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Minimization Efforts at Los Alamos
National Laboratory

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**An Analysis of Radioactive Waste
Minimization Efforts at
Los Alamos National Laboratory**

**Stewart L. Voit
Stephen T. Boerigter**

**Los Alamos National Laboratory
Technology and Safety Assessment Division
Technology Modeling and Analysis Group
TSA-7**

September 30, 1997

This work conducted in support of the Nuclear
Materials and Stockpile Management Program
Office Los Alamos National Laboratory.

Los Alamos
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Los Alamos, New Mexico 87545

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AN ANALYSIS OF RADIOACTIVE WASTE MINIMIZATION EFFORTS AT LOS ALAMOS NATIONAL LABORATORY

1. ABSTRACT

Los Alamos National Laboratory's (LANL) central mission is reducing the danger of nuclear weapons and nuclear materials worldwide. The statutory responsibility is the stewardship and management of the nuclear stockpile. In keeping with this mission, LANL will be the primary DOE facility for plutonium research and development and plutonium processing. Key operations that are in support of the LANL mission produce byproducts that are disposed of as radioactive waste.

A summary of the currently generated waste types, volumes, generating facilities or programs, and disposal costs are given in this report along with future waste generation projections that include operations that support the stockpile stewardship.

Several key existing technologies have been identified that could be introduced to reduce the generated waste at LANL. Four of these are discussed in detail in this report: electrolytic surface decontamination, electrochemical treatment of mixed wastes, Long Range Alpha Detection (LRAD), and Segmented Gate and Containerized Vat Leach System (SGS/CVL). The implementation of these technologies will save approximately \$59 million over the next ten years. These technologies may be implemented as modifications in upstream processes as well as more efficient volume reduction and segregation. The deployment of these technologies will also serve to protect worker health and safety by eliminating the most urgent risks and reducing the amount of radioactive material handled.

The four technologies discussed in detail in this report are mature enough to be implemented in the next two to three years and can be done so with the support for capital and operational costs. These recommendations are applicable not only to all organizations at LANL but when fully implemented, these cross cutting technologies can serve as pilot programs for waste minimization efforts across the DOE complex.

Also discussed in this report is a small sample of some of the recent waste minimization success stories that have been implemented. In addition, several technologies are presented that are either currently being investigated or on hold due to lack of funding at LANL but show potential for making significant gains in waste minimization.

This report is not intended to be all inclusive of the many waste minimization and pollution prevention technologies currently under investigation at LANL, but rather provide a review of the waste minimization issues and analysis of the impact of implementing a few of these technologies.

2. INTRODUCTION

Although positive steps have been taken during the past decades to remedy the world's environmental problems, the nation's ability to respond to many current and future environmental challenges depends on technological advances produced through sound fundamental research and development. As a National Laboratory, Los Alamos (LANL) has the responsibility to set an example for the Department of Energy (DOE) complex and the nation in the area of waste management. The disposition of both currently generated and legacy wastes are actively pursued by focusing the relevant LANL competencies on the research and development of emerging waste minimization technologies and by the deployment of currently available technologies.

To better address the environmental legacy, four major focus areas for waste management and remediation at LANL are targeted for action on the basis of risk, prevalence, or need for technology development to meet environmental requirements and regulations. Other areas may be added to ensure that currently available technology can be deployed and research and technology development programs can remain focused on the DOE's most pressing remediation and waste management needs. These four waste types are transuranic, low level, decontamination and decommissioning, and remediation wastes. In addition, a fraction of the radioactive waste generated at LANL contains Resource Conservation and Recovery Act (RCRA) or Toxic Substance Control Act (TSCA) hazardous components. These wastes are classified as mixed wastes and are regulated by the state of New Mexico.

Transuranic (TRU) and mixed transuranic (MTRU) waste.

At LANL and across the DOE complex, many facilities contain large amounts of TRU and MTRU waste in the form of residues, scrap, oxides, and metal. This is because TRU waste, material that contains alpha emitting contaminants in excess of 100 nCi/gram of waste, is a natural byproduct of operations involving plutonium. In addition, a key element of the nuclear weapons complex is the establishment of a pit component fabrication capacity at LANL, which will require extensive capabilities to treat, package, store and transport radioactive waste produced as a part of its operations. LANL is pursuing initiatives that will lead to better and less expensive characterization, retrieval, handling, treatment, and disposal of these wastes.

Low level (LLW) and mixed low level (MLLW) waste.

The DOE also faces major technological challenges in the management of LLW and MLLW. These wastes, essentially all other non-TRU radioactive waste, are generally high volume wastes therefore disposal capacity is expensive and severely limited. Millions of dollars are spent annually to store mixed waste because of the lack of accepted treatment technology and disposal capacity. Research and technology development areas must focus on the development of safe, reliable, and cost-effective methods for the characterization, treatment, and final disposition of these wastes.

Decontamination and Decommissioning wastes (D&D).

The aging of the DOE's weapons facilities, along with the reduction in nuclear weapons production, has resulted in a need to decommission, deactivate, and dispose of numerous facilities contaminated with radionuclides. While building and scrap materials at the sites are a potential resource with a significant economic value, current regulations lack clear release standards. This indirectly discourages the recovery, recycling, and reuse of the resources. The deployment of current technology and the development of new technologies for the decontamination of these materials will improve material handling, enhance worker safety, and reduce overall system cost.

Remediation wastes.

Radioactive contaminants in soil and ground water exist at LANL as well as many sites across the DOE complex. There is insufficient data at most sites that can be used to quantify contaminant distribution and concentration. Many current characterization, containment, and treatment technologies are not cost effective. Improvements are currently being realized at LANL in the areas of radionuclide detection and soil remediation.

Because of the present regulatory requirements for nuclear materials processing, the minimization of waste streams from DOE activities is an integral component of all operations. Technologies exist that could greatly reduce the waste generated at LANL with potential impact to sites across the complex. If deployed, these technologies could realize significant overall handling and disposal cost reductions and protect worker health and safety by eliminating the most urgent risks.

3. BACKGROUND

The Los Alamos National Laboratory mission is to "reduce the global nuclear danger". The LANL will perform research and development (R&D), non-nuclear testing, and limited production of War Reserve components in support of this mission. Preparations for manufacturing operations will include upgrading of the Chemistry and Metallurgy Research (CMR) and TA-55 nuclear facilities. In addition, the LANL Environmental Restoration (ER) Project will continue to remedy environmental impact from past operational practices.

Over the next ten years the LANL will dispose of significant quantities of transuranic (TRU) and mixed transuranic (MTRU), low level waste (LLW), and mixed low level waste (MLLW). These wastes include legacy wastes from past operations and waste volumes anticipated from future activities. LANL is focused on implementing a waste minimization program and the importance of such a program is summarized as follows:

- Waste minimization practices reduce detrimental impacts on the environment that are associated with radionuclide migration and contamination by reducing the volume of waste that requires disposal.
- Activities associated with the processing, treatment, surveillance, maintenance, and disposal of radioactive waste are expensive and time-consuming. Often the original

facility cost estimates do not account for the costs associated with D&D and waste storage. Waste minimization practices help to reduce the overall expenses related to decommissioning a radioactive facility by reducing these additional costs.

- Waste minimization increases the public knowledge of waste generators that are expanding efforts to operate in an environmentally benign manner.

