DOE/AL/63805--T1-App.

WASTE-MANAGEMENT EDUCATION & RESEARCH CONSORTIUM

(WERC)

MASTER

ANNUAL PROGRESS REPORT, 1991-1992
APPENDIXES
APRIL 1992

Administrative Office: New Mexico State University, Box 30001, Department 3805
Las Cruces, New Mexico 88003-0001

DOE/AL/63805--T1-App.

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APPENDIX A

REQUIREMENTS FOR UNDERGRADUATE LEVEL

Basic Requirements:

1. All requirements for a Bachelor s Degree as set by the Department of registration.

2. A minimum of 18 credit-hours of courses from:

   a. The Department Environmental Management Minor List,

   b. The "Undergraduate Minor" list, and

   c. The "Off-Campus Course" list.

3. The 18 credit-hours include:

   a. 6 credit-hours from the "Undergraduate Minor" list outside of the major undergraduate engineering field.

   b. 6 credit-hours of environmental management courses from the outside the student's home university through the WERC ITV Program or on a student exchange basis.

   c. 2 credit-hours of Seminar.

   d. FALL, 1 credit. Environmental Management Seminar I.

   e. SPRING, 1 credit. Environmental Management Seminar II.

The above is a general guideline; there are slight variations in each institution.

APPENDIX A

WASTE-MANAGEMENT EDUCATION AND RESEARCH CONSORTIUM

EXAMPLES OF COURSES FULFILLING THE REQUIREMENTS
OF THE ENVIRONMENTAL MANAGEMENT MINOR

NEW MEXICO STATE UNIVERSITY

Undergraduate Minor

(Prerequisites in Parentheses; COI: Consent of Instructor)

Engineering Design

A EN 459	Design of Water Wells/Pumping Systems (CE 331)	3 cr.
A EN 475	Soil and Water Conservation (CE 331)	3 cr.
A EN 476	Conservation Engineering	1 cr.
CH E 475	Biochemical Engineering I (Math 192 and CHEM 312, or COI)	3 cr.
CH E 476	Biochemical Engineering II (CH E 475)	3 cr.
CH E 478	Special Methods in Industrial Microbiology (BIOL 477 or CH E 475, or COI)	3 cr.
CH E 486	Industrial Waste Treatment Systems (COI)	3 cr.
CH E 492	Nuclear Chemical Engineering (New Course, No Listing)	3 cr.
C E 356	Fundamentals of Environmental Engineering (C E 256)	3 cr.
C E 455	Solid and Hazardous Waste System Design (C E 356)	3 cr.
C E 456	Environmental Engineering Design (C E 356)	3 cr.
M E 475	Power Plant Engineering (M E 341)	3 cr.
M E 496	Kinematics and Dynamics of Robots	3 cr.

Engineering Science

C E 256	Environmental Science (CHEM 102 or CHEM 104, and MATH 192)	3 cr.

APPENDIX A (continued)

C E 355	Technology and the Global Environment (Math 115 and One Semester CHEM or BIOL)	3 cr.
C E 462	Sampling and Analysis of Environmental Contaminants (C E 356)	3 cr.
C E 483	Surface Water Hydrology (C E 331 or COI)	3 cr.
G EN 451/ GEOL 451	Subsurface Geotechnical Investigation (MATH 192, and GEOL 300 or GEOL 332; or COI)	3 cr.
G EN 452 GEOL 452	Geohydrology (MATH 192, and GEOL 330 or GEOL 332; or COI)	3 cr.
G EN 453	Geotechnical Site Evaluation (G EN 357)	3 cr.
M E 468	Compressible Flow (M E 338, M E 340)	3 cr.
M E 492	Nuclear Engineering (PHYS 315, M E 341)	3 cr.

Basic Science

BIOL 301	Principles of Ecology (BIOL 190)	3 cr.
BIOL 403/ GEOG 403	Ecology of Deserts	3 cr.
BIOL 419	Ecology of Microorganisms (BIOL 221, and CHEM 221 or CHEM 311 and 312)	3 cr.
BIOL 461	Human Ecology (2 Semesters Humanities or Social Sciences, and 3 Semesters Pure Science; or COI)	3 cr.
CHEM 485	Nuclear and Radiochemistry (CHEM 102)	3 cr.
GEOG 357	Climatology (MATH 115, and GEOG 155 or GEOG 257; or COI)	3 cr.
GEOG 458	Hydrometeorology (GEOG 257 or GEOG 357)	3 cr.
GEOG 470	Environmental Pollution CHEM 102 or BIOL 110, or COI)	3 cr.
GEOL 295	Environmental Geology	3 cr.
GEOL 474	Ground Water Geology	3 cr.
HL S 470	Epidemiology (HL S 395 or HL S 465, or COI)	3 cr.

PHYS 485	Physics of the Atmosphere (PHYS 215)	3 cr.
PSY 316	Environmental Psychology (PSY 201)	3 cr.
SOIL 424/ CHEM 424/ GEOL 424	Soil Chemistry (SOIL 312 or GEOL 460 or 3 Semesters CHEM)	3 cr.
SOIL 476 BIOL 476	Soil Microbiology (BIOL 221 and SOIL 252)	3 cr.
SOIL 477/ GEOG 477	Soil-Water Relations (MATH 142 or 185, or SOIL 252; or COI)	3 cr.
SOIL 479	Environmental Soil Chemistry (SOIL 312 or GEOL 460 or 3 Semesters CHEM)	3 cr.
TOX 461	Toxicology I (BIOL 110 and CHEM 345)	3 cr.
WLSC 458	Ecology of Inland Waters (CHEM 102 and BIOL 220 and 301 and WLSC 256 and MATH 142)	3 cr.

Environmental Policy

AG E 337/ ECON 337	Natural Resource Economics (ECON 201 or ECON 251)	3 cr.
AG E 437/ ECON 437	Resource Economics for Engineers and Planners (ECON 201 or ECON 251)	3 cr.
AG E 497/ ECON 497	Water Resources Economics (ECON 201 or ECON 251)	3 cr.
B A 322	Water and Mineral Law	3 cr.
PLAN 275	Environmental/Water Management	3 cr.
ECON 463	Cost-Benefit Analysis (ECON 251 and ECON 252)	3 cr.
GOVT 442	The Regulatory Process	3 cr.
IE 411	Industrial Safety (MATH 191, or COI)	3 cr.
PLAN 351	Environmental Planning	1-3 cr.
PLAN 465	Public Land Analysis	3 cr.
PLAN 475	Transportation Planning (COI)	3 cr.
WLSC 310	Management of Endangered Species	3 cr.
WLSC 437	Wildlife Damage Control (COI)	3 cr.
WLSC 447	Wildlife Law, Policy, and Administration	3 cr.

WASTE-MANAGEMENT EDUCATION AND RESEARCH CONSORTIUM

EXAMPLES OF COURSES FULFILLING THE REQUIREMENTS OF THE ENVIRONMENTAL MANAGEMENT MINOR

NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

Undergraduate Minor

(Prerequisite in Parentheses; COI: Consent of Instructor)

BIOL 343	Environmental Microbiology (BIOL 111, BIOL 341)	3 cr.
BIOL 344	Introductory Ecology (BIOL 204, CHEM 122, BIOL 202)	3 cr.
BIOL 346	Introduction to Environmental Toxicology (BIOL 204, CHEM 333, BIOL 344)	3 cr.
CHEM 422	Environmental Chemistry (CHEM 311, 331, or 333)	3 cr.
ENE 201	Introduction to Environmental Science and Engr. (CHEM 122 & 122L, MATH 132, PHYS 122 & 122L, CS 200)	3 cr.
ENE 312	Water and Wastewater Engineering	3 cr.
ENE 410	Air Pollution Engineering (CHEM 311, ENG. SCI. 347, and COI)	3 cr.
ENE 411	Solid Waste Engineering (CHEM 331, ENG. SCI. 314, and COI)	3 cr.
ENE 426	Case Studies in Industrial Environ. Problems (Senior and COI)	3 cr.
ENE 431	Water and Wastewater Systems Hydraulic Design	3 cr.
ENE 4XX	Radiation Protection Engineering	3 cr.
ENE 491	Radioactive Waste Management	3 cr.

APPENDIX A (continued)

GEOCH 422	Environmental Geochemistry (CHEM 311, or 331, or 333)	3 cr.
GEOL Eng 415	Design of Hydraulic Structures	3 cr.
HYD 411	Groundwater Hydrology (PHSY 121, MATH 231 or COI)	3 cr.
HYD 465	Geophysical Methods of Groundwater Evaluation (COI)	3 cr.
MIN Eng. 314	Environmental Management of Mining Waste	3 cr.
MIN Eng. 491	Mine Reclamation	3 cr.
PET 491	Treat. of Produced Water for Disposal by Reinjection	2 cr.
MATE 335	Materials Engineering (MATE 202)	3 cr.
METE 454	Energy and the Environment	3 cr.
MATH 487	Spatial Variability and Geostatistics (MATH 382, CS 121 or 200)	3 cr.

APPENDIX A (continued)

WASTE-MANAGEMENT EDUCATION AND RESEARCH CONSORTIUM

EXAMPLES OF COURSES FULFILLING THE REQUIREMENTS
OF THE ENVIRONMENTAL MANAGEMENT MINOR

UNIVERSITY OF NEW MEXICO

Undergraduate Minor

(Prerequisites in Parentheses; COI: Consent of Instructor)

CHNE 231	Radiation Safety Engineering (CHNE 230, CHEM 121L, ENGR-F 120L)	3 cr.
CHNE 441	Air Pollution Control (Junior in Science or Engineering)	3 cr.
CHNE 466	Nuclear Environmental Safety Analysis (CHNE 330L, CHNE 430, MATH 316, ENG. SCI.	3 cr.
C E	Intermediate Hydrology (C E 332)	3 cr.
C E 433	Groundwater Engineering (C E 332, or COI)	3 cr.
C E 436	Biological Wastewater Treatment (C E 435)	3 cr.
ENGR-N 337	Water Pollution Control	3 cr.
ENGR-N 338	Air Management and Environment	3 cr.

These are only examples; other courses are available from the Associate Dean.

APPENDIX A (continued)

APPENDIX B

REQUIREMENTS FOR GRADUATE LEVEL

To obtain an Environmental Management Minor as part of a graduate level program, a student must complete the following requirements:

1. All requirements for a graduate degree in the major field.

2. A minimum of 8-12 credit-hours of courses from the "Graduate Minor" lists (see attachments) acceptable for graduate credit within the major department. Credit for individual study, thesis, or dissertation may not be used to fulfill this requirement. The credits must include:

   a. A minimum of 3 credit-hours of courses from the home university "Graduate Minor" list, acceptable for graduate credit within the major department, and taken from outside of the major graduate and undergraduate fields.

   b. A minimum of 3 credit-hours acceptable for graduate credit within the major department, offered by partner universities through the WERC Interactive Television Program or on a student exchange basis.

3. Two credit hours of seminar courses in Environmental Management:

   a. 1 credit. Environmental Management Seminar I. A survey of practical and new developments in hazardous and radioactive waste management provided through a series of guest lectures and reports of ongoing research.

   b. 1 credit. Environmental Management Seminar II. A survey of practical and new developments in hazardous and radioactive waste management provided through a series of guest lectures and reports of ongoing research.

4. Either a dissertation, thesis, or an independent study course approved by the major department, as appropriate for the degree, relating to environmental management.

The above guidelines vary slightly between the academic institutions.

APPENDIX B

WASTE-MANAGEMENT EDUCATION AND RESEARCH CONSORTIUM

EXAMPLES OF COURSES FULFILLING THE REQUIREMENTS
OF THE ENVIRONMENTAL MANAGEMENT MINOR
OFFERED AT NEW MEXICO STATE UNIVERSITY

Graduate Minor

AEEC 503	Welfare and Resource Economics	3 cr.
AEN 459	Design of Water Wells/Pumping Systems	3 cr.
AGE 497	Water Resources Economics	3 cr.
BIOL 476	Soil Microbiology	3 cr.
BIOL 519	Microbial Ecology	3 cr.
CHE 475	Biochemical Engineering I	3 cr.
CHE 476	Biochemical Engineering II	3 cr.
CHE 478	Special Methods in Industrial Microbiology	3 cr.
CHE 486	Industrial Waste Treatment Systems	3 cr.
CHE 492	Nuclear Chemical Engineering	3 cr.
CHE 620	Topics in Reservoir Modeling	3 cr.
CHE 630	Topics in Bioengineering	3 cr.
CHE 670	Topics in Combustion and Emission Control	3 cr.
CHEM 485	Nuclear and Radiochemistry	3 cr.
CE 455	Solid & Hazardous Waste System Design	3 cr.
CE 456	Environmental Engineering Design	3 cr.
CE 462	Sampling & Analysis of Environmental Contaminants	3 cr.
CE 483	Surface Water Hydrology	3 cr.
CE 551	Unit Processes/Operations of Water Treatment	4 cr.

APPENDIX B (continued)

CE 552	Unit Processes/Operations of Wastewater Treatment	4 cr.
CE 553	Chemical Theories of Environmental Engineering	3 cr.
CE 554	Microbiological Theories of Environmental Engineering	3 cr.
CE 555	Natural Water and Pollution Control	3 cr.
CE 581	Ground Water Hydrology	3 cr.
CE 582	Statistical Hydrology	3 cr.
ECON 690	Economics of Risk, Uncertainty & Information	3 cr.
GEN 451	Subsurface Geotechnical Investigation	3 cr.
GEN 452	Geohydrology	3 cr.
GEN 453	Geotechnical Site Evaluation	3 cr.
GEOL 474	Groundwater Geology	3 cr.
GEOL 560	Geochemistry of Aqueous Systems	3 cr.
GEOG 458	Hydrometeorology	3 cr.
GEOG 470	Environmental Pollution	3 cr.
GOVT 531	Public Program Evaluation	3 cr.
GOVT 544	Public Policy Analysis	3 cr.
IE 537	Large Scale Systems Engineering	3 cr.
ME 504	Combustion	3 cr.
PHYS 485	Physics of the Atmosphere	3 cr.
PLAN 475	Transportation Planning	3 cr.
SOIL 477	Soil-Water Relationship	3 cr.
SOIL 479	Environmental Soil Chemistry	3 cr.

