABORATORIES I. UNDERGROUND LINES AND PIPING	RETRIEVE, PROCESS, STORE, AND SHIP WASTE FOR 200 AREA AND/OR OFFSITE DISPOSAL (FACILITIES OUTSIDE 200 AREA)	GENERATION • IN SITU PRETREATMENT

DECOMMISSIONING SHEET 2 OF 7

CONTINUED FROM DRAWING DCLDD1A SHEET-1

ALTERNATIVES

TECHNOLOGY

STATUS

IMMOBILIZE	IMMOBILIZING TECHNIQUES <ul style="list-style-type: none"> • FIXATIVES • FOAMS • OTHERS
SOLATE	PHYSICAL BARRIERS
TABILIZE	PHYSICAL BARRIERS FOR ISOLATION
	STABILIZATION TECHNIQUES <ul style="list-style-type: none"> • OROUT • ISV • OTHERS
DECONTAMINATE IN SITU	BIOLOGICAL TREATMENT TO DESTROY ORGANICS
	REMOTE MECHANICAL DEVICES <ul style="list-style-type: none"> • SCABBLING • BRUSHING • SPALLING
	ABRASIVES <ul style="list-style-type: none"> • ICE • CO₂ • ORIT BLASTING
	THERMAL <ul style="list-style-type: none"> • HEATED AIR • STEAM • MICROWAVE • CRYOGENICS
	LIQUID-PHASE DECONTAMINATION <ul style="list-style-type: none"> • AQUEOUS • FOAMS AND GELS • ELECTROCHEMICAL • CHELATING AGENTS
	GAS-OR VAPOR-PHASE DECONTAMINATION
	VIBRATORY FINISHING TECHNIQUE
	REMOVABLE COATINGS
	HIGH-INTENSITY RADIANT ENERGY
	FOAMS AND GELS
	ACIDS, CAUSTICS, AND OXIDANTS
	CHELATING AGENTS
	ELECTROPOLISHING
	ROBOTICS
	AREAL SENSORS
	DUST CONTROL
	CRACK DECONTAMINATION
	LASERS
	CONTAINMENT
	CHARACTERIZATION FOR DETECTION OF LOW-LEVEL RADIATION
	METHOD TO CLEAN 2-3 INCHES OF CONCRETE SURFACE LAYER
	MOBILE TREATMENT CAPABILITY
	REAL-TIME MONITORING/VERIFIABLE MEANS TO SEPARATE TRU/TRUM

MATCH LINE ON DRAWING DCLDD3A SHEET-3

DCLDD2A/CEW/8-10-93-B

PROBLEM

MATERIAL STRATEGY

FUNCTIONS

1. CONTAMINATED FACILITIES AND STRUCTURES

A. REACTORS AND SUPPORT FACILITIES

- DEFUELED CORE STRUCTURES
- EFFLUENT TREATMENT SYSTEMS
- ANCILLARY STRUCTURES/BUILDINGS
- FFTF
- IRRADIATED FUEL STORAGE FACILITIES

B. Pu PROCESS FACILITIES (NON-CANYON)

C. PUREX TUNNELS

D. CANYON FACILITIES

E. U PROCESS FACILITIES

F. HOT CELL FACILITIES

G. FUEL FABRICATION FACILITIES

- H. OTHER FACILITIES
- SMALL WASTE TANKS
 - LABORATORIES

I. UNDERGROUND LINES AND PIPING

RETRIEVE, PROCESS, STORE, AND SHIP WASTE
FOR 200 AREA AND/OR OFFSITE DISPOSAL
(FACILITIES OUTSIDE 200 AREA)

ALTERNATIVES

TECHNOLOGY

STATUS

MATCH LINE FROM DRAWING DCLDD2A SHEET-2

DISMANTLE COMPONENTS
AND FACILITY

- THERMAL METAL DISMANTLING
 - ARC SAW
 - LASERS
 - OXYACETYLENE
 - PLASMA ARC TORCH
 - CRYOGENICS
- PHYSICAL METAL DISMANTLING
 - DIAMOND WIRE
 - SAWS
 - ABRASIVE WATER JETS
 - SHEARS
 - EXPLOSIVES
- THERMAL CONCRETE DISMANTLING
 - LASERS
 - THERMAL LANCE
- PHYSICAL CONCRETE DISMANTLING
 - EXPANDING GROUT
 - SAWS
 - RAM HOE
 - WATER JET
 - EXPLOSIVES
 - LIQUIFIED GAS JET
 - DIAMOND WIRE
- NONCONTAMINATION IMBEDDING
SECTIONING TECHNIQUES
 - LIQUID EMBRITTLEMENT
 - NONTHERMAL DISMANTLING
- ROBOTICS
- PHYSICAL STABILIZERS
- PERSONNEL PROTECTION
- REMOTE MECHANICAL DEVICES
 - SCABBLING
 - BRUSHING
- ABRASIVES
 - ICE
 - CO₂
 - GRIT BLASTING
- THERMAL
 - HEATED AIR
 - STEAM
 - MICROWAVE
 - CRYOGENICS
- LIQUID-PHASE DECONTAMINATION
 - AQUEOUS
 - FOAMS AND GELS
 - ELECTROCHEMICAL
 - CHELATING AGENTS
- VIBRATORY FINISHING TECHNIQUE
- REMOVABLE COATINGS
- HIGH-INTENSITY RADIANT ENERGY
- ACIDS, CAUSTICS, AND OXIDANTS
- CHELATING AGENTS
- CONTAINMENT
- SIZE REDUCTION METHODS

