APPENDIX H

INNOVATIVE TECHNOLOGIES

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Appendix H
Innovative Technologies

H.1 Introduction

Much progress has been made in recent years in the development and application of innovative technologies in remediating environmental damage. This appendix provides a description of the following types of technologies concluding with some selected technologies that may be applicable to mine site cleanups. EPA does not make any representation of these technologies but has included them as example of available technology. Selected technologies that are available include:

Soil and Water Treatment Technologies.

- Bioremediation
- Chemical Treatment
- Soil Washing/Flushing
- Solidification and Stabilization
- Solvent/Chemical Extraction
- Thermal Desorption and Thermal Destruction
- Vapor Extraction

Remediation Management Practices

- Application of Mining and Beneficiation Techniques
- Constructed Wetland Remediation
- Reclamation
- Contamination Prevention
- Monitoring and measurement

Several sources are available to gather information about current technologies available. First among these are EPA's Technology Innovation Office (TIO). Most of the information TIO generates resides on the Agency's Clean-Up Information (CLU-IN) home page at **http://clu-in.com.**

H.2 EPA's Technology Innovation Office and Website

The U.S. Environmental Protection Agency, Technology Innovation Office (TIO) was created in 1990 to act as an advocate for new technologies. TIO's mission is to advance the use of new technologies for characterization and remediation. To accomplish this mission, TIO works in concert with states, other federal agencies, professional associations and private companies to create a marketplace with a rich diversity of cost-effective solutions for the Nation's remediation needs. TIO produces numerous one-time and periodic publications and electronic information on technologies and markets for soil and ground water remediation. TIO strives to provide information that is relevant to technology developers, academics, consulting engineers, technology users, and state and federal regulators.

CLU-IN is intended as a forum for all stakeholders in waste remediation and contains information on policies, programs, organizations, publications and databases useful to regulators, consulting engineers, technology developers, researchers, and remediation contractors. The site contains technology descriptions and reports as well as current news on business aspects of waste site remediation and links to other sites important to managers interested in site characterization and soil and groundwater remediation technologies.

Information on the TIO Website **(http://www.epa.gov/swertio1/index.htm)** includes:

Site Remediation Technologies: Technologies Encyclopedia, Descriptions, Technology Selection Tools, Programs & Organizations, Publications

Site Characterization Technologies and Publications

Regulatory Information: Federal Registers, Regulatory Changes

Supply & Demand for Remediation Technologies: Supply of Technologies, Demand for Technologies, Marketing of Technologies, Publications

Publications and Software: Alphabetical list and an indexed list of publications and software organized by subject area.

Other Internet and Online Resource: Related WWW Sites, Other Environmental WWW Sites, Mailing Lists (Listservs), Electronic Bulletin Boards.

APPENDIX I

EPA MINING CONTACTS

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Appendix I
EPA Mining Contacts

I.1 Introduction

This appendix provides a list of contacts at the Environmental Protection Agency who may be able to provide assistance with concerns at abandoned mining and mineral processing sites. The first section provides a list of contacts within various EPA Headquarters Offices. The second section provides a list of contacts at the EPA Regional Offices. The final section provides a list of the members of the EPA Hardrock Mining Team.

This list of contacts was developed in 1998 and will change with time.

I.2 EPA Headquarters Offices			
Name	**Address**	**Phone**	**Fax**
Shahid Mahmud	Superfund Office US EPA 1235 Jefferson Davis Highway Arlington, VA 22202	703-603-8721	703-603-9104
		703-603-8755	
Joe Tieger	Superfund US EPA 401 M St. Washington, DC 20460	202-260-3104	202-260-9007
Steve Hoffman	Mining Coordinator Office of Solid Waste 2800 Crystal Drive Arlington, VA 22101	703-308-8413	703-308-8686
Clara Mickles	Indian Affairs US EPA 401 M St. Washington, DC 20460	202-260-7519	
Steve Silverman	Office of General Counsel US EPA 401 M St. Washington, DC 20460	202-260-7629	202-260-7702
Steve Neugeboren			
Keith Brown	Office of Compliance Manufacturing covering mining US EPA 401 M St. Washington, DC 20460	202-564-7124	
Jorge Rangel	NAFTA US EPA 401 M St. Washington, DC 20460	202-260-0259	202-260-9459
Elaine Suriano	Office of Federal Activities US EPA 401 M St. Washington, DC 20460	202-564-7162	202-260-0129

I.2 EPA Headquarters Offices			
Name	**Address**	**Phone**	**Fax**
Dan Weese	US EPA Office of Water - Nonpoint Source Branch 401 M St. Washington, DC 20460	202-260-6809	
Jennifer Sachar		202-260-1389	
Mary Kay Lynch	Office of Federal Facilities Compliance US EPA 401 M St. Washington, DC 20460	202-564-2581	

I.3 EPA Regional Contacts

Region	Name	Address	Phone	Fax
1	Dennis Huebner Superfund Branch	Waste Management Division 1 Congress Street Boston, MA 02114	617-918-1203	617-573-9662
2	Ray Basso New Jersey Superfund Branch	Emergency and Remedial Response Division 290 Broadway New York, NY 10007-1866	212-637-4109	212-637-4439
	John LaPadula New York/Carribbean Superfund Branch		212-637-4262	
3	Abraham Ferdas Superfund Office	Hazardous Waste Management Division 1650 Arch Street Philadelphia, PA 19107	215-814-3143	215-597-9890
	Maria Parisi Vickers RCRA Programs Office		215-814-3149	215-597-3150
4	Richard Green Superfund and Emergency Response Office	Waste Management Division 61 Forsyth Street Atlanta, GA 30303-3415	404-562-8651	404-347-0076
	Alan Farmer RCRA Permit and Compliance Branch		404-562-8295	
5	Jody Traub Superfund Division	Waste Management Division 77 West Jackson Blvd. Chicago, IL 60604-3507	312-353-2147	312-353-9306
	Norm Niedergang RCRA Division		312-886-7435	312-353-4788
6	Carl Edlund Superfund Programs Branch	Hazardous Waste Management Division Fountain Place 1445 Ross Avenue Suite 1200 Dallas, TX 75202	214-665-8126	214-665-6660
	Arnold Ondarzo RCRA Programs Branch		214-665-6790	214-665-7263
7	Robert Morby Superfund Branch	Waste Management Division 726 Minnesota Avenue Kansas City, KS 66101	913-551-7682	913-551-7060

I.3 EPA Regional Contacts

Region	Name	Address	Phone	Fax
8	Paul Arell Superfund Management Branch	Hazardous Waste Management Division 999 18th Street Suite 500 Denver, CO 80202-2405	303-312-6649	303-293-1230
	Jim Dunn		303-312-6573	
	Carol Russell		303-312-6310	
	Orville Kiehn		303-312-6540	
	Mike Bishop	US EPA Montana Field Office Helena, MT	406-441-1150	
9	Keith Takata - Director Superfund Program	Hazardous Waste Management Division 75 Hawthorne Street San Francisco, CA 94105	415-744-1730	415-744-1916
	John Hillenbrand		415-744-1912	
	Rich Vaille		415-744-2090	
10	Nick Ceto Regional Mining Coordinator	Hazardous Waste Division 1200 Sixth Avenue Seattle, WA 98101	206-553-1816	206-553-0124
	Chris Field Superfund Response and Investigations Branch - Emergency Planning		206-553-1674	
	Bill Riley Office of Water Mining Specialist		206-553-1412	206-553-1441
	Sylvia Kawabata Program Management - Unit Manager		206-553-1078	
	Cindi Godsey	Alaska Operation Office 222 West 7th Ave., #19 Anchorage, AK 99513-7588	907-271-6561	
	Dave Tomten	Idaho Operation Office 1435 North Orchard Street Boise, ID 83706	208-378-5763	

I.4 EPA Hardrock Mining Team				
Region	**Name**	**Address**	**Phone**	**Mail Drop**
Headquarters Contacts				
HQ	Ashley Allen	USEPA Headquarters 401 M Street, SW Washington, DC 20460	703-308-8419	5306W
HQ	Elaine P. Suriano		202-564-7162	2252A
HQ	Joseph Tieger		202-564-4276	2272A
Regional Contacts				
5	Daneil Cozza	Waste Management Division 77 Jackson Blvd. Chicago, IL 60604-3507	312-886-7252	WS-15J
6	Kathleen Aisling	Hazardous Waste Management Division Fountain Place 1445 Ross Avenue Dallas, TX 75202	214-665-8509	6SF-LP
7	Pat Costello	Waste Management Division 726 Minnesota Avenue Kansas City, KS 66101	913-551-7939	WWPD/RMB
8	James Dunn	Hazardous Waste Management Division 999 18th Street Suite 500 Denver, CO 80202-2405	303-312-6573	8EPR-EP
	Carol Russell		303-312-6310	8OC
9	John Hillenbrand	Hazardous Waste Management Division 75 Hawthorne Street San Francisco, CA 94105	415-744-1912	WTR-7
10	Nick Ceto	Hazardous Waste Division 1200 Sixth Avenue Seattle, WA 98101	206-553-1816	ECL-117

APPENDIX J

INTERNET RESOURCES

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APPENDIX J
INTERNET RESOURCES

J.1 Introduction

The purpose of this appendix is to provide the user with information useful to mine site cleanups. This includes accessing the Internet to locate data that may be relevant to mine site remediation activities, information on the technical resources at the Office of Water, and a list of documents relating to Corrective Action. There is a wealth of information on websites sponsored by the Environmental Protection Agency , other federal government agencies , various state governments, academic institutions, sites pertaining to groundwater, publications and journals, Institutes an Ogranizations, both public and private).

Each of the website sections presents the name, Internet address, and a short description of sites containing potentially useful information. The user should note that most of the sites contain a great deal of information that is not related to remediation but which may be of indirect interest. Note also that the following list of sites is not comprehensive, but is, rather, a sampling of the most accessible and useful sites available when this list was prepared.

J.2 Environmental Protection Agency Websites

The EPA homepage provides a map that guides the user to EPA generated information available on the Internet. Of particular interest to site managers will be the following areas within the EPA website.