APPENDIX B (continued)

SOIL 540	Advanced Soil Microbiology	3 cr.
SOIL 551	Advanced Soil Chemistry	3 cr.
SOIL 552	Soil Physics	4 cr.
TOX 461	Toxicology I	3 cr.
TOX 523	Environmental Toxicology	3 cr.
WLSC 458	Ecology of Inland Waters	3 cr.

APPENDIX B (continued)

WASTE-MANAGEMENT EDUCATION AND RESEARCH CONSORTIUM

EXAMPLES OF CURRENT LIST OF EXISTING COURSES DIRECTLY RELATED TO WASTE MANAGEMENT & ENVIRONMENTAL RESTORATION OFFERED AT NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

GRADUATE MINOR

(Prerequisites from NMIMT in parentheses; COI: Consent of Instructor)

BIOL 522	Biology of Aquatic Pollutants (BIOL 347, BIOL 346)	3 cr.
CHEM 532	Atmospheric Chemistry	3 cr.
HYD 504	Hydrogeology (COI)	3 cr.
HYD 525	Hydrogeochemistry (CHEM 122, HYD 411, or COI)	3 cr.
HYD 526	Isotope Hydrology HYD 411	3 cr.
HYD 528	Groundwater Contamination (HYD 411 and HYD 525)	3 cr.
HYD 534	Advanced Groundwater Hydrology (HYD 411)	3 cr.
HYD 538	Vadose Zone Hydrology (HYD 411 or COI)	4 cr.
METE 542	Corrosion and Oxidation (Materials Science 335 or COI)	3 cr.

These are only examples; other courses are available from the Associate Dean.

APPENDIX B (continued)

WASTE-MANAGEMENT EDUCATION AND RESEARCH CONSORTIUM

EXAMPLES OF CURRENT LIST OF EXISTING COURSES DIRECTLY RELATED TO WASTE MANAGEMENT & ENVIRONMENTAL RESTORATION OFFERED AT THE UNIVERSITY OF NEW MEXICO

GRADUATE MINOR

(Prerequisites from UNM in parentheses; COI: Consent of Instructor)

C E 531	Physical-Chemical Water and Wastewater Treatment (C E 435)	3 cr.
C E 532	Advanced Physical-Chemical Water and Wastewater (C E 531)	3 cr.
C E 533	Water Resources Engineering (COI)	3 cr.
C E 534	Environmental Engineering Chemistry (C E 437L)	3 cr.
C E 538	Design of Water and Wastewater Treatment Systems (C E 436, C E 531, or COI)	3 cr.
C E 551	Problems/Special Topics	1-3 cr.

These are only examples; other courses are available from the Associate Dean.

APPENDIX B (continued)

APPENDIX C

GRADUATE DEGREE IN ENVIRONMENTAL ENGINEERING

M. S. ENVIRONMENTAL
ENGINEERING PROGRAM

- Needs Identified
- New Program
- ABET Accredited Program Majority Faculty PE or EIT (4)

Focus Areas: 2/4
- Air Pollution Control
- Water-wastewater
- Solid-Hazardous Waste
- Environmental-Occupational Health

Engineering Design:
- Integrated Approach
- All Environmental Media
- Operation & Maintenance

Laboratory Experience
- Physical/Chemical Biological
- Unit Processes/Operations

Research Project

APPENDIX C

APPENDIX D

NON-DEGREE CERTIFICATE PROGRAM

NON-DEGREE CERTIFICATE PROGRAM REQUIREMENTS

Individuals who have received a bachelor's and/or graduate degrees in appropriate technical fields may obtain WERC Certificates without formally enrolling in a degree program. Such students will normally enroll in the "Non-Degree" status. Below are general guidelines that vary slightly between the academic institutions.

To obtain a "WERC Certificate" in environmental management studies a student must complete a program which includes:

1. A minimum of 15 credit-hours completed with a cumulative GPA of 3.0 or higher of courses acceptable for graduate credit. The 15 credits must include:

    a. A minimum of 6 credit-hours in environmental management courses from the home university "Graduate Minor" list.

    b. A minimum of 6 credit-hours offered from outside the student's home university through the WERC Interactive Television Program or on a student exchange basis.

    c. A 3-hour independent study course in waste management studying a specific problem of interest to the student and under the supervision of a graduate faculty member.

2. Two credit hours of seminar courses in Environmental Management:

    a. 1 credit. Environmental Management Seminar I. A survey of practical and new developments in hazardous and radioactive waste management provided through a series of guest lectures and reports of ongoing research.

    b. 1 credit. Environmental Management Seminar II. A survey of practical and new developments in hazardous and radioactive waste management provided through a series of guest lectures and reports of ongoing research.

The WERC Education Committee will have final review authority on all applications.

APPENDIX D

APPENDIX E

CURRICULUM FOR ASSOCIATE DEGREE PROGRAM

Curriculum for Associate Degree

Fall Semester		Credits
CHEM 110	Chemistry in Our Time	4
ENGL 111	Freshman Composition I	4 (3 + 2p)
MATH 115	Intermediate Algebra	3
ET 115*	Intro. To Hazardous Materials	3
PHYS 211	General Physics	3
PHYS 211L	General Physics Lab	1
	Total	18

Spring Semester		
COMM 265	Prin. of Human Communication	3
ECON 251	Prin. of Macroeconomics OR	
ECON 252	Prin. of Microeconomics OR	
CS 110	Computer Literacy OR	
	Business Related Course	3
ET 121**	Applied Radiation Technology	3
ET 275	Haz. Mat. Sampling & Analysis	4 (3 + 2p)
PHYS 212	General Physics II	3
PHYS 212L	General Physics II Lab	1 (3p)
	Total	17

*ET 115 is a prerequisite for all advanced hazardous materials courses.
**ET 121 is a prerequisite for all advanced radioactive materials courses.

Fall Semester		
ET 268	Applied Robotics	3
MATH 180	Trigonometry	2
ET 211	Radiation Detection	4 (4 + 2p)
ET 225	Industrial Safety & Hygiene	3
ET 271	Radiation Protection	3
PSY 201	Introduction to Psychology OR	
SOC 101	Introduction to Sociology	3
	Total	18

Spring Semester		
ENGL 204	Business Writing OR	
ENGL 218	Tech. & Prof. Communication	3
MATH 185	College Algebra	3
ET 215	Haz. Mat. Management	3
ET 298	Rad/Haz Waste Management	3
ET 297	Emergency Response Tech	2
ET 221	Applied Radiation Biology	2
	Total	16

Degree Requirements: Regular Admission status, cumulative GPA of 2.0, total of 69 hours.

APPENDIX E

APPENDIX F

CURRICULUM FOR NCC PROGRAM

The proposed curriculum for the A.S. degree in DESRT is given below. Subject abbreviations are: AGR, agriculture; ASC, animal science; BIO, biology; CHM, chemistry; GLG, geology; MTH, mathematics; and PHY, physics.

PROGRAM REQUIREMENTS (32 credit hours):

BIO 180	Principles of Biology (+ Lab)	4
CHM 151	General Chemistry I (+ Lab)	5
CHM 154	General Chemistry II (+Lab)	5
ENV 250	Introduction to Environmental Health	3
ENV 271	Environmental Regulation	3
ENV 299	Environmental Internship (Summer)	4
GLG 101	Physical Geology (+ Lab)	4
MTH 115	College Algebra and Trigonometry	4

PROGRAM ELECTIVES (11 or 12 credit hours):
Students choose 3, in consultation with advisor; choice depends on planned major after transfer to B.S. program at 4-year college. (3 is the minimum; students may take more if they choose.)

Choose 2 of the following Science electives:

BIO 184	Plant Biology (+ Lab)	4
BIO 205	Microbiology	4
CHM 235	General Organic Chemistry I	4
GLG 102	Historical Geology	4
PHY 111	General Physics I	4
CSC 121	Programming	4

Plus 1 of the following Environmental electives:

AGR 231	Soil Science (+ Lab)	4
AGR 246	Introduction to Range Science	3
CHM 220	Analytical Chemistry	4
ENV 275	Waste Management	3
ENV 280	Industrial Hygiene	3
GLG 275	Environmental Geology and Hydrology	4

GENERAL EDUCATION REQUIREMENTS (23 credit hours):

Communications (2 courses)	6
Humanities and Fine Arts (1 course)	3
Navajo and Indian Studies (3 courses)	9
Physical Education (1 course)	2
Social Science (1 course)	3

TOTAL FOR A.S. DEGREE PROGRAM 66-67 credit hours

APPENDIX F

APPENDIX G

INFORMATION 1991 TELECONFERENCE SERIES

Hazardous/Radioactive Waste Management Training

An eleven-program series with emphasis on:

- Environmentally sound waste management
- Methods of waste remediation
- Waste minimization
- Regulations and laws pertaining to waste
- Scientific and technological aspects of waste

Videoconference Training Series

A live, interactive satellite series on crucial issues facing business and industry today

The need for information and technologies in the area of hazardous waste and waste management is critical and faces a growing public concern. By eliminating the cost of travel and per diem budgets, this videoconference series addresses the issue in a cost-effective manner. The low cost and local availability also means that more people can be trained for the same investment.

Broadcasting on Wednesdays beginning in April 1991

Presented by

Waste-management Education and Research Consortium

composed of

New Mexico State University • University of New Mexico • New Mexico Institute of Mining and Technology • Sandia National Laboratories • Los Alamos National Laboratory • Navajo Community College (Associate)

APPENDIX G

Hazardous/Radioactive Waste Management

A Technology Transfer Initiative — Professional Training Necessary in the 1990s

This videoconference series has been developed and is presented by the New Mexico Waste-management Education and Research Consortium (WERC), a collaboration of: New Mexico State University, University of New Mexico (series origination site), New Mexico Institute of Mining and Technology, Sandia National Laboratories, Los Alamos National Laboratory, and Navajo Community College (affiliate member). WERC is funded by the Department of Energy. The consortium works together to address hazardous waste issues, facilitating technology transfer, education, training, and research in hazardous waste.

This initiative recognizes the critical nature of waste management in light of the serious ecological problems confronting the country. The series will incorporate the latest technology and research showing practical application for business, industry, research and educational facilities across the country.

WERC is in a unique position to bring together the experts in many aspects of waste management from educational institutions, national research laboratories, and private industry with the aim to encourage responsibility, research, innovative solutions, and environmentally sound practices in waste management, waste remediation, and waste minimization.

OUR AUDIENCE: This training is useful to engineers, scientists, technical managers and supervisors actively working or planning to work in hazardous/radioactive waste management. Representatives from industry, education, utilities, municipalities, and government, as well as university professors, lab personnel, CEOs, operations officers, safety directors, insurance adjusters, and private consultants can all benefit.

CERTIFICATION: WERC awards an official certificate to all students completing the series. CEUs are available. WERC also offers Hazardous Waste Management Credit Courses on KU-band satellite from the three participating universities. Call for details.

PROGRAM DESCRIPTION

This series is composed of eleven programs featuring experts from national laboratories, universities, and industry as well as private consultants. Each program will dedicate a segment to legalities and regulations concerning hazardous waste. Each program will also address scientific and technological aspects of the topic, provide a technology transfer component, and contain case studies and new developments. The audience will have the opportunity to interact with the presenters during the two question/answer segments of each program.

All programs air on Wednesday. A complete description of the program times and a segment breakdown of the four-hour program follows the registration form.

1 - April 3 — Toni K. Ristau, Leader
Introduction: What Is Waste?
- Background of WERC
- Overview of series
- Hazardous and toxic wastes
- Radioactive wastes
- Mixed wastes
- Legal definitions
- Applicable laws and regulations
- Emerging issues
- Technology development/transfer

2 - April 24 — John Hernandez, Leader
Risks Associated with Hazardous and Radioactive Wastes
- Assessment, perception, management
- Toxicology
- Dose-response and exposure models
- Limits of knowledge
- New developments
- Case Studies

3 - May 8 — John L. Wilson, Leader
Transport Processes Related to Wastes
- Groundwater transport, hydrology
- Species transport in groundwater
- Surface water transport and dispersion
- Colloid transport
- Air transport and dispersion
- Interphase transport
- New developments

4 - May 22 — David Kauffman, Leader
Waste Form Modification
- Applicable regulations and standards
- Incinerators - current industrial operation/new developments
- Selected examples of new research and development in chemical treatment of hazardous wastes
- Case studies

5 - June 12 — Randall T. Hicks, Leader
Site Characterization
- Applicable regulations and definitions
- Site characterization requirements
- Geophysical surveys
- Geohydrology, geochemistry, and geostatistics
- Sampling wells
- Case studies

6 - June 26 — Craig Scott Leasure, Leader
Sampling and Analysis
- Applicable regulations
- Field screening methods
- Quality
- Sampling & sample management
- Laboratory analytical methods
- New developments

— Series breaks for summer —

7 - Sept. 11 — Adrian Hanson, Leader
Soil & Groundwater Remediation I: Physical/Chemical Processes
- Overview of contamination sources
- Organic contaminants: airstripping, activated carbon, soil venting
- Inorganic contaminants: heap leaching, soil washing
- New developments

8 - Sept. 25 — Ricardo Jacquez, Leader
Soil and Groundwater Remediation II: Biological Processes
- Fundamentals of bioremediation
- Decision making—Is bioremediation the appropriate option?
- Lab to the field—development process
- Engineering concepts for bioremediation
- Future developments and directions
- Case studies

9 - Oct. 9 — Douglas G. Brookins and Bruce M Thomson, Leaders
Radiation and Radioactive Materials
- Natural radiation background and indoor radon
- Nuclear fuel cycle: where wastes are generated
- NWPA, other regulations and policy
- Spent fuel and high level wastes
  - Waste form and engineered barriers
  - Yucca Mountain site (NNWSI)
- Oklo and other natural analogues

10 - Oct. 23 — Bruce M. Thomson and Douglas G. Brookins, Leaders
Radioactive and Mixed Wastes Management
- TRU and WIPP
- WIPP: overview and science
- Transportation of TRU
- Uranium mill tailings
- Low-level wastes
- Mixed wastes

11 - Nov. 13 — Joan B. Woodard, Leader
Waste Minimization and Series Close
- Waste minimization issues
- Case studies
- New developments
- Series summary and close-out

APPENDIX G (cont.)