The LANL Decommissioning Project, under which structures no longer in use are decontaminated and demolished, is included in the ER Project. Over the LANL's 50-year history, many facilities, such as laboratories and experimental reactors, have been built, used, and phased out of use. Many of these structures housed operations that involved hazardous materials, such as high explosives and/or radionuclides. LANL has currently identified 97 structures to be demolished and/or decontaminated. During FY96, 15 of these structures are being decontaminated or demolished as part of 6 subprojects now being conducted by the Decommissioning Project. Each year, the Decommissioning Project begins decommissioning activities at additional facilities.

Los Alamos National Laboratory's ER Project is part of a national effort by the DOE to clean up the facilities involved in its weapons production program. The goal of this effort is to ensure that DOE's past operations do not threaten human or environmental health and safety. The program is governed primarily by the corrective action process prescribed in the Resource Conservation and Recovery Act (RCRA) but is also subject to other applicable laws and regulations. The ER Project is investigating all sites that may have been contaminated by past operations to determine the nature and extent of any contamination.

Of the approximately 2,100 potential release sites (PRS) at LANL, about 940 are sites that have been proposed for no further action (NFA) because thorough investigations indicate that no contaminating operations ever occurred there or because levels of contamination are below current standards. In FY95, the project remediated 40 sites and is projecting remediation of about 60 sites in FY96¹. As sites are cleaned up, they are removed from the project's list of PRS's.

Waste minimization has become an increasingly important part of daily operations at LANL and recent initiatives have been employed to enhance even further current minimization and restoration efforts. A limited R&D effort is underway to develop new production processes that produce significantly less waste compared to past nuclear weapons production practices. LANL is also pursuing an active forward looking pollution prevention R&D program that would create the technological solutions necessary for the future pollution prevention improvements.

4. CURRENT STATUS OF WASTE GENERATION

A summary of the currently generated waste types, volumes, generating facilities or programs, and disposal costs are given in this section. The data presented reflect volumes associated with both the current Stockpile Stewardship and Management (SS&M) mission wastes and legacy wastes. However, data that illustrates the D&D and remediation efforts contribution to the waste streams are imprecise and are only considered where quantifiable.

4.1 TRU/MTRU:

The volumes of TRU/MTRU waste generated over the last three years are displayed in Figure 4.1. The waste volume data is separated into three categories: current mission, non-current mission / non-ER, and ER. Also presented is a description of the legacy wastes generated from past operations. The waste types and trends are discussed below².

4.1.1 Current Mission Waste

TRU waste consists of materials contaminated with radioactive elements with atomic number (Z) greater than that of Uranium (Z=92), and with half-lives greater than 20 years. The contamination must be greater than 100 nCi/g of waste. MTRU waste also includes RCRA constituents. TRU wastes are classified into two categories: current mission waste and legacy waste. The majority of the current mission wastes are associated with the plutonium operations at the TA-55 and CMR facilities and are dominated by five waste stream components which account for ~96% by volume of the TRU/MTRU waste generated.

- Combustible waste. (~44%). Mainly organic materials e.g. plastics, paper, rubber, and wood.
- Metal waste. (~25%). The major source is lead and stainless steel. A significant amount of additional volume of metal waste is likely to be generated by upgrade and construction projects and has not been fully captured in the TRU/MTRU projections.
- Combined combustible and noncombustible waste. (~11%). This waste stream consists mostly of glove boxes and glove box trash that has been packaged without segregation.
- Hydrogenous sludge. (~10%). From the nitric acid process line.
(~ 3%). From the hydrochloric acid process line.
- Glass waste. (~3%).

4.1.2 Legacy Wastes

Between 1989 and 1995, legacy TRU waste generation ranged from ~60m³ to ~310m³ per year. The legacy waste consists of much of the same type of material produced as current mission waste. As of December 31, 1995, the amount of legacy TRU/MTRU waste stored at LANL was 11,167 m³. A fraction of this amount is designated for removal to the Waste Isolation Pilot Plant (WIPP); however, a substantial portion of the stored TRU waste may have to be repackaged to satisfy WIPP acceptance criteria resulting in the generation of significant amounts of secondary waste volume.

4.1.3 Non-Current Mission / Non-ER Wastes

The non-current mission / non-ER waste volumes have varied over the past three years mainly due to the upgrading of the CMR and the TA-55 nuclear facilities. The variations in the data reflect the uncertainty in projecting program status and funding. Items included in this waste stream are technical equipment, glove boxes, ductwork, piping, and other construction debris that has been determined to be contaminated.

4.1.4 ER / Decommissioning Wastes

The ER waste has increased from zero in 1994 to 17m³ in 1996, reflecting the transition from a characterization phase to a remediation and D&D phase in the ER Project. D&D wastes are similar to the wastes associated with the upgrades. Remediation wastes consist mostly of excess contaminated soils or secondary wastes from treatment processes including ion exchange resins and filters.

Figure 4.1. TRU/MTRU Waste Volume by Fiscal Year (m³)

4.1.5 Cost

The estimated costs for handling, storage, and disposal of TRU/MTRU waste are \$50,000/m³ and are based on the average costs per unit volume².

4.2 MLLW:

Mixed low level waste contains both radioactive and Resource Conservation and Recovery Act (RCRA) or Toxic Substance Control Act (TSCA) hazardous components where the transuranic content contributes to less than 100 nCi/g of waste. The MLLW is both difficult and costly to dispose of as a result of the regulatory blanket that this type of waste comes under. Because MLLW contains a radioactive component, it is regulated by the DOE. As it contains RCRA and TSCA constituents, it is also regulated by the State of New Mexico².

4.2.1 Current Mission Waste

Approximately 87% of the current mission waste is comprised of routine waste from research and production operations materials and chemicals from SS&M activities. Lead components that are radioactively contaminated are sent offsite for encapsulation and disposal. Spent chemicals are consolidated before shipping offsite. Current MLLW generation trends are shown in Figure 4.2. Current mission waste volume have declined over the past few years due to successful upstream treatment projects

4.2.2 Legacy Waste

The Federal Facilities Compliance Order / Site Treatment Plan (FFCO/STP), which stipulates treatment requirements for mixed wastes, lists approximately 900 m³ of legacy MLLW stored at TA-54. The legacy waste consists of much of the same type of material produced as current mission waste and is to be treated over the next five years. A minimal amount of secondary waste is anticipated from disposing of this legacy.

4.2.3 Non-Current Mission / Non-ER Wastes

Non-ER wastes include large pieces of equipment, such as glove boxes, that contain activated or contaminated lead shielding or objects with both lead paint and radioactive contamination. This stream accounts for 70% of the non-current mission, non-ER waste. Non-ER wastes also include all hazardous materials removed from Radiologically Controlled Areas (RCA). These 'suspect' MLLW include circuit boards or any other material with lead solder, PCB oil filled ballasts, and fluorescent lights. This waste stream has increased dramatically due to facility upgrades necessary for the SS&M mission.

Figure 4.2. MLLW Waste Generation by Fiscal Year (m³)

4.2.4 ER / Decommissioning Wastes

ER wastes are predominantly soils and debris from removal activities. D&D operations produce small amounts of waste similar to non-ER waste but at much lower levels due to a successful segregation and volume reduction campaign.

4.2.5 Cost

The handling, packaging, and disposal costs for MLLW are estimated at \$70,000/m³. The DOE has eliminated funding for back end technologies as all MLLW will be shipped for off-site processing per DOE. As a result, it is unlikely in the near future to reduce the cost of disposal per m³ but progress can be made by decreasing the total volume designated for disposal.