(http://www.epa.gov)

J.2.1 The Office of Solid Waste and Emergency Response (OSWER)

OSWER homepage--provides links to the following offices within OSWER
(http://www.epa.gov/swerrims/index.htm)

Other Wastes - Mining and Oil and Gas Wastes Information about other solid wastes regulated under RCRA Mining Wastes, Ash and Oil and Gas.
(http://www.epa.gov/epaoswer/osw/other.htm)

Technology Information Office Information about innovative treatment technologies to the hazardous waste remediation community. Includes programs, organizations, publications and other tools for federal and state personnel, consulting engineers, technology developers and vendors, remediation contractors, researchers, community groups, and individual citizens.
(http://www.epa.gov/swertio1/index.htm)

Hazardous Waste - RCRA Subtitle C Information about the hazardous waste program including identification, generation, management and disposal of hazardous wastes.
(http://www.epa.gov/osw/)

Superfund Program - CERCLA Information concerning EPA's program to identify and clean up abandoned or uncontrolled hazardous waste sites and to recover costs for parties responsible for the contamination.
(http://www.epa.gov/superfund/)

Underground Storage Tanks Information concerning underground storage tanks containing petroleum products and other hazardous substances.

(http://www.epa.gov/swerust1/)

Rules and Regulations Federal Register notices concerning EPA's waste programs are posted daily. In addition, there is a list server available for receipt of these Federal Register notices daily. Also, links that contain the Code of Federal Regulations (CFR) and the United States Code (USC).

(http://www.epa.gov/swerrims/rules.htm)

J.2.2 EPA Remedial Technology Information

Technical Information Office/CLU-IN - The Hazardous Waste Clean-up Information Web Site provides information about innovative treatment technologies to the hazardous waste remediation community.

(http://clu-in.com/)

Alternative Treatment Technology Information Center (ATTIC) is a comprehensive computer database system providing up-to-date information on innovative treatment technologies. ATTIC v2.0 provides access to several independent databases as well as a mechanism for retrieving full-text documents of key literature. The system provides information needed to make effective decisions on hazardous waste clean-up alternatives. ATTIC can be accessed with a personal computer (PC) and modem 24 hours a day, and there are no user fees. Please note, ATTIC access requires the use of a modem or telnet application within a web browser program.

(http://www.epa.gov/attic)

Treatment and Destruction Branch - conducts bioremediation and thermal and physical/chemical treatment research. Bioremediation research is focused on using indigenous microorganisms to degrade hazardous organic chemical contaminants in soils and sediments. The thermal and physical/chemical treatment research involves the field-scale evaluation of in-situ and ex-situ vitrification, thermal desorption, soil vapor extraction, and air stripping.

(http://www.epa.gov/ORD/NRMRL/lrpcd/tdb/)

SITE (Superfund Innovative Technology Evaluation) Program - encourages the development and implementation of (1) innovative treatment technologies for hazardous waste site remediation and (2) monitoring and measurement In the SITE Demonstration Program, the technology is field-tested on hazardous waste materials. At the conclusion of a SITE demonstration, EPA prepares an Innovative Technology Evaluation Report, Technology Capsule, and Demonstration Bulletin. These reports evaluate all available information on the technology and analyze its overall applicability to other site characteristics, waste types, and waste matrices. Testing procedures, performance and cost data, and quality assurance and quality standards are also presented.

(http://www.epa.gov/ORD/SITE)

Office of Radiation & Indoor Air Radiation Protection Division Remediation Technology and Tools Center develops guidance for better, faster, and more cost-effective remedial actions, providing technical support to EPA's Superfund program, and developing, organizing, and executing Inter-Governmental projects which foster innovative, effective, and efficient treatment technologies. The Center's main focus areas include Technology Development, Technology Evaluation, Technology Transfer, and Partner Interaction. This website includes links to past project successes and public announcements. Access to publication information and other websites is also included.

(http://www.epa.gov/docs/rpdweb00)

J.2.3 Other EPA Offices and Data Sources

Office of Research and Development (ORD), is the scientific and technological arm of the U.S. Environmental Protection Agency (EPA). ORD is organized around a basic strategy of risk assessment and risk management to remediate environmental and human health problems. ORD focuses on the advancement of basic, peer-reviewed scientific research and the implementation of cost-effective, common sense technology.

(http://www.epa.gov/ORD/)

The **Office of Water** site provides links to a wide variety of information regarding the nation's surface and groundwater resources. Included in these links are sites related to: contaminated sediments; ecosystem protection; groundwater protection; monitoring, data and tools; nonpoint source pollution control; pollution prevention; water quality models; and watershed management programs.

(http://www.epa.gov/OW/)

EPA - Data Systems and Software provides access to numerous database systems available for use in understanding the environment. Some of the available systems include: Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS); Resource Conservation and Recovery Information System (RCRIS); Hazardous Waste Data; and the National GIS Program

(http://www.epa.gov/epahome/Data.html)

EPA National Library Network Program maintains a list of servers providing reference materials, research documents, and other information for use by RPMs. Sites include a sorted list of EPA libraries.

(http://www.epa.gov/natlibra/index.html)

The **Research Programs** site provides information on past, current, and future research efforts undertaken by the Agency and has links to most of the EPA documents available on-line.

(http://www.epa.gov/epahome/research.htm#programs)

J.2.4 SLATE (State, Local, and Tribal Environmental Networks)

(http://www.epa.gov/regional/statelocal/index.htm)

State Governments Home Page provides resources to State Governments involved in implementing environmental protection programs. This page provides a focal point for State governments to exchange information with EPA and each other.

(http://www.epa.gov/regional/statelocal/)

Local Governments Home Page provides resources to Local Governments involved in implementing environmental protection programs. This page provides a focal point for Local governments to exchange information with EPA and each other.

(http://www.epa.gov/regional/statelocal/)

The **American Indian Environmental Office (AIEO)** coordinates the Agency-wide effort to strengthen public health and environmental protection in Indian Country, with a special emphasis on building Tribal capacity to administer their own environmental programs.

(http://www.epa.gov/indian/)

Drinking Water and Health Fact Sheets: The U.S. EPA Office of Groundwater and Drinking Water has introduced fact sheets about chemicals that may be found in some public or private drinking water supplies. These chemicals may cause health problems if found in amounts greater that the health standard set by the U.S. EPA. The consumer version of the fact sheet describes the chemical and how it is used, why the chemical is being regulated, what the health effects are, how much is released into the environment, and several other important facts about the chemical, The technical version of the fact sheets contains similar information plus the chemical and physical properties, trade names for the chemical and other regulatory information. The versions currently available include consumer versions for inorganic chemicals and technical versions for synthetic organic chemicals.

(http://www.epa.gov/OGWDW/dwhintro.html)

J.3 Other Federal Agencies

J.3.1 U.S. Department of Energy

Environment, Safety and Health InfoCenter: Combining information technology and services, the Office of Information Management seeks to facilitate access to quality environment, safety and health information. Through the ES&H InfoCenter, an experienced research staff provides multi-media access to Federal, industry and international information sources.

(http://tis-hq.eh.doe.gov/)

Labs and Facilities Servers site provides a list of links to all the laboratories, sites, and facilities maintained by the Department of Energy.

(http://WWW.DOE.GOV/html/servers/labtitls.html)

J.3.2 U.S. Department of Defense

Defense Environmental Network & Information eXchange (DENIX):: Provides the general public with timely access to environmental legislative, compliance, restoration, cleanup, safety & occupational health, security, and DoD guidance information. Information on DENIX is updated daily and can be accessed through the series of menus, the site map, or via the DENIX full-text search engine.

(http://denix.cecer.army.mil/denix/Public/public.html)

Library: A shared library of environmental information covering compliance, restoration, pollution prevention, natural & cultural resources, occupational safety & health, pest management, environmental planning, etc.

(http://denix.cecer.army.mil/denix/Public/Library/library.html)

Environmental Security Programs: Environmental program information includes: international activities, pollution prevention, conservation, compliance, cleanup/installation restoration, education & training, safety & occupational health, and program integration.

(http://denix.cecer.army.mil/denix/Public/ES-Programs/env-sec.html)

J.3.3 U.S. Geological Survey

U.S. Geologic Survey Mine Drainage Interest Group. The mission of the U.S. Geological Survey (USGS) Mine Drainage Interest Group (MDIG) is to promote communication, cooperation, and collaboration among USGS scientists working on problems related to mining and the environment. The group is interdisciplinary and includes members from all three program divisions of the USGS: Water Resources, Geologic, Biological Resources, and National Mapping.

(http://water.wr.usgs.gov/mine/)

Natural Resources Theme Page: USGS activities in the natural resources theme area inventory the occurrence and assess the quantity and quality of natural resources. Activities also include monitoring changes to natural resources, understanding the processes that form and affect them, and forecasting the changes that may be expected in the future.

(http://www.usgs.gov/themes/resource.html)

Environment Theme Area: Information on this site includes studies of natural physical, chemical, and biological processes, and of the results of human actions. Activities include data collection, long-term assessments, ecosystem analysis, predictive modeling, and process research on the occurrence, distribution, transport, and fate of contaminants as well as the impacts of contaminants on biota.

(http://www.usgs.gov/themes/environ.html)

Publications and Data Products: Provides downloadable files, and links to other sites with information relevant to site remediation, restoration, and reclamation.

(http://www.usgs.gov/pubprod/)

J.3.4 Office of Surface Mining

Environmental Restoration: All functions that contribute to reclaiming lands affected by past coal mining practices are included under environmental restoration. The Office of Surface Mining is developing quantitative on-the-ground measures for performance in this area. When completed in 1998, statistics will be reported that compare on-the-ground performance with appropriated funding.

(http://www.osmre.gov/osm.htm)

Technology Development and Transfer: The Office of Surface Mining provides assistance to enhance the technical skills states and Indian tribes needed to operate regulatory and reclamation programs.