ABOUT THE PRESENTERS

Each program will feature three to six presenters with broad backgrounds—technical, management, technology transfer, and regulations. The presenters are from national laboratories, universities, and industry. With more than seventy technical experts involved in this program, we cannot include all biographies, but we would like to introduce you to the individual program leaders:

Videoconference Series Program Director — Roland DeRose has over 30 years of diversified experience in both government and industry that includes logistics, systems analysis, occupational safety and health, and environmental protection. He is a professional member of the Society of Safety Engineers. Roland was the chairman of an environmental management tiger team and is a former Safety Director at Kirtland Air Force Base.

Moderator — Connie Callan, the WERC Manager for Continuing Education and the Marketing Director for the University of New Mexico, Professional Engineering Development/Instructional Television Department. A UNM graduate, Ms. Callan has worked in many departments at the University including the Anderson Schools of Management, Continuing Education, and New Mexico Engineering and Research Institute.

1. Introduction: What is Waste? — Toni K. Ristau serves as the Southwest Regional Director for Geoscience Consultants, Ltd. and provides technical support as an environmental engineer, architect and environmental attorney. She has over 18 years of professional experience in environmental regulatory compliance and enforcement and environmental project/program management. Ms. Ristau has worked as program manager for the CERCLA section for the State of Utah and as Director of Western States Hazardous Waste Project through the Attorney General's Office in Arizona.

2. Risks Associated with Hazardous & Radioactive Wastes — John Hernandez has been a professor of Civil Engineering at New Mexico State University for the past 25 years specializing in water quality management. He has served at both the state (New Mexico Department of Public Health) and at the federal level (Deputy Administrator of the U. S. Environmental Protection Agency). He has broad experience in the management of solid and hazardous wastes and in the regulatory structure on which design criteria is based.

3. Transport Processes Related to Wastes — John L. Wilson is a professor and Director of the Hydrology Program at New Mexico Institute of Mining and Technology in Socorro. He is currently a delegate to the Universities Council on Water Resources, and associate editor of the journal, " Hazardous Waste." Dr. Wilson chairs the Groundwater Hydrology Committee of the American Geophysical Union and is a member of the Committee on Flow in Porous Media, International Association for Hydraulic Research. Dr. Wilson also serves as Vice-Chairman of the Science Advisory Committee, EPS Western Region Hazardous Waste Research Center, Stanford University.

4. Waste Form Modification — David Kauffman is the Associate Dean of the College of Engineering at the University of New Mexico. He is also an associate professor of Chemical and Nuclear Engineering. His areas of specialization include chemical engineering, process plant design, safety and reliability; environmental engineering; geothermal energy; kinetics and catalysis; and engineering design education. Dr. Kauffman is the technical leader of Education Programs for WERC.

5. Site Characterization — Randall T. Hicks is a Certified Professional Geologist specializing in hydrogeology, ground-water monitoring programs, contaminant transport in the unsaturated zone, and geochemistry. Mr. Hicks has directed projects involving the design and installation of waste management systems for many large industrial clients ranging from fiberboard manufacturers to oil refineries. In addition, he has performed geohydrologic evaluations of hazardous waste sites, RCRA and CERCLA sites, municipal wastewater treatment plants, and other facilities. He is the co-author of the 1981 Underground Injection Control Regulations for the state of New Mexico. Mr. Hicks serves as the Senior Vice-President Technical Services for Geoscience Consultants Ltd.

6. Sampling and Analysis — Craig Scott Leasure is Health and Environmental Chemistry Group leader at Los Alamos National Laboratory. He is responsible for chemical analyses supporting radiation protection, industrial hygiene, waste management, and environmental compliance activities. Earlier work at Lockheed included applied research and test projects in support of space shuttle and space station and environmental analysis in air, water and soil.

7. Soil & Groundwater Remediation I: Physical/Chemical Processes — Adrian T. Hanson is an assistant professor in Environmental Engineering with the Civil Agricultural and Geological Engineering Department at New Mexico State University. Working as a project engineer for a consulting firm, Dr. Hanson has had practical experience in municipal, industrial, and hazardous waste treatment. He teaches all phases of environmental engineering, but specializes in chemical/physical treatment. His research has involved diverse topics from in situ sludge digestion for the reclamation of eutrophic lakes to the effect of temperature on turbulent flow field structure and metal chemistry in flocculation. He is currently researching the reclamation of metals contaminated soils using heap leaching.

8. Soil & Groundwater Remediation II: Biological Processes — Ricardo Jacquez is a professor of Civil Engineering at New Mexico State University. Dr. Jacquez is a Technical Head of the Research and Education Programs of the Waste-management Research and Education Consortium (WERC). He is a registered professional engineer in the state of New Mexico. His areas of specialization include environmental engineering; bioremediation of domestic, industrial and hazardous wastes; ground water monitoring and remediation; and hazardous waste management.

9. Radiation and Radioactive Materials — Douglas G. Brookins, Professor of Geology at the University of New Mexico in Albuquerque, teaches courses in environmental geochemistry, radioactive waste disposal, hazardous waste disposal and environmental problems. He has been a consultant and advisor to industry, government and national laboratories in the areas of radioactive waste and geochemistry since 1979. He has written three books and edited a fourth on the subject of geochemical and geological aspects of radioactive waste.

10. Radioactive and Mixed Wastes Management — Bruce M. Thomson, is an associate professor with the Department of Civil Engineering at the University of New Mexico. Dr. Thomson served as a visiting professor of the Environics Division, US Air Force Engineering & Services Center at Tyndall AFB in Florida. He has also consulted for the United Nations Industrial Development Organization in Chile; Sandia National Laboratories; Deuel & Associates; Sullivan Design Group; and Intel Corporation, all in New Mexico. His book, Deserts As Dumps: The Disposal of Hazardous Materials in Arid Ecosystems, will be published in late 1990.

11. Waste Minimization and Series Close — Joan B. Woodard is Director of Manufacturing and Environmental Research and Development Programs at Sandia National Laboratories. She is responsible for research and development in waste minimization, waste treatment, instrumentation, remediation, and waste management. Her earlier work at Sandia included material characterization, combustion research, and solar thermal systems research.

WASTE MANAGEMENT REGISTRATION FORM

Organization/Site Rate

(A site is one geographic location for employees of that organization only.)

Site employing over 4,000 people..... $10,000
Site employing over 1,000 people..... $ 7,000
Site employing over 100-1,000 people..... $ 5,000
Site employing 1-100 people..... $ 3,000
University site..... $ 4,500
One program only..... 20% of series price
First six, or last five programs only..... 80% of series price

Individual Rate

One person may attend at any of the participating WERC universities for $100 per program, or $500 for the entire series of eleven programs.

TAPING RIGHTS: A site automatically receives authorization to tape the broadcasts and use them for in-house training for one month at no additional cost. A site can purchase the permanent rights to the video tapes for double the above-listed prices.

REGISTRATION DEADLINE: Registrations received before February 14, 1991 will not be charged a late fee.

LATE REGISTRATION/CANCELLATION: To avoid a late fee, registrations should be received by February 14, 1991. To cancel a registration or request a refund, call Connie Callan at (505) 277-7750. WERC reserves the right to cancel this series if enrollment is insufficient.

Return registration form to: Attention Connie Callan, The University of New Mexico, College of Engineering, Farris Engineering Center, Room 151, Albuquerque, New Mexico 87131-1387
FAX to (505) 277-7833 Telephone (505) 277-7750

Name_____

Title_____

Signature_____

Organization_____

Address_____

City_____ State_____ Zip_____

Work phone_____ Amount of order_____

Order (please check)

__One program (specify title)_____

__Full series (rates based on the size of the organization).

__First half of series __ Second half (80% of the full series price)

__Individual attending at consortium university site;

please specify which site_____

(If you want to retain the permanent rights to video tapes, remember to double the price.)

Make your check payable to UNM - Professional Engineering Development/Instructional Television.

If you would like us to bill your organization, please provide your purchase order number_____

BROADCAST INFORMATION

TECHNICAL: This series is broadcast on C-Band and KU-Band. Facilities with a satellite dish anywhere in the United States can receive this series, providing on-site training for all your interested employees. We will be happy to help you locate a site in your area.

FACILITATOR TRAINING: A test of your signal and a site coordinator training program will air on March 13, 1991 from 11:00AM-1:30PM Eastern Time. Participants can check the operation of their equipment and learn how to become an effective site coordinator.

BROADCAST DATES: The Waste Management Series begins in April 1991 and is broadcast on Wednesdays. The series breaks for two months in the summer with the final broadcast presented on November 13, 1991.

HOURS:

Eastern	11:30 AM -	3:30 PM
Central	10:30 AM -	2:30 PM
Mountain	9:30 AM -	1:30 PM
Pacific	8:30 AM -	12:30 PM

(A 30-minute test signal precedes each four-hour program)

Basic outline of each program in our series shown in Eastern Standard Time:

11:30-11:35	Introduction
11:35-Noon	First presentation
Noon-12:25	Second presentation
12:25-12:35	Break
12:35-1:00	Third presentation
1:00-1:25	Fourth presentation
1:25-1:35	Short question and answer session
1:35-1:55	Break/lunch
1:55-2:20	Fifth presentation
2:20-2:45	Sixth presentation

About New Videoconferencing Locations

This series can be received anywhere in the United States. Most organizations already have the equipment necessary for receiving these instructional television broadcasts. Organizations not having this capability can purchase a satellite dish for a minimum investment, a one-time cost for equipment. If you are interested in locating a satellite dish in your area, we will be happy to help you.

Ask some of our satisfied customers about our successful videoconferences.

We have a proven track record in producing effective videoconference training. Below are some of our customers, who can provide references about the quality of our programs.

(Partial List)

BDM International
Honeywell
Signetics
Digital Equipment Corporation
Siemans Transmissions
Kirtland Air Force Base
Albuquerque Public Schools
Sandia National Laboratories
Los Alamos National Laboratory
Argonne National Laboratory
Corpus Christi Army Depot
Defense Systems Management College
Naval Ordnance Station
Advanced Micro Devices
General Electric
Goodyear Tire & Rubber Company
Lockheed Missiles & Space Company
University of Missouri
Iowa Central Community College
Tandem Computers
Xerox Corporation

MATERIALS:

A participant's packet, containing a full outline of the course with charts and illustrations used by the presenters, will be provided to each registered site. The packets are designed to follow along with the presenters. Each site has the right to duplicate the packets for participants. Site coordinators will receive a facilitator training packet for the entire series.

MARKETING ASSISTANCE:

A customized brochure, news release, and advertisements can be developed for each site. A ten-minute promotional tape will be available after January 20, 1991. Call for details about the cost of camera-ready art or methods for obtaining a copy of the promotional tape.

Concurrent with the broadcasting of this videoconference series is a compatible series on Total Quality Management. There is a tremendous need for people involved in waste management to understand the principles of Total Quality Management, which include charting and record keeping, managing changing regulations, and perceiving perfection as the only goal.

DISCOUNT

A discount is available for sites enrolled in both these series starting in April from the University of New Mexico. For further information call (505) 277-7750.

APPENDIX G (cont.)

For more information about any aspect of this videoconference, contact:

Connie Callan
WERC Manager
for Continuing Education

Telephone:
(505) 277-7750
FAX: (505) 277-7833

Increasingly, budget cuts have reduced the funds available for travel and conferences. Yet employees must keep abreast of new regulations and technology. The cost-effective training solution for the 1990s:

Videoconferencing Instructional Television

Live and Interactive Satellite Series on
a Crucial Topic for the Times
Now Available:

Hazardous/Radioactive Waste Management

Sponsored by the Waste-management Education Resource Consortium

Printed on Recycled Paper

The University of New Mexico
College of Engineering,
Farris Engineering Center, Rm. 151
Albuquerque, N. M. 87131-1387

Address Correction Requested

Non-Profit Organization
U.S. Postage
PAID
Albuquerque, NM
Permit No. 39

APPENDIX H

INFORMATION ON 1992 TELECONFERENCE SERIES

ESSENTIAL TRAINING FOR INDUSTRY AND GOVERNMENT

Waste Minimization and Pollution Prevention Videoconference Training Series

BEYOND COMPLIANCE – IT MAKES GOOD BUSINESS SENSE!

DOE IS ACTIVELY PARTICIPATING IN THIS EDUCATIONAL ENHANCEMENT INITIATIVE

LIVE TELEVISION INTERACTIVE TECHNOLOGY TRANSFER VIA SATELLITE

Series Starts March 1992, Broadcast on Wednesdays

This televised training addresses the critical nature of waste minimization in light of the serious ecological problems confronting the country. The series will incorporate the latest technology and research showing practical application for business, industry, and educational facilities nationwide.

All programs place a strong emphasis on environmentally-conscious manufacturing.

What is waste minimization and pollution prevention?

Although it is impossible to have entirely "clean" manufacturing, we can reduce the waste generated from nearly all processes. Much of what we call "waste" is actually an unused by-product that could be further processed or refined and sold as a product. Often toxic waste resulting from manufacturing can be reduced significantly through better process control, or avoided entirely by an alternate process.

Presented by

Waste-management Education and Research Consortium

Composed of

New Mexico State University • University of New Mexico • New Mexico Institute of Mining and Technology • Sandia National Laboratories • Los Alamos National Laboratory • Navajo Community College

in Cooperation with

RIOTECH of New Mexico

WERC

DOE NCC SANDIA LOS ALAMOS NMSU

APPENDIX H

Videoconference Training Series

A live, interactive satellite series on crucial issues facing business and industry today.