PROBLEM

MATERIAL STRATEGY

FUNCTIONS

1. CONTAMINATED FACILITIES AND STRUCTURES

A. REACTORS AND SUPPORT FACILITIES

- DEFUELED CORE STRUCTURES
- EFFLUENT TREATMENT SYSTEMS
- ANCILLARY STRUCTURES/BUILDINGS
- FFTF
- IRRADIATED FUEL STORAGE FACILITIES

B. Pu PROCESS FACILITIES (NON-CANYON)

C. PUREX TUNNELS

D. CANYON FACILITIES

E. U PROCESS FACILITIES

F. HOT CELL FACILITIES

G. FUEL FABRICATION FACILITIES

- H. OTHER FACILITIES
- SMALL WASTE TANKS
 - LABORATORIES

I. UNDERGROUND LINES AND PIPING

RETRIEVE, PROCESS, STORE, AND SHIP WASTE
FOR 200 AREA AND/OR OFFSITE DISPOSAL
(FACILITIES OUTSIDE 200 AREA)

RE
IN
(1)

RD

DECOMMISSIONING SHEET 4 OF 7

ALTERNATIVES

TECHNOLOGY

STATUS

MATCH LINE FROM DRAWING DCLDD5A SHEET-3

MOVE LARGE COMPONENTS
ONE PIECE
0 AREA REACTORS)

- THERMAL METAL DISMANTLING
 - OXYACETYLENE
 - PLASMA ARC TORCH
 - ARC SAW
 - LASERS
 - CRYOGENICS
- PHYSICAL METAL DISMANTLING
 - DIAMOND WIRE
 - SAWS
 - ABRASIVE WATER JETS
 - SHEARS
 - EXPLOSIVES
- THERMAL CONCRETE DISMANTLING
 - LASERS
 - THERMAL LANCE
- PHYSICAL CONCRETE DISMANTLING
 - EXPANDING GROUT
 - SAWS
 - RAM HOE
 - WATER JET
 - EXPLOSIVES
 - LIQUIFIED GAS JET
 - DIAMOND WIRE
- ROBOTICS
- PHYSICAL STABILIZERS
- PERSONNEL PROTECTION
- REMOTE MECHANICAL DEVICES
 - SCABBLING
 - BRUSHING
- ABRASIVES
 - ICE
 - CO₂
 - GRIT BLASTING
- THERMAL
 - HEATED AIR
 - STEAM
 - MICROWAVE
 - CRYOGENICS
- LIQUID-PHASE DECONTAMINATION
 - AQUEOUS
 - FOAMS AND GELS
 - ELECTROCHEMICAL
 - CHELATING AGENTS
- VIBRATORY FINISHING TECHNIQUE
- REMOVABLE COATINGS
- HIGH-INTENSITY RADIANT ENERGY
- ACIDS, CAUSTICS, AND OXIDANTS
- CHELATING AGENTS
- NONCONTAMINATION IMBEDDING
SECTIONING TECHNIQUES
 - LIQUID EMBRITTLEMENT
 - NONTHERMAL DISMANTLING

CYCLE

- METAL RECYCLING
- CONCRETE RECYCLING

CONTINUED ON DRAWING DCLDD5A SHEET-5

DCLDD4A/CEW/8-11-83-8

PROBLEM	MATERIAL STRATEGY	DECONTAMINATION AND FUNCTIONS
1. CONTAMINATED FACILITIES AND STRUCTURES A. REACTORS AND SUPPORT FACILITIES • DEFUELED CORE STRUCTURES • EFFLUENT TREATMENT SYSTEMS • ANCILLARY STRUCTURES/BUILDINGS • FFF • IRRADIATED FUEL STORAGE FACILITIES B. Pu PROCESS FACILITIES (NON-CANYON) C. PUREX TUNNELS D. CANYON FACILITIES E. U PROCESS FACILITIES F. HOT CELL FACILITIES G. FUEL FABRICATION FACILITIES H. OTHER FACILITIES • SMALL WASTE TANKS • LABORATORIES I. UNDERGROUND LINES AND PIPING	<div>RETRIEVE, PROCESS, STORE, AND SHIP WASTE FOR 200 AREA AND/OR OFFSITE DISPOSAL (FACILITIES OUTSIDE 200 AREA)</div>	<div>MATERIAL RETRIEVAL</div> <div>ONSITE TRANSPORTATION</div> <div>STORAGE</div> <div>• RETRIEVED MATERIAL STAGING</div> <div>TREATMENT</div> <div>• RETRIEVED MATERIAL PARTITIONING</div> <div>• DISPOSAL FORM CONVERSION</div> <div>• PACKAGING</div> <div>STORAGE</div> <div>• PACKAGED MATERIAL INTERIM STORAGE</div> <div>DISPOSAL</div> <div>• ONSITE DISPOSAL FACILITY</div> <div>• DISPOSAL FACILITY CLOSURE</div> <div>• RETRIEVAL SITE CLOSURE</div> <div>• ENVIRONMENTAL MONITORING</div> <div>• OFFSITE TRANSPORTATION</div>

DECOMMISSIONING SHEET 5 OF 7

CONTINUED FROM DRAWING DCLDD4A SHEET-4

ALTERNATIVES

TECHNOLOGY

STATUS

CRAWLERS/CRANES
 PACKAGING
 PHYSICAL STABILIZERS
 ROBOTICS
 PERSONNEL PROTECTION
 WATER-REMOVAL PUMPS AND ION-EXCHANGE FILTERS

