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Management of Hazardous Wastes Lawrence Livermore National Laboratory

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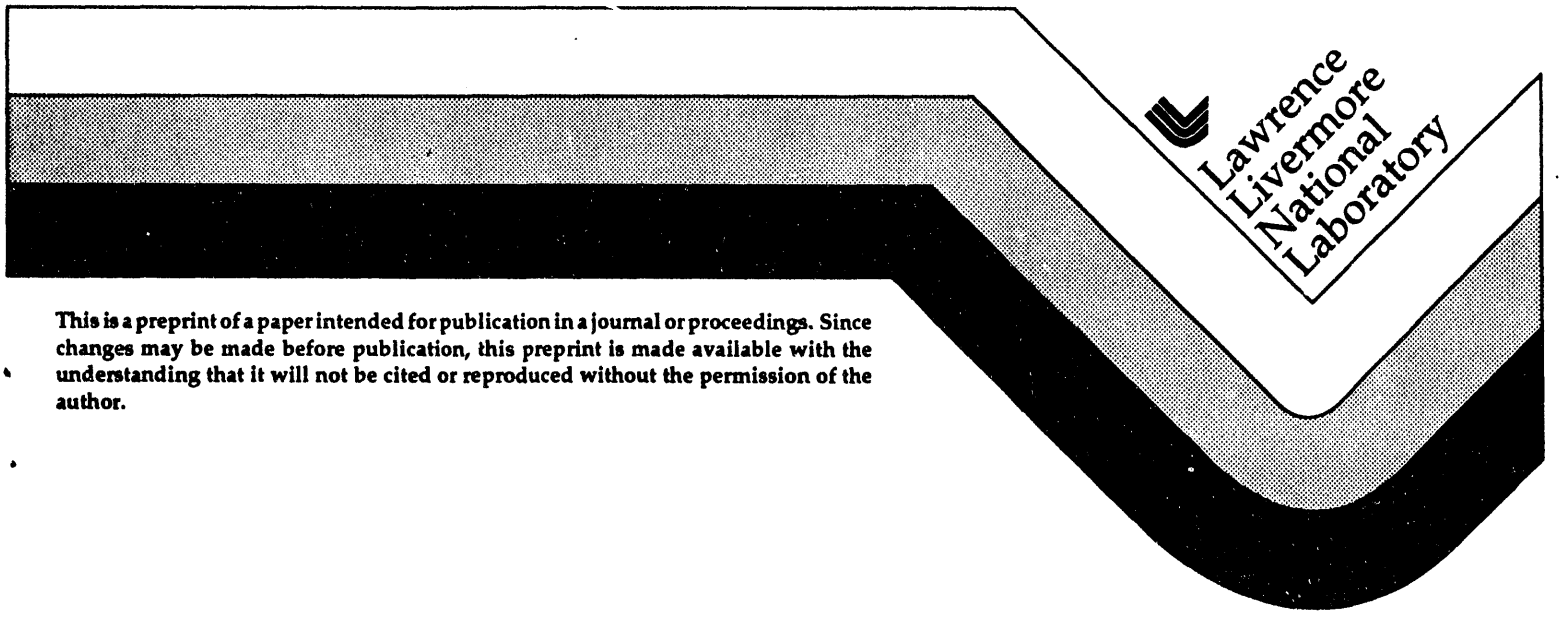

DISCLAIMER

Management of Hazardous Wastes
Lawrence Livermore National Laboratory

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Hazardous Waste Management at Lawrence Livermore National Laboratory

Summary

Lawrence Livermore National Laboratory (LLNL), during the course of numerous research activities, generates hazardous, radioactive, and mixed (radioactive and hazardous) wastes. The management of these waste materials is highly regulated in the United States (U.S.). This paper focuses on the hazardous waste regulations that limit and prescribe waste management at LLNL.

Introduction

The number of Federal and state environmental agencies and regulations has increased significantly as a result of public concern, media attention, toxicological and epidemiological studies regarding health effects, and studies indicating the long-term global effects of pollution. The regulation of air, water, and waste discharges from industrial and Federal facilities began in the late 1960s and has grown throughout the 1990s. In 1970, the Environmental Protection Agency (EPA) was formed by the Federal government to implement various environmental laws and regulations. The regulations are the result of more than 17 pieces of congressional legislation and Executive Orders signed by the President. (See Appendix A for an example of the types and scope of Federal regulations currently in effect.)