The need for information and technologies in the area of waste minimization is critical and faces a growing public concern. By eliminating the cost of travel and per diem budgets, this videoconference series addresses the issue in a cost-effective manner. The low cost and local availability also means that more people can be trained for the same investment.

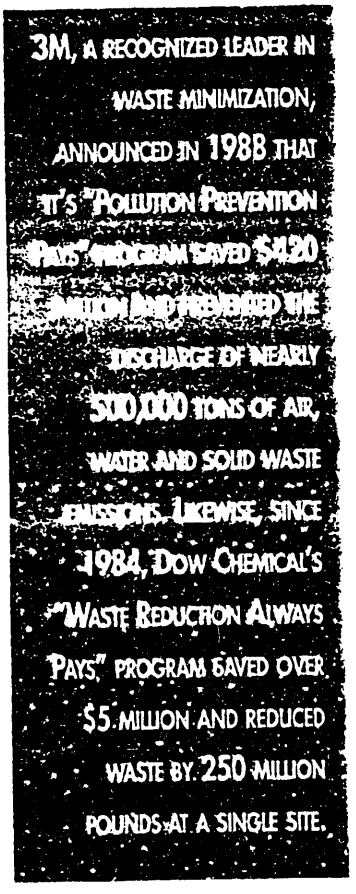
This eight-part series will address hazardous and non-hazardous waste forms. Each program will feature a variety of technical experts, including representatives from universities, national laboratories, and industry.

Every program will include:

- Video demonstrations
- Regulations
- Cost benefits
- Successful applications
- Total Quality Management
- Technology transfer

The Audience: The training is useful to engineers, scientists, technical managers, and supervisors actively working or planning to work on changing processes to implement waste minimization.

Certification: WERC awards certificates of completion to participants. CEUs are also available.



A Technology Transfer Initiative

Waste Minimization and Pollution Prevention Program Description

The audience will have the opportunity to interact with the presenters during the two question/answer segments of each program. All programs air on Wednesday.

Orientation for Facilitators – March 4, 1992, Facilitator Training Meeting

Special program designed to teach facilitators how to use this training series effectively at individual sites.

1. Overview—Why Minimize Waste?—March 25, 1992

Co-Leaders: Joan Woodard, Ph.D., Sandia National Laboratories

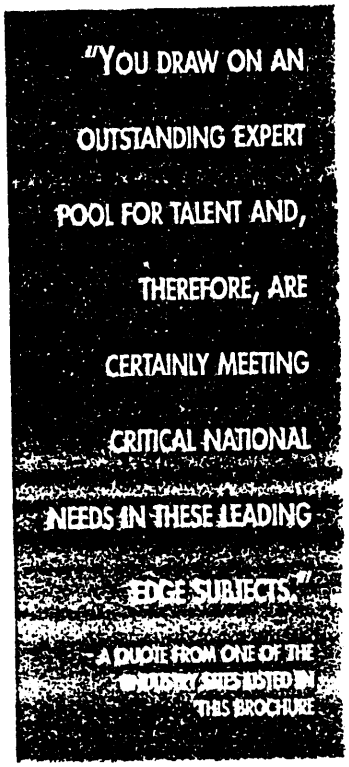
Mary Ann Baker, Esq., NM Environment Dept.

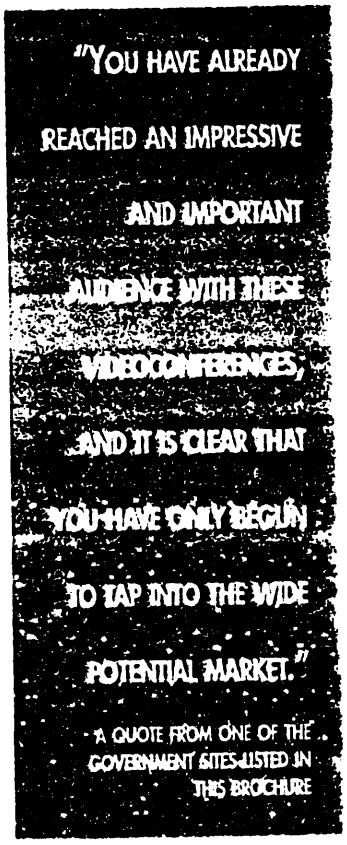
- What is waste minimization?
- Beyond compliance—waste minimization makes good business sense from a cost benefit perspective
- Federal regulations (existing and proposed) and State samples
- Determining baselines—how is it done?
- Goal setting/Looking for opportunities
- How waste minimization affects small businesses
- International concerns/Issues

2. Where Do We Start Waste Minimization?—April 22, 1992

Lead Presenter: Jeff Weinrach, Ph.D., Los Alamos National Laboratory

- The need for assessments
  - Establishing base line
  - Up-front planning (technical, organizational, TQM, teams)
- The methods for assessments
  - Mass balance techniques
  - Life cycle (costs, risks, etc.)
- The goals for assessments
  - Waste minimization
  - Cost effectiveness
  - Knowledge of process
- The follow-through to assessments
  - Metrics for success
  - Design of Environmentally Conscious Processes





3. How Does Recycling/Reuse/ Reclamation Make Economic Sense? – May 6, 1992

Lead Presenter: John Hernandez, Ph.D., NM State University

- Marketable products as by-products
- How to avoid permitting
- Myths versus facts
- The world view: In-process materials substitutions
- Packaging
- Not changing the front-end processes, changing middle
- Case studies (Siemens, etching)

4. Are the Right Product/ Process Designs Being Addressed? – May 20, 1992

Lead Presenter: Robert V. Fultyn, Sc.D., Digital Equipment Corporation (retired)

- How to get it right from the start
- How to use TQM approaches to lower environmental impact
- Concurrent engineering
- New concepts for product and process design
- Discovering and evaluating alternative materials and methods
- Cost effectiveness of redesign
- Measuring and controlling
- Continuous improvement

5. Solvents and Organic Chemicals – June 17, 1992

Co-Leaders: Barry Granoff, Ph.D., Sandia National Laboratories
Jon Nimitz, Ph.D., University of New Mexico

- Overview and purpose
- Alternative chemicals
- Alternative processes
- Systems and cost/benefit analyses
- Success stories
- Beyond compliance

6. How to Implement Minimization in Metals, Plating, and Electrical Interconnects – September 9, 1992

Lead Presenter: Fred Kear, Ph.D., Siemens Stromberg-Carlson

- Waste minimization opportunities in metallization and soldering
- The regulatory impetus for minimizing waste
- Electroplating waste reduction: process changes and recycling
- Lead legislation and electronic soldering alternatives
- Health-related risks associated with lead use
- Alternate processes/Materials for electronic interconnects

7. How to Minimize "End of Life" Problems – September 30, 1992

Lead Presenter: Larry L. Barton, Ph.D., University of NM

- Before the cradle and beyond the grave
- Liability and federal regulations
- Case studies and success stories
- Lead/acid batteries and other products
- Waste incompatibilities and corrosion

8. Planning and Preparing for the Future—October 21, 1992

Panel of Industry, University, and Government Presenters

- Overview of Case studies, direct applications
- Lessons Learned
- Minimization series summary
- Introduction of the next series: **"The Social & Technological Aspects of Risk"**
- Social and technological issues
- Impact on global environment

About the Lead Presenters

Each program will feature three to six presenters with broad backgrounds—technical, management, technology transfer, and regulations. The presenters are from national laboratories, universities, and industry. With more than forty technical experts involved in this program, we cannot include all biographies, but we would like to introduce you to the individual program leaders:

Mary Ann. R. Baker, Esquire, is an Assistant General Counsel for the New Mexico Environment Department (NMED), concentrating on RCRA/UST regulatory enforcement and litigation, CERCLA negotiations, and advising NMED's management on a wide variety of environmental law issues. In addition, she teaches a course on Hazardous Materials Regulations Applicable in New Mexico at the Santa Fe Community College.

Larry Barton, Ph.D., is a faculty member of the UNM Biology Department, where his laboratory studies the microbial transformation of lead, selenium, and chromium. He has also worked with the Dept. of Biochemistry at the University of Georgia and the School of Health and Hygiene at Johns Hopkins University. His research includes physiological activities of microorganisms, focusing on metabolism of inorganic compounds by bacteria.

Robert V. Fultyn, Sc.D., served as a staff member at Los Alamos National Laboratory for over 17 years, engaged in data analysis and modeling of atmospheric phenomena; computer-based laboratory instrumentation; and administrative data processing techniques. He recently retired from Digital Equipment Corporation, after more than ten years of involvement in the advancement of quality and productivity issues by statistical data analysis.

Barry Granoff, Ph.D., is Manager of the Environmentally Conscious Manufacturing (ECM) Programs at Sandia National Laboratories, where his work focuses on waste minimization and pollution prevention, with an emphasis on precision cleaning and solvent substitutes for chlorofluorocarbons and chlorinated hydrocarbons. Prior to this, he has worked in materials science, process chemistry, and energy conversion. He has been involved in numerous technical programs.

John Hernandez, Ph.D., has been a professor of Civil Engineering at NM State University for the past 25 years, specializing in water quality management. He has served at both the state (New Mexico Department of Public Health) and at the federal level (Deputy Administrator of the U.S. Environmental Protection Agency). He has broad experience in the management of solid and hazardous wastes and in the regulatory structure on which design criteria is based.

Fred Kear is a Staff Process Engineer at Siemens Stromberg-Carlson, involved with manufacturing issues and environmental and OSHA compliance. His memberships include: Siemens USA Environmental Network; U.S. Chamber of Commerce Occupational Health and Safety Council, and the Electronics Industry Ad Hoc Lead Committee. He has authored five engineering texts dealing with process engineering and printed circuit manufacture.

Jon Nimitz, Ph.D., joined the NM Engineering Research Institute as a Senior Scientist after teaching chemistry at the University of New Mexico for several years. His specialties include development, assessment, and review of alternative chemicals and processes to minimize ozone depletion, global warming, and nuclear wastes. He has co-authored over 30 technical reports and papers, plus an organic chemistry laboratory textbook.

Jeff Weinrach, Ph.D. earned his doctorate in physical-inorganic chemistry from the University of Wisconsin-Milwaukee in 1987. He has served as a staff member on the Waste Minimization Team for two years. His major responsibility is overseeing and managing the Los Alamos National Laboratory Waste Minimization Program. During the past two years he has delivered 13 presentations regarding waste minimization and pollution prevention.

Joan Woodard, Ph.D., is Director of Manufacturing and Environmental Research and Development Programs at Sandia National Laboratories. She is responsible for research and development in waste minimization, waste treatment, instrumentation, remediation, and waste management. Her earlier work at Sandia included material characterization, combustion research, and solar thermal systems research.

"THE SERIES PLANNED ON WASTE MINIMIZATION SHOULD BE A TIMELY INFORMATION TOOL. REDUCING WASTE WILL MINIMIZE COST OF PRODUCTION, INCREASE SAFETY AND INCREASE PRODUCTIVITY. THUS, THIS SERIES IS CRITICAL FOR EVERYONE IN INDUSTRY AND BUSINESS."

A QUOTE FROM ONE OF THE INDUSTRY SITES LISTED IN THIS BROCHURE.

Why Videoconference Training?

Increasingly, budget cuts have reduced the funds available for travel and conferences. Yet employees must keep abreast of new regulations and technology. Videoconferencing instructional television has proven to be the cost-effective training solution for the 1990s.

About New Videoconferencing Locations

The series can be received anywhere in the United States. Most organizations already have the equipment necessary for receiving these instructional television broadcasts. Organizations not having this capability can purchase a satellite dish for a minimum investment, a one-time cost for equipment. If you are interested in locating a satellite dish in your area, we will be happy to help you.

Broadcast Information

TECHNICAL: This series is broadcast on C-Band and KU-Band. Facilities with a satellite dish anywhere in the United States can receive this series, providing on-site training for all interested employees.

FACILITATOR TRAINING: A test signal and a site coordinator training program will air on March 4, 1992 from 11:00AM-1:30PM Eastern Standard Time. Participants can check the operation of their equipment and learn how to become an effective site coordinator.

BROADCAST DATES: The Waste Minimization/Pollution Prevention series begins on March 25, 1992 and is broadcast on Wednesdays. The series breaks for two months in the summer, with the final broadcast presented on October 21, 1992.

Materials

A participant's packet containing a full outline of the course with charts and illustrations used by the presenters will be provided to each registered site. The packets are designed to follow along with the presenters. Each site has the right to duplicate the packets for participants. Site coordinators will receive a facilitator's training packet for the entire series.

Marketing Assistance

A customized brochure, news release, and advertisements can be developed for each site. A brief promotional tape is also available. Call for details about the cost of camera-ready art or methods for obtaining a copy of the promotional tape.

Broadcast Hours

Eastern	11:30AM - 3:30PM
Central	10:30AM - 2:30PM
Mountain	9:30AM - 1:30PM
Pacific	8:30AM - 12:30PM

(A 30-minute test signal precedes each four-hour program.)
Basic outline of each program in our series shown in Eastern Standard Time:

Agenda Example
(Eastern Time)

CLOCK	DESCRIPTION
11:00AM - 11:30AM	Test Signal, 30 minutes
Section #1	
11:30AM - 11:31AM	Introduction to the Program
11:31AM - 11:35AM	Introduction to the Topic
11:35AM - 12:00PM	First Presentation
12:00PM - 12:25PM	Second Presentation
12:25PM - 12:35PM	Break
Section #2	
12:35PM - 1:00PM	Third Presentation
1:00PM - 1:25PM	Fourth Presentation
1:25PM - 1:35PM	Question and Answer Session
1:35PM - 1:55PM	Lunch
Section #3	
1:55PM - 2:20PM	Fifth Presentation
2:20PM - 2:45PM	Sixth Presentation
Section #4	
2:45PM - 3:00PM	Final Presentation
3:00PM - 3:20PM	Questions and Answers
3:20PM - 3:25PM	Program Wrap-Up
3:25PM - 3:30PM	Introduction to Next Program
3:30PM	Off Air

ASK SOME OF OUR SATISFIED CUSTOMERS ABOUT OUR VIDEOCONFERENCES

We have a proven track record in producing effective videoconference training for use by government contractors, colleges and universities, and industries. The following customers can provide references about the quality of our programs.