TRANSPORTERS
 • CRANES/CRAWLERS
 PERSONNEL PROTECTION
 CONTAINMENT
 TRUCKS
 RAIL

ID WASTE MISSION

ID WASTE MISSION

ID WASTE MISSION

ID WASTE MISSION

ID WASTE MISSION

KFILL/SURFACE BARRIER

KFILL/LANDSCAPE

ID WASTE MISSION

CONTINUED ON DRAWING DCLDD6A SHEET-6

DCLDD6A/CEW/6-11-93-8

DECONTAMINATION AND

PROBLEM

1. CONTAMINATED FACILITIES AND STRUCTURES

A. REACTORS AND SUPPORT FACILITIES

- DEFUELED CORE STRUCTURES
- EFFLUENT TREATMENT SYSTEMS
- ANCILLARY STRUCTURES/BUILDINGS
- PFTF
- IRRADIATED FUEL STORAGE FACILITIES

B. PU PROCESS FACILITIES (NON-CANYON)

C. PUREX TUNNELS

D. CANYON FACILITIES

E. U PROCESS FACILITIES

F. HOT CELL FACILITIES

G. FUEL FABRICATION FACILITIES

- #### H. OTHER FACILITIES
- SMALL WASTE TANKS
 - LABORATORIES

I. UNDERGROUND LINES AND PIPING

MATERIAL STRATEGY

IN SITU TREATMENT OF WASTE FOR
ON-SITE DISPOSAL

(200 AREA FACILITIES)

FUNCTIONS

PRSCLEANUP INVENTORY
MANAGEMENT

• EXISTING STORAGE MANAGEMENT

• CHARACTERIZATION

TREATMENT

• INSITU TREATMENT

ALTERNATIVES TECHNOLOGY STATUS

PROBLEM

MATERIAL STRATEGY

FUNCTIONS

1. CONTAMINATED FACILITIES AND STRUCTURES
 - A. REACTORS AND SUPPORT FACILITIES
 - DEFUELED CORE STRUCTURES
 - EFFLUENT TREATMENT SYSTEMS
 - ANCILLARY STRUCTURES/BUILDINGS
 - FTTF
 - IRRADIATED FUEL STORAGE FACILITIES
 - B. Pu PROCESS FACILITIES (NON-CANYON)
 - C. PUREX TUNNELS
 - D. CANYON FACILITIES
 - E. U PROCESS FACILITIES
 - F. HOT CELL FACILITIES
 - G. FUEL FABRICATION FACILITIES
 - H. OTHER FACILITIES
 - SMALL WASTE TANKS
 - LABORATORIES
 - I. UNDERGROUND LINES AND PIPING

IN SITU TREATMENT OF WASTE FOR
ON-SITE DISPOSAL
(200 AREA FACILITIES)

DISPOSAL

• RETRIEVAL SITE CLOSURE

• ENVIRONMENTAL MONITORING

SI
SL
LA
LC
LC
RE
BA
MA
FE

DECOMMISSIONING SHEET 7 OF 7

CONTINUED FROM DRAWING DCLDD6A SHEET-6

ALTERNATIVES

TECHNOLOGY

STATUS

FACE BARRIERS
SURFACE BARRIERS
DSCAPE
O-TERM SURVEILLANCE
O-TERM SITE MAINTENANCE
ORDS RETENTION
KFILL
IKING AND COMMUNICATION
AL REPORT/LESSONS LEARNED

DCLDD7A/CEW/6-11-93-7

A.5 NUCLEAR MATERIALS

PROBLEM

1. SNM
 - A. ASH
 - B. OXIDE
 - C. METAL
 - D. SAND, SLAG & CRUCIBLE
 - E. POLYUBES
 - F. HEPA FILTERS
 - G. SOLUTIONS
 - H. MISCELLANEOUS
 - I. CONTAMINATED EQUIPMENT