4.3 LLW:

Low level radioactive waste is defined as waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent nuclear fuel. Test specimens of fissionable material irradiated for research and development only and not for the production of power or plutonium may be classified as LLW, provided that the alpha activity is less than 100nCi/g of waste².

4.3.1 Current Mission Waste

Current mission LLW is generated in RCA's of the five major radiation facilities: CMR, TA-53 (accelerator), TA-55 (plutonium), TA-48 (radiochemistry), and Sigma (processing technologies) at LANL. Typical LLW generated in these facilities include personal protective equipment (PPE), compactable laboratory trash, contaminated wastewater, spent radioactive materials, and process sludges. As shown in Figure 4.3, the LLW excluding ER sources has declined over the past three years due to conscientious pollution prevention efforts. However, due to expected increases in routine operations at the radioactive facilities, this waste stream will be a significant contributor.

Figure 4.3. Low Level Waste Generation by Fiscal Year (m³)

4.3.2 Legacy Waste

Legacy wastes that have been generated at LANL have been characterized and disposed of at the onsite LLW disposal facility at TA-54 Area G. The legacy waste material is similar to the generated current mission, ER, and D&D wastes.

4.3.3 Non-Current Mission / Non-ER Waste

Additional high priority waste results from non-current mission wastes from ER projects and non-ER upgrades, construction, and decommissioning projects. This stream has increased steadily over the last three years and includes material from inventory cleanout, ventilation ducts, piping, and equipment from building upgrades at CMR, TA-55, and Sigma.

4.3.4 ER / Decommissioning Wastes

The annual waste generation rate at LANL has increased over the past three years. Since 1994, the LLW contribution from ER projects has become a dominant source of waste. This results from the transition from an investigation and characterization phase to an active remediation and D&D phase. This trend is expected to continue during the next five years. The ER/D&D waste consisting of soil, PPE's and other compactable items together with the upgrade and construction wastes comprise 63% of all LLW and thus are a priority target for minimization efforts.

4.3.5 Cost

Based on FY 1996 Area G operating costs, LLW debris costs an average of \$1590/m³ to dispose on site. LLW soils cost \$425/m³ to dispose. These costs also include characterization, administrative processing, and transportation. A recent analysis has indicated that the Landfill at Area G will reach capacity during FY 2000 given planned disposal rates. This fact will affect future LLW disposal costs because of construction, legal, and regulatory costs associated with additional landfill pits.

5. FUTURE WASTE GENERATION PROJECTIONS

Over the next century, LANL will play the primary role in Stockpile Stewardship and Management, a key element of which is the establishment of a pit component fabrication capability. This is expected to increase TRU/MTRU and other radioactive waste volumes concurrent with the continued reduction of legacy wastes volumes and remediation and D&D efforts. Table 5.1 gives the total anticipated waste volumes for LANL from 1996 through 2002². This data reflects the ramp up of activities related to the Stockpile Management Mission. However, the effects of ongoing remediation and D&D efforts are not well understood and are only gross estimates at this time.

5.1 TRU / MTRU Waste

TRU/MTRU waste is expected to increase beginning in FY1997 due to the ramping of programs associated with SS&M. The levels are shown to peak in 1999 when wastes will officially be designated current mission wastes. The downward trend in volumes after 1999 results from the anticipated implementation of proposed treatment options. If the treatment options are not implemented, the volumes will continue at the 1999 rate.

5.2 MLLW

MLLW volumes are expected to increase into 1998 due to upgrades necessary for the SS&M mission and then decreasing steadily as a consequence of proposed upstream treatment projects. For current mission MLLW, the 1993 level was 12.32 m³. The DOE has set a routine MLLW volume limit of 6.16 m³ by the year 1999. Waste minimization and other upstream treatment projects are expected to reduce routine MLLW by 40%. Projects yet to be identified are needed to achieve the DOE goal.

5.3 LLW

LLW volumes will increase for the next two years and then level out at ~10,000 m³ per year, even with current waste minimization efforts and proposed upstream treatment projects. Significant volumes are expected over the next five years from remediation soils, D&D debris, and low-density compactible trash.

Table 5.1. Projected Radioactive Waste Volumes

YEAR	TRU/MTRU (m ³)	MLLW (m ³)	LLW (m ³)
1996	140	79	3960
1997	223	350	6034
1998	324	479	7647
1999	324	440	7647
2000	300	397	7697
2001	261	383	7697
2002	228	375	6084

6. WASTE MINIMIZATION TECHNOLOGIES

The waste projections given in the last section are a function of the waste minimization programs and technologies employed. Several key existing technologies have been identified that could be introduced to reduce the generated waste by modifications in upstream processes as well as more efficient volume reduction and segregation.

The technologies listed in this section were selected as representative of the fundamental and applied research conducted at LANL for the purpose of developing and implementing innovative, cost-effective methods that address environmental needs. The aim is to apply these technologies to the needs at LANL, the DOE, the defense complex, and the U.S. at large (through technology commercialization).

6.1 Electrolytic Liquid Waste Treatment Process

6.1.1 Technology Description

The application of electrochemical processes in the environmental arena is being pioneered at LANL. This process has a unique potential for being widely used as a cross cutting technology for several reasons:

- Unlike chemical or mechanical treatments, electrochemical systems do not increase the volume of waste.
- The electrochemical process is able to separate RCRA components from diversified mixed waste streams.
- Greater control can be exercised over reactions via the application of applied potential.
- Electrochemical systems greatly minimize workers exposure to toxic chemicals.

The electrochemical treatment unit consists of a stack of electrochemical cells and auxiliary equipment such as pumps, agitators, pH meters, rectifiers, and the waste feed system³. A schematic of the electrochemical treatment system is shown in Figure 6.1.1. The waste feed container may be the original overpacked drum in which the waste was shipped. In this case, the portable pump and agitator will be inserted into the drum. More commonly, the waste is pumped into an anolyte tank then transferred into the electrolytic system reservoir where it will undergo treatment and flow back to the feed container. The waste will continue to be circulated until treatment is determined to be complete. Metals will be either deposited on the cathodes or will complex and precipitate out of solution. The waste water solution is considered LLW and is sent to an appropriate radioactive liquid waste treatment facility.

Figure 6.1.1. Schematic of the Electrolytic Treatment System

The electrochemical treatment cell may be used with two different configurations. The first includes an undivided cell where the waste solution circulates freely between the anodes and cathodes in the electrolytic cell. The second includes a divided cell where a membrane permeable only to hydronium ions separates the anodic and cathodic compartments of the electrolytic cell. Use of the divided or undivided cell depends on the constituent(s) of concern being removed or degraded in a particular waste stream, as well as the concentration of the constituent(s) in the waste. The divided cell is more effective at treating low concentrations wastes. Metals are electrochemically extracted from the waste solutions and deposited on cathodes, cyanides are decomposed to carbon dioxide, nitrates are reduced to nitrogen, sulfides form complexes with other heavy metals in the waste stream and precipitate out of solution, and organics are oxidized to carbon dioxide and water.