Advanced Sciences Inc.
Aerospace Guidance & Meteorology Center
Air Force Institute of Technology
Allied Signal Aerospace
Argonne National Laboratory
AT&T Bell Laboratories
AT&T Technologies
Auburn University
Barksdale AFB
Beale AFB
Bureau of Land Management
Carlswell AFB
Castle AFB
Columbia Basin College, Hanford
Deere and Company
Digital Equipment Corporation
DOE, Albuquerque Operations Office
Dyess AFB
Eaker AFB
EG&G Rocky Flats
EG&G Mound Applied Technology
Electronic Power Research Institute
Ellsworth AFB
El Paso Natural Gas Co.
Envirco
Fairchild AFB
F E Warren AFB
GE - Canada
GE-Neutron Devices
Grand Forks AFB
Griffiss AFB
Grissom AFB
Harris Corporation
Hewlett Packard
IBM
John Deere Dubuque Works
K I Sawyer AFB
Logistics Command
Loring AFB
Los Alamos National Laboratory
Magnavox Electronic Systems
Martin Marietta
Martin Marietta Energy Systems
Malstrom AFB
March AFB
Mason and Hanger Pantex Plant
Metrum Information Storage
Miller Brewing Company
Minot AFB
Motorola
Muskegon Community College
National Cash Register
National Semiconductor
National Technological University
Naval Research Laboratory
Naval Weapons Support
NCR Corporation
New Mexico Junior College
New Mexico State University
ND University Systems
NM Institute of Mining and Technology
NM Primate Research Lab
Oklahoma State University
Offutt AFB
Pacific Bell
Paducah Community College
Plains Electric Corporation
Pike's Peak Community College
Plattsburgh AFB
Postal Service
Purdue University
Rio Grande Minority Purchasing Council
San Juan College
Sandia Livermore National Lab
Sandia National Laboratories
Savannah River Laboratories
Siemens
Southern Methodist University
State of NM Environment Dept.
Tennessee Eastman Company
UNC
UNI - Chem International
UNM, Occupational Health & Safety
U.S. Army Corps of Engineers
University of Maryland
University of New Mexico
Western New Mexico University
Westinghouse, WIPP Site
Whiteman AFB
Wurtsmith AFB

Registration Information

Registrations received before December 31, 1991 receive a 10% discount. For more information, call toll-free, 1-800-292-7051.

Late Registration/Cancellation: To avoid a late fee, registrations should be received by March 2, 1992. To cancel a registration or request a refund, call Connie Callan at (505) 277-7750. WERC reserves the right to cancel this series if enrollment is insufficient.

Taping Rights: A site automatically receives authorization to tape the broadcasts and use them for in-house training for one month at no additional cost. A site can purchase the permanent rights to the video tapes for double the listed prices.

ORDER FORM

(please check below)

Eight-program series (and Facilitator Program) price (unlimited viewers at one site)

- ❑ Corporate rate ($7000 per site)
- ❑ Government rate ($5900 per site)
- ❑ University rate ($5000 per site)

Per-program price

- ❑ Individual rate at any site ($100 per person, per program)
- ❑ Unlimited attendance at any site ($900 per program)

Taping Rights: A site automatically receives authorization to tape the broadcasts and use them for in-house training for one month at no additional cost. A site can purchase the permanent rights to the video tapes for double the listed prices.

Name _____ Title _____

Address _____ City, State, & Zip _____

Organization _____ Work phone _____

Signature _____ Amount of order _____

Please make your check payable to UNM, Professional Engineering Development/ITV.

If you would like us to bill your organization, please provide your purchase order number:

Return registration form to:

Waste-management Education and Research Consortium
c/o The University of New Mexico, College of Engineering
Farris Engineering Center, Room 151, Albuquerque, NM 87131-1387
or FAX to: (505) 277-7833

Also Available:

"Hazardous/Radioactive Waste Management Training, an 11-program videotape series presented by WERC. A packet of briefing materials accompanies each program on the following topics:

- What Is Waste?
- Risks Associated with Hazardous and Radioactive Wastes
- Transport Processes Related to Wastes
- Waste Form Modification
- Site Characterization
- Sampling and Analysis
- Soil and Groundwater Remediation I: Physical/Chemical Processes
- Soil and Groundwater Remediation II: Biological Processes
- Radiation and Radioactive Materials
- Radioactive and Mixed Wastes Management

Waste Minimization and Series Close

Also Available through WERC: Televised academic courses leading to a certificate in Hazardous Waste Management.

"Total Quality Management, a 7-part videotape training series, produced by the University of New Mexico. Briefing materials accompany each videotaped program.

- Introduction and Implementing TQM in Your Organization
- Organizational Change and Leadership in TQM
- Selecting and Understanding Processes for Improvement in TQM
- Designing Experiments and Gathering Information in TQM
- Analysis and Interpretation of Results in TQM
- Implementing Process Change and Institutionalizing TQM in Your Organization

Videoconferences and live workshops – "Technical Training for Engineers and Managers"

- Total Quality Management (TQM)
- Hazardous Waste Management
- Waste Minimization/Pollution Prevention
- Fuzzy Logic

For more information contact:

Connie Callan

WERC Manager for Continuing Education

Telephone
(505) 277-7750

Toll Free
1-800-292-7051

FAX
(505) 277-7833

A Live and Interactive Satellite Series on a Crucial Topic for the Times Is Now Available:

Waste Minimization and Pollution Prevention

Presented by the Waste-management Education Resource Consortium, in Cooperation with Riotech

The cost-effective training solution for the 1990s:
Videoconferencing Instructional Television

Beyond Compliance–It Makes Good Business Sense!

The University of New Mexico
College of Engineering
Farris Engineering Center, Rm. 151
Albuquerque, NM 87131-1387

APPENDIX I

WERC INTERACTIVE TELEVISION COURSES

FALL 1991 INTERACTIVE TELEVISION COURSES

AG E 337	Natural Resources Economics MWF 11:30-12:20 p.m. Instructor: Frank Ward Origin: NMSU	3 cr
IE 411	Industrial Safety MW 4:30-5:45 p.m. Instructor: John McGee Origin: NMSU	3 cr
ENV 401	Air Pollution Engineering MWF 3:00-3:50 p.m. Instructor: Clinton Richardson Origin: NMIMT	3 cr
METE 454	Energy and the Environment TTH 9:30-10:45 a.m. Instructor: Osman Inal Origin: NMIMT	3 cr
CHNE 466	Nuclear Environment Safety Analysis MW 7:30-8:45 a.m. Instructor: Bob Busch Origin: UNM	3 cr
CHNE 515/ CE 551	Legal Issues in Environmental Engineering T 7:00-9:30 p.m. Instructor: TBA Origin: UNM	3 cr

SPRING 1992 INTERACTIVE TELEVISION COURSES

CE 539	Radioactive Waste Management MW 5:30 - 6:45 pm Instructor: Bruce Thomson & Glenn Pierce Origin: UNM	3 cr
CHNE 499	Indoor Air Pollution M 7:00 - 9:30 pm Instructor: A. S. Shankar Origin: UNM	3 cr
PET 481	Waste Mgmt Issues in Domestic Petroleum Explore & Production Th 7:00 - 8:45 pm Instructor: Robert Bretz Origin: NMIMT	2 cr
MATE 455	Energy and the Environment II TTh 4:00 - 5:15 pm Instructor: Osman Inal Origin: NMIMT	3 cr
ES 481	Introduction to Health Physics W 7:00 - 9:30 pm Instructor: Maryla Wasiolek Origin: NMIMT	3 cr
SOIL 476	Soil Microbiology MWF 4:30 - 5:20 pm Instructor: William Lindemann Origin: NMSU	3 cr
BIOL 461	Human Ecology T 7:00 - 9:30 pm Instructor: Walt Whitford Origin: NMSU	3 cr
ECON 490	Economics & Management of Nuclear Waste TTh 5:30 - 6:45 pm Instructor: Tom McGuckin Origin: NMSU	3 cr

APPENDIX J

WERC RESEARCH SEMINAR SERIES

ABOUT THE 1991 WERC RESEARCH SEMINAR SERIES . . . .

This Research Seminar Series is brought to you by the Waste-management Education and Research Consortium (WERC). WERC is composed of New Mexico State University, the University of New Mexico, the New Mexico Institute of Mining and Technology, Sandia National Laboratories and Los Alamos National Laboratory. WERC is funded by the United States Department of Energy.

One of the primary objectives of WERC is to offer satellite instructional television courses, special lectures and research seminars. These satellite presentations cover a wide range of topics related to waste management and environmental restoration.

REGISTRATION

There is a registration fee for each of the summer research seminars. The fee is used to cover the production and delivery cost of the seminar. For your registration fee, you will receive a packet os seminar materials and a 1/2" VHS videotape copy of the seminar. You will also be entitled to ask questions during and after the presentations.

COST PER SEMINAR

Individual	$ 50.00
Site	$200.00

Or you can purchase the entire summer series:
Site $1,500.00 Individual $375.00

For additional information or to register call the WERC Office at 1-800-523-5996

1991 WERC RESEARCH SEMINAR SERIES

June 4	Surface-Altered Zeolites for Removal of Organics and Heavy Metals from Contaminated Water	Robert Bowman NMIMT
June 11	Combined Air Stripping & Biodegradation of Petroleum Contaminants	Bruce Thomson UNM
June 18	Remediation of Hazardous Waste Sites by Heap Leaching	Adrian Hanson/ Zohrab Samani NMSU
June 25	Social Costs of Nuclear Waste Transportation	Ron Cummings UNM
July 2	Mobility of Radioactive Colloid Particles in Groundwater	Eric Nuttall UNM

July 9	Environmental Toxicology	Wolfgang Mueller NMSU
July 16	Slurry-Phase Bioremediation of Oil Field Production Pit Sludges	Nirmala Khandan NMSU
July 23	Bioremediation of Metals: Challenges & Expectations	Larry Barton UNM
July 30	Degradation of TNT by Plant Cells	Wolfgang Mueller/ G. Bedell NMSU
August 6	Semi-coarsening Multigrid Methods for the Fast Solution of Porous Flow Simulation Problems	Steve Schaffer NMIMT
August 13	Applications of Gelling Agents to Hazardous Waste Treatment	John Hernandez NMSU

APPENDIX K

SITES FOR HAZARDOUS/RADIOACTIVE WASTE MANAGEMENT SERIES

SITES FOR HAZARDOUS/RADIOACTIVE WASTE MANAGEMENT SERIES

May 15, 1991

DOE, Albuquerque Operations Office	Albuquerque, NM
Allied Signal Aerospace	Kansas City, KS
EG&G Rocky Flats	Golden, CO
EG&G Mound Applied Technology	Miamisberg, OH
GE-Nutron Devices	Largo, FL
Mason & Hanger, Pantex Plant	Amarillo, TX
Westinghouse, WIPP Site	Carlsbad, NM
New Mexico State University	Las Cruces, NM
NM Institute of Mining & Technology	Socorro, NM
Western New Mexico University	Silver City, NM
State of NM Environment Department	Santa Fe, NM
Columbia Basin College, Hanford	Richland, WA
Sandia National Laboratories	Albuquerque, NM
Savannah River Laboratory	Aiken, SC
Air Force Institute of Technology	Wright-Patterson AFB, OH
Los Alamos National Laboratory,	Los Alamos, NM
Motorola	Mesa, AZ
Sandia National Laboratories	Livermore, CA
El Paso Natural Gas Company	El Paso, TX
Bureau of Land Management	Six cities in NM
New Mexico Junior College	Hobbs, NM
Martin Marietta Energy Systems	Piketon, OH
U.S. Army Corps of Engineers	Vicksburg, MS
University of Hartford	West Hartford, CT
IBM	Tucson, AZ
IBM	Essex Junction, VT
Naval Research Laboratory	Washington, DC
Lawrence Livermore National Lab	Livermore, CA
Magnavox Electronic Systems	Ft. Wayne, IN
Digital Equipment Corporation	Albuquerque, NM
Argonne National Laboratory	Argonne, IL
San Juan College	Farmington, NM
Aerospace Guidance & Metrology Center	Newark AFB, OH
National Cash Register	West Columbia, SC
Southern Methodist University	Dallas, TX
Paducah Community College	Paducah, KY
Tennessee Eastman Company	Kingsport, TN
IBM Corporation	Research Triangle Park, NC
NM Primate Research Lab	Holloman AFB, NM
Auburn University	Auburn, AL
Plains Electric, Steve Holmberg	Grants, NM
IBM	Owego, NY
IBM	Charlotte, NC

SITES FOR HAZARDOUS/RADIOACTIVE WASTE MANAGEMENT SERIES (CONTINUED)

IBM	Boulder, CO
New Mexico State University	Alamogordo, NM
Individual Registrations	
EID-Las Lunas Office	Albuquerque, NM
Carl Davidson, Public Ad. Student	Albuquerque, NM
UNM, Occupational Health & Safety	Albuquerque, NM
Advanced Sciences, Inc.	Albuquerque, NM
Siemens	Albuquerque, NM
Public Administration Env. Health	Albuquerque, NM
UNC	Albuquerque, NM

Key: Underlined sites = NTU Sites

APPENDIX L

SUMMARY OF TECHNOLOGY DEVELOPMENT OF THE SECOND YEAR

DYNAMIC MODELING FOR DESIGNING TRANSPORTATION PACKAGING COMPONENTS

Principal Investigator:

A. K. Maji
University of New Mexico

Co-Principal Investigator:

H. L. Schreyer
University of New Mexico

Collaborators:

M. K. Nielsen
Sandia National Laboratories

R. E. Glass
Sandia National Laboratories

ABSTRACT

The development of suitable, economical, safe and well regulated packaging for waste transportation is a key issue in waste management. 'Soft impact limiters' such as Polyurethane Foams and Aluminum Honeycomb are widely used in transportation packages as impact or shock absorbers. Currently, design procedures using these materials are based on empirical formulae which do not adequately account for the different types of prospective packaging components. The different energy absorption mechanisms were studied, to evaluate the effect of dynamic loading rates, confinement and other constraints on the deformation. Based on these experimental observations, engineering models are being developed to assist in the design process using these materials. In addition, constitutive models for cellular materials are being developed to reflect progressive damage during the crushing of cell walls, and the subsequent stiffening caused by the collapse of voids. The models developed, can be used to inspect and evaluate packaging components.