In addition to Federal legislation and regulations, most states have their own legislation and regulations. State regulations are similar to Federal regulations and are often even more stringent. Therefore, most industry is required to comply with both state and Federal regulations and in some cases, local (city or county) regulations. At LLNL, Federal, state (California), and local regulations are implemented and enforced by 16 different environmental regulatory agencies. (See Appendix B for a list of these agencies.)

Department of Energy (DOE) facilities and many other Federal facilities have considered themselves exempted or excluded from these regulations for many years, or they have considered themselves exempt under other forms of legislation. In the past, facilities that chose to comply with Federal environmental regulations were only minimally impacted. However, several Presidential Executive Orders have been signed that require facilities to comply with *all* environmental regulations (Federal, state, and local) and the subsequent hazardous waste regulations.

Hazardous Waste Regulations

In 1976, the U.S. Congress passed the Resource Conservation and Recovery Act (RCRA). The act was intended to regulate the generation and management of hazardous waste and required the use of a permitting process to store, treat,

and dispose of hazardous waste. In 1980, the Environmental Protection Agency began to develop regulations to implement the RCRA legislation as it applies to Treatment, Storage, and Disposal Facilities (TSDFs). This has had a significant impact on industrial and Federal facilities that use and/or manage hazardous materials.

The regulations defined what constitutes a hazardous waste and set standards for storage and treatment in tanks and containers, surface impoundments, land treatment, incineration, and disposal into and on the land. Land disposal covers a broad area of waste management. The Hazardous Waste Management Division (HWMD) at LLNL is responsible for the storage, treatment, and preparation of waste for off-site shipment to permitted treatment and/or disposal facilities. LLNL has 30 regulated units that require permitting. Examples of the different types of units include:

- Tank or container storage units
- Centrifuge unit
- Wastewater treatment tank farm unit
- Lab packing unit
- Cold vapor extraction unit
- Silver recovery unit
- Blending units
- Solidification unit
- Receiving and segregation unit
- Carbon absorption unit
- Shredding unit
- Waste water filtration unit

Hazardous Waste Definitions

To determine if a waste or material is hazardous, regulations require that it be evaluated to determine if it is a "solid waste." The term solid waste means any garbage, refuse, or sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility. The definition also includes other discarded material such as solid, liquid, semi-solid, or contained gaseous material.

Discarded material is another key to defining waste. A material is considered discarded if it has been:

- Abandoned by disposal, burned or incinerated, accumulated, stored, or treated prior to disposal.
- Recycled by being used in a manner constituting disposal, burned for energy recovery, reclaimed and speculatively accumulated.
- Considered inherently "waste like" and not excluded.

Therefore, if the material is determined to be a solid waste and is discarded, it must then be evaluated to determine if it is hazardous. The range of hazardous waste materials, as defined by the state and Federal agencies, is broad and includes lists of hazardous wastes or materials and wastes with specific chemical characteristics.

The chemical characteristics that classify wastes as hazardous under RCRA (Federal) are ignitable, corrosive, reactive, and toxic (state definitions are broader). The typical (but not all-inclusive) definitions of these are:

- Ignitable—Flash point less than 140° F Closed-Cup Tester. (D001)*
- Corrosive—pH less than 2.0 or greater than 12.5. (D002)*
- Reactive—Generates toxic gases, reacts violently with water. (D003)*
- Toxicity—Establishes thresholds for heavy metal, pesticides, and other organic chemicals using an specified extraction procedure. (D004-43)*

There are three types of listings that define hazardous waste:

- Non-Specific Sources
  Examples include spent solvents and sludge used in degreasing, metal treating wastes such as electroplating waste. (F Codes)*
- Specific Sources
  Examples includes API separator sludges, pink water from the production of TNT. (K Codes)*
- Commercial Chemical Products
  Specific chemicals that when discarded, or intended to be discarded, are hazardous wastes such as phenol, vinyl chloride, etc. (P and U Codes)*

Based on the definition of hazardous waste, the wastes generated at LLNL are diverse and reflect the organization's wide range of scientific activities. Laboratory wastes include wastewater, laboratory equipment, used laboratory chemicals, photographic solutions, machining, and medical wastes.