6.1.2 Feed Stream

Electrochemical treatment can be used to treat liquid MTRU or MLLW containing metals, cyanides, nitrates, sulfides, and low concentrations of organic constituents. The liquid MLLW/MTRU wastes result from various recovery processes at TA-55 and spent chemicals and plating baths produced from CST and MST division research projects. It is estimated that between 10 and 20% of both the newly generated and legacy wastes or about 55,000 liters per year are candidates for this technology⁴.

Presently, these liquid wastes are accumulated at the point of generation, then transported to the MLLW storage and characterization area at TA-54. It is characterized, consolidated, certified, and shipped off-site to commercial disposal facilities.

6.1.3 Estimated Waste Reductions

Since the electrochemical treatment technology uses electricity not chemical reagents, which would be added to the reacting species, very little final waste residues are produced. The volume of unrecyclable solid residues is about 5% of the initial waste volume. The liquid effluent after treatment does not contain RCRA components, only concentrations of radionuclides. In the treatment process, the wastes that were originally classified as hazardous under 20 NMAC 4.1, Subpart II, 261 Subpart C, no longer exhibit a hazardous characteristic and are not required to be managed as hazardous waste.

A cost comparison of on-site and off-site treatment of electrochemical candidate wastes is given in Table 6.1.1 and 6.1.2 and show that approximately \$29 can be saved per liter of MLLW⁵. The average generation rate of liquid MLLW over the next 10 years is expected to be 55,000 liters/year and will result in a cost savings of \$1,600,000 per year. Additionally, there are presently over 500 drums in storage that are candidates for this treatment which could translate into a one time savings of \$3,000,000.

Table 6.1.1. On-site Electrolytic Treatment Costs for MLLW

Category	#FTE	hr/FTE*L	Rate (\$/hr)	Quantity	Units	Total (\$)
Locate/Sort	3	0.0019	106.50	1	each	0.61
Survey/Unpack	1	0.0039	106.50	1	each	0.42
(tsm)	1	0.0039	130.24	1	each	0.51
(tech)	2	0.0039	106.50	1	each	0.84
Assay	2	0.0039	106.50	1	each	0.84
misc.				1	liter	37.93
Transportation	2	0.0009	106.50	1	each	0.20
Treatment.	2	0.039	106.50	1	each	8.19
Disposal (solid)				0.00004	m ³	3.00
(liquid)				0.96	liters	0.12
Total Estimated On-site Cost for Electrolytic Treatment of MLLW per Liter						\$ 52

Table 6.1.2. Off-site Treatment Costs of MLLW

Category	#FTE	hr/FTE*L	Rate (\$/hr)	Quantity	Units	Total (\$)
Locate/Sort	3	0.0019	106.50	1	each	0.61
Survey/Unpack	1	0.0039	106.50	1	each	0.42
(tsm)	1	0.0039	130.24	1	each	0.51
(tech)	2	0.0039	106.50	1	each	0.84
Assay	2	0.0039	106.50	1	each	0.84
misc.				1	liter	37.93
Repackaging	2	0.0039	106.50	1	each	0.84
misc.				1	each	0.24
Transportation*				1	liter	0.74
Treatment**				1	liter	38.14
Disposal***				1	liter	0.39
Total Estimated Off-site Cost for Electrolytic Treatment of MLLW per Liter						\$ 81

* Labor and transportation costs estimated for shipment from Los Alamos to Catholic University.

** Assumed treatment at Catholic University under contract.

*** Assumed residues will be sent to Envirocare for disposal.

6.1.4 Present Status of Technology/Deployment

Difficult to treat waste streams found at LANL have been effectively treated by electrochemical treatment in a pilot study in June of 1996. An RD&D permit was sent to NMED in September of 1996 for approval for treatment of

specific waste streams currently on site at LANL. NMED has to date taken no action on this permit.

6.1.5 Other Important Factors

This technology will have an impact site wide providing the ability to treat liquid mixed waste in line at the source prior to transfer to the RLWTF. Many facilities supply the RLWTF through pipelines. Over the lifetime of this transfer system, a build up of sludge lines the inside of the pipe. This poses problems when the pipe must be removed because the sludge is either MTRU or MLLW depending on the source and must be disposed of accordingly. The deployment of this technology inline before transfer through the pipe system will eliminate the hazardous waste component thus making decommissioning of the system after useful life less expensive and less difficult.

6.2 Electrolytic Surface Decontamination

The electrolytic surface decontamination offers stripping of paint and radioactive contamination from surfaces without use of toxic solvents or abrasive media. Layers of contaminated metals can be removed in a clean process with great control of the thickness. Small objects can be immersed in electrolytic baths and larger objects are treated using a chamber with electrolyte that moves along the surface. Items decontaminated by this method can either be reused or disposed of as LLW.

6.2.1 Technology Description

Historically, plutonium-contaminated metal surfaces were decontaminated by repeated scrubbing with strong acids. Electrolytic decontamination makes use of a sodium sulfate or sodium nitrate solution and electrochemical methods to decontaminate metal surfaces. The sodium nitrate solution is contained in a chamber that attaches to the surface and serves as one electrode, while the surface to be decontaminated serves as the other electrode⁶. By making use of electrochemical methods, a far superior decontamination is realized. Also, the plutonium dissolved in the decontamination solution can be precipitated or filtered on-line. This allows for solution re-use, significantly reducing the amount of decontamination solution required.

Figure 6.2.1. Schematic of Glove Box Decontamination Unit

6.2.2 Feed Stream

The Chemistry and Metallurgy Research (CMR) facility has served as a primary special nuclear materials analytical materials laboratory since the early 1950's. The CMR facility is currently undergoing significant construction and reconfiguration. There are up to 300 glove boxes and hoods at the CMR facility that are potential candidates for this procedure.

Similarly, the PF-4 facility at TA-55 is gearing up to support the pit manufacturing effort and contains up to 150 glove boxes that may be decommissioned.

Currently lead components that are routinely contaminated with depleted uranium or plutonium and are classified as MLLW are sent offsite for encapsulation and disposal. Further, items that are removed from RCA's and

large pieces of equipment such as glove boxes, lead shielding, and ventilation ducts that are listed as solid MLLW and disposed of similarly. Items such as glove boxes that are classified as TRU/MTRU waste are transported to TA-54 where they are certified, size reduced, and stored for ultimate disposal at WIPP.

6.2.3 Estimated Waste Reductions

If glove boxes and similar contaminated equipment are decontaminated then disposal costs are reduced from the MTRU/TRU cost of \$50,000/m³ to \$1575/m³ and are disposed of in a designated LLW landfill. A comparison of the current cost of glove box disposal as TRU waste and the cost of disposal as LLW after electrolytic decontamination is given in Tables 6.2.1, and 6.2.2⁷.

Table 6.2.1. TRU Glove Box – No Electrolytic Decontamination

Category	#FTE	hr/FTE*GB	Rate (\$/hr)	Quantity	Units	Total (\$)
Assay	1	1	106.50	8	each	852.00
misc.				7	each	1,050.00
Packaging	6	3.45	107.60	1	each	371.22
misc.				1	each	1,260.33
Transportation	13	11.8	105.20	1	each	1,240.97
misc.				1	each	229.37
TA-54 Storage				82.5	cu. ft.	33,528.75
Size Reduction				5	days	20,000.00
Disposal at WIPP				2.3	cu. ft.	77,532.98
Total Estimated Cost of Disposal per TRU Waste Glove Box						\$ 136,000

Of the glove boxes that have been decontaminated to date, most of them have been reused or prepared to be reused within the PF-4 facility. If a glove box that has been decontaminated is designated to accept a new process then the glove box will not be removed/reconnected, but instead may remain in its current location. The avoidance of costs associated with disconnection, disposal, new glove box purchase, and reconnection could be significant and are reflected in Figure 6.2.2.