Results of the uniaxial static compression tests were evaluated, considering plastic deformation, buckling and other deformation mechanisms of the cells. It was found that currently available theoretical models do not capture the experimentally observed behavior. This observation reinforces the necessity for experimental results. Under uniaxial compression, the materials exhibit quasi-brittle behavior, and can be understood from fracture mechanics principles. Under confined compression, the materials are mostly insensitive to the confinement pressure. Therefore, a cap model based on the deviatoric stress space was found to provide the best description of the test results.

Under dynamic loading, the specimens exhibit a strain-rate dependence. This dependence is however coupled with the specimen size. The failure mechanisms were found to vary, depending on the material's density and size. These effects can be explained by the collapse of the voids to allow dissipation of internal pressure build-up, during impact loading. Also, the densified foams exhibit characteristics of brittle failure, and the consequent size-effect.

A three-dimensional rate-dependent plasticity model has been developed for rigid polyurethane foams. In this model, the materials is decomposed into the skeleton and the solid matrix from which the material is made. Both of these are then represented by an elastic-plasticity model. The transverse anisotropy of the material is included by incorporating a shift in the effective stress calculation. The sift, the limit stress for the skeleton, and the hardening parameter for the solid are functions of volumetric strain rate, to account for strain rate effects. For uniaxial compression, the stress-strain relation predicted by the model is suitable for numerical calculations in three dimensions, where the stress path is not necessarily one dimensional.

DEVELOPMENT OF PERMEABLE BARRIERS FOR AQUIFER RESTORATION

Principal Investigator:

Bruce M. Thomson
University of New Mexico

Co-Principal Investigator:

John W. Hernandez
New Mexico State University

James L. Botsford
New Mexico State University

ABSTRACT

With national recognition of the magnitude of ground water contamination problems, there becomes a critical need for more effective methods of addressing them. Current options have a number of constraints including the need for large surface disruptions for long periods of time, management of large volumes of residuals (contaminated soils, treated water, and sludges) from the remediation process, and institutional obstacles associated with permitting and other processes. This study will continue development of a management/treatment alternative consisting of barriers that are permeable to water, but intercept or degrade pollutants and remove them from the ground water.

Two alternatives have been previously investigated: development of combined air stripping and biodegradation barriers for removal of volatile and/or biodegradable constituents, and application of gelling agents that are permeable to water but swell upon exposure to hydrocarbons and bond them inside a relatively inert matrix. This investigation has two components. First, is to operate an air stripping/biodegradation barrier for at least one year to determine its operational characteristics. Performance will be monitored by following removal of specific contaminants, plate counts of heterotrophic bacteria, and impacts on other water quality parameters including coliform bacteria. Previous laboratory and field work has demonstrated excellent removal of aromatic compounds (benzene, toluene, and o-xylene) at very low air-to-liquid flow ratios; these results will be substantiated with field studies. At the conclusion of the study the barrier will be excavated and analyzed for biomass and inorganic precipitates that might result in its plugging.

The study of gelling agents will address two questions: what is the long term stability of the gels with respect to biological degradation, and what is the susceptibility of gelled pollutants to geological degradation. These will be investigated in several ways. First, water will be passed through the gels and the microbial activity of the leachate determined by measuring both numbers and diversity of bacteria present. Next, a direct determination of the biodegradability of the gels will be performed by placing them in respirometric flasks and monitoring microbial activity. Finally, degradation of the immobilized pollutants will be investigated by immobilizing carbon-14 hydrocarbons in candidate gelling agents and monitoring $^{14}CO_2$ evolution.

REMEDIATION OF HAZARDOUS WASTE SITES BY HEAP LEACHING

Principal Investigator:

Zohrab A Samani
New Mexico State University

Adrian Hanson
New Mexico State University

Collaborator:

Don York
Los Alamos National Laboratory

ABSTRACT

Efforts are being made to devise technologies and treatment systems to remediate heavy metal contaminated soils, on-site without generating significant wastes for off-site disposal. Heap leaching, a technique used extensively in the mining industry, has been investigated by the authors as a method for the remediation of soils contaminated with heavy metals. This has been a three year project which is funded by DOE/WERC. During the first year of this project, laboratory scale column studies were conducted to evaluate the removal of chromium (VI) from four New Mexico soils (sand, sandy loam, and 2 clay) using heap leaching. The column study was conducted on both laboratory spiked soils and soils from a contaminated site at the White Sands Missile Range. The study showed that more than 99 percent of the chromium (IV) can be removed from all four soils using tap water as the leaching agent. The study also showed that the salinity level of the leaching agent, the application rate of the leaching agent and the agglomeration of the soil did not have a significant effect on the removal of chromium from soils. During the second year, batch and column studies were conducted on the removal of lead from contaminated soils. Both laboratory spiked soils and a contaminated soil from a superfund site in New Mexico were used in the study. Before starting the column study, more that a dozen leaching agents were used in the batch study to identify the most effective leaching agent, and 8 lead salts were evaluated for use in contaminating the laboratory spiked soils. The parameters considered in identifying the most effective leaching agent were the rate of removal of the contaminant and the magnitude of dispersion of the soil aggregates by the leaching agent. The dispersion of the soil aggregates by the leaching agent is considered an undesirable factor leading to reduced hydraulic conductivity of the soil and prolonging the remediation process. Among the leaching agents used, Dipotassium EDTA was identified as the most effective leaching agent. Subsequent column studies showed that in excess of 85 percent of the lead can be removed from contaminated soils using a mixture of tap water and EDTA. During the third year, the removal of lead and chromium from contaminated soils will be studied at the field scale. Both laboratory spiked soils and soils from superfund contaminated sites will be evaluated. During the field scale study the techniques for extrapolation of the laboratory parameters to field scale operation will be studied. Other parameters to be evaluated during the third year are: leaching effectiveness and spacial variability of leaching.

TREATMENT OF WATER CONTAMINATED WITH BTX AND HEAVY METALS USING TAILORED ZEOLITES

Principal Investigator:

Fernando Cadena
New Mexico State University

Co-Principal Investigator:

Robert S. Bowman
New Mexico Tech

ABSTRACT

Zeolites are natural minerals with significant cation exchange capacity (CEC). The natural cation in zeolites (typically sodium) can be exchanged with organic cations (quaternary amines). The resulting tailored zeolites have physical and chemical properties that are different in nature from the original zeolite. For instance addition of organic tailoring agents at a dose equal to the CEC of the zeolite results in a neutrally-charged solid medium (the zeolite mineral) covered with a monolayer of organic molecules. Neutrally-charged pollutants (in particular the BTEX family) are removed by adsorption on such organically tailored zeolites.

Addition of tailoring agent above the CEC results in charge reversal on the surface of the zeolite. The positive charge induced by the excess tailoring agent may be used to remove anions from solution. Hexavalent chromium, which hydrolyzes in water, exists as an anion in near-neutral solutions. Zeolites tailored with long-chain quaternary amines at doses above their CEC are excellent adsorbents for the removal of this carcinogenic heavy metal from water.

MINIMIZATION AND REMEDIATION OF DOE NUCLEAR WASTE PROBLEMS USING SELECTIVE ACTINIDE CHELATORS

Principal Investigator:

Aravamudan Gopalan
New Mexico State University

Collaborator:

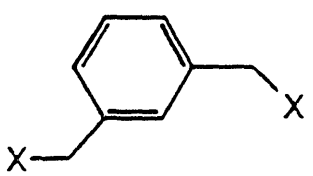
Paul Smith
Los Alamos National Laboratory

ABSTRACT

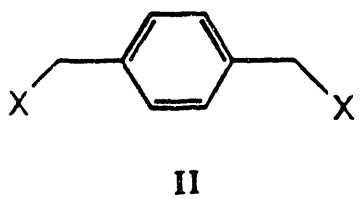
The design and synthesis of chelators for the specific binding of actinide ions is both of pharmacological and environmental interest. Since the advent of the Manhattan Project in the early 1940's, radioactive actinides have been discharged in various forms into the world environment. These discharges have occurred as a result of weapons production, medical research and other sources including nuclear power plant by-product. Selective removal of radioactive and highly toxic actinide ions such plutonium(IV) and americium(III) from process waste streams and soils which often contain high concentrations of iron or aluminum presents a formidable challenge.

Hydroxamates and catecholates are known for their ability to strongly complex highly charged metal ions such as plutonium(IV) and iron(III). Therefore, many chelators containing these functionalities have been synthesized and their actinide sequestration properties have been examined. It is generally accepted that octadentate ligands possess the characteristics necessary for selective actinide complexation. The larger size of the actinide ion and its flexible coordination geometry relative to transition metals provides an avenue for differentiation.

As part of a research program for the development of cost-effective organic chelators for practical remediation of actinides, we have recently prepared a new class of tetrahydroxamates that show potential for environmental applications. Two such chelators, I and II, were chosen based on the following considerations. 1) The spacial arrangement of the four hydroxamates meet the requirements of actinide ions. 2) The diamine bridge can be readily varied to optimize actinide selectivity. 3) These chelators are easily prepared from readily available starting materials and can be modified for incorporation into polymeric supports. 4) The presence of the amines helps to provide water solubility for the ligand and its complexes.



I



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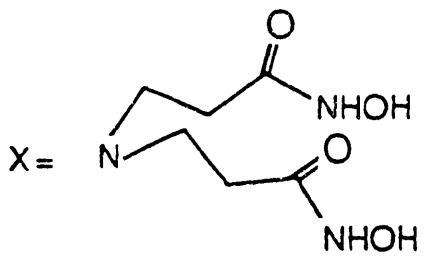

The ligands have been evaluated potentiometrically and spectroscopically to determine their protonation and metal binding constants. For our metal binding studies we chose thorium(IV) as a surrogate for plutonium(IV) and neodymium(III) for americium(III). The substantial depression of the potentiometric titration curves observed for both chelators with thorium, neodymium and iron is an indication that these metals are strongly complexed even at low pH. A qualitative assessment based upon our studies indicates that these chelators have a larger affinity for the metal ions which have higher charge to radius ratios. Even though neodymium has a substantially smaller charge to radius ratio relative to thorium (IV) and iron(III), it is strongly complexed by both chelators. The similarities of the binding constants indicates no

structural bias of either ligand toward neodymium, and the binding constants are comparable to other hydroxamic acid chelators such as desferrioxamine-B. From our data, it is clear that I is more selective for thorium(IV) than iron(III) while II shows no selectivity. The selectivity observed for I could be explained by greater steric interactions between the chelate arms upon complexation of the smaller ferric ion.

Efforts are underway to further improve the binding specificities of this class of chelators through structural modifications. The synthesis of other complex chelators with the correct geometrical arrangement of ligands to allow maximum interaction with actinide ions (using computer modelling studies) is being carried out. Also strategies for incorporation of known and new chelators into insoluble polymeric matrices for downstream concentration of toxic ions will be examined.

APPLICATION OF BIOTECHNOLOGY IN MANAGEMENT OF INDUSTRIAL WASTES CONTAINING TOXIC METALS

Principal Investigators:

Larry L. Barton
University of New Mexico

William C. Lindemann
New Mexico State University

Laurel O. Sillerud
Los Alamos National Laboratory

C. Joanne Pigg
Sandia National Laboratories

Frank A. Fekete
University of New Mexico

Robert Blake
Meharry Medical School

Terry Rogers
Delphi Research

ABSTRACT

The overall goal of this research is to establish a bioremediation process which would be useful for the detoxification of sites containing chromium and lead. We tested several bacteria which displayed rapid transformation of Pb II to Pb°, Cr VI to Cr III as well as tolerance to high concentrations of diverse toxic metals. We identified these bacteria and found that they belonged to the following genera: *Pseudomonas, Enterobacter, Alkaligenes, Corynebacteria, Moraxella* and *Bacillus*. Studies were also conducted with a yeast, *Rhodotorula*, which we isolated from an industrial site containing high concentrations of chromium.

We found that a *Pseudomonas* isolate and the *Moraxella* isolate transformed Pb II at the highest rate. Bacterial cells taken from stationary phase of growth rapidly transformed Pb II when placed in a buffered lead solution and to a very small extent when the bacterial were placed in soil containing lead. From soil and solution studies, it is apparent that the soil containing lead should first be subjected to an extraction treatment. Bacteria can transform lead from various lead-ligand systems. The lead colloids produced from bacterial action have a minimal diameter of 120 nm but may aggregate to diameters of 3600 nm. Due to the high concentration of cellular material associated with the bacterially produced lead colloids, the transformed lead quickly settles out. Bacterial transformation is two step process: initial binding followed by energy-dependent colloid formation.

The bacteria which reduce Cr VI to Cr III also accomplish this with resting cells. About 24 mg/gram of Cr VI are transformed/day/gram of bacteria. Bacteria bind Cr III to the surface of the cell at a rate which is similar to the reduction rate. This reduction and binding is independent on the types of heavy metal cations present in the environment. Additionally, we found that the *Pseudomonas* isolate would overproduce siderophore, ad Fe III binding compound, when grown in elevated concentrations of Cr III. We are exploring the use of this siderophore in detoxification of Cr III sites.