MATERIAL STRATEGY

RETRIEVE, PROCESS, STORE, AND SHIP
MATERIAL FOR 200 AREA AND/OR
OFFSITE DISPOSITION

FUNCTIONS

PRE CLEANUP INVENTORY MANAGEMENT
•EXISTING INVENTORY MANAGEMENT

INT
STO
MON
REP

GENERATION (RETRIEVAL)
•RETRIEVAL/RECOVERY OF
RESIDUAL HOLDUP

DUC
ASS

TREATMENT

•PARTITIONING

DIS
DIH
PYI

•DISPOSAL FORM CONVERSION

STA
SOI
SEP

•PACKAGING

SHI
TRL
LOI

LONG TERM STORAGE

•ONSITE STORAGE

VAI

DISPOSAL

•OFFSITE SHIPMENT

SEC
TRL

MATERIALS SHEET 1 OF 3

ALTERNATIVES

TECHNOLOGY

STATUS

CONTINUED ON DRAWING DCL108

DCL10A/CEW/6-8-83-7

PROBLEM

2. URANIUM
 A. METAL BILLETS
 B. FUEL ELEMENTS
 C. URANIUM OXIDE
 D. UNH
 E. MISCELLANEOUS SCRAP

MATERIAL STRATEGY

RETRIEVE, PROCESS, STORE, AND SHIP
 MATERIAL FOR 200 AREA AND/OR
 OFFSITE DISPOSITION

FUNCTIONS

PRECLEANUP INVENTORY MANAGEMENT
 •INVENTORY MANAGEMENT

INT
 INV

TREATMENT

•PARTITIONING

MEC
 CHE

•DISPOSAL FORM CONVERSION

ST/
 SEP

•PACKAGING

DRL
 T-V
 BOX

STORAGE

•INTERIM STORAGE

LEU

DISPOSAL

•OFFSITE SHIPPING

TERIALS SHEET 2 OF 3

ALTERNATIVES

TECHNOLOGY

STATUS

RIM MATERIAL STORAGE
 NTORY CHARACTERIZATION

ANICAL DECLAD ———— SHEAR/LEACH
 ICAL DECLAD ———— ZIRFLEX/DISSOLVE
 HF/DISSOLVE

ILIZE ———— SOLIDIFY (GROUT)
 DIRECT CALCINE
 ROAST
 RATED U CONVERSION ———— DIRECT CALCINE

IS
 PERS
 S

STORAGE FACILITY

PROBLEM

3. IRRADIATED FUEL
A. H FUEL
B. FFTF FUEL
C. PWR CORE 2
D. SPR FUEL

MATERIAL STRATEGY

RETRIEVE, PROCESS, STORE, AND SHIP
MATERIAL FOR OFFSITE DISPOSITION

FUNCTIONS

PRECLEANUP INVENTORY MANAGEMENT

•EXISTING INVENTORY MANAGEMENT

ONSITE TRANSPORTATION

TREATMENT

•PARTITIONING

•DISPOSAL FORM CONVERSION

•PACKAGING

STORAGE

•ONSITE STORAGE

DISPOSAL

•OFFSITE SHIPMENT

IN
IN
BA
EX
NE
DE
SE
FU
PA
OX
FU
VI
DR
CA
DR
RA
TR

MATERIALS SHEET 3 OF 3

ALTERNATIVES	TECHNOLOGY	STATUS
INTERIM STORAGE FORM CONVERSION	<ul style="list-style-type: none"> SODIUM REMOVAL BY WATER REACTION MECHANICAL SIZE REDUCTION/OXIDATION 	
INTERIM STORAGE SYSTEMS		
ENHANCED CURRENT STORAGE	<ul style="list-style-type: none"> BARRIER/LINERS FOR WATER BASINS ENCAPSULATE N FUEL CONSOLIDATION RACKING 	
NEW DRY STORAGE	<ul style="list-style-type: none"> ENCAPSULATION METAL FUEL SAFETY STUDIES 	
SIN SLUDGE REMOVAL	<ul style="list-style-type: none"> VACUUM TRANSFER/SOLIDIFICATION DISPOSITION CHARACTERISTICS STUDY 	
EXISTING CASKS		
N/C CASKS (BUY, BUILD, OR LEASE)		
CLADDING	<ul style="list-style-type: none"> MECHANICAL: SHEARING/LASER CHEMICAL: ZIRFLEX/CAUSTIC 	
SEPARATIONS	<ul style="list-style-type: none"> PUREX PYROCHEMICAL 	
FUEL ELEMENTS		
MECHANICAL SIZE REDUCTION/OXIDATION	<ul style="list-style-type: none"> FLUIDIZED BED MOLTEN SALT DIRECT OXIDATION OFFGAS SYSTEM 	
SHEAR/DISSOLVE/VITRIFY	<ul style="list-style-type: none"> HIGH-FISSILE CONTENT VITRIFICATION PROCESS OFFGAS SYSTEM 	
ALTERNATE WASTE FORM TECHNOLOGIES		
PARTITIONING FRACTIONS	<ul style="list-style-type: none"> Pu/U CONVERSION SOLID/LIQUID WASTE CONVERSION EFFLUENT/PROCESS MONITORING & CONTROL 	
INDIVIDUALIZED FUEL PACKAGING	<ul style="list-style-type: none"> CANISTER FILL AND CLOSURE ENCAPSULATION/BRIQUETTING 	
FUEL ELEMENT PACKAGING	<ul style="list-style-type: none"> APPLY COMMERCIAL FUEL PACKAGING SYSTEM 	
TRIFIED MATERIAL PACKAGING	<ul style="list-style-type: none"> APPLY HWVP SYSTEM 	
STORAGE VAULT		
CASK ON PAD		
CASK WELL IN GROUND		
SKID CASK		
BUCK CASK		

A.6 LIQUID EFFLUENTS

PROBLEM	MATERIAL STRATEGY	FUNCTIONS
1. LIQUID EFFLUENTS	RETRIEVE, PROCESS, STORE, AND SHIP WASTE FOR 200 AREA AND/OR OFFSITE DISPOSAL	PRE CLEANUP INVENTORY MANAGEMENT • WASTE CHARACTERIZATION
A. EXISTING FACILITY EFFLUENTS		
• SANITARY WASTE, MIXED LDR		
• LOW LEVEL WASTE,		
• NON RADIOACTIVE WASTE		
• SPENT FUEL STORAGE WATER		
• LEACHATE FROM COLLECTION SYSTEMS		
B. FUTURE EFFLUENTS		
• SPENT FUEL STORAGE WASTE (N/K BASINS)		GENERATION • RETRIEVAL
• LEACHATE FROM COLLECTION SYSTEMS		ONSITE TRANSPORTATION
• ER STREAMS (IF GENERATED)		
• SOIL FLUSHING WASTEWATER		INTERIM STORAGE
• PUMP/TREAT GROUNDWATER SUPPORT		
		TREATMENT • PARTITIONING/PRETREATMENT
		• SECONDARY WASTE TREATMENT
		STORAGE • INTERIM • LONG TERM
		DISPOSAL • ONSITE DISPOSAL
		ENVIRONMENTAL MONITORING