(http://www.osmre.gov/tech.htm)

J.3.5 Bureau of Land Management

Information on this site includes BLM state office, strategic plan, public contact, 98 fiscal budget and calender of events. It provides updated information concerning surface management regulations. **(http://www.blm.gov)**

J.3.6 U.S. Forest Service

This site contains information about all aspects of the U.S. Forest Service. Information in areas of software applications, databases, forest health, forest issues, and upcoming events are available on this site. A directory of contacts is also available.
(http://www.fs.fed.us)

J.4.0 State Websites

J.4.1 Colorado

Colorado Department of Public Health and Environment (CDPHE). This site provides information on Colorado hazardous waste regulations and programs, including research documents. Also contains a list of links to other sites of interest.
(http://www.state.co.us/gov_dir/cdphe_dir/hm/)

Division of Mining, Mine Safety, and Mined Land Reclamation: Contains links to the Colorado Mined Land Reclamation Board, Coal Regulatory Program Office of Active and Inactive Mines, and the Minerals Regulatory Program
(http://www.dnr.state.co.us/geology/)

J.4.2 Montana

Remediation Division, Montana DEQ: The Remediation Division is responsible for overseeing investigation and cleanup activities at state and federal Superfund sites; reclaiming abandoned mine lands; implementing corrective actions and overseeing groundwater remediation at sites where agricultural and industrial chemical spills have caused groundwater contamination. Contains links to the Mine Waste Remediation Bureau, and Hazardous Waste Remediation Bureau, were not functional at the time of publication. **(http://www.deq.mt.gov/rem/index.htm)**

Remediation Division - Information Systems: The Division maintains two information systems of potential interest to RPMs. The: Superfund Site Tracking System (SSTS) - contains information relating to the 278 Montana Superfund sites, including locational information, contaminant information, and agency action information. The Clark Fork Data Management System (CFDMS) serves as a point of assimilation for all chemical/physical/biological analytical information relating to the Upper Clark Fork River Basin. The CFDMS is closely associated with the Natural Resource Information System (NRIS) Geographic Information System (GIS), located at the Montana State Library.
(http://www.deq.mt.gov/rem/infosys.htm)

J.4.3 Nevada

Nevada Department of Environmental Protection, Department of Conservation and Natural Resoruces: This page is the homepage for the state agencies reponsible for mining regulation and reclamation.

(http://www.state.nv.us/ndep/)

The Nevada Division of Minerals: The Nevada Division of Minerals administers programs and activities to further the responsible development and production of Nevada's mineral resources: minerals produced from mines; geothermal; and oil and gas. The division regulates drilling operations of oil, gas, and geothermal wells; administers a program to identify, rank, and secure dangerous conditions at abandoned mines; and manages the state reclamation performance bond pool.

(http://www.state.nv.us/b&i/minerals/)

The Nevada Bureau of Mines and Geology (NBMG): The Nevada Bureau of Mines and Geology (NBMG) is a research and public service unit of the University of Nevada and is the state geological survey. NBMG is part of the Mackay School of Mines at the University of Nevada, Reno. NBMG scientists conduct research and publish reports on mineral resources, engineering geology, environmental geology, hydrogeology, and geologic mapping. Current activities in geologic mapping and mineral resources include detailed geologic mapping and stratigraphic studies in Nevada, comparative studies of bulk-mineable precious-metal deposits, geochemical investigations of mining districts, metallic and industrial mineral resource assessments, igneous petrologic studies, hydrothermal experiments, and research on the origin of mineral deposits.

(http://www.nbmg.unr.edu/)

J.4.4 New Mexico

Bureau of Mines and Mineral Resources: The Bureau is non-regulatory, and serves as the state geological survey to conduct studies and disseminate information on geology, mineral and energy resources, hydrology, geologic hazards, environmental problems, and extractive metallurgy.

(http://geoinfo.nmt.edu/)

Mining and Minerals Division: The Mining and Minerals Division is responsible for implementing the programs which regulate and support development of mining operations in New Mexico. The division also works on safeguarding abandoned mines which pose a danger to people or the environment. Publications are produced by the division which provide information on the mining industry and permitting requirements for development of mining in New Mexico.

(http://www.emnrd.state.nm.us/mining/)

J.4.5 Utah

Division of Environmental Response and Remediation contains information on Underground Storage Tanks, Superfund and Emergency Response.

(http://www.eq.state.ut.us/eqerr/errhmpg.htm)

Division of Water Quality provides information regarding the quality of Utah's lakes and rivers, water quality permitting and regulations.

(http://www.eq.state.ut.us/eqwq/dwq_home.ssi)

J.4.6 Washington

Washington State Department of Ecology: Links to information on site cleanup responses, standards, and regulations; watershed assessments; environmental reviews; hazardous waste sites; and State initiatives. Also contains links to other sites.

(http://www.wa.gov/ecology/)

J.4.7 Florida

Florida Department of Environmental Quality: The mission of Florida's DEQ protect public health and the environment through promotion of waste management practices that minimize waste generation, encourage reuse and recycling, ensure proper management of generated waste, prevent discharges of chemicals and petroleum products contained in storage tank systems, and ensure adequate and timely cleanup of the environment from contamination caused by discharges of hazardous substances and petroleum products.

(http://www2.dep.state.fl.us/waste/)

J.5 Academic Sites

Information on Laurentian University Mining and Environment Databases: It has been developed at Laurentian University Sudbury Ontario, and contains 13,000 journal articles, books and government reports on mining reclamation. Topics include abandoned mines and land use planning, land reclamation, acid mine drainage, leaching, sulphide-based tailings, design and costs, mine closure techniques, and a wide variety of other related topics.

(http://laurentian.ca/www/library/medlib.htm)

Remediation and Restoration at UCLA's Center for Clean Technology. The mission of the Center for Clean Technology's thrust in the area of remediation and restoration is to discover and develop efficient remediation technologies that can achieve acceptable levels of risk and cost for both mankind and the environment.

(http://cct.seas.ucla.edu/cct.rr.html)

Pacific Institute for Advanced Study. The Environmental Group of the PIAS has acquired a broad spectrum of technical capabilities in contaminant characterization, environmental management services, air pollution control using advanced technology biofiltration, innovative soil washing technologies, design and construction of biopiles and biofilters, site and ground water bioremediation, environmental policy and planning, and computer simulation of area migration of contaminants including free phase light hydrocarbons, multicomponent organic liquids, dissolved transport in unconfined aquifers and estimating hydrocarbon recovery by in situ vacuum extraction. The Institute's linkages with a large network of researchers assure that solutions can be quickly and efficiently found to difficult and/or unusual problems that have resisted solutions by traditional means.

(http://www.sway.com/~pacific)

Water Resources Research - Environmental Information Systems Laboratory @ McMaster University. Hydrodynamic Pollutant Transport Simulation ~ Education and Training, Air / Water Interaction ~ GIS and Remote Sensing ~ Municipal Hydraulics, Surface and Groundwater flow. Includes extensive book lists and bibliographical lists with abstracts.

(http://water.eng.mcmaster.ca/home.htm)

Arizona State University's Center for Environmental Studies. The Center conducts research on risk assessment focusing on hazardous materials transportation, contamination and mitigation; social impact assessments; vegetation research focusing in riparian plant ecology, restoration, and effects of anthropogenic disturbances on native plant communities; hazard studies focusing hazardous waste facilities, nuclear waste policy, solid and hazardous waste management, emergency management, and public perception. The site is searchable.
(http://www.asu.edu/ces/)

University of Nevada, The Mackay School of Mines. Provides information and expertise in earth science and engineering. Site provides links to research libraries, Academic departments, and a number of laboratories and research facilities focused on Nevada mines and mining issues.
(http://www.seismo.unr.edu/ftp/pub/unr/board.html)

Colorado School of Mines: Colorado School of Mines is a public university devoted to engineering and applied science related to resources. It is one of a very few institutions in the world having broad expertise in resource exploration, extraction, production and utilization which can be brought to bear on the world's pressing resource-related problems. As such, it occupies a unique position among the world's institutions of higher education. **(http://www.mines.colorado.edu/)**

EH Library Bulletin, University of Washington. The online EH Library Current Contents Bulletin includes new EH Library acquisitions, on-line information, general environmental health news, grant information, and news items that review Web sites, USENET and email groups, and more.
(http://weber.u.washington.edu /~dehlib/textindex.html)

The Research Center for Groundwater Remediation Design, or (RCGRD). The Center conducts research to reduce the costs, risks, and uncertainties associated with groundwater systems. Soils, water-saturated aquifers, the unsaturated zone, and DNAPL are all within the scope of RCGRD's conceptual, computational, and mathematical research activities. Site is under construction, so data may or may not be available. **(http://www.rcgrd. uvm.edu/)**

University of Alabama, Hydrogeology Group. The Hydrogeology Program is actively engaged in research on a wide range of issues of both scientific and practical implications on the nation's groundwater resources. Current Research Topics include: multi-species contaminant fate and transport modeling, simulation-optimization framework for remediation design, global optimization approach for parameter identification; influence of aquifer heterogeneity on groundwater remediation; numerical simulation of tracer tests at the MADE site; and abnormal fluid pressures in sedimentary basins. **(http://hydro.geo.ua.edu/)**

Surfactants Virtual Library at MIT. This site contains links to interesting surfactant and detergent related web sites, with information on surfactant phenomena such as foaming, detergency, micelles, surface tension, emulsions, microemulsions, as well as surfactant applications such as cleaning, cosmetics, environmental remediation, etc. The library is broken down into the following categories: companies, publishers, professional societies, conferences, universities and research centers with interfacial phenomena or surfactant research programs, people involved in surfactant research, surfactant related articles and abstracts published on the Internet, and surfactant applications.
(http://www.surfactants.net)

The Hydrogeology program, Stanford University. This site provides limited access to research on groundwater remediation and research. Current Research Topics include: aquifer heterogeneity; coupled inversion; geologic simulation; in-well VOC removal; optimal aquifer remediation; and rate-limited mass transfer. Contacts and links to other sites are provided.

(http://pangea.stanford.edu/hydro/)

UIC Thermodynamics Research Laboratory. This site provides abstracts of presentations and bibliography for the following topics: statistical mechanics, equations of state, phase equilibria and non-equilibria, asymmetric mixtures characterization, surface and interfacial properties, solubilities in liquids and supercritical gases.

(http://www.uic.edu/~mansoori/TRL_html)

J.6 Groundwater Sites

THE GROUNDWATER REMEDIATION TECHNOLOGIES ONLINE RESOURCE GUIDE. The purpose of this guide is to present a selection of online resources that describe the methods, designs, and effectiveness of various groundwater remediation technologies. Although that is the emphasis of the guide, many of the resources mentioned herein will be useful for researching other matters peripheral to groundwater remediation. Resources include references to web sites; electronic bulletin boards, file servers, subscriber services, and newsgroups.