VADOSE ZONE MICROBIOLOGY: BIOMINERALIZATION, CHELATION, AND BIOCONCENTRATION OF MIXED HAZARDOUS WASTE

Principal Investigator:

Thomas L. Kieft
New Mexico Tech

Collaborator:

Larry E. Hersman
Los Alamos National Laboratory

ABSTRACT

This project was undertaken to determine the potential for microorganisms in the unsaturated (vadose) zone to influence the fate and transport of organic and inorganic pollutants. The majority of research in the relatively new field of subsurface microbiology has been focused on saturated zones, whereas this project is directed towards vadose zone microorganisms. We have selected a limited number of pollutants and limited number of microorganisms for study. Using 15 strains of bacteria isolated from the vadose zone at the Pajarito Plateau in Los Alamos, NM, we have found that the sorption of heavy metals (Cd and Ni) to the surfaces of volcanic tuff collected from the same area is inhibited when microorganisms are present. This finding has important implications for the modeling of metal contaminant transport in the subsurface, particularly at facilities situated in or on volcanic tuff. Microbial metabolites may cause accelerated transport of metals in the subsurface. In studies of toluene-degrading consortium of microorganisms isolated from a contaminated unsaturated subsoil, we have found that matric water potential has a strong effect on the rate of biomineralization of toluene to carbon dioxide. Desiccation decreases mineralization rates; however, measurable biomineralization proceeded even in the most desiccated subsoils. This indicates that organic pollutants such as toluene can be biologically degraded, even under the harsh conditions of the vadose zone. Manipulation of contaminated vadose zones (e.g. by nutrient addition) may stimulate rates of pollutant biodegradation.

A NEW FAST SCANNING ENVIRONMENTAL SEM FOR USE IN WASTE STUDIES

Principal Investigators:

Timothy J. Ross
University of New Mexico

Larry L. Barton
University of New Mexico

Joe L. LaPointe
New Mexico State University

Collaborators:

Martin J. Carr
Sandia National Laboratories

ABSTRACT

Failures of buried metal pipes and storage tanks caused by microbially induced corrosion have been well documented by many industries including the nuclear power industry, the electrical power industry, and the petroleum processing service industry. The main cause of corrosion of ferrous metals in anaerobic or semianaerobic environments is the activity of sulfate-reducing bacteria (SRB). One proposed mechanism by which SRB influence the electrochemical corrosion process is cathodic depolarization via the hydrogenase enzyme.

The hydrogenase enzymes that are associated with the most corrosive SRB use the molecular hydrogen that forms a protective film on the cathode. The SRB have a highly efficient electron transport system which uses hydrogenase to enzymatically break down the protective hydrogen film. The focus of our research is to establish a rapid, sensitive assay which can be used to measure the in situ oxidation of hydrogen contributing to microbially induced corrosion. We have developed a system which uses tetrazolium salts as electron acceptors and the magnitude of the enzyme activity is quantified using scanning electron microscopy (SEM). We are using two new SEM methods: fast scanning SEM and environmental (or wet) SEM. While oxidized tetrazolium is soluble in water, the reduced tetrazoliums are termed formazans and are not soluble in water but readily crystalize in the reaction mixture. By quantifying either the number of reduced formazan crystals or by measuring the increase in formazan crystal size, a correlation is made between the physical characteristics of the formazan crystal and the enzyme activity.

In our research, we demonstrate the suitability of formazan crystal growth for measuring the amount of enzyme activity. We are currently developing a method to follow formazan crystal formation using the two new types of electron microscopy. The novel use of the fast and wet scanning electron microscopes, currently in development, will enable us to evaluate the in situ activity of the SRB in the biocorrosion process. One goal of our research is to develop a process or product to control corrosion attributed to SRB.

In addition, microfilms of water on rocks which are to become subsurface repositories are of considerable concern. We feel that direct observations of these subsurface specimens after treatment of several different flocculating agents would provide enhanced stability of the bacteria and even the toxic compounds in the aqueous region. In our research we have successfully imaged cells with SEM which have been flocculated by a commercially available EPA-approved agent. We have worked out the conditions necessary to image the cells using SEM. Another goal of our research is to find ways to evaluate cell concentration, pH, and flocculation concentration to get optimum conditions for imaging.

SLURRY-PHASE BIOREMEDIATION OF OILFIELD PRODUCTION PIT SLUDGES

Principal Investigator:

Thomas L. Kieft
New Mexico Tech

Collaborators:

Clinton P. Richardson
New Mexico Tech

Nirmala Khandan
New Mexico State University

ABSTRACT

The purpose of this research project has been to develop methods for biologically treating oilfield production pit sludges and produced water to reduce the content of hydrocarbons. Waste pit sludges consist of the high molecular weight fractions of crude oil and they are often also contaminated with various organic and inorganic additives (e.g. de-emulsifiers, corrosion inhibitors, and heavy metals). Produced water is pumped from formations along with crude oil and removed from the oil in a separator. Produced water contains residual hydrocarbons and they are often quite saline.

For the biodegradation of waste pit sludges, we have cultured hydrocarbon-degrading bacteria from oil-contaminated surface soils and from waste oil-produced water mixtures, and we have increased the numbers and activities of these hydrocarbon-degrading bacteria through enrichment culture. We have then tested the capabilities of the cultures to degrade waste oil under various environmental conditions. We have found that addition of water, nutrient amendment, and acid neutralization are essential for enhanced biodegradation. Additions of a surfactant (Tween 80) appears to favor biodegradation of the oil. It was also found that vigorous aeration of the slurry-phase bioreactor increased rates of both volatilization of the lighter fractions of waste oil and degradation of all fractions. Analysis by GC-MS showed that a large proportion of the waste oil consists of unbranched alkanes ranging in size from C13 to C31. Biological treatment of the waste oil was shown to reduce the concentrations of these unbranched alkanes to below detection. We have isolated two hydrocarbon-degrading bacteria in axenic culture and are currently testing them to determine which components of the hydrocarbon mixture are degraded. We have also assessed microbial activity in slurry-phase bioreactors by measuring oxygen consumption with a respirometer. A pilot-scale bioreactor has been designed for testing at the Hobbs Oil and Water Experimental Facility (HOWE).

Studies of hydrocarbon degradation in produced waters have been performed using water samples from several production facilities in New Mexico. A commercial inoculum (Petrobac-S) was used. This culture was chosen because it is adapted to the saline conditions found in the samples. Biotreatment of the produced water samples with this culture resulted in 65 to 90% reduction in the total petroleum hydrocarbon concentration.

BIODEGRADATION OF EXPLOSIVES

Principal Investigator:

Glenn W. Bedell
New Mexico State University

Co-Principal Investigator:

Wolfgang F. Mueller
New Mexico State University

Consultant:

Paul J. Jackson
Los Alamos National Laboratory

ABSTRACT

Arsenals of the U. S. Government that produce trinitro-toluene (TNT) generate large volumes of highly toxic, nitrobody-containing effluent called "pink water". Pink water, depending on its source, may contain up to several hundred parts per million (ppm or mg/of TNT isomers, 2,4-dinitrotoluene (DNT), and other explosives (e.g. RDX and HMX). DNT is a potent carcinogen for which EPA ambient water quality standards have been established. To date, all conventional treatment technologies permit an escape of toxic pink water components that exceed EPA effluent discharge levels, and the high toxicity of those remaining component levels has made biological wastewater remediation efforts unsuitable. At shooting and bombing ranges as well as blast sites used for weapons development and testing, large areas are contaminated with TNT and other high explosives, probably at fairly shallow depths of penetration below the surface.

Based on preliminary work performed at LANL with tissue-cultured cells of Datura innoxia (Jimson Weed), our experiments have shown that the cells both rapidly remove and metabolize ^{14}C-labeled TNT that had been added to their growth medium. Observations from these experiments may be summarized as follows:

1) Unlike bacterial bioremediation efforts, the added TNT (up to 200 mg/L) is completely removed from the growth medium in less than 24 hours.

2) The radiolabel is internalized by the cells, not adsorbed to the outer surface.

3) Chromatographic analysis shows that during the first 24 hours of contact the TNT is converted into several new compounds that are more polar than TNT.

Studies with suspension cell cultures derived from the wild tomato plant Lycopersicon peruvianum showed that both the uptake and the biotransformation of TNT is not limited to the Datura species, but that it can be achieved by other plants as well. For the subsequent work, both Datura and Lycopersicon cell cultures were used. Isolation and purification of the biotransformation products from cell extracts was achieved by preparative and analytical scale HPLC; the purified metabolites were analyzed by gas chromatography - mass spectrometry after derivatization to enhance volatility. Biotransformation products identified so far include an amino-dinitrotoluene, a diamino-nitrobenzyl alcohol, and a diaminonitrobenzoic acid. This demonstrates that the plant cells use the metabolic pathways of nitroreduction and oxidation of the methyl group in combination. Evidence from total recovery of ^{14}C indicates that part of the TNT added to the cultures is broken down further and potentially mineralized completely.

RECOVERY OF TOXIC HEAVY METALS FROM CONTAMINATED GROUNDWATERS

Principal Investigator:

Gary D. Rayson
New Mexico State University

Co-Investigator:

Dennis W. Darnall
New Mexico State University

Collaborator:

Paul J. Jackson
Los Alamos National Laboratory

ABSTRACT

This proposal specifically addresses Section 2.5.5.2 in the Department of Energy's Applied Research, Development, Demonstration, Testing and Evaluation (RDDT&R) Plan for Environmental Restoration and Waste Management. Section 2.5.5.2 state: "To protect public health and the environment, DOE must provide reduction or elimination of radioactive, heavy metal, and/or inorganic contamination in groundwaters through extraction and *in situ* technologies."

While it may be possible to treat organic contaminants *in situ* by biological or chemical oxidation methods, the *in situ* treatment of metal ions is much more difficult. In many cases the only effective method of treatment will be to pump the waters from the ground and treat them.

In wastewaters, whether industrial, mining, surface leachates or groundwaters, concentration of heavy metal ions which must be treated are relatively low, typically in the 0.1-100 parts per million range. Energy intensive methods, such as distillation, evaporation or reverse osmosis, are not economical for treating these waters. Commercial ion exchange resins, including specialty chelating resins, may be effective in some instances for removing and recovering heavy metals, but if the waters contain a high salt content or contain large amounts of calcium or magnesium ions, the extraction proficiency drops dramatically.

The proposed studies will involve the evaluation of a new, biologically-derived, heavy metal recovery agent (cultured cells from the plant *Datura innoxia*) for the extraction of heavy metals from contaminated groundwaters. This metal recovery agent will be supplied by Dr. Paul Jackson at Los Alamos National Laboratory. Dr. Gary Rayson and his research group at New Mexico State University will evaluate the conditions under which these metal binding agents are most effective and will ascertain which heavy metal ions can be accumulated from water under laboratory conditions. This information will be obtained from both phenominological observations and fundamental investigations of the mechanism(s) responsible for metal binding to the cell material. These mechanisms will be investigated using laser-induced solid-state luminescence and nuclear magnetic resonance spectrometry. These biomaterials will be immobilized to make a product which will be packed in columns and used much as ion exchange resins are now commercially used. Bio-Recovery Inc. of Las Cruces, New Mexico, using information gained from Dr. Rayson's laboratory, will then test these new materials on "real" contaminated groundwaters from Superfund or DOE sites if laboratory studies are sufficiently promising. From this data an economic analysis for commercial treatment will be made.

REFORMING AND GASIFICATION TECHNOLOGY FOR THE DESTRUCTION OF WASTES

Principal Investigator:

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Collaborators:

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ABSTRACT

The incineration of waste is a disposal strategy that is here to stay. Municipal waste, medical waste, and industrial waste, such as solvents and oils, are all candidates for this method of disposal. The primary problem with incineration is the possibility of discharging potentially harmful by-products of combustion to the environment. These by-products may be either solid or gaseous. The number of possible gaseous compounds is almost limitless-dioxins, furans, and chlorinated benzene are just three of particular interest to the current project. All these compounds contain chlorine. Chlorinated compounds may be present in the original waste, for example polychlorinated biphenyls (PCBs) from transformers or trichloroethylene (TCE) used as a solvent. Of special concern are those compounds, not originally present, that form directly or indirectly as a result of the combustion process. Many examples of de novo formation have been observed. There is a need to understand the processes that lead to the formation of these unwanted and harmful by-products, and a need to develop modified incineration methods based on this understanding.

A joint Mechanical and Chemical Engineering combustion facility has been built to study the gas phase formation of toxic by-products of combustion. The approach taken in this project is to provide a geometrically simple reaction volume that minimizes the data that need to be taken, simplifies data interpretation, and allows existing computer models to be applied. A flat-flame burner is employed to provide a nearly one-dimensional reaction zone. The flat-flame facility has an advantage over other possible burners in that it is free of surfaces that could act as catalysts. This is an important consideration since some evidence is available that the formation of certain toxic compounds is more rapid when surfaced catalyzed. With the flat-flame facility homogeneous gas phase reactions can be investigated. The possibility of adding surfaces in the form of a chimney, particulates, or solid surfaces placed directly in the flow still exists for future studies.

The procedure for the present research is to add our target compounds to a methane or propane flame (both are available). The initial tests will use TCE and benzene, either separately or together. Samples from various points above the flame zone will be analyzed for large molecular weight hydrocarbons and chlorohydrocarbons. For example, chlorobenzene, dioxins, and furans will be quantitatively measured using a GC/Mass Spectrometer. The air/fuel ratio will be varied to assess the effect of this important parameter. In addition, steam will be added to promote dechlorination and the formation of HCl. A comparison of TCE addition alone to

TCE plus benzene will be investigated to determine the importance of ring structures as precursors. Modeling is being facilitated with the CHEMKIN code from Sandia. Preliminary tests have been conducted with propane and trichloroethylene. Fine tuning of the facility is being completed to obtain quantitative results.

ENHANCEMENT OF SOLAR PHOTOCATALYTIC DETOXIFICATION BY ADSORPTION OF PROPHYRINS ONTO TiO_2 AND Al_2O_3 SUBSTRATES

Principal Investigator:

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Collaborators:

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Solal Thermal Collector Tech. Div.