At present, a conservative decontamination schedule that will process 15 glove boxes per year and dispose of them as LLW will result in cost savings of \$1,800,000 per year. With an estimated 450 glove boxes⁷ as candidates for this process, a lifetime savings of \$55,000,000 could be realized.

Table 6.2.2. LLW Glove Box by Electrolytic Decontamination

Category	#FTE	hr/FTE*GB	Rate (\$/hr)	Quantity	Units	Total (\$)
Decontamination	3	22	107.60	1	each	4,520.48
misc.				1	each	500.00
Assay	1	1	106.50	1	each	106.50
misc.				1	each	150.00
Packaging	3	1.5	106.50	1	each	159.76
misc.				6	each	1,662.83
Transportation	11	17.12	72.50	1	each	1,050.91
misc.				1	each	114.66
Disposal				96	cu. ft.	4,848.00
Total Estimated Cost of Disposal per LLW Glove Box						\$ 13,000

Figure 6.2.2. Glove Box Replacement Cost Comparison

6.2.4 Status of Technology/Deployment

Electrochemical surface decontamination is currently being tested in several areas. To date, seven glove boxes have been decontaminated at PF-4. Additional tests have been scheduled to decontaminate glove boxes contaminated with Pu^{238} . Tests will be performed later this year to strip the RCRA and radioactive contamination from glove boxes associated with the CMR upgrade project.

Equipment used for excavation and cleanup of ER projects are routinely contaminated and must be decontaminated before they can be used for other cleanup efforts. Electrolytic surface decontamination is currently being used in the decontamination of equipment before it is removed from the cleanup site for use at another site.

6.3 Long-Range Alpha Detection (LRAD)

At LANL, as well as other sites across the DOE complex, the lack of methodology for the characterization and detection of radioactive materials for free release has been identified as a major concern. For example, if an item at LANL is slightly contaminated, the entire item is considered contaminated and is disposed of as radioactive waste.

Over the LANL's 50-year history, many facilities, such as laboratories and experimental reactors, have been built, used, and phased out of use. Many of these structures housed operations that involved hazardous materials, such as high explosives and/or radionuclides. When operations or experiments cease, the structures are decontaminated. If complete decontamination is possible the structures can serve another purpose. If the structure cannot be put to another use because it is obsolete or because the cost of upgrading would be excessive, the structure is demolished and removed from the site, and reusable materials are recycled. LANL has currently identified 97 structures to be demolished and/or decontaminated.

6.3.1 Technology Description

LRAD is an established technology that could be used with free release criteria to allow the disposal of portions of an item as clean waste, as long as contamination levels were below defined limits.

The long-range alpha detector operates by detecting the ions created by alpha particles in ambient air rather than detecting the alpha particles directly. The ions can travel many meters in air, as compared to a few centimeters for alpha particles⁸. This technology is well suited for use across the DOE complex where many facilities have large amounts of contaminated concrete, equipment, and miscellaneous items. Plutonium and other transuranic elements that are primarily alpha emitters are often difficult or impossible to detect in field conditions, such as the current upgrade project at the CMR facility.

Waste volumes projected for the upgrades project are estimated to be as high as 11,500 m³ and are listed in Table 6.3.1⁹. This assumes that all waste is radioactively contaminated until proven otherwise by the use of a monitoring technique such as LRAD.

Figure 6.3.1. D&D Waste Material Flow Using LRAD

6.3.2 Feed Stream

Waste volume projections for the proposed D&D projects are not complete. However, data does exist for the current upgrade project at the CMR facility that provides insight into potential cost savings. The waste stream associated with the CMR upgrade is representative of what can be expected from D&D efforts and consists of non-current mission waste including construction and demolition debris, PPE, glove boxes, ductwork, exhaust hoods, and acid waste drains. Waste volumes projected for the upgrade project are as high as 11,500 m³. This assumes that all waste is radioactively contaminated until proven otherwise by the use of a monitoring technique such as LRAD.

All materials removed from these areas are assumed to be radioactively contaminated until proven otherwise. Glove boxes, exhaust hoods, acid waste drains, and ductwork are assumed to be TRU waste until proven otherwise. Items that have been involved in the processing of, or have had contact with, RCRA contaminants are considered mixed wastes.

Disposal costs for radioactive and mixed radioactive waste are expressed in \$/m³ and much of the materials that result from D&D and upgrade projects are large, bulky, and contain air space. This translates into extremely high disposal costs.

Table 6.3.1. Estimated Waste Volume from CMR Upgrade

Waste Classification	Volume
TRU/MTRU	1546 m ³
MLLW	200 m ³
LLW	9694 m ³
Estimated Radioactive Waste Volume From CMR Upgrade	11,500 m³

6.3.3 Estimated Waste Reductions

Applying the LRAD technology to all doors, wall panels, pipe, back panels, counters, wiring, conduit, etc. will allow sorting and segregating for reuse or recycle and is projected to reduce the total waste volume by 58%¹⁰. The estimated volume reduction by waste type is given in Table 6.3.1 and the estimated disposal cost savings is shown graphically in Figure 6.3.1. If this technology is coupled with electrochemical decontamination then the total waste generation is expected to be reduced by 88% thus further increasing the potential cost savings.

Table 6.3.1. Estimated Volume Reduction Using LRAD

Category	Waste Type	Factor	Unit	Total
Projected Reduction Using LRAD	TRU/MTRU	58 %	1546 m ³	897 m ³
	MLLW	58 %	200 m ³	12 m ³
	LLW	58 %	9694 m ³	5623 m ³

Figure 6.3.1. Estimated Waste Volume Disposal Cost Comparison

Table 6.3.4. Estimated LRAD Operation Costs

Category	#FTE	hr/FTE*m ³	Rate (\$/hr)	Quantity	Units	Total (\$)
LRAD Costs	3	0.043	106.50	11,500	m ³	\$ 158,000
	1	0.043	106.50	11,500	m ³	\$ 52,600
Segregation	3	0.022	106.50	11500	m ³	\$ 80,800
misc.				1	each	\$ 1,000
Estimated Total LRAD Operation Costs						\$ 292,000

6.3.4 Status of Technology/Deployment

Field demonstrations have been completed and a commercial supplier has been identified. Designs are commercially available and flexibility allows this technology to be applied as part of a larger detector system.

6.3.5 Other Important Factors

This technology has applications in other areas as well. For example, LRAD can play a significant role in the finding and cleaning up of radioactively contaminated soil. At LANL, approximately 2100 sites have been designated as potentially contaminated. An investigation phase has been completed and many sites have been determined to be free of contamination and have been removed from the list. This technology could be used at many DOE and DOD facilities for the characterization of potentially contaminated sites. The LRAD monitors can easily distinguish areas with natural background radiation levels from areas with radioactive contamination.

6.4 Remediation of Radioactively Contaminated Soils

Many of the sites in the DOE complex have expressed a number of common concerns. ORNL, RFETS, INEL, and other sites identified remediation of contaminated soils as a high priority. At LANL, approximately 1160 sites are classified as potential release sites (PRS) and are designated for remediation strategies. TA-33 was one such site and was specified for use in an environmental pilot treatment study for the remediation of uranium contaminated soil. This study identified a two step, zero-discharge, 100% recycle system remediation technology that meets the DOE criteria for soil release (114 pCi/g)¹⁰.