(http://gwrp.cciw.ca/Internet/online.html)

Mine Environmental Neutral Drainage Program (MEND): Acidic drainage is the largest single environmental problem facing the Canadian mining industry today. Technologies to prevent or substantially reduce acidic drainage from occurring in waste rock piles and tailings sites, and on walls of open pits, need to be developed and proven. These new technologies will substantially reduce the long term financial liabilities facing public agencies at abandoned mine waste sites. In response to this need, in 1989, the Mine Environment Neutral Drainage (MEND) program was established in Canada to initiate and co-ordinate research efforts. Because of special technical needs concerning large waste rock piles, a compatible research program was established in British Columbia, the BC Acid Mine Drainage Task Force.

(http://www.nrcan.gc.ca/mets/mend/)

The Water Librarians' Home Page. This page contains links to resources that developed by a librarian in a California water agency. Topics include: water agencies, water reference databases, comprehensive water pages, water mailing lists; science and technology: earth sciences, engineering, environmental science; and law and government agencies.

(http://www.wco.com/~rteeter/waterlib.html)

J.7 Publications/Journals Sites

Journal of Soil Contamination. This journal provides access to publications of the Association for the Environmental Health of Soils (AEHS). It provides a link between the association's membership and those disciplines concerned with the technical, regulatory, and legal challenges of contaminated soils. The journal will be a quarterly, internationally peer-reviewed publication focusing on scientific and technical information, data, and critical analysis in analytical chemistry, site assessment, environmental fate,

environmental modeling, remediation techniques, risk assessment, risk management, regulatory issues, legal considerations a subscription is required to obtain copies of the journal. **(http://www.crcpress.com/jour/sss/soilhome.htm)**

The Northern Miner: a weekly newspaper covering the activities of North American-based mining companies wherever they are working. Content includes exploration results, onsite reports, company profiles, international projects, property acquisitions, mergers, joint ventures, mine development, stock market activity, complete mining stock table listings and more. Each week our editorial team reports on the latest North American and international developments from such mining hot spots as Chile, Argentina, Peru, Mexico, North America, Australia and Africa. Our reporters have experience in the mining business and know what's important for readers. Our team includes geologists, mining engineers and seasoned editors.
(http://www.northernminer.com)

The Mining Journal: The Mining Journal Ltd is one of the world's leading mining and related construction industry publishers. We have a wide range of publications, many of them leaders in their own particular field, a management consultancy division, and also one of the most comprehensive company and mining databases available. All of our products and services are written, edited and managed by experts from the mining, metallurgical, geological and construction industries.
(http://www.mining-journal.com/mj/)

EPP Publications specializes in the fields of land contamination and reclamation, property development, waste and recycling, and environmental law and policy. Reports must be ordered, and each report must be purchased. This site provides a short abstract of papers that can be ordered, and subscription information to the various journals they publish.
(http://www.btinternet.com/~epppublications/)

Soil and Groundwater Cleanup Online Magazine. This site provides back issues of their magazine. Items of interest include information on: bioremediation; groundwater; in-situ technologies; ex-situ technologies; mixed wastes; site assessment; innovations; industry links; and news on new state and federal regulations.
(http://www.sgcleanup.com/)

J.8 Institutes/Organizations

Eastern Oregon Mining Association: Eastern Oregon Mining Association (EOMA) is a nonprofit organization representing and advocating for the role of mining in the Pacific Northwest. Its membership is primarily made up of operators of small mines, prospectors, and others interested in mining. EOMA is dedicated as well to the preservation of American mineral independence and proper stewardship of the environment. Headquartered in Baker City, Oregon, it has membership from the Cascades to the Rockies and from Washington to Nevada. It routinely provides assistance to Oregon state agencies in mining matters, and is in the forefront of policy making and consultation on multiple use and environmental matters.
(http://www.oregontrail.net/~eoma/)

The Minerals, Metals & Materials Society: Headquartered in the United States but international in both its membership and activities, The Minerals, Metals & Materials Society (TMS) is a professional organization that encompasses the entire range of materials and engineering, from minerals processing and primary metals production to basic research and the advanced applications of materials. Included among its members are metallurgical and materials engineers, scientists, researchers, educators, and administrators from more than 70 countries on six continents.

(http://www.tms.org/)

The Institute of Mining and Metallurgy: The IMM, founded in 1892, is a professional/learned body for engineers in the minerals industry and has its headquarters in London, UK. The IMM is a member of the Council of Mining and Metallurgical Institutions and of Eurominerals, and is a nominated body of the Engineering Council. The aims of the IMM may be summarized as: To advance the science and practice of operations within the minerals industry; To acquire, preserve and communicate knowledge of the industry. The IMM supports the professions involved with most sectors of the industry and technical disciplines include exploration, engineering and mining geology, mining engineering, petroleum engineering, mineral processing and extractive metallurgy as well as health and safety, management and environmental aspects of the industry.

(http://www.imm.org.uk)

The National Mining Association: The National Mining Association (NMA) is the voice of one of America's great basic industries- mining. It was created in 1995 as a result of the merger of two major organizations representing the mining industry at the national level: the National Coal Association and the American Mining Congress. While NMA is a relatively new organization, its predecessor organizations have a long history and tradition. The National Coal Association was founded in 1917 and the American Mining Congress was founded in 1897.

(http://www.nma.org/)

The Gold Institute: The United States is the world's second largest gold producer, capable of meeting all of its domestic gold needs, while exporting 36% of its production. While gold is widely used in jewelry and as a store of value, its importance has increasingly derived from a combination of properties that makes it vital to some of our most advanced technologies.

(http://www.goldinstitute.com)

American Institute of Mining, Metallurgical and Petroleum Engineers: AIME was founded in 1871 by 22 mining engineers in Wilkes-Barre, PA. Just as when it was founded, the goal of AIME today is to advance the knowledge of engineering and the arts and sciences involved in the production and use of minerals, metals, materials and energy resources, while disseminating significant developments in these areas of technology.

(http://www.idis.com/aime/)

Northwest Mining Association: NWMA is a regional association representing our members throughout the United States and Canada. NWMA serves in the role of the state mining association for Oregon and Washington, working closely with sister organizations representing the aggregate industry. We also work closely with the National Mining Association, state mining associations in the western United States, as well as provincial and regional mining associations throughout Canada.

(http://www.nwma.org)

The Society for Mining, Metallurgy and Exploration, Inc.: a member society of AIME - is an international, nonprofit association of some 17,000 professionals working in the mineral industries. SME members have the technical expertise acquired through training and experience and the innovative ability to enhance their industry.
(http://www.smenet.org/)

Rocky Mountain Mineral Law Foundation: Organized in 1955, the Rocky Mountain Mineral Law Foundation is an educational organization which studies the legal issues surrounding mineral and water resources. The Foundation encourages the scholarly and practical study of the law relating to oil and gas, mining, water, public lands, mineral financing and taxation, land use, environmental protection, and related areas. Its programs include institutes, short courses, and workshops in various U.S. and Canadian locations; the development and publication of treatises, books, forms, substantive newsletters, and specialized multi-volume looseleaf services; the administration of scholarships and research grants; and programs for natural resources law teachers.
(http://www.rmmlf.org/)

Nevada Mining Association: This site contains a newsletter on materials in the mining industry.
(http://www.nevadamining.org)

American Academy of Environmental Engineers. This site provides information on most aspects of environmental engineering. Contains an online list of publications relating to site remediation, pollution control, pollution prevention, and other environmental engineering topics.
(http://www.enviro-engrs.org/)

J.9 Other Websites

Waste Prevention World: The California Integrated Waste Management Board's Waste Prevention World site focuses on "doing more with less". It's about efficiency and rethinking daily activities. The site features specific tips on reducing waste at home, in the business place, and when landscaping. It also offers an online database for a topical search, as well as recycling coordination information.
(http://www.ciwmb.ca.gov/mrt/wpw/wpmain.htm)

Mining USA: The staff of Mining Internet Services, Inc. (MISI) is comprised of mining professionals with many years of engineering and industry experience. MISI was created solely to provide Internet services tailored to the mining community. We believe that the Internet is an exciting medium that can be developed into a platform to educate the public about mining. Our goal is to establish the premier mining home page that will set the standard for the industry. Therefore, we are offering extremely competitive rates to those companies and individuals that participate in achieving our goal.
(http://www.miningusa.com/)

INFO - MINE contains some of the most informative mining information on the Internet. Contents include: a daily news service; publications, technical information; company profiles; employment opportunities; and more. Some services require a subscription.
(http://www.info-mine.com/)

MINE-NET an information resource for the mining industry providing information on specific companies; products offered; scientific discoveries; sources of government, academic, professional publications. Contains some remediation data. The site is searchable and contains links to other sites.
(http://www.microserve.net/%7Edoug/index.html)

ENVIRO-LINK is a non-profit organization that is dedicated to providing you with the most comprehensive, up-to-date environmental resources available. Contains some site remediation information, and links to many other sites throughout the world.
(http://www.envirolink.org/)

The AI-GEOSTATS Homepage. Provides a searchable bibliography of geo-statistical information, on-line list of references, and a large list of geo-science publications that deliver subscriber information and data via e-mail.
(http://curie.ei.jrc.it/biblio/index.html)

The Environmental Health Clearinghouse: The site provides an easily accessible, free source of information on environmental health effects. The purpose of the EHC is to help the public get answers to their questions about environmental health and related issues. The EHC can provide information on an assortment of environmental topics including worker exposure, hazardous waste sites, chemical spills and releases, information for schools and students and other environmental health topics. The Clearinghouse uses environmental health technical information specialists to handle inquiries and provide online computer searches, mailing NIEHS publications, conducting research on inquiries, and/or referring the public to appropriate governmental agencies or to private sector organizations.
(http://www.infoventures.com/e-hlth/)

Pacific Northwest Laboratory Protech Online: The Protech Online Web Site is an resource for researching innovative groundwater remediation technologies.
(http://texas.pnl.gov:2080/webtech/menu.html)

J.10 Office of Water, Technical Resources Bibliography

The U.S. Environmental Protection Agency's (EPA) Office of Water serves to protect the nations surface water, groundwater, and drinking water resources. As part of that mission, the Office of Water has prepared a large number of technical documents relating to the remediation of waters contaminated by mining wastes. A selection of these documents are provided below.