Mixed Wastes

The EPA also regulates "mixed waste" management. The origins of the definitions of a mixed waste evolved from interpretations and agreements between the EPA, the DOE, NRC, and the definition of "by-product material" as defined by the Atomic Energy Act. Simply stated, mixed waste can be defined as a radioactive waste that also contains chemical constituents that are hazardous waste under the EPA regulations. The environmental agencies do not regulate the radionuclide itself, but they do have the authority to regulate the hazardous component of the waste. Therefore, all individual constituents of mixed wastes are subject to regulation. In private industry, the Nuclear Regulatory Commission regulates the radioactive component of the waste. For LLNL and other Federal agencies, DOE regulates the management of the radioactive component through DOE Orders.

* These codes are EPA identifiers of specific wastes.

Hazardous Waste Permitting Regulations

The EPA and state regulations define the requirements for managing and permitting hazardous and mixed waste. Each type of hazardous waste management unit (i.e., tank, incinerator, landfill, etc.) has detailed design and operational requirements that are defined in the regulations. The requirements are extensive, and as a result, it is a significant effort to document the management of hazardous waste at a facility. These requirements are prescriptive in nature and include, but are not limited to, location standards, design and construction standards, and operational requirements.

Location standards have been defined for siting of all new and existing TSDFs relative to flood plains and earthquake faults. Existing TSDFs that cannot demonstrate compliance with the location standards must mitigate the effects of location. There is also a buffer zone requirement for siting new TSDFs in California.

Examples of the types of design and construction requirements for storage and treatment in tanks and containers such as LLNL's HWM facility include:

- A demonstration of the compatibility of construction materials with the types of wastes to be managed.
- Construction of secondary containment for tanks and containers that meet specific capacity requirements.
- Engineering certifications of design and construction.
- Security (i.e., fencing & access controls).

Similarly, operational requirements for storage and treatment include such items as:

- Waste Analysis Plans
- Inspection Plans
- Personnel Training Plans
- Manifest Systems and Record Keeping
- Preparedness and Prevention
- Contingency Plans
- Monitoring Plans
- Corrective Action Plans
- Financial and Insurance Requirements
- Closure Plans

This is a brief overview of the types of requirements covered under state and Federal hazardous waste regulations. Other regulations that cover activities such as recycling, research and development permitting, and numerous exclusions have not been discussed here.

Hazardous Waste Land Disposal Restrictions

Hazardous waste management regulations include "Land Disposal Restrictions" (LDRs). These regulations prohibit the disposal of *untreated* hazardous wastes. Therefore, for each hazardous waste, EPA has established a treatment standard designed to diminish the toxicity of wastes and reduce the likelihood of migration of hazardous constituents so that the short-term and long-term threats to human health and the environment are minimized when wastes are land disposed. Land disposal includes placement in a landfill, surface impoundment, waste pile, injection wells, land treatment of wastes, salt domes or salt bed formations, underground mines or caves, and concrete vaults or bunkers.

These same LDR requirements also apply to the hazardous constituents of mixed wastes. LDR regulations also prohibit storing wastes for longer than one year if the wastes have not been specifically treated to meet the standard.

Best Demonstrated Available Technology

LDR requirements are met by using one or more specified treatment technologies, or they require that wastes be treated to meet specific concentration limits on the hazardous constituents. Those specific treatment technologies that constitute Best Demonstrated Available Technology (BDAT) are determined by the EPA. BDAT as determined by the EPA means:

Best—Based on performance data from well-designed and well-operated systems.

Demonstrated—Treatment technologies currently in use. The technology must present less risk to human health and the environment than land disposal of the untreated waste and the technology must provide substantial treatment. EPA does not consider pilot and bench-scale operations when identifying "demonstrated" treatment technologies.

Available—Technologies that are available for purchase or lease. A proprietary or patented technology that cannot be purchased is considered unavailable for BDAT purposes.

Examples of BDAT include:

- Incineration
- Carbon absorption
- Wet air oxidation
- Stabilization
- Neutralization
- Recovery of organics
- Thermal recovery of metal/organics
- Chemical or electrolytic oxidation

Concentration Standards

Specific concentration limits are determined by using an assumption that the wastes are treated by the BDAT and although wastes can be treated by any technology, the concentration of the hazardous constituents in the treatment residues cannot exceed those obtained by using BDAT. An example of how these concentration standards are developed is provided below.