6.4.1 Technology Description

In the first step, following excavation, the soil is sorted by use of the ThermoNuclear Services segmented gate system (SGS) into two different streams: One stream with radioactivity greater than 30 pCi/g, the other stream with radioactivity less than 30 pCi/g. Following the sorting, the soil with radioactivities less than 30 pCi/g is returned to the excavation site as it meets regulatory soil release guidelines. The portion of soil with radioactivities greater than 30 pCi/g is chemically treated in a second step containerized vat leach process by use of leach reagents that target radionuclides. A schematic of the SGS/CVL system is shown Figure 6.4.1.

Figure 6.4.1. Schematic of SGS/CVL Contaminated Soil Remediation System

The object of the second step is to chemically leach nuclides from the SGS segregated soil, by use of the containerized vat leach (CVL) system so that the activity concentrations of the soil produced a total dose of less than 15 mrem/yr. and thereby permitting the soil to be returned to the excavation site. Radioactive components are removed from the leach solution by use of ion exchange resins. (Soil sorting criteria for the SGS is to divert the soil with greater than 30 pCi/g to the CVL system for treatment.) Following treatment the resins are to be disposed of in an approved low-level radioactive landfill.

6.4.2 Feed Stream

At LANL, approximately 1160 sites are classified as potential release sites (PRS) and are designated for remediation strategies. Of these, 90% are considered candidates for accelerated cleanup (an abbreviated version of the full corrective action process that regulators authorize for sites where levels of contamination are known and cleanup processes are obvious).

The total volume of soil contaminated by radioactive waste across the DOE complex has yet to be accurately quantified; however, DOE's Baseline Environmental Management Report (BEMR) estimates that soil volumes in the millions of cubic yards will require treatment and disposal for radioactive and/or hazardous waste (U.S. DOE, March 1995). As a conservative estimate it is assumed that the total volume of contaminated soil at the PRS's equals 100,000 cubic yards.

A small fraction of the PRS's are being restored by current cleanup efforts. Many other sites designated for remediation are awaiting corrective action. Contaminated soil previously was used as backfill at the TA-54 Area G landfill, however LANL management has recently decided not to accept any more construction waste, demolition waste, or suspect soil at Area G due to limited capacity and lifetime of the disposal facility.

6.4.3 Estimated Waste Reductions

The baseline approach for the remediation of soils containing radioactive and/or hazardous waste is excavation, pretreatment, containerization, and disposal at a federally approved landfill. A conservative estimate for excavation and screening of radioactively contaminated soil at \$100 per cubic yard is assumed to apply. Costs for disposal of soils containing LLW at an appropriate facility such as Envirocare run about \$225 per cubic yard. Transportation costs to Envirocare for LLW are approximately \$300 per cubic yard. However, LANL offers the option of storing its own LLW at Area G for only \$2 per cubic foot, or \$54 per cubic yard. Transportation costs within LANL boundaries amount to approximately \$25 per cubic yard. Using these estimates, Figure 6.5.2 illustrates the total cost for disposal of the 218 cubic yards of soil from TA-33 compared to disposal of 5000 cubic yards of soil at Envirocare and at LANL's Area G, versus the cost of volume reduction and treatment via SGS/CVL¹¹.

Three important conclusions can be drawn from Figure 6.4.1. First, the availability of onsite disposal greatly skews the cost comparison between SGS/CVL and excavation for transportation off-site. Decisions concerning the fate of radioactively contaminated soil based solely on economics favor onsite disposal for small volumes of soil. Second, if onsite disposal is not an option, then costs for treatment via SGS/CVL vs. offsite disposal are similar for the small volume of soil at the test site. Third, projected costs for SGS/CVL at the 5000 cubic yard soil volume show the technology to be more cost effective than either of the two baseline alternatives.

Figure 6.4.2. Cost Dependence on Soil Volume Remediated for Three Remedial Options

To compare how the cost savings may apply to the total estimated volume of contaminated soil at LANL, Table 6.4.1 compares the costs of using SGS/CVL against conventional disposal costs for the processing of 100,000 cubic yards of contaminated soil. For this comparison, the initial soil volume reduction via SGS is assumed to be a conservative 80%. Area G at LANL does not have the capacity to store soil volumes of this magnitude, so for comparison to conventional disposal, it is assumed that contaminated soil would need to be shipped to Envirocare. The \$700/cubic yard unit cost given for disposal under SGS/CVL in Table 6.4.1 presumes that some secondary waste stream is generated by CVL, and that the secondary waste stream is in the form of resins and leachate that would require pretreatment in the form of stabilization/solidification. This adds approximately \$175/cubic yard to the basic cost of transportation and disposal.

Table 6.4.1. Potential Cost Savings Using SGS/CVL to Clean 100,000 Cubic Yards of Radioactively Contaminated Soil.

Conventional Disposal Costs	
Excavation/Screening	\$ 100 per yd ³
Transportation	\$ 300 per yd ³
Disposal (Envirocare)	\$ 225 per yd ³
Total Unit Cost	\$ 625 per yd ³
Total Cost per 100,000 cubic yards without SGS/CVL	\$ 62,500,000

Disposal Costs Using SGS/CVL at 20% Contamination	
Excavation*	\$ 50 per yd ³
Soil Processing via. SGS	\$ 55 per yd ³
Leaching	\$ 50 per yd ³
Disposal (Pretreatment and Transport)	\$ 7 per yd ³
Total Unit Cost	\$ 162 per yd ³
Total Cost per 100,000 cubic yards with SGS/CVL	\$ 16,200,000

- Screening included in SGS soil processing costs, excavation is not.

6.4.4 Status of Technology/Deployment

Successful remediation of 218 cubic yards of soil at TA-33 reduced uranium contamination to a level approximately one-quarter of the DOE-allowed dose of 15 mrem per year for recreational use. The process is ready for full-scale tests at LANL.

6.5.5 Other Important Factors

Los Alamos National Laboratory is proposing to demonstrate the SGS/CVL technologies for the remediation of mixed waste. With the addition of laser induced breakdown spectroscopy (LIBS) metals detectors (another technology developed at LANL), the SGS system would have the capability to segregate metals-contaminated as well as radioactively-contaminated soil. The proposed technology demonstration will take place at LANL's R-44 firing site, an area heavily contaminated with uranium, lead, and beryllium. As costs for disposal of mixed waste are much higher than for low-level radioactive waste, even greater cost savings can be expected for remediation of mixed waste using SGS/CVL.

7. RECENT ACCOMPLISHMENTS

The past several years has seen a symbiotic relationship with the programmatic and RD&D activities at LANL. The result from this cooperation has been a reduction in the total cost and volume of radioactive waste as well as the total volume generated at LANL. Funding that has supported RD&D projects has produced many successful technologies and have even won RD&D awards. Several of these successful projects are given in this section to illustrate the potential payoffs achievable with support.

7.1 Hydride/Dehydride Process

The dismantlement of nuclear weapons requires the plutonium to be extracted from a weapon's nuclear package, and the traditional extraction method of acid leaching is no longer an acceptable technology. With acid leaching, plutonium was extracted, or recovered, by way of a multi-step aqueous process. The plutonium was dissolved in order to be leached out. It was then converted to an oxide and reduced, returning it to its metal form for disposition.