Two Internet web pages provide a great deal of information related to the protection of water resources. These include the USEPA Office of Water home page, at:
(http://www.epa.gov/ow)

and MineInfo, a privately operated resources for individuals interested in the mining industry, at
(http://www.info-mine.com)

APPENDIX K

LAND DISPOSAL RESTRICTIONS OVERVIEW AND BIBLIOGRAPHY

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Appendix K
Land Disposal Restrictions Overview and Bibliography

K.1 Introduction

The purpose of this appendix is to provide the user with an understanding of RCRA's Land Disposal Restrictions program and rulemakings and to present a bibliography of related documents that may assist the user in evaluating remediation options at Superfund mine sites.

K.2 History of the Land Disposal Restrictions

Hazardous waste managed under the auspices of RCRA are addressed by a two-part regulatory strategy. The first involves technical standards for management units and is intended to ensure that hazardous waste is contained within the units in which it is managed. Undermining this first part of the strategy, however, is the assumption that land-based units are incapable of long-term containment. The LDR program grew out of the second piece of the strategy, which is to treat the wastes going into these management disposal units to ensure that should containment fail the waste will have little impact on human health and the environment. In the 1984 Hazardous and Solid Waste Amendments (HSWA) to RCRA, Congress specified that land disposal of hazardous waste be prohibited unless the waste meets treatment standards established by EPA. HSWA requires that treatment standards substantially diminish the toxicity or mobility of the hazardous waste, so that short- and long-term threats to human health and the environment are minimized.

K.2.1 LDR Treatment Standards

A waste identified or listed as a RCRA hazardous waste becomes subject to LDR when the Agency establishes treatment levels that the waste must meet before it can be land disposed. RCRA Section 3004(g) requires that EPA prohibit hazardous wastes from land disposal within six months of promulgating a new listing or characteristic. Until the Agency does so, however, newly listed or identified wastes are not subject to LDR and they may continue to be land disposed. Once EPA promulgates final treatment levels for a waste, handlers must manage it in accordance with all the requirements of Part 268 and the waste cannot be land disposed until it meets the treatment level.

Technology-based Treatment Standards: HSWA requires EPA to promulgate treatment standards that reduce the toxicity or mobility of hazardous constituents so that short-and long-term threats to human health and the environment are minimized. To implement this mandate EPA chose to base treatment standards on technical practicability instead of risk assessment. To this end, EPA conducts extensive research into available treatment technologies. Of all the proven, available technologies, the one that best minimizes the mobility and/or toxicity of hazardous constituents is designated as the **Best Demonstrated Available Technology (BDAT)** for that waste. The Agency then establishes a waste code-specific treatment standard based on the performance of the BDAT. These LDR treatment standards are expressed as either concentration levels or required technologies.

> **Concentration levels--** When treatment standards are set as concentration levels, treatment is not limited to the BDAT used to establish the treatment standard; instead the Agency uses BDAT to determine what is the appropriate level of treatment for each hazardous constituent commonly found in the waste. The regulated community may then use any method or technology (except for impermissible dilution) to meet the treatment standard. After treatment, waste analysis or application of knowledge must

be used to determine if the applicable concentration-based standards in Section 268.40 have been met.

Required Technologies-- When a treatment standard is a required technology, that technology must be used, unless it can be demonstrated that an alternative method can achieve a level of performance equivalent to the required technology. Whenever possible, EPA prefers to use numeric treatment standards in order to stimulate innovation and development of alternative treatment technologies.

Since the physical and chemical composition of a waste significantly impacts the effectiveness of a given treatment technology, EPA divided the treatment standard for each waste code into two categories: wastewaters and non-wastewaters. The Agency defines these two categories based on the percentages of total organic carbon (TOC) and total suspended solids (TSS) present in a waste (Section 268.2), since these factors commonly impact the effectiveness of treatment methods.

Universal Treatment Standards: Use of BDATs to set treatment standards for hazardous wastes gave rise to an unintended consequence: the numeric treatment standard applied to an individual hazardous constituent, like benzene, could vary depending on the performance of the BDAT on each listed or characteristic wastestream that was evaluated (e.g., non-wastewater forms of the listed wastes F005 and U019 both require treatment for benzene; however, the treatment standard originally set for benzene in the spent solvent was 3.7 mg/kg, while the standard originally set for unused, discarded benzene was 36 mg/kg, an order of magnitude difference). To simplify the LDR program and eliminate this lack of consistency between standards, the Agency examined the range of numeric standards applied to each hazardous constituent found in restricted hazardous wastes. Based on the range, EPA assigned a single numeric value to each constituent and listed its two treatment standards (wastewater and non-wastewater) in Section 268.48. These standards are known as the Universal Treatment Standards (UTS). Applying these universal treatment standards has not changed the hazardous constituents that must be treated in a particular waste, as only the numeric standards were amended. As a result, a common constituent found in multiple, different wastes will nonetheless carry the same numeric treatment level (e.g., treatment standards for F005 and U019 non-wastewaters continue to address benzene, but the level for each has been adjusted to 10 mg/kg).

Creation of the UTS significantly simplifies the process of assigning treatment standards to wastes that are newly identified or listed in the future. When a new waste contains hazardous constituents that have already been addressed in the UTS, the Agency will be able to apply the existing BDAT-based numeric standards for those particular constituents. Constituents not already included in the UTS can be evaluated individually and then added to Section 268.48.

Hazardous Debris Standards: Section 268.45 contains alternate treatment standards for manufactured items and environmental media that are contaminated with hazardous waste. These alternative standards were developed because materials such as rocks, bricks, and industrial equipment (known generically as debris) contaminated with hazardous waste may not be amenable to the waste code-specific treatment standards in Section 268.40. Section 268.45 allows an owner/operator to choose among several types of treatment technologies, based on the type of debris and the waste with which it is contaminated. The alternative treatment standards for debris can be divided into three categories: extraction, destruction, and immobilization technologies. When using an alternate debris treatment standard, the waste handler must ensure that the treatment process meets the design and operating requirements

established in Section 268.45. In order to be eligible for land disposal, the debris must meet the specified performance standards in Table 1 of Section 268.45. Once hazardous debris has been treated according to the specification of one of these technologies, it may be land disposed in a hazardous waste unit. If hazardous debris no longer exhibits any characteristic following treatment with an extraction (e.g., sandblasting) or destruction (e.g., incineration) technology, it is eligible for land disposal and can be disposed of as nonhazardous or simply returned to the environment (Section 261.3(f)).

K.2.2 LDR Rulemakings

Due to the large number of hazardous waste codes that existed prior to HSWA, LDR treatment standards were developed in stages. In HSWA, Congress set a time frame for the implementation of treatment standards for all wastes listed or identified as hazardous on or before November 8, 1984. Congress set specific prohibition dates for certain high-risk and high-volume wastes and established a three-part schedule with specific deadlines for EPA to develop treatment standards for the remaining listed and characteristic wastes. Wastes identified subsequent to HSWA are considered newly identified or listed; additional rulemakings, promulgated in "phases," have since begun to address these new wastes. This section highlights some especially pertinent parts of those rulemakings and identifies and explains certain complex areas.

Solvent and Dioxin-containing Waste: The solvent and dioxin-containing wastes were the first wastes EPA addressed under the LDR program. Congress set a statutory deadline for EPA to establish treatment standards for these wastes because they are generated either in high volumes (solvent wastes) or are considered highly toxic (dioxin- containing wastes). The final rule published November 7, 1986 (51 FR 40572) established treatment standards for F001-F005 solvent wastes and F020-F023 and F026-F028 dioxin- containing wastes. The rule also established the basic framework for the land disposal restrictions program.

California List Waste: A second group of hazardous wastes for which Congress set a specific LDR deadline is known as the California list as it was compiled from a California Department of Health Services' program. The California list, effective July 8, 1987, prohibited the land disposal of liquid hazardous wastes containing certain toxic constituents or exhibiting certain properties unless subjected to prior treatment (52 FR 25760). The targets of the list included cyanides, pH, polychlorinated biphenyls (PCBs), halogenated organic compounds (HOCs), and metals. Certain HOC-containing wastes were also prohibited even when in solid form. As waste code-specific treatment standards subsequently have been issued, the California list prohibitions have been superseded by treatment standards specific to the RCRA waste code addressing the constituent (or property) of concern.

Thirds: Congress required EPA to meet a schedule for establishing treatment standards for all hazardous wastes identified or listed prior to HSWA. EPA was required to rank the listed wastes from high to low priority, based on the wastes' intrinsic hazard and volume generated. High-volume, high-intrinsic hazard wastes were scheduled to be addressed first, while low-volume, lower-hazard wastes, including characteristic waste, were to have treatment standards established last. Wastes with treatment standards promulgated in the first portion of the three-part schedule are known as First-Third wastes (53 FR 31138; August 17, 1988),followed by the Second-Third wastes (54 FR 26594; June 23, 1989), and Third-Third wastes (55 FR 22520; June 1, 1990).

Treatment Standards for Newly-identified or Newly-listed Wastes: HSWA further requires EPA to establish treatment standards for all hazardous wastes listed or identified after November 8, 1984. EPA is developing treatment standards for these wastes in phases.

The Phase I rule, the first of these rulemakings, was published in the Federal Register on August 18, 1992 (57 FR 37194). In addition to promulgating restrictions for certain new wastes, Phase I finalized the alternative treatment standards for hazardous debris.

The Phase II rule was finalized in the Federal Register on September 19, 1994 (59 FR 47982). This final rule consolidated the existing treatment standards into Section 268.40, created the UTS, and promulgated treatment standards for toxicity characteristic organic wastes, coke by-products, and chlorotoluenes.

The Phase III rule was finalized in the Federal Register on April 8, 1996 (61 FR 15566 and 15660). These final rules modified treatment standards for reactive wastes and decharacterized wastewaters, and promulgated new treatment standards for carbamate wastes and spent aluminum potliners.

The Phase IV rule was published on May 26, 1998 and is important to remediation efforts at mine sites as it addresses the previously exempt Bevill wastes (i.e., wastes from mineral processing facilities that were not among the 20 wastestreams retained in the Bevill exemption) and adjusts the treatment standards applicable to wastes that exhibit the toxicity characteristic for a metal constituent.