UID EFFLUENTS

ALTERNATIVES

TECHNOLOGIES

STATUS

SAMPLING	<ul style="list-style-type: none"> TIME COMPOSITE FLOW COMPOSITE GRAB SAMPLE 	
CONTINUOUS IN-LINE MONITORING	<ul style="list-style-type: none"> RADIOLOGICAL <ul style="list-style-type: none"> • ALPHA • BETA • GAMMA CHEMICAL <ul style="list-style-type: none"> • INORGANIC • ORGANIC 	
WASTE MINIMIZATION	DESIGN MODIFICATIONS	
RECYCLE/REUSE	WASTEWATER REUSE	
COLLECTION PIPES	CONSTRUCTION MATERIAL ALTERNATIVES	
TANK TRUCKS	STANDARD	
RAIL TANK CARS	STANDARD	
DOUBLE-LINED LEACHATE COLLECTION	<ul style="list-style-type: none"> CONSTRUCTION DURABLE COVERS DURABLE LINERS POST USE CLEANUP 	
DOUBLE-SHELL TANKS	STANDARD	
ABOVEGROUND SSTs	STANDARD	
PHYSICAL	<ul style="list-style-type: none"> FILTRATION AIR STRIPPING ADSORPTION REVERSE OSMOSIS SUPPORTED LIQUID MEMBRANE FREEZE DRYING PERVAPORATION TRITIUM REMOVAL VIA MEMBRANE 	
CHEMICAL	<ul style="list-style-type: none"> PRECIPITATION IONEXCHANGE COAGULATION/FILTRATION UV OXIDATION CHEMICAL OXIDATION CHELATION ELECTRODIALYSIS ELECTROLYTICALLY REGENERATED IX SUPER CRITICAL WATER OXIDATION 	
BIOLOGICAL	<ul style="list-style-type: none"> BIDPOLYMERS MICROORGANISMS 	
SOLIDIFICATION	<ul style="list-style-type: none"> GROUT POLYMERIZATION GLASS FREEZE DRYING 	
DESTRUCTION	INCINERATION	
CONTAINMENT	SEE INTERIM STORAGE	
CONTAINMENT	SEE INTERIM STORAGE	
TREATED WATER <ul style="list-style-type: none"> • RIVER • AIR • GROUND • RECYCLE 		
SECONDARY WASTE	BASED ON SOLID WASTE IDENTIFIED TECHNOLOGIES	
ONSITE WELLS	SAMPLING AND MONITORING	
RIVER SAMPLING	TECHNOLOGIES SIMILAR TO WASTE CHARACTERIZATION	

APPENDIX B

FUNCTIONAL NEEDS DIAGRAMS

5 of 5

APPENDIX B

FUNCTIONAL NEEDS DIAGRAMS

B.1 TANKS

FIGURE B.1.1. Overview of Tank Waste Functional Needs

FIGURE B.1.2. Characterization Functional Flow Diagram for Reference System

FIGURE B.1.3. Characterization Functional Flow Diagram for Enhanced and Alternative Systems

Baseline Development

Enabling Functions

Primary Functions

Legend:
 [] Function
 [] Reference
 - Text Enhancements

Rev. Date 3/28/93 79210134.114

FIGURE B.1.4. Retrieval Functional Flow Diagram

FIGURE B.1.5. Pretreatment Functional Flow Diagram for Extensive Separations Approach

B.7

FIGURE B.1.6. Pretreatment Functional Flow Diagram for High-Capacity Vitrification Approach

Baseline Development

Rev. Date 3/28/93 792101:14.70

FIGURE B.1.7. High-Level Waste Immobilization Functional Flow Diagram for Reference System

79210134.82
 Rev. Date 3/28/93

FIGURE B.1.9. Low-Level Waste Immobilization and Disposal Functional Flow Diagram for Reference System

FIGURE B.1.10. Low-Level Waste Immobilization and Disposal Functional Flow Diagram for Enhancements and Alternative Systems

Rev. Date 3/29/93 79210134.112

FIGURE B.1.11. Waste Tank Safety and Operations Functional Flow Diagram for Reference System

FIGURE B.1.12. Tank Safety and Operations Technology Development Activities for Enhanced Systems

FIGURE B.1.13. Tank Safety and Operations Technology Development Activities for Alternative Systems

B.2 SOLID WASTE

FIGURE B.2.1. Overview of Solid Waste Functional Needs

FIGURE B.2.2. Functional Needs Diagram for Solid Waste Inventory Function

FIGURE B.2.3. Functional Needs Diagram for Solid Waste Characterization Function

STRATEGIC DECISION MODELING

FIGURE B.2.4. Functional Needs Diagram for Solid Waste Strategic Decision Modeling Function

FIGURE B.2.5. Functional Needs Diagram for Solid Waste Retrieval Function

FIGURE B.2.6. Functional Needs Diagram for Retrieved Waste Packaging and Transport Functions

FIGURE B.2.7. Functional Needs Diagram for Solid Waste Sorting and Treatment Functions

FIGURE B.2.8. Functional Needs Diagram for Solid Waste Retrieval Site Small-Scale Waste Treatment and Recycling Functions

FIGURE B.2.9. Functional Needs Diagram for Solid Waste Storage and Disposal and Retrieval and Disposal Site Closure Functions

FIGURE B.2.10. Functional Needs Diagram for Solid Waste Acceptance Criteria Generation Function

FIGURE B.2.11. Functional Needs Diagram for Solid Waste In Situ Treatment Function

B.3 ENVIRONMENTAL RESTORATION

FIGURE B.3.1. Overview of Environmental Restoration (ER) Functional Needs

FIGURE B.3.2. Functional Needs Diagram for Environmental Restoration In Situ Field Measurement Function

FIGURE B.3.3. Functional Needs Diagram for Environmental Restoration Information and Decision Support Tools Functions

FIGURE B.3.4. Functional Needs Diagram for Environmental Restoration Laboratory Analysis Function

FIGURE B.3.5. Functional Needs Diagram for Environmental Restoration In Situ Pretreatment Function

FIGURE B.3.6. Functional Needs Diagram for Environmental Restoration In Situ Treatment Function

FIGURE B.3.7. Functional Needs Diagram for Environmental Restoration Material Retrieval Function

FIGURE B.3.8. Functional Needs Diagram for Environmental Restoration Retrieved Material Function

FIGURE B.3.9. Functional Needs Diagram for Environmental Restoration Ex Situ Treatment Function