The EPA has determined that incineration is the BDAT for many hazardous organic wastes. To determine the concentration standards for these wastes in lieu of incineration, the agency must take into account the concentrations in the waste residues of an incinerator. The typical waste residues of incineration are ash and scrubber wastewater. EPA analyzed the concentrations of specific hazardous waste constituents in the ash and scrubber water when a particular hazardous waste was incinerated and then used those concentrations to determine the concentrations that must be met by alternative treatment technologies. These treatment standards are expressed in terms of the maximum constituent-specific concentrations in non-wastewater, or the maximum specific concentration in treated wastewater. If a waste contains more than one hazardous constituent, the waste must meet the LDR standard for each constituent. Examples are shown in the table below.

Constituent	BDAT for Wastewater	Wastewater mg/l	BDAT for Non-wastewater	Non-wastewater mg/kg
D006-Cadmium	Chemical precipitation	1.0	Stabilization/ metal recovery	1.0*
D007-Chromium (total)	Chromium reduction, precipitation	5.0	Chromium reduction, stabilization	5.0*
D008-Lead	Chemical precipitation, sludge dewatering	5.0	Stabilization	5.0*
F006- Wastewater treatment sludges from electroplating operations: Cadmium Chromium Lead Nickel Silver Cyanides (total) Cyanides (amenable)	Alkaline chlorination, chromium reduction, precipitation with lime and sulfides	 1.6 0.32 0.040 0.44 - 1.2 0.86	Alkaline chlorination, chemical precipitation, settling, filtration, and stabilization	 0.066 5.2* 0.51* 0.32* 0.072* 590 30
U-220-Toluene	Biological treatment or wet-air oxidation followed by carbon adsorption	0.08	Incineration	28.0
U-188 Phenol	Biological treatment or wet-air oxidation followed by carbon adsorption	0.039	Incineration	6.2
U-228 Trichloroethylene	Biological treatment or wet-air oxidation followed by carbon adsorption	0.054	Incineration	5.6

*Toxicity Characteristic Leachate Procedure —Analytical procedure used to determine the concentrations of hazardous constituents in an extract of the waste or waste residue.

The effect of these regulations, especially on mixed wastes, is broad. The hazardous portion of mixed waste must meet BDAT treatment standards. The majority of hazardous waste treatment technologies specified in the standards are not typically used in the U.S. for treatment of radioactive contaminated wastes. The effect of LDR on mixed wastes has resulted in the stockpiling of mixed wastes until acceptable methods of treatment are determined that will meet the standards. The regulations, in contrast, do not allow for the stockpiling of wastes. This places most facilities in the position of being in violation of Federal regulations.

The Federal Facilities Compliance Act was passed in order to solve this problem and force a solution to the lack of demonstrated technologies and capacity for the treatment of mixed waste. This act allows for continued stockpiling (basically during required planning and development of permitted facilities) for the purpose of treating mixed wastes. The approvals and agreement must come from the states within which the different facilities are located. Additionally, dates and milestones are mandated within the act.

Conclusion

Public fears and media attention in high publicity cases, studies indicating long term global effects, and toxicological and epidemiological studies concerning health effects have driven the formation of Federal and state environmental agencies and regulations. This aggressive regulatory and enforcement posture, though not always based on scientifically demonstrated health risks, has defined the limits within we must operate. In addition to the regulation of sources of air pollution and water discharges, the regulations dictate how facilities locate, design and construct, and manage hazardous and mixed waste. This has resulted in an expensive system of hazardous waste management that does not always lead to environmental benefits. As responsible residents of the global community, it is imperative that we be held accountable for the environmental impacts that result from our actions.

Appendix A

Examples of Federal Environmental Laws

NEPA 1969	The National Environmental Policy Act is intended to ensure that Federal agencies and departments consider potential environmental impacts prior to making decisions.
NHPA 1966	The National Historic Preservation Act is intended to ensure consideration of the values of historic properties in carrying out Federal activities.
AAA	The American Antiquities Act and its associated regulations are intended to protect historic, prehistoric ruins, monuments, and antiquities (paleontological resources) on Federally controlled lands.
ARPA	The Archaeological Resources Protection Act is intended to protect archaeological resources located on public and Indian land.
AIRFA 1978	The American Indian Religious Freedom Act in intended to reaffirm Native American rights regarding freedom of religion.
ESA 1973	The Endangered Species Act is intended to ensure that any Federal Agency actions do not unduly jeopardize the continued existence of an endangered or threatened species or cause the destruction or adverse modification of a critical habitat.
CAA	The Clean Air Act is the Federal program intended to ensure the preservation of the nation's air resources and the protection of public health and welfare. The regulations enforced under this legislative authority also include the regulation of radioactive emissions. This law has been amended several times.
CWA, 1972	The Clean Water Act is the Federal program intended to regulate discharges of water through the establishment of ambient water quality standards and effluent discharge limitations (includes sanitary wastewater discharges). These regulations also require compliance with all point-source discharges with technology based standards. This law has been amended several times.
EO 11988	Executive Order 11988 Flood Plain Management 1977 is the Federal mechanism intended to preserve, maintain, and minimize the impacts of floods on human health and welfare as well as preserve and restore the natural and beneficial values served by flood plains.