K.3 Bibliography of Selected Documents

The following is a bibliography of selected documents published in the dockets supporting Land Disposal Restrictions (LDR) Best Demonstrated Available Technology (BDAT) Phase I through Phase IV Rulemakings that may provide information on how Universal Treatment Standards (UTS) can be met at Superfund Mining sites. For ease of reading, the bibliography has been divided into five sections for documents:

Specific to Toxicity Characteristic (TC) Metals,
Specific to Mineral Processing,
Specific to Treatment Technologies ,
Other BDAT Background Documents (Corrosive Wastes and General), and
Publications by Other EPA Office or Outside Groups Included in the LDR Dockets.

The bibliography also includes the docket-document number, which identifies the docket and is followed by the document number (i.e., for document number F-96-PH4A-S0054, F-96-PH4A is the docket for the first supplemental Phase IV proposed rule, and -S0054 is the document number). The rule and its status also is indicated, since information in proposed rule dockets may not be finalized or may change prior to promulgation.

A review of history helps in understanding the utility of the documents listed. EPA established treatment standards for Extraction Procedure (EP) metals in the LDR Third Third rule finalized in 1990. In 1992, EPA established treatment standards for hazardous waste contaminated debris, including inherently hazardous debris such as lead pipe. Some remedial wastes may be debris-like and may be subject to debris standards. In 1994, EPA finalized the Universal Treatment Standards and established standards for electric arc furnace dust (K061). In establishing the K061 standard and UTS for metals, EPA changed the basis of the BDAT for

many metals to High Temperature Metals Recovery (HTMR). This has not necessarily resulted in a real change in actual waste treatment technologies used.

EPA staff confirmed that stabilization remains the most common treatment method for non-wastewater forms of metal-bearing wastes. Stabilization data appear in documents supporting the Third Third final rule and the Phase IV proposed and final rule. For wastewater forms of metal-bearing wastes, various technologies can be used. These are best described in the UTS background document for wastewaters and the Phase IV proposed rule background documents. Debris is addressed as a separate waste form with unique alternative treatment standards that apply.

None of the BDAT background documents listed in the bibliography are available online. However, in developing BDAT, EPA uses various sources of data, some of which are available to the public via the Internet. While not included in the bibliography, two databases are available through EPA's Alternative Treatment Technology Information Center (ATTIC): the Treatment Technology Database and the Treatability Study Database. ATTIC is available at http//:www.epa.gov/attic/accessattic.html. Other online sources of treatment technology and treatability data are available and have been accessed to support LDR rulemakings.

LAND DISPOSAL RESTRICTIONS (LDR)
BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)
APPLICATION BIBLIOGRAPHY

Document No.	Rule/Status	Title	Notes (Description of waste codes at end of table)
U.S. EPA/Office of Solid Waste LDR Publications			
Specific to TC Metals			
F-96-PH4A-S0054, F-95-PH4P-S0285	Phase IV First Supplemental, Phase IV Proposed	Proposed Best Demonstrated Available Technology (BDAT) Background Document for Toxicity Characteristic Metal Wastes D004-D011, U.S. EPA, with Attachments A and B	Provides waste characterization data and information on treatment technologies for developing BDAT standards for wastewater and nonwastewater forms of the eight TC metal wastes (D004 - D011)
F-95-PH4P-S0289	Phase IV Proposed	Metal Treatment Performance Data From Comments to the Phase III Proposed Rule (Excerpts from Public Comments), U.S. EPA, OSW, WTB, with Attachments A through G	Contains metals treatment performance data from commenters on the Phase III Proposed Rule.
F-94-CS2F-S0021	Phase II Final	Memorandum to Lisa Jones, U.S. EPA, Regarding Final Report of Treatment Data for Nickel-Containing Wastes, From Radian Corporation, with Attachments A through J	Provides a compilation of HTMR treatment performance data used to develop previously promulgated BDAT standards for nickel wastes including K061, F006, K048-K052 and F024.

Document No.	Rule/Status	Title	Notes (Description of waste codes at end of table)
F-94-CS2F-S0023	Phase II Final	Memorandum to Lisa Jones, U.S. EPA, Regarding Comparison of Chromium Data, From Radian Corporation	Contains a comparison of waste treatment data used to develop proposed UTSs for chromium waste with treatment data submitted by Occidental Corp. in their comment (CS2P-00143) to the Proposed Phase II LDR. Includes treatment technology information and performance data for nonwastewater chromium wastes (K061).
F-94-CS2F-S0024	Phase II Final	Memorandum to the Administrative Record for Universal Standards for Metals, Regarding the Report on Chromium Treatment and the Development/Derivation of the Universal Standard for Chromium, with Attachments A and B	Provides detailed discussion of the HTMR and stabilization technologies specifically for the K061 rulemaking.
F-95-PH4P-S0190 F-95-PH4P-S0275	Third Third Final	Final Best Demonstrated Available Technology (BDAT) Background Document for K031, K084, K101, K102, Characteristic Arsenic Wastes (D004), Characteristic Selenium Wastes (D010), and P and U Wastes Containing Arsenic and Selenium Listing Constituents, U.S. EPA [From Third Third]	Provides treatment technology information, performance data, and explains the determination of BDAT for arsenic- and selenium-containing wastes: K031, K084, K101, K102, D004, D010 and P and U wastes.

Document No.	Rule/Status	Title	Notes (Description of waste codes at end of table)
F-95-PH4P-S0274	Third Third Final	Final, Best Demonstrated Available Technology (BDAT) Background Documents for D006 Cadmium Wastes, U.S., EPA	Contains waste-specific information, treatment technology information, and performance data for cadmium-containing wastes (D006) .
F-95-PH4P-S0279	Third Third Final	Final, Best Demonstrated Available Technology (BDAT) Background Documents for Barium Wastes (D005 and P013), U.S. EPA	Contains treatment technology information and performance data for barium-containing wastes (D005). Also details the development of the treatment standards for barium cyanide wastes (P013).
F-95-PH4P-S0280	Third Third Final	Final, Best Demonstrated Available Technology (BDAT) Background Documents for Chromium Wastes D007 and U032, U.S. EPA, with Attachment A and B	Provides treatment technology information, performance data, and performance data analyses for chromium wastes (D007). Also details the development of the treatment standards for calcium chromate wastes (U032).

Document No.	Rule/Status	Title	Notes (Description of waste codes at end of table)
F-95-PH4P-S0281	Third Third Final	Final, Best Demonstrated Available Technology (BDAT) Background Documents for D008 and P and U Lead Wastes, U.S. EPA, with Attachments A and B	Provides treatment technology information, performance data, and performance data analyses for lead-containing wastes (D008). Also discusses lead-containing P- and U-code wastes and details the development of treatment standards for these wastes.
F-95-PH4P-S0282	Third Third Final	Final, Best Demonstrated Available Technology (BDAT) Background Document for Mercury-Containing Wastes D009, K106, P065, P092, and U151, U.S. EPA, With Attachments A and B	Provides treatment technology information, performance data, and performance data analyses for the mercury-containing wastes K106, K071 (nonwastewaters), P065, P092, U151, and mercury TC wastes (D009).
F-95-PH4P-S0283	Third Third Final	Final, Best Demonstrated Available Technology (BDAT) Background Document for Silver-Containing Wastes	Provides treatment technology information and performance data for silver-containing wastes (D011). Also discusses associated silver-containing P-code wastes and details development of treatment standards for these wastes.
Specific to Mineral Processing			

Document No.	Rule/Status	Title	Notes (Description of waste codes at end of table)
F-96-PH4A-S0036	Phase IV First Supplemental	Best Demonstrated Available Technology (BDAT) Background Document for Mineral Processing Wastes, U.S. EPA	Contains a review of several applicable treatment and recovery technologies, comparative analysis, and performance data for mineral processing wastes characteristic for corrosivity (D002) and/or reactivity (D003)
Specific to Treatment Technologies			
F-96-PH4A-S0033	Phase IV First Supplemental	Letter to Anita Cummings, U.S. EPA, Regarding the Preliminary Assessment of Available Data on Metal Recovery Performances, ICF Inc., including Appendix A: Metal Recovery Technology Performance Summaries	Presents performance data from recovery of the 14 BDAT metals from mineral processing wastes. Focuses on electric arc furnace dusts from steel production (K061). Describes what types of waste INMETCO's recovery processes can handle, i.e., K061, K062, F006, D002, D006, D007, D001 and other wastes.

Document No.	Rule/Status	Title	Notes (Description of waste codes at end of table)
F-96-PH4A-S0037	Phase IV First Supplemental	Profiles of Metal Recovery Technologies for Mineral Processing Wastes and Other Metal-Bearing Hazardous Wastes, U.S. EPA	Contains information on characteristics and performance of 30 metal recovery technologies. Provides a preliminary assessment of whether a particular technology is suited for a specific waste (focused on mineral processing waste).
F-96-PH4A-S0038	Phase IV First Supplemental	Review Sheets for Literature on Metal Recovery Technologies for Mineral Processing Wastes, U.S. EPA	Contains review sheets for articles related to mineral processing. Specific information provided includes: if article is applicable to mineral processing wastes; level of development of technology; type of waste; specific waste application; type of process; metals or other products recovered; and if the article contains generation or characterization data on a mineral processing waste.
F-95-PH4P-S0256	Phase IV Proposed	Treatment Technology Background Document, U.S. EPA, OSW, with Attachments A through E	Contains treatment performance data and treatment technology information that may be used to treat wastewaters and nonwastewaters subject to the LDR.

Document No.	Rule/Status	Title	Notes (Description of waste codes at end of table)
F-95-PH4P-S0259	Phase IV Proposed	Proposed Data Document for Characterization and Performance of High Temperature Metals Recovery Treatment and Stabilization for Metal-Bearing Nonwastewaters, U.S. EPA, with Attachments A through Q	Contains performance and characterization data of HTMR treatment and stabiliztion for metal-bearing nonwastewaters including K061, K062, F006, F024, K048-K052, K046, K002, K003, K004, K006, K031, D007, D009, and K106.
F-94-CS2F-S0025	Phase II Final	Memorandum to the Administrative Record for Universal Standards for Metals, Regarding the Report on High Temperature Metal Recovery Processes and Stabilization Considered in the Development of Land Disposal Restrictions for K061 Nonwastewaters, U.S. EPA, 1994	Provides detailed discussion of the HTMR and stabilization technologies specifically for the K061 rulemakings.
F-94-CS2F-S0027	Phase II Final	Final Data Document for Characterization and Performance of High Temperature Metals Recovery Treatment and Stabilization for Metal Bearing Nonwastewaters, U.S. EPA	Presents characterization data and treatment performance data for metals in the Universal Standards Final Rule.
F-94-CS2F-S0030	Phase II Final	Memorandum to the Record, Regarding HTMR versus Stabilization, U.S. EPA, 1994	Contains statement saying that stabilization of metals achieves levels slightly higher than recovery of metals via HTMR.