FIGURE B.3.10. Functional Needs Diagram for Environmental Restoration Waste Form Conversion Function

FIGURE B.3.11. Functional Needs Diagram for Environmental Restoration Waste Form Packaging, Storage, and Shipping Functions

B.4 DECONTAMINATION AND DECOMMISSIONING

FIGURE B.4.1. Overview of Decontamination and Decommissioning Functional Needs

FIGURE B.4.2. Functional Needs Diagram for Decontamination and Decommissioning Nonintrusive Characterization Function

INTRUSIVE CHARACTERIZATION

FIGURE B.4.3. Functional Needs Diagram for Decontamination and Decommissioning Intrusive Characterization Function

INSITU PRETREATMENT

(a)

FIGURE B.4.4. Functional Needs Diagram for Decontamination and Decommissioning In Situ Pretreatment Function

(b)

FIGURE B.4.4. (contd)

MATERIAL RETRIEVAL

FIGURE B.4.5. Functional Needs Diagram for Decontamination and Decommissioning Material Retrieval Function

INSITU TREATMENT

(Waste Form Conversion)

FIGURE B.4.6. Functional Needs Diagram for Decontamination and Decommissioning In Situ Treatment Function

RETRIEVAL SITE CLOSURE

FIGURE B.4.7. Functional Needs Diagram for Decontamination and Decommissioning Retrieval Site Closure Function

ON SITE TRANSPORTATION

FIGURE B.4.8. Functional Needs Diagram for Decontamination and Decommissioning Onsite Transportation Function

B.5 NUCLEAR MATERIALS

IRRADIATED FUEL

FIGURE B.5.1. Overview of Irradiated Fuel Functional Needs

FIGURE B.5.2. Functional Needs Diagram for Irradiated Fuel Inventory Management Function

FIGURE B.5.3. Functional Needs Diagram for Irradiated Fuel Onsite Transportation Function

FIGURE B.5.4. Functional Needs Diagram for Irradiated Fuel Inventory Partitioning Function

FIGURE B.5.5. Functional Needs Diagram for Irradiated Fuel Disposal Form Conversion Function

FIGURE B.5.6. Functional Needs Diagram for Irradiated Fuel Packaging Function

FIGURE B.5.7. Functional Needs Diagram for Irradiated Fuel Onsite Storage Function

FIGURE B.5.8. Functional Needs Diagram for Irradiated Fuel Offsite Shipment Function

SPECIAL NUCLEAR MATERIAL

FIGURE B.5.9. Overview of Special Nuclear Material Functional Needs

FIGURE B.5.10. Functional Needs Diagram for Special Nuclear Material Inventory Management Function

FIGURE B.5.11. Functional Needs Diagram for Special Nuclear Material Retrieval and Recovery Functions

FIGURE B.5.12. Functional Needs Diagram for Special Nuclear Material Partitioning Function

FIGURE B.5.13. Functional Needs Diagram for Special Nuclear Material Disposition Form Conversion Function

FIGURE B.5.14. Functional Needs Diagram for Special Nuclear Material Packaging, Storage, and Shipment Functions

B.6 LIQUID EFFLUENTS

FIGURE B.6.3. Functional Needs Diagram for Liquid Effluents Generation, Transportation, and Storage Functions

FIGURE B.6.4. Functional Needs Diagram for Liquid Effluents Treatment Function

PARTITIONING/PRETREATMENT

FIGURE B.6.5. Functional Needs Diagram for Liquid Effluents Partitioning and Pretreatment Function

SECONDARY WASTE TREATMENT

FIGURE B.6.6. Functional Needs Diagram for Liquid Effluents
Secondary Waste Treatment Function

FIGURE B.6.1. Overview of Liquid Effluents Functional Needs

WASTE CHARACTERIZATION

FIGURE B.6.2. Functional Needs Diagram for Liquid Effluents Waste Characterization Function

FIGURE B.6.7. Functional Needs Diagram for Liquid Effluents Storage, Disposal, and Monitoring Functions

APPENDIX C

WORKSHOP PARTICIPANTS

C.1 TANKS

C.1.1 Problem Prioritization Workshop Participants

January 8, 1992

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- * These individuals were not able to attend the workshop on June 12, 1992, so they scored the technology needs at a later date.

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APPENDIX D

HANFORD STAKEHOLDERS INTERVIEWED

APPENDIX D

HANFORD STAKEHOLDERS INTERVIEWED

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APPENDIX E

REGULATORY AND INSTITUTIONAL CONSTRAINTS TO NEW TECHNOLOGY APPLICATIONS

APPENDIX E

REGULATORY AND INSTITUTIONAL CONSTRAINTS TO NEW TECHNOLOGY APPLICATIONS^(a)

The incorporation of new technologies into the portfolio of proven and accepted cleanup technologies can be time-consuming, expensive, and encumbered by major regulatory, institutional, and technical obstacles. There are significant delays between the research (basic and applied), development (bench- and pilot-scale), demonstration (to determine effectiveness and reliability), and full-scale implementation of technologies that make it "virtually impossible to get a new technology accepted in any reasonable time" (McGough 1987).

These uncertainties tend to increase our reliance on older, traditional technologies rather than risk missing cleanup deadlines or remedial action goals using new technologies that could perform cleanups faster, cheaper, or better. In the private sector, the tendency to rely upon existing technologies is also compounded by a somewhat adversarial relationship between regulators and problem-owners (e.g., industry). The perception is that regulators want to rely only on proven technologies, while industry wants to avoid meeting environmental standards (Roy 1990).

Responsible parties and technology developers are also concerned about the long-term effectiveness of innovative technologies and their potential liability should the technologies not perform as predicted. They are concerned about the liability that may develop when today's "acceptable" work is judged against tomorrow's standards.