EO 11990	Executive Order 11990 Protection of Wetlands 1977 is the Federal mechanism intended to avoid to the extent possible, long and short-term adverse impacts to wetlands and to avoid direct or indirect construction in wetlands if there is a practical alternative.
RCRA 1976	The Resource Conservation and Recovery Act is the Federal program intended to govern all aspects of the generation, treatment, storage, and disposal of hazardous wastes as defined by the regulations. This legislation has three major components; management of non-hazardous solid wastes, hazardous wastes, and underground storage tanks.
CERCLA 1980	The Comprehensive Environmental Response Compensation and Liability Act is intended to cover all aspects of the identification, investigation, and remediation of sites where contamination exists or may occur. This legislation is usually referred to as "Superfund."
HSWA 1984	Hazardous and Solid Waste Amendments that mandated stringent new land disposal limitations.
SARA 1986	The Superfund Amendments and Reauthorization Act was passed to increase the funding for the Superfund program and set new, strict standards and schedules. This legislation also provided for new programs, most notably the Emergency Planning and the Community Right-to-Know Act. These amendments have had the effect of greatly increasing the participation and role of the private citizen in the implementation of CERCLA at individual clean-up sites.
HMTA 1975	The Hazardous Materials Transportation Act was intended to establish regulations applicable to all modes of transportation of hazardous material. This includes the transportation of hazardous waste.
SWDA 1974	The Safe Water Drinking Act is intended to protect the nation's underground sources of drinking water from contamination.
TSCA	The Toxic Substances Control Act is intended to regulate and control harmful chemicals and toxic substances in commercial use. The most common chemical regulated under TSCA is Polychlorinated Biphenyls (PCBs).
FIFRA	The Federal Insecticide, Fungicide, and Rodenticide Act was intended to control the manufacture, shipment, storage, and use of all insecticides, fungicides, and rodenticides.

Appendix B

Primary Regulatory Agencies That Oversee LLNL Activities

U.S. Environmental Protection Agency

California Environmental Protection Agency

Bay Area Air Quality Management District

San Joaquin Valley Unified Air Pollution Control District

Regional Water Quality Control Board

—San Francisco Bay Region

—Central Valley Region

U.S. Department of Fish and Wildlife

State Department of Fish and Game

Alameda Country Health Care Services

San Joaquin County Public Health Services

City of Livermore Water Reclamation Plant

California Department of Toxic Substances Control

California Department of Health Services

State Historic Preservation Office

U.S. Corps of Engineers

Department of Energy

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Environmental Regulations define the management system of hazardous waste at the Lawrence Livermore National Laboratory (LLNL)

Introduction

Hazardous Waste Regulations

- Hazardous waste definitions
- Mixed wastes
- Hazardous waste permitting regulations

Hazardous Waste Land Disposal Restrictions

- Best Demonstrated Available Technology (BDAT)
- Concentration standards

Conclusions

Introduction

Public fears have resulted in a proliferation of environmental regulations

Public fear has been driven by:

- **Highly publicized cases**
- **Studies indicating long term global effects**
- **Toxicological and epidemiological studies concerning health effects**

Federal and state governmental response has resulted in a proliferation of environmental agencies and regulations:

- **Over 17 pieces of federal legislation**
- **Federal, California State, and local regulations are implemented and enforced by 16 different environmental regulatory agencies**

Hazardous Waste Regulations

The Resource Conservation and Recovery Act (RCRA) provided broad authority for regulating the management of hazardous waste

- Hazardous waste definitions
- Mixed wastes
- Hazardous waste permitting regulations

Evaluating waste to determine if it is hazardous is a multi-step process

- Is the waste or material a solid waste?
- Is the solid waste to be discarded?
- Does the waste meet the characteristic of a hazardous waste or is it listed?