Document No.	Rule/Status	Title	Notes (Description of waste codes at end of table)
Other BDAT Background Documents (Corrosive Wastes and General)			
F-93-CS2P-S0156	Third Third Final	Final Best Demonstrated Available Technology (BDAT) Background Document for Characteristic Ignitable Wastes (D001), Characteristic Corrosive Wastes (D002), Characteristic Reactive Wastes (D003), and P and U Wastes Containing Reactive Listing Constituents, (Title Page Only)	Contains applicable treatment technologies, characterization, and performance data for ignitable wastes (D001), corrosive wastes (D002), reactive wastes (D003) and P- and U-code wastes containing reactive listing constituents.
F-94-CS2F-S0028	Phase II Final	Final Best Demonstrated Available Technology (BDAT), Background Document for Universal Standards, Volume A: Universal Standards for Nonwastewater Forms of Listed Hazardous Wastes, U.S. EPA, July 1994.	Provides rationale and technical support including treatment technology information and performance data for selecting constituents for regulation under UTS and for developing UTS for nonwastewater forms of listed hazardous waste.
F-94-CS2F-S0046	Phase II Final	Final, Best Demonstrated Available Technology (BDAT), Background Document for Universal Standards, Volume B: Universal Standards for Wastewater Forms of Listed Hazardous Wastes, U.S. EPA, July 1994.	Contains descriptive text and tables showing performance data for treatment of metals in wastewater.

Document No.	Rule/Status	Title	Notes (Description of waste codes at end of table)
F-95-PH4P-S0284	Phase IV Proposed	Draft, Compilation and Examination of Metal Information, U.S. EPA, with Attachment A through D	Discusses treatment technologies and alternative technologies for metal wastes (D004 - D011). Information is also presented for non-TC metals such as antimony, beryllium, nickel, thallium, vanadium and zinc.
F-92-CD2F-S0113	Phase I Final	Memorandum to Mark Mercer Regarding Information on Immobilization of Hazardous Debris and Highly Contaminated Debris, Radian Corporation, Including Attachments A through E regarding organics interferences.	Contains information on immobilization of hazardous debris and examples of highly contaminated hazardous debris.
F-92-CD2F-S0118	Phase I Final	Hazardous Debris Final Rule Technical Support Document, U.S. EPA, 1992, with Attachments A through C.	Contains detailed descriptions of each treatment technology listed as BDAT for hazardous debris and a description of the performance standards applicable to each technology.
Publications by Other EPA Offices or Outside Groups Included in LDR Dockets			
F-95-PH4P-S0026	Phase IV Proposed	Physical/Chemical Treatment Technology Resource Guide, EPA/542-B-94-008, U.S. EPA, TIO.	Provides sources of physical/chemical treatment technology information and technical assistance such as bulletin boards, catalogs, databases, dockets and hotlines.

Document No.	Rule/Status	Title	Notes (Description of waste codes at end of table)
F-95-PH4P-S0222	Phase IV Proposed	Superfund Innovative Technology Evaluation Program: Technology Profiles, Seventh Edition, U.S. EPA, ORD.	Provides descriptions of innovative technologies and what waste they treat (mostly organic but includes heavy metals).
F-92-CD2F-S0061	Phase I Final	Review of In-Place Treatment Techniques for contaminated Surface Soils, Volume 1: Technical Evaluation, U.S. EPA, OSWER, OERR, MERL, and ORD.	Presents information on *in-situ* treatment technologies applicable to contaminated soils less than 2 feet deep. Includes treatment of heavy metals.
F-92-CD2F-S0062	Phase I Final	Review of In-Place Treatment Techniques for Contaminated Surface Soils, Volume 2: Background Information for *In-Situ* Treatment, U.S. EPA, OSWER, OERR, MERL, and ORD.	Presents information on *in-situ* treatment of hazardous waste contaminated soils. Information presented on monitoring to determine treatment effectiveness.
F-92-CD2F-S0064	Phase I Final	Handbook on *In-situ* Treatment of Hazardous Waste-Contaminated Soils, U.S. EPA, ORD, RREL	Provides an analysis of *in-situ* treatment of hazardous waste contaminated soils.

Document No.	Rule/Status	Title	Notes (Description of waste codes at end of table)

Description of Waste Codes

D001 - Characteristic for ignitability
D002 - Characteristic for corrosivity
D003 - Characteristic for reactivity
D004 - Toxicity characteristic (TC) for arsenic
D005 - TC for barium
D006 - TC for cadmium
D007 - TC for chromium
D008 - TC for lead
D009 - TC for mercury
D010 - TC for selenium
D011 - TC for silver

F006 - Treatment sludge from electroplating operations
F024 - Process wastes including distillation residues, heavy ends, tars, and reactor clean-out wastes, from the production of certain chlorinated aliphatic hydrocarbons by free radical catalyzed processes.

K002 - Wastewater treatment sludge from production of chrome yellow and orange pigments.
K003 - Wastewater treatment sludge from production of molybdate orange pigments.
K004 - Wastewater treatment sludge from production of zinc yellow pigments.
K006 - Wastewater treatment sludge from production of chrome oxide green pigments (anhydrous and hydrated).
K031 - By-product salts generated in the production of MSMA and cacodylic acid.
K046 - Wastewater treatment sludge from manufacturing, formulation and loading of lead-based initiating compounds.
K048 - Dissolved air floatation (DAF) float from the petroleum refining industry.
K049 - Slop oil emulsion solids from the petroleum refining industry.
K050 - Heat exchanger bundle cleaning sludge from the petroleum refining industry.
K051 - API separator sludge from the petroleum refining industry.
K052 - Tank bottoms (leaded) from the petroleum refining industry.
K061 - Emission control dust/sludge from the primary production of steel in electric furnaces.
K062 - Spent pickle liquor generated by steel finishing operations of facilities within the iron and steel industry (SIC Codes 331 and 332).
K071 - Brine purification muds from the mercury cell process in chlorine production, where separately prepurified brine is not used.
K084 - Wastewater treatment sludge generated during the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds.
K101 - Distillation tar residues from distillation of aniline-based compounds in the production of veterinary pharmaceuticals from arsenic or organo-
arsenic compounds.
K102 - Residue from the use of activated carbon for decolorization in the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds.
K106 - Wastewater treatment sludge from the mercury cell process in chlorine production.

P013 - Barium cyanide
P065 - Mercury fulminate (R,T)
P092 - Mercury, (aceto -o) phenyl-

U032 - Calcium chromate
U151 - Mercury

APPENDIX L

MINE WASTE TECHNOLOGY PROGRAM

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Appendix L
Mine Waste Technology Program (MWTP)

L.1 Introduction

The purpose of this appendix is to provide the user with information and contacts for the Mine Waste Technology Program (MWTP). This program was created to provide engineering solutions to national environmental issues resulting from the past practices of mining and smelting of metallic ores. The MWTP has developed and implemented a program that emphasizes treatment technology development, testing and evaluation at bench- and pilot-scale, and an education program emphasizing training and technology transfer. Evaluation of the treatment technologies focuses on reducing the mobility, toxicity, and volume of waste; implementability; short- and long-term effectiveness; protection of human health and the environment; community acceptance; and cost reduction.

This program was formed through an interagency agreement between the United States Environmental Protection Agency (EPA) and the Department of Energy (DOE). The program is being implemented by MSE Technology Applications, Inc. (MSE) of Butte, Montana. Montana Tech of the University of Montana (Montana Tech) also located in Butte, Montana, currently provides analytical and computer support to MSE.

L.2 Information Management

As part of MWTP, Montana Tech is documenting mine waste technical issues and innovative treatment technologies. These issues and technologies are then screened and prioritized in categories related to a specific mine waste problem. Technical issues of primary interests are:

Mobile toxic constituents in water, including acid generation issues;
Mobile toxic constituents in air;
Cyanide;
Nitrate;
Arsenic; and
Pyrite.

Waste forms related to these issues include point- and nonpoint-source acid drainage, abandoned mine acid drainage, stream-side tailings, impounded tailings, priority soils, and heap leach-cyanide/acid tailings.

In conjunction with the data collection, Montana Tech has prepared a generic quality assurance project plan that provides specific instructions on how data will be gathered, analyzed, and reported for all activities of the MWTP. Features of both the EPA and DOE quality requirements are incorporated into this plan. Project-specific quality assurance project plans are developed by MSE; in addition, MSE provides oversight for all quality assurance activities performed by Montana Tech.

L.3 Demonstration Projects

As of 1996, MSE had undertaken seven pilot-scale demonstrations of innovative technologies for remediation of mining waste. Brief descriptions of six of the seven pilot projects follow this introduction; Project 6, the Pollution Magnet project, was dropped from the MWTP for reasons related to its similarity with competing technologies that were more developed and had a use that was non-mining-specific. The demonstrations were chosen after a thorough investigation of the technical issue is performed, the specific waste form to be tested is identified, and a sound engineering and cost determination of the innovative technology is formulated.

In addition to the pilot scale programs conducted by MSE, Montana Tech is conducting bench- or small pilot-scale research on several innovative techniques that show promise for cost-effective remediation of mine waste. One major criteria for these projects is the potential for scaling to demonstration pilot plants. One example, the Berkeley Pit Innovative Technologies Project, was initiated to focus on bench-scale testing of remediation technologies to help assist in defining alternative remediation strategies for EPA's future cleanup objectives for the Berkeley Pit waters. The Berkeley Pit is an inactive, open-pit copper mine that has been filling with acidic water since pump dewatering of adjacent underground mines ceased in 1982.