(a) This appendix is summarized from the paper "Introducing New Technologies into Today's Cleanup Arena" (Gephart, Keller, and Stein 1991).

E.1 NO CENTRAL SOURCE OF TECHNOLOGY INFORMATION

While the development and selection of new technologies are key to making cleanup programs work more efficiently, no organized and routinely maintained source of technology information exists. In turn, new technology development capabilities are not captured and rapidly communicated. Contributing to this issue is the fact that the nature and extent of the DOE Complex's cleanup needs are only now being analyzed. Therefore, the applicability of existing and new technologies has been approached in a piecemeal fashion. New vendors are entering the cleanup market, but wide dissemination of supportive scientific information for their new technologies and the unbiased scrutiny of new technology performance information remain poorly organized. As a result, contractors are forced to use traditional cleanup approaches or develop duplicate performance information that exists elsewhere.

Access to a central source of technology performance information is being addressed by the Remedial Action Assessment System (RAAS) technology information system developed by Pacific Northwest Laboratory (PNL) for the U.S. Department of Energy (DOE). RAAS will function like an electronic encyclopedia, sorting technology performance, waste characteristic, environmental setting, and regulatory information to quickly focus on potentially suitable technologies. Similar computerized databases of environmental remediation technologies have been developed by other federal agencies (e.g., the U.S. Environmental Protection Agency [EPA]). In addition, the engineering baseline work being performed in support of the Office of Environmental Restoration (EM-40) is resulting in the development of a Complex-wide quantitative perspective on the type of engineering facilities and contamination problems facing DOE.

E.2 REGULATORY AND PERMITTING BARRIERS

The technology development process is closely tied to major regulatory standards and site cleanup goals that dictate how clean is clean, future land use, and other waste release or handling restrictions. This information is used to establish technology performance standards. Therefore, principal

drivers to new technology development involve determining: 1) whether there are regulatory standards or cleanup goals that must be met, 2) whether these standards will be enforced or accepted by the major stakeholders, and 3) how these standards might be negotiated with the regulators based upon site-specific demographics, health risk, technology performance levels, and costs.

Nationally, the regulatory arena is viewed as fragmented because of the different compliance standards or enforcement levels between states and localities (Bishop 1990) and the uncertainties associated with tomorrow's regulatory requirements. These concerns are also barriers to introducing new technologies because developers are uncertain about the extent to which cleanup standards will be enforced, as well as whether or not the regulatory requirements will change before the technology is commercialized/deployed.

The need for federal and/or state permits for conducting onsite cleanup activities is another regulatory issue. (This is not to be confused with offsite Resource Conservation and Recovery Act [RCRA] permitting requirements for treatment, storage, and disposal facilities.) Permitting requirements can significantly increase the cost and time needed to bring new technologies on-line. This is particularly true for technologies with little historical performance data. There is also no assurance that a new technology will receive a permit even if considerable time and money have been spent on it.

Permitting is complicated by the fact that regulatory standards do not exist for permitting cleanup technologies. A corollary issue is the issuance of permits for mobile treatment units. Such units are being increasingly looked upon to reduce the cost, time, environmental risk, and transportation difficulties associated with site cleanups, especially those involving off-site treatment or disposal (Center for Environmental Management 1988).

Innovative technologies need to meet the same substantive standards as permanent, proven treatment facilities; however, they should not be subject to the same permitting process. For new, innovative technologies with little potential for creating a safety or environmental discharge problem, exemption from the RCRA permitting process or a flexible permitting process may be appropriate. For technologies with a higher potential for unacceptable waste releases, a permitting process might be imposed that is more extensive than

the process used for technologies with few safety or environmental hazards, yet less restrictive than the process required for a permanent facility.

In spite of these regulatory and permitting barriers, the Hanford Site has been successful in demonstrating innovative technologies under "treatability study exclusions." One example is the in situ vitrification demonstration conducted at the 116-B Crib in the 100 Areas. Furthermore, the regulators have shown a commitment to more rapid demonstration of technologies under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Treatability Study guidelines. One example of this is the planned construction of the Hanford Prototype Barrier at the 216-B-57 crib site (200-BP-1 Operable Unit) during FY 1993. The National Environmental Policy Act (NEPA) can present formidable roadblocks to technology demonstrations; however, Hanford has been able to take advantage of existing categorical exclusions where appropriate.

Another regulatory issue involves delisting requirements of hazardous waste. EPA is working on alternative approaches to delisting waste residues. Where waste data are not yet available (e.g., from a new technology), the applicant will likely be required to submit a variety of information that the regulators would use to set delisting levels and sampling/analysis requirements. Public comment and a final evaluation would follow.

Meeting NEPA requirements is another regulatory issue inhibiting the introduction of new technologies. To what extent do NEPA requirements or their DOE equivalents apply to the demonstration and testing of new technologies? This is uncertain. Potential documentation needs span the full spectrum from simple environmental evaluation checklists to environmental assessments and full-scope environmental impact statements. The development of some site cleanup technologies (e.g., treatment of single-shell tank wastes at Hanford) will require NEPA determinations and commensurate public participation.

E.3 TECHNOLOGY PERFORMANCE STANDARDS

Technology developers need technology-based cleanup standards to guide decisions on where to invest their research and development (R&D) dollars.

E.4

For many, the RCRA regulations that address alternative technologies by setting standards for miscellaneous cleanup units are too vague (Booze, Allen, and Hamilton, Inc. 1988). On the other hand, EPA has avoided setting specific technology standards because of their concern that such standards might preclude permitting new technology for which no standard has been set.