The hydride/dehydride recycle process is a one-step, zero-waste method of recovering metallic plutonium from nuclear weapons¹². This process takes advantage of plutonium oxides strong affinity for hydrogen gas, a reaction that forms plutonium hydride. The reaction takes place in a vacuum chamber inside a glove box. A heated crucible in the lower part of the chamber creates a hot zone. A worker places the weapon component in the upper cold zone and introduces a small amount of hydrogen gas that has been generated by heating a uranium hydride bed. A small amount of hydrogen gas is allowed into the cold zone to react with some of the weapon component's plutonium. Plutonium hydride forms and falls as a powder into the hot crucible below. The crucible's heat re-releases the hydrogen gas allowing it to react with more of the component's plutonium.

The small quantity of hydrogen gas recycles within the vacuum chamber until the plutonium is completely extracted. The hydrogen is then pumped out and used to replenish the uranium hydride bed. When the process is complete, the plutonium that has

been collected in the bottom of the crucible is melted and incorporated into a storage-ready ingot.

The hydride/dehydride recycling is simpler (a single step vs. a multi-step process), faster (5 hours vs. 16 hours), and more efficient (99.9% recovered vs. 96%). Most importantly, the process generates no mixed or liquid waste as compared to the 360,000 kg of mixed waste generated per year by acid leaching.

This technology, which was funded by DOE/DP, was a Los Alamos Laboratory 1995 R&D 100 Award Winner and according to R&D Magazine was one of 1995's 100 most significant technological innovations.

7.2 LLW Decontamination

DOE/Headquarters High ROI Project funding has been used to reduce LLW generated in RCA's by reducing the area of RCA's at LANL, as well as by increasing the volume of waste from RCA's that can be released for non-radioactive disposal through decontamination and radiological surveying². The goal for area reduction was 50,000 ft². The project surpassed this goal by reducing RCA's by 150,000 ft². Area reductions include:

- 133,000 ft² of RCA space at the Sigma facility, where large amounts of stored equipment were considered suspect LLW, was determined not to be contaminated.
- 12,000 ft² at the CMR facility was downgraded from a high contamination area to a radiological buffer area, which allowed for free release of waste materials based on surveys proving that radiological contamination was not present.
- 3,500 ft² at TA-35, TA-48, and TA-50 was decontaminated.
- 15,000 ft² at CMR was released through decontamination and radiological surveys.

7.3 WAND (Waste Acceptance for Nonradioactive Disposal)

The WAND instrument consists of two independent screening systems that are used to verify the absence of a broad variety of radionuclides so that potentially contaminated (suspect) room trash can be separated from low level waste. The detection system uses a Phoswich type detector to detect several of the most common radionuclides in DOE wastes: isotopes of plutonium, americium, uranium, and thorium. Additionally, the detector is extremely sensitive for the detection of most fission products and activation products that are frequently found in waste materials.

One component of the system is a conveyor belt system that slowly moves thin layers of cellulose materials beneath a heavily shielded array of six detectors. The conveyor belt system can process flat groups of paper and plastics that are either directly

placed or shredded and fed onto the belt by means of a screw-type auger. The conveyor belt system is complemented by a second screening system that consists of a lead shielded box counter which minimizes background radiation.

The prototype system has been fully demonstrated under a pilot program implemented at TA-55. It has been shown that an average of 70% of the suspect compactible LLW can be segregated and diverted to a sanitary landfill. This program is expected to reduce the cost of compactible LLW disposal by half from \$2.25 million/yr. to \$1.1 million/yr.¹³.

8. FUTURE R&D

A key element of any strategic waste minimization plan is the establishment of an alternative technology development capability within LANL that will replace or upgrade current technologies that reduce volume, toxicity, and radionuclide content of all waste streams from the LANL.

The pollution prevention programs that are ready for implementation today were developed from 1989-1991 by a joint (DOE/EM)/(DOE/DP) pollution prevention R&D program. The process of new technology development to continually improve waste minimization and pollution prevention must become an essential function of LANL operations as a policy. Several technologies are either currently being investigated or on hold due to lack of funding at LANL that show potential for making significant gains in waste minimization. A sample of these is given in this section along with several key areas that need to be focused upon¹⁴.

8.1 Nitrate Reduction

Nitrate wastes represent an important environmental problem. Nitrate-based solvents are used in weapons research and production and contribute to a significant fraction of the waste volume that exists across the complex. Mining, chemical, farming, and other industries are also major generators of nitrate wastes. Such wastes contaminate natural waters if released into the environment. The strong oxidizing power of nitrates causes excessive biological activity, growth, and precipitation of organic residue to bottoms of streams, rivers, lakes, and oceans.

At LANL, the nitric acid liquid waste stream produces about 115 barrels of grouted (in Portland cement) TRU waste each year. The volume of nitric acid effluent sent to the WasteWater Treatment Facility, TA-50, ranged from 159,505L in 1983 to 6209L in 1993. When this waste stream is combined with the hydrochloric acid liquid waste stream/caustic liquid waste stream, they can produce 5-10 (or more) additional barrels of grouted TRU waste at TA-50 each year. The caustic waste stream sent to TA-50 ranged from 64,870L in 1983 to 1995L in 1993.

- Investigators at LANL have patented a simple and economical process that reduces nitrates in waste streams to more environmentally benign substances. Nitrates are reduced to nitrogen gas by contacting the nitrates with a metal to

reduce the nitrates to nitrites. The nitrites are then contacted with an amide to produce carbon dioxide and nitrogen, which can be released to the atmosphere. Minor amounts of metal catalysts are used in the reduction of the nitrates to nitrites and metal salts that form in the reaction can be recovered using an electrochemical process.

This technology can be used for upgrading the capabilities of existing wastewater treatment plants for the processing of nitrate streams from nuclear, industrial, mining, farming operations, and in environmental restoration projects.

8.2 Glass Wastes

Glass wastes arise from sample bottles and various glass laboratory equipment that is used in glove box processes contaminated with either ^{239}Pu or ^{238}Pu . Processes for decontamination, compaction, or destruction (melting) of these wastes are listed below.

Plasma decontamination is a potentially useful technique that is still in the development stage. This process will convert the constituents of the glass, namely the silica (SiO_2) to silicon tetrafluoride (SiF_4), prior to removing the bulk of the actinides. This process may or may not prove useful for the decontamination of glass items due to the bulk removal of the SiO_2 .

Plasma hearth or other molten metal technology could be used on glass just as it is used for contaminated metals. It is unclear what would happen to the SiO_2 at the present time but potentially the actinides may end up in the slag, thus minimizing the volume of TRU waste.

8.3 Hydrochloric acid liquid waste stream

The hydrochloric acid liquid waste stream is a relatively minor waste stream (~10-15% of the HNO_3 waste stream volume), however it contains ~80% of the total radionuclide activity that is discarded to TA-50. There are numerous processes/techniques that can be used to decrease the volume and radionuclide content of the HCl stream and several of these are listed below.

- Total HCl recycle will eliminate the current requirement to neutralize the entire HCl waste stream with caustic.
- Using enhanced or improved ion exchange resins can increase Pu removal.
- Additional waste stream polishing can remove both the Pu and Am using water soluble polymers followed by ultrafiltration.
- Better precipitation reagents than alkali or alkaline earth hydroxides can be used to more completely and more efficiently remove the actinides from the aqueous stream.
- Recovery of ^{241}Am could lead to a significant reduction of the number of drums of TRU waste produced that cannot meet the WIPP-WAC.