Project 1: Remote Mine Site Demonstration

EPA asked MSE to develop a treatment facility to treat acidic metal-laden water. Due to the remote nature of some mine sites, this facility must operate for extended periods of time on water power alone, without operator assistance.

An example of a remote mine site with a point-source aqueous discharge is the Crystal Mine. Located seven miles north of Basin, Montana, the Crystal Mine was an ideal site for this demonstration. In addition, the site has been identified by the Montana State Water Quality Bureau as a significant contributor of both acid and metal pollution to Uncle Sam Creek, Cataract Creek, and the Boulder River.

The Remote Site Demonstration Project at the Crystal Mine was to be conducted in the field for a minimum of 1 year under all weather conditions. Acid mine drainage from the lower portal of the Crystal Mine began passing through the system on a full-time basis in early September 1994. Initial analytical data from the project showed a greater than 90% removal of toxic metals from the mine drainage. The system was operated and data was collected for 2 years.

Project 2: Clay-Based Grouting Demonstration

Surface and groundwater inflow into underground mine workings becomes a significant environmental problem when water contacts sulfide ores, forming acid drainage. Clay-based grouting has the ability to reduce or eliminate water inflow into mine workings by establishing an impervious clay curtain in the formation. Groundwater flow is the movement of water through fissures and cracks or intergranular spaces in the earth. With proper application, grout can inhibit or eliminate this flow. Grouting is accomplished by injecting fine-grained slurries or solutions into underground pathways where they form a groundwater barrier. The Ukrainian clay-based grouting technology was selected for testing and evaluation because it offered a potentially long-term solution to acid mine drainage problems.

The project was finalized at the Mike Horse Mine near Lincoln, Montana. This site was selected because of its geologic characteristics. A major factor in the selection was an identified point-source inflow from Mike Horse Creek into the mine causing acid drainage that could potentially be controlled using a grouting technology. Grout injection began September 20, 1994, and was completed November 1, 1994.

Approximately 1,600 cubic yards of grout were injected during the initial phase. A second phase of grout injection was planned for the summer of 1995; however, high water damned up within the mine caused extensive damage to the mine and to the monitoring stations for the demonstration. As a result, Phase Two was discontinued.

Project 3: Sulfate-Reducing Bacteria Demonstration

Acid generation typically accompanies sulfide-related mining activities and is a widespread problem. Acid is produced chemically, through pyritic mineral oxidation, and biologically, through bacterial metabolism. This project focuses on a source-control technology that has the potential to retard or prevent acid generation at affected mine sites. Biological sulfate reduction is being demonstrated at an abandoned hard-rock mine site where acid production is occurring with associated metal mobility.

For aqueous waste, the biological process is generally limited to the reduction of dissolved sulfate to hydrogen sulfide and the concomitant oxidation of organic nutrients to bicarbonate. The particular group of bacteria chosen for this demonstration, sulfate-reducing bacteria (SRB), require a reducing environment and cannot tolerate aerobic conditions for extended periods. These bacteria require a simple organic nutrient.

At the acid-generating mine site chosen for the technology demonstration, the Lilly/Orphan Boy Mine near Elliston, Montana, the aqueous waste contained in the shaft is being treated by using the mine as an in situ reactor. An organic nutrient comprised mainly of cow manure was added to promote growth of the organisms. This technology will also act as a source control by slowing or reversing acid production. Biological sulfate reduction is an anaerobic process that will reduce the quantity of dissolved oxygen in the mine water and increase the pH, thereby slowing or stopping acid production.

The shaft of the Lilly/Orphan Boy Mine was developed to a depth of 250 feet and is flooded to the 74-foot level. Acid mine water historically discharged from the portal associated with this level. Pilot-scale work at the Western Environmental Technology Office (WETO) in Butte was performed in 1994. The objective of these tests was to determine how well bacterial sulfate reduction lowers the concentration of metals in mine water at the shaft temperature (8°C) and pH (3.0).

During 1996, the field demonstration was again monitored on a regular basis. The data generally demonstrated a decrease in metals concentrations. An increase in metals was observed during spring runoff; however, the levels decreased when flow rates returned to normal. Monitoring of the field demonstration will continue for an additional year.

Project 4: Nitrate Removal Demonstration

The presence of nitrates in water can have detrimental effects on human health and the environment. As a result, regulatory agencies have limited the allowable concentration of nitrates in effluent water. Nitrates may be present in mine discharge water as a result of the following mining activities: residuals from ammonium nitrate and fuel oil (ANFO) used in blasting; cyanide breakdown from leaching; and leaching of ANFO contamination from waste rock. To comply with Federal and State water quality standards, mining companies have typically used ion exchange or reverse osmosis to remove nitrates from discharge water. Both, however, are expensive and generate a concentrated wastestream requiring disposal.

Of the 20 technologies screened, the following 3 showed the most promise in making nitrate removal more cost effective and environmentally responsible: ion exchange with nitrate-selective resin; biological denitrification; and electrochemical ion exchange (EIX).

The best solution to the nitrate problem may be some combination of the three technologies that balances capital costs with operating costs, reliability, and minimization of wastestreams requiring disposal. Each combination has advantages and disadvantages that will be addressed during the project. A test process train was developed that is flexible and optimizes equipment capital while acquiring value-added test data. The demonstration included the following innovative technologies: ion exchange combined with biological denitrification for destruction of the concentrated brine; ion exchange combined with EIX for destruction of the concentrated brine; biological denitrification as a stand-alone process; and EIX as a stand-alone process.

The Nitrate Removal Demonstration Project was conducted at the TVX Mineral Hill Mine near Gardiner, Montana, where a building to house the equipment was constructed. Conventional ion exchange was used to remove nitrates from the mine water and produce a concentrated brine for additional testing. Biological denitrification units and an EIX unit were used to process both mine water and concentrated nitrate brine. Of all the technology combinations tested, biological denitrification of concentrated nitrate brine was the most successful at meeting these goals.

Biological denitrification was performed on both mine water and concentrated brine. This removal rate met the project goals and was typically greater than 99%. Biological denitrification of the raw mine was less successful. A removal rate of approximately 50% was typically achieved.

Electrochemical ion exchange was able to remove nitrate from the raw mine water more effectively than from the brine. Nitrate was removed at first, however, fouling of the resin by dirty water occurred quickly and the process was rendered ineffective after one batch. Filters were installed to alleviate the problem, but the size and nature of the particles made filtration difficult.

Project 5: Biocyanide Demonstration

The primary use of cyanide in the mining industry is to extract precious metals from ores, and the use of cyanide has expanded in recent years due to increased recovery of gold using heap leach technologies. Most processes use chemicals to oxidize the cyanide and produce nontoxic levels of carbon dioxide and nitrogen compounds. These are relatively expensive to operate.

Biological destruction of cyanide compounds is a natural process that occurs in soils and dilute solutions. To take advantage of this natural destruction, a strain of bacteria was isolated by researchers at Pintail Systems, Inc. The bacteria has been tested on cyanide-contaminated mine waters and has shown degradation rates of over 50% in 15 minutes. The main goal of this project is to use a strain of bacteria to destroy cyanide associated with precious metal mining operations. Another project goal is to develop a reactor design that will best use the cyanide-degrading effects of the bacteria to destroy cyanide from mining wastewater.

The field demonstration portion of the project is located at the Echo Bay McCoy/Cove Mine, southwest of Battle Mountain, Nevada. The mining rate at the mine exceeds 160,000 tons of ore per day. Milling of high-grade and sulfide ores occurs simultaneously with the cyanide solution heap leaching of lower grade ores.

Actual cyanide mine water was processed through the reactors to study the kinetics of cyanide degradation. The results from the tests were then used to design the pilot-scale reactors to be used at the mine. The final process train consists of tanks where both aerobic and anaerobic cyanide-degrading organisms are grown in large quantities. The bacteria are then pumped to the reactors for reinoculation. The cyanide solution enters the aerobic first where aerobic organisms degrade a large portion of the cyanide. The solution then moves through a series of anaerobic units for further degradation. Finally, an aerobic polishing step removes the last traces. Since cyanide is known to degrade by mechanisms other than biological, a series of control reactors was installed to run concurrently with the biological reactors.

Project 6: Arsenic Oxidation

The Arsenic Oxidation Project was proposed to demonstrate and evaluate arsenic oxidation and removal technologies. The technology being demonstrated during this project was developed jointly by the Cooperative Research Center for Waste Management and Pollution Control Limited (CRC-WMPC) and the Australian Nuclear Science & Technology Organization (ANSTO) from Lucas Heights, New South Wales, Australia.

Arsenic contamination in water is often a by-product of mining and the extraction of metals such as copper, gold, lead, zinc, silver, and nickel. In most cases, it is not economical to recover the arsenic contained in process streams because there is little demand worldwide for arsenic.

The small-scale pilot project demonstrated a two-step process for removing arsenic from contaminated mine water. The first step and primary objective of this project was to evaluate the effectiveness of a photochemical oxidation process to convert dissolved arsenic(III) to arsenic(V) using dissolved oxygen as the oxidant. The technology provides a method for the oxidation of arsenic(III) in solution by supplying an oxidant, such as air or oxygen, and a nontoxic photo-absorber, which is capable of absorbing photons and increasing the rate of arsenic(III) oxidation to the solution. The photo-absorber used is economical and readily available. Ultraviolet oxidation using high-pressure mercury lamps and solar energy was tested. The second step of this project resulted in the removal of arsenic(V) from the solution by using an accepted EPA method, adsorption using ferric iron.

The photochemical oxidation process was very effective at oxidating arsenite to arsenate at optimum conditions in the batch mode for both the solar tests and the photoreactor tests. Design problems with the photoreactor unit in the continuous mode, however, would not allow ANSTO to achieve their claim of 90% oxidation of arsenite in solution. Channeling of the process waters in the photoreactor unit was the reason for poor oxidation of arsenite, and steps

to correct the problem during the field demonstration were unsuccessful. Modifications to the baffle system are necessary to prevent further channeling.

For further information on any of these demonstration projects, contact:

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APPENDIX M

REMEDIATION REFERENCES

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Appendix M
Remediation References

M.1 Introduction

The purpose of this appendix is to provide the user with a list of references related to EPA's Groundwater Remediation Program, Cyanide Treatment, and EPA's Corrective Action Program.

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