Also, EPA's implementation of the Superfund process has included many different cleanup levels for essentially the same types of sites. As a result, responsible parties can point to the least stringent cleanup as a precedent for providing effective environmental protection (Office of Technology Assessment 1989). Proposed actions to solve this problem include:

- identification of cleanup levels (e.g., quantitative concentration or risk acceptance targets) and required technology performance standards
- development of long-term land use strategies
- clarification of the meaning of such statutory terms as permanence, toxicity reduction, cost-effectiveness, or waste treatment. The qualitative language of EPA's nine selection criteria should be better defined to support given treatment decisions and cleanup preferences
- federal facility agreement support to the identification and development of treatment technologies.

E.4 FINANCIAL LIABILITY

Another issue is liability coverage for damages resulting from the failure of technologies to perform as expected. Without well-documented cost information and operational history, contractors/regulators are reluctant to recommend an innovative technology, even when technologies are implemented prudently and responsibly. This caution has developed at a time when large environmental-damage lawsuits have led many insurance companies to stop writing liability policies for hazardous waste--or at least to raise premiums and limit coverage (Gilbert 1988). Liability concerns cause firms to carefully select cleanup technologies and to rely on proven technologies even if they are less effective or more costly (Bishop 1990).

In the past, contractors could receive indemnification from the EPA against claims brought for negligent liability (Occupational Hazards 1987). However, indemnification did not apply to RCRA permits, nor does it preempt state laws that could hold contractors liable under a strict, joint liability standard (i.e., not requiring determination of fault). A contractor could be required to pay full damages when responsible for only a limited percentage of a pollutant's release if an innovative technology releases unacceptable pollutant levels or if it does not meet agreed-to performance standards. EPA is working on this issue and has approved a cleanup liability insurance policy covering work performed at Superfund sites (Superfund Report 1991).

E.5 INVESTMENT INCENTIVES

A committed investment support for developing a new technology is as critical to delivering a new technology as strong scientific, regulatory, and business backing. Presently, the uncertainty and roadblocks to introducing new technologies tend to undermine sustained economic support to bring new technologies on-line.

The difficulties in acquiring sustained financial support for new technologies can be mitigate

- knowing where the greatest technology development needs are
- realistically assessing the financial commitments needed, time required, and risk inherent to develop and deploy new technologies
- proactively working regulatory acceptance issues for new technologies.

E.6 REFERENCES

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Gilbert, S. October 1988. "Finding a Place for Hazardous Waste." High Technology Business. pp. 26-30.

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Roy, K. A. July 1990. "Innovative Technology Finds a New Ally--the National Environmental Technology Corp." Hazmat World. pp. 35-38.

APPENDIX F

LONG-TERM PLANNING FOR SITE SUPPORT

APPENDIX F

LONG-TERM PLANNING FOR SITE SUPPORT

The Hanford Site work breakdown structure (WBS) includes the following mission areas as sub-elements of Site Support:

- Analytical Services
- Maintenance
- Engineering Services
- Compliance Verification and Performance Assessment
- Environmental Support
- Safeguards and Security
- Health, Safety, and Quality
- Site Infrastructure
- Public Information
- Legal Services
- Procurement
- Plans and Budgets
- Financial Services
- Human Resources.

Several of these mission areas (e.g., analytical services, engineering services, site infrastructure, procurement, human resources) could benefit from continuous involvement in the Hanford Integrated Planning Process (HIPP) science and technology (S&T) planning workshops. The HIPP S&T needs assessment activities could be strengthened by involving Site Support representatives in the S&T needs assessment process. The workshop results could then be incorporated into Site Support's annual long-term planning activities. Conversely, Site Support groups could provide important information to the S&T Needs Team regarding the potential costs and impacts of different technology alternatives under consideration.

In the Hanford Mission Plan (DOE/RL 1992), major facility requirements were identified based on the results of the HIPP Strategic Systems Analysis Task. Similarly, the prioritized lists of S&T needs and solutions would provide key information to Site Support planners as they try to anticipate and prepare for the Site Support needs for future new research programs, technology development activities, or technology implementation activities.

As the Hanford Mission Plan states, the shift of people and activities to major new facilities across the Site (e.g., Hanford Waste Vitrification Plant, Waste Receiving and Processing) will require significant extensions and upgrades of existing Site Support services. As the work force mix by job type and location continues to change, new facilities, land, and services to house and support these activities will be required. Proactive planning and programming are necessary to meet the new requirements.

Similarly, evaluations of Site Support needs associated with the 1992 planning basis must be compared with impacts of insertion of alternative technologies into the baseline. It is conceivable that Site Support issues could have major impacts on the decisions made regarding which alternative technologies are viable candidates for consideration. For example, if implementation of a particular technology requires construction of a new supporting facility to supply some raw material or store some secondary waste by-product, the capital costs, manpower, and lead time of building that new facility must be included in the analysis of the technology. An alternative technology that does not have such requirements may be more attractive, depending on numerous issues and constraints that would need to be considered on a case-by-case basis. Site Support personnel could provide valuable data to the S&T needs assessment process to help evaluate the impacts of such requirements on the Site as a whole.

Now that the first round of HIPP S&T needs assessment workshops have been completed, we must focus on defining ways in which the workshop results can be communicated in a timely manner to the appropriate Site Support organizations for use in their long-term planning efforts. The issues must be addressed of which organizations should be involved in future S&T workshops, how they should be involved, and at what point in time. In addition, some thought must be given to developing a structured approach to identifying and prioritizing Site Support needs, similar to the S&T needs assessment process described in Section 4.0.

For the highest-priority Hanford S&T needs, the related Site Support needs (e.g., manpower, utilities, roads, land use, analytical laboratories,

information management) must be identified. Once these support needs are identified, they should be prioritized on a Sitewide basis.

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