- Selective actinide precipitation reagents that would allow for uncomplicated and efficient acid recycle (not neutralization).
- Segregation of all process residues containing chlorides for processing via the HCl process flow sheet, not mixing or adding to the HNO₃ process stream.

8.4 238Pu Recovery

This is not currently done at Los Alamos, although it has been tried on a very small trial basis. Because ²³⁸Pu is becoming relatively scarce, there are several reasons for doing this. NMT-9 submitted a Technology Deployment Initiative (TDI) proposal early in 1997 for molten salt oxidation and aqueous recovery for ²³⁸Pu. The project is currently unfunded. Capital and operational cost investment in this commercially available system could lead to a substantial reduction in the number of ²³⁸Pu waste drums that currently can not meet the current WIPP Waste Acceptance Criteria (WIPP-WAC).

8.5 Source Reduction

Source Reduction is an ongoing technique used to reduce the amount of waste in general. This technique reduces waste by the removal of packaging materials, and other extraneous items before the equipment or parts are introduced into the glove boxes and/or waste drums unless they are absolutely necessary. Stated in other words, this is known as "waste avoidance".

9. FUTURE ANALYSIS

Future analysis needs to consider the waste generation as it pertains to future and ongoing missions. As an example, current TRU/MTRU waste generation rates are based on present rates with some consideration of new technologies that 'may' be implemented in the future. With the upcoming pit manufacturing effort, the processing schedules and material throughputs are going to be significantly different from what is currently being seen with the 94-1 work off. Archived data exists from the early to mid 80's that along with detailed data from TA-50 liquid waste treatment can be coupled to generate estimates on the waste volumes through the recovery operations. Several of the operations both within recovery and outside but with a direct impact on recovery have changed since the 80's (including acid recycle, hydride/dehydride, Pu purity requirements, etc.) and these changes must be considered as well. An evaluation of this will also affect any decision on whether pretreatment operations should exist and if so where should the treatment take place (i.e. TA-55 or TA-50). Current estimates of the activity and flow rates expected through TA-50 room 60 do not take into account these changes and could have a significant impact on future spending.

Figure 9.1 shows the relative TRU/MTRU waste volumes as a function of DP missions. This illustrates clearly the waste streams that will contribute significantly over the next ten years but does not predict accurately the pit manufacturing effort. This figure also shows for example that the recovery operations are very sensitive to input. Because the waste is generated per gram of Pu input, inaccurate estimates will have an impact on downstream operations. Additionally, small improvements or modifications to operations upstream will have a large impact downstream.

Currently there is a need for more emphasis on upstream improvements. Sensitivity analysis should also be performed to determine whether the implementation of a particular technology would have the best overall reduction of waste and cost. An example can be illustrated using Figure 9.1. The nitric acid line produces a significant waste volume and therefore should be addressed however, reduction of this waste stream will have a minimal effect on the overall number of drums generated by TA-50 to be sent to WIPP. Also some of the nitrate line is used for dilution with the caustic line which means that additional neutralization will have to be provided from an additional source. On the other hand, there would be cost savings associated with a smaller operation at TA-50 pre-treatment, which would stimulate discussions regarding the existence of room 60 at TA-50. Because the waste volumes produced from recovery operations are a function of the input, waste minimization technologies and/or comprehensive waste avoidance practices that are implemented upstream could potentially have the most significant impact. There are other issues associated with this scenario that have not been mentioned here, however, a comprehensive analysis needs to be performed that considers all of the relevant issues before a particular technology will be considered for implementation.

As a first step towards this type of analysis, it would be instructive to develop a model of the generation and flow of both solid and liquid waste at LANL. The use of a discrete event modeling tool will allow the development of a dynamic waste stream processing model. This model will promote a better understanding of the sensitivity of waste processing to various factors including, new technologies, technology upgrades, or improved waste minimization awareness.

Figure 9.1. TRU/MTRU Relative Waste Process Volume

10. SUMMARY

As a whole, LANL is aggressively pursuing a waste minimization program with both volume reduction and minimization technologies. However, there needs to be more long term vision with an overall scope of the radioactive waste problem. An analysis that couples a global view with a detailed systems analysis can have significant impact on Lab wide costs. As an example, the pretreatment operations at TA-50 should not be considered as a separate system independent of TA-55 but should be coupled with an analysis of the waste streams that emanate from specific operations at TA-55 through final disposal at WIPP.

Several key existing technologies have been identified that could be introduced to reduce the generated waste by modifications in upstream processes as well as more efficient volume reduction and segregation. Four of these are discussed in detail in this report and are summarized below.

The electrolytic surface decontamination can strip radioactive contamination from surfaces without use of toxic solvents or abrasive media. Layers of contaminated metals can be removed in a clean process with great control of the thickness. Items decontaminated by this method are no longer classified as TRU waste and can either be reused or disposed of as LLW. At the PF-4 and CMR facilities, there are approximately 450 glove boxes that are candidates for this technology. If this method is used to decontaminate 15 glove boxes per year then an estimated \$1.8 million can be saved per year in TRU waste disposal costs as shown in Figure 10.1.

Figure 10.1. Disposal Cost Comparison for TRU and MLLW

The electrochemical treatment of MLLW is a process that is able to separate RCRA components from diversified mixed waste streams. Unlike chemical or mechanical treatments, electrochemical systems do not increase the volume of waste. Electrochemical treatment can be used to treat liquid MTRU or MLLW containing metals, cyanides, nitrates, sulfides, and low concentrations of organic constituents. It is estimated that between 10 and 20% of both the newly generated and legacy wastes or about 55,000 liters per year are candidates for this technology. With the implementation of this technology, approximately \$1.6 million can be saved per year in MLLW (Figure 10.1).

LRAD is a commercially available long-range alpha detection system that could be used with free release criteria to allow the disposal of portions of an item as clean waste, as long as contamination levels were below defined limits. Typically, all waste is assumed radioactively contaminated until proven otherwise by the use of a monitoring technique such as LRAD. The use of this technology for D&D work at the CMR facility is expected to reduce the total radioactive waste volume by 58%. As shown in Figure 10.2, this translates into cost savings of approximately \$101 million.

The SGS/CVL radioactive soil remediation system is a two-part system that removes radioactive constituents from contaminated soil and then returns the soil to the site. The first step uses a conveyor belt and detection system to segregate contaminated from uncontaminated soil. The second part of the system uses a process that leaches the radionuclides from the soil. There are approximately 1160 PRS's at LANL that are designated for remediation efforts. If a conservative estimate of 100,000 cubic feet is used as the total volume of soil that is to be processed, then an about \$46 million can be saved by using this process.

Figure 10.2. Disposal Cost Comparison for D&D and LLW

The cooperation between the DOE and RD&D activities at LANL, has produced many successful technologies which have resulted in a reduction in the total cost and volume of radioactive waste at LANL. These technologies are key elements in a waste minimization plan that includes the establishment of an alternative technology development capability that will replace or upgrade current technologies. Only a fraction of the technologies currently being investigated are discussed in this report. However, these technologies are representative of the waste reductions and cost savings that can be realized at LANL with potential impact across the DOE complex given funding support.

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