State and federal agencies define "hazardous waste materials" broadly

Chemical characteristics that classify wastes as hazardous:

- **Ignitable**
- **Corrosive**
- **Reactive**
- **Toxicity**

Three types of listings define hazardous waste:

- **Non-specific Sources – spent solvents and sludges used in degreasing**
- **Specific-Sources – examples includes API separator sludges**
- **Commercial Chemical Products – phenol, vinyl chloride**

Hazardous Waste Regulations

The regulation of "mixed waste" evolved over time

"Mixed wastes" can be defined as radioactive wastes that also contain chemical constituents which are defined as hazardous waste

The Environmental protection Agency, the Nuclear Regulatory Commission and the Department of Energy all have some authority over the management of mixed wastes.

Regulations define requirements by which hazardous and mixed waste must be managed and permitted

Requirements are prescriptive in nature and include:

- **Location standards**
  - **— flood plains**
  - **— earthquake faults**
  - **— buffer zones**
- **Design and construction standards**
  - **— compatibility of construction materials**
  - **— secondary containment**
  - **— engineering certifications**
  - **— security**

Regulations define requirements by which hazardous and mixed waste must be managed and permitted (cont.)

- Operational requirements
  - — waste analysis plans
  - — inspection plans
  - — personnel training plans
  - — manifest systems and record keeping
  - — preparedness and prevention
  - — contingency plans
  - — monitoring plans
  - — corrective action plans
  - — Financial and Insurance Requirements
  - — Closure Plans

Hazardous waste management regulations include Land Disposal Restrictions (LDRs)

The regulations prohibit the disposal of untreated hazardous wastes through:

- **Best Demonstrated Available Technology (BDAT)**
- **Concentration standards**

Specific treatment technologies constitute Best Demonstrated Available Technology (BDAT)

"Best" - based on performance data

"Demonstrated"- treatment technologies are currently in use

"Available" - technologies are available for purchase or lease

Examples of BDAT include:

- **Incineration**
- **Carbon absorption**
- **Wet air oxidation**
- **Stabilization**
- **Neutralization**
- **Recovery of organics**
- **Thermal recovery of metal/organics**
- **Chemical or electrolytic oxidation**

Specific concentration standards are determined by assuming that the wastes are treated by BDAT

EPA analyzes the concentrations of specific hazardous waste constituents in the residues of wastes treated by a BDAT technology

- **Treatment standards are expressed in terms of the maximum constituent-specific concentrations for non-wastewater**

AND

- **Maximum specific concentrations for treated wastewater**

A waste has to meet the LDR standard for each hazardous constituent.

Concentration and BDAT Table

Constituent	BDAT for Wastewater	Wastewater (mg/l)	BDAT for non-wastewater	Non-wastewater (mg/kg)
D006-Cadmium	chemical precipitation	1.0	stabilization/ metal recovery	1.0*
D007-Chromium (total)	chromium reduction, precipitation	5.0	chromium reduction, stabilization	5.0*
D008-Lead	chemical precipitation, sludge dewatering	5.0	stabilization	5.0*
F006- Wastewater treatment sludges from electroplating operations:	Alkaline chlorination, chromium reduction, precipitation with lime and sulfides		Alkaline chlorination, chemical precipitation, settling, filtration, and stabilization	
Cadmium		1.6		0.066
Chromium		0.32		5.2*
Lead		0.040		0.51*
Nickel		0.44		0.32*
Silver		—		0.072*
Cyanides (total)		1.2		590
Cyanides (amenable)		0.86		30
U-220-Toluene	biological treatment, or wet-air oxidation followed by carbon adsorption	0.08	incineration	28.0
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*Toxicity characteristic leachate procedure - analytical procedure used to determine the concentrations of hazardous constituents in an extract of the waste or waste residue.

Conclusions

Public fears have driven the formation of a proliferation of federal and state environmental agencies and regulations

Regulations dictate how facilities locate, design, construct, and manage hazardous and mixed waste; this has resulted in an expensive system of management of hazardous waste

As responsible residents of the global community, it is imperative that we be held accountable for the environmental impacts that result from our actions

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Alameda County Health Care Services
San Joaquin County Public Health Services
City of Livermore Water Reclamation Plant
California Department of Toxic Substances Control
California Department of Health Services
State Historic Preservation Office
U.S. Corps of Engineers
Department of Energy

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