ABSTRACT

This project addresses the problem of utilizing solar technology for toxic waste disposal on three levels. The immediate (short term) goals are to couple existing solar collector technology, and metalloporphyrin (MP) photoactivity to produce a more efficient system for photodegradation of toxic wastes. These studies have begun with laboratory scale testing of TiO_2 sensitized with MPs already familiar to Ondrias and Shelnutt and rapidly progress to field tests utilizing solar thermal collectors in place at Sandia National Laboratories (SNL).

During the past year significant progress was made in this area. $Sn(IV)Cl_2$ uroporphyrin (SnUroP) adsorbed onto an aqueous suspension of powdered TiO_2 at pH 6 was found to enhance the photodegradation of a model toxin salicylic acid (SA) considerably when only visible light was used. SnUroP adsorbed onto an aqueous suspension of powdered Al_2O_3 at pH 6 was found to be photocatalytically active towards oxidative degradation of SA when illuminated with visible light ($\lambda > 390$nm). No photodegradation of SA is observed in aqueous mixtures with either the porphyrin or the alumina alone. Photodestruction of SA occurs only when porphyrin is immobilized on the alumina surface below pH 8. Irradiation under anaerobic and aerobic conditions shows that oxygen is necessary for the photodegradation reaction to occur on the alumina surface. In other experiments, we have observed photoreduction of $Cr_2O_7^{=}$ to Cr^{+3} by the SnUroP adsorbed onto Al_2O_3 (pH 2). Further, the $Cr_2O_7^{=}$ reduction reaction is catalytic in the presence of SA, which apparently is needed to complete the redox cycle. We are currently investigating the stability and photocatalytic activity of other porphyrins, including ZnUroP and $Sn(IV)Cl_2$ tetrakis (*p*-carboxyphenyl)porphyrin, on both surfaces.

The longer term goals of this project involve the optimization of the photodynamics of the surface/dye systems for greater efficiency and stability. This will require two methodologies: (1) time-resolved optical spectroscopy of isolated dyes and surface/dye systems in order to characterize the mechanisms of MP dyes and their interaction with various surfaces. Such basic knowledge is crucial to the development of a new generation of photocatalysts that will allow these processes to be pursued on a commercial scale. A firm basis for both of these efforts has now been established at UNM and SNL, Albuquerque.

DEVELOPMENT OF CONSTRAINED MOTION CONTROL FOR TELEAUTONOMOUS ROBOT HANDLING OF HAZARDOUS WASTE

Principal Investigator:

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ABSTRACT

During the sorting and repackaging of recovered waste, robotic systems for grasping and manipulating odd-shaped objects of varying sizes will be needed. Also, during the removal of buried waste, there will be items which need "surgical" removal, e.g. grasping by a multifingered dexterous gripper attached to a robot arm. It may not be possible to employ simple parallel-jaw grippers commonly used in current robot systems to grasp such ill-defined objects. Instead, dexterous end-effectors with grasping capabilities similar to human hands may need to be developed. The proposed research is to develop a prototype workcell using a multifingered hand to handle such objects. The proposed system will consist of a robot arm employing a three-fingered dexterous hand, plus a vision system, all controlled by the same computer. The system will be capable of locating and identifying odd-shaped objects, synthesizing fingertip grasp locations on the objects, and grasping and manipulating them. This prototype system will directly address the three areas discussed above, and will serve as an example of state-of-the-art sensing and control technology applied to ER&WM. This dexterous grasping and manipulation technology is somewhat generic, and will serve the needs of a wide variety of applications, beyond those mentioned above.

ADAPTIVE CONTROL OF MANIPULATORS AND TELEROBOTS HANDLING HAZARDOUS WASTE

Principal Investigator:

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Collaborator:

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ABSTRACT

The objectives of this research project are: (1) To develop a robust high performance adaptive impedance control system for robots possessing kinematic and/or actuator redundancy; (2) To construct an accurate and detailed computer simulation environment for modelling important robotic environmental restoration and waste management (ER & WM) tasks; (3) To begin evaluation of the robot impedance control system's capability to perform ER & WM tasks though both computer simulation and experimentation.

Progress toward achieving the three major research objectives is proceeding ahead of schedule. The theoretical development of the adaptive impedance controller for redundant robotic systems has been completed, and this development has yielded two important results. The first contribution is the derivation of the first reported globally stable direct adaptive impedance controller for general manipulators. This controller provides the excellent performance, efficiency, and robustness properties associated with direct adaptive impedance controllers while ensuring the global stability formerly only provable for indirect adaptive impedance controllers. The second contribution is the development of a unified framework for controlling robotic systems possessing any combination if kinematic and/or actuator redundancy. This result permits the development of redundant robotic systems which possess significantly increased performance capabilities reliability, and fault tolerance compared with conventional robotic systems.

Development of the computer simulation environment for modelling robotic ER & WM operations is on schedule. A general robotic system dynamics simulation environment has been completed. This simulation package incorporates models of all important dynamics subsystems and phenomena; for example, all rigid body, actuator, and transmission dynamics are modelled, and fairly sophisticated models for joint friction and transmission phenomena are included. Additionally, significant progress has been made in constructing computer models of important ER & WM tasks, including radiological swiping of waste containers (e.g., for inspection at WIPP), inspection of cluttered workspaces (e.g., underground waste storage tanks), simple mechanical assembly (as required in automated TRUPACT handling), and robotic deburring for waste minimization (e.g., edge and surface finishing of uranium parts in weapons production). Evaluation of the proposed robot control system is also progressing on schedule, and thusfar has focused on the problem of effectively utilizing the available redundancy. Computer simulation studies have been conducted to examine resolution of both kinematic and actuator redundancy to achieve a wide range of performance objectives, including improved dynamic response, obstacle avoidance, joint limit avoidance, singularity avoidance, increased dexterity, and improved reliability and tolerance to joint failure. Experiments have been initiated at JPL, and to date have considered the problem of utilizing kinematic redundancy to improve dexterity and avoid workspace obstacles. The research results summarized here have been published at the international level, in the form of journal articles (five), book chapters (one), and conference papers (six), and the interested reader is referred to these publications for additional details.

DESIGN OF OPERATOR INTERFACES FOR HAZARDOUS WASTE REMOVAL SYSTEMS

Principal Investigator:

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ABSTRACT

A major environmental problem involves the cleanup of hazardous nuclear and chemical wastes. Some of this material is so toxic that handling it will require the use of remotely controlled robots. Operators of these robots will be situated remotely and will need a user interface for controlling the robot within its environment. The remote robot will have a variety of sensors in addition to the usual video feedback. The three dimensional data from these multiple sensors must be displayable in an integrated way on the two dimensional user interface.

This project has investigated the design of a user interface for tele-robotic systems. We have developed a number of three dimensional visualization tools which can be used with standard user interface toolkits. We have addressed issues such as user configurability of the interface and display of data from multiple sensors.

Training users to operate tele-robots and enabling scientists to visualize environments in which tele-robots might operate is a related project we have also worked on. We have built up a three dimensional model of the WIPP site and are planning to add an interface to physical and geological models.

DEVELOPMENT OF SENSORS FOR WASTE MANAGEMENT APPLICATIONS

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ABSTRACT

The primary goal of our research is the development of sensors that can be applied in the nuclear fuel reprocessing industry or in monitoring the environment surrounding waste disposal sites. A sensor is a measurement system designed to exhibit an experimental response relatable to the quantity of a chemical species or class of chemical species present in a liquid, gaseous, or solid sample. The difference between a sensor and a conventional analytical instrument is that a sensor is generally designed to be small, rugged, portable, and to operate *in situ*. Thus, sensor development will bring the measurement process to the sample, rather than bring the sample to a laboratory. The specific analytes targeted in our program include the uranyl and plutonly ions, other lanthanide ions, and nitrate ion and nitric acid. The sensors for these analytes must function in the presence of all components of raffinate solutions, particularly high nitric acid concentrations. The sensors for uranly/plutonyl are based on the fact that these ions selectively form colored complexes with Arsenazo (III) under high acid conditions. The color change due to the complexation when the Arsenazo is immobilized at the end of a fiber optic is sensed spectrophotometrically. A number of other ligands that will potentially form fluorescent compounds with these ligands are also being investigated. One type of nitrate sensor being investigated is based on changes in the spectral properties, particularly changes in fluorescence, of a probe ion. More recently, we have discovered that the nitrate ion Raman band shifts proportionally to the amount of acid present. This latter phenomenon has great potential as a nitrate ion/nitric acid sensor and will be further investigated in the coming year.

DESIGN OF COMPACT MICROSENSORS FOR MONITORING ORGANIC CONTAMINANTS

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Co-Principal Investigator:

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ABSTRACT

This project is aimed at the design of a new generation of highly selective and sensitive microsensors for monitoring the environment and waste disposal sites.

Microporous zeolite crystals were first successfully attached to the gold electrodes of quartz crystal microbalances (QCM). Monolayers of thiol-alkoxysilanes on the gold surface served as interfacial layers for the subsequent adhesion of the zeolite crystals to the QCM. The process of anchoring the zeolite crystals via the thiol-saline monolayers was studied by reflection adsorption infrared (IR) spectroscopy, contact angle, and scanning electron microscopy (SEM). Dynamic sorption isotherms or organic vapors and nitrogen as well as the transient sorption behavior of organic vapor pulses were studied to characterize the zeolite-coated QCMs. The regular micropores (0.3-1.2 nm) of the QCM-attached zeolite crystals were found to efficiently control molecular access into the coating. Selectivity of the frequency response in excess of 100:1 toward molecules of different size and/or shape could be demonstrated.

Novel microporous thin films composed of zeolite crystals and a porous silica binding phase were formed on the substrate of piezoelectric crystals (QCM). A surface tailoring technique for the microporous thin films utilizing molecular "gate" layers at the gas-thin film interface has been developed in this study. Selective adsorption based on kinetic or equilibrium exclusion from the microporous film could be achieved.

Successful design of such films can also be achieved through *adjusting* intrazeolite microporosity. Different cations, *i.e.* Ca^{2+}, K^{+}, Na^{+}, and Rb^{+}, were exchanged into the films containing zeolite A coupled to the QCM. The external and internal surface areas of the cation-exchanged films were studied *in situ* on the piezoelectric crystals by measuring nitrogen adsorption isotherms. The effective pore sizes of the films were evaluated by sorption kinetics and isotherms of organic vapors with different molecular sizes and shapes. Step by step exclusion of progressively smaller molecules from the films as a function of cation size and location in the zeolite could be established. This strategy is a promising approach towards piezoelectric chemical sensors with tailored and adjustable selectivity.

STABLE ISOTOPE STUDY OF SOIL-AND GROUND-WATER, WIPP SITE NEW MEXICO: ESTIMATION OF RECHARGE TO THE RUSTLER AQUIFERS

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ABSTRACT

An important issue in waste management is the hydrologic characterization of the natural environment surrounding waste repositories. In the arid southwestern climate this must include characterization of fluid flow in the unsaturated (vadose) zone. It is through the vadose zone that recharge to lower aquifers occurs. The rate of recharge is an important factor in the rate at which contaminants will move away from a storage site. At the WIPP, not only is the rate of fluid flow in the aquifers overlying the repository is uncertain, but many other hydrologic parameters such as recharge and the change in recharge due to climatic changes have not been determined. These parameters are needed as inputs for the performance assessment modeling.

From five sites around WIPP we have collected soil core samples to determine the recharge rate. The core was taken in increments of 5 to 10 cm and immediately sealed in tight jars. In the laboratory the soil water was distilled from the soil and collected for isotopic analysis. The residual soil was leached to determine the amount of chloride. The first technique which we have used to calculate recharge is a mass balance approach based on soil chloride and soil water contents. The resulting recharge rates range from .23 mm/year up to 1.98 mm/year. The relative values of recharge vary with the geomorphology of the sampling. The lowest recharge rate is from the crest of a sand dune, intermediate values for flat areas and the highest rate is from a topographic depression. The accumulation of chloride in the soil column can also be used to determine the age of the water as it infiltrates the vadose zone. In the deepest hole sampled, soil water at 4.5 meters was close to 600 years old.

Recharge will also be calculated using stable isotope techniques. We have finished the oxygen isotope analysis of the soil water but the hydrogen isotopic composition will not be available until next year. The oxygen isotope valves of the water infiltrating through the vadose zone can also be compared with the water in the shallow aquifers. Our steady-state isotopic valves range from $\delta^{18}O$ = -1.4% to -2.9%. These values fall within the range of those shown by Lambert and Harvey to be waters from recent recharge.

LABORATORY VALIDATION OF NEW MATHEMATICAL MODELS OF GROUNDWATER POLLUTION TRANSPORT PHENOMENA

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ABSTRACT

Many hazardous waste sites, oil field produced water pits, petrochemical industry facilities and leaking underground storage tanks involve groundwater contaminated by hydrocarbons, solvents and other non-aqueous phase organic liquids. These organic liquids migrate through the soil and groundwater, leaving behind a residual trapped by capillary forces in the pore matrix. The organic liquid dissolves into the aqueous phase contaminating groundwater supplies, and volatilizes into the air phase. Site characterization and remediation efforts are often based on mathematical models of these multiphase flow and transport processes. The models incorporate porous media continuum concepts and other important assumptions and are often poorly validated by experimental and theoretical work.

The late 1980's there were rapid advances with two non-continuum mathematical modeling approaches for porous media: percolation networks (PN) and cellular automata (CA). These advances provide fundamental theoretical approaches to fluid flow and pollutant transport. From these advances we are gaining a better understanding of behavior, an ability to test many of assumptions incorporated in conventional continuum models, and the insight to improve these conventional tools. However, the new non-continuum approaches are themselves largely unvalidated by experimental work. This project employs etched glass micromodels to experimentally validate PN and CA mathematical models, by making observations at both pore network and pore body scales. The models are validated for selected single and multiphase flow and transport processes, and applied to the study of particular phenomena of interest in aquifer contamination characterization and remediation.

These immediate results will lead to improved continuum level models, to be used for hazardous waste site characterization and remediation. The anticipated improvements in understanding and capabilities will undoubtedly suggest new remediation design and operation alternatives. The experiments simulating two and three-phase PN models has already pointed out several

shortcomings of PN, which are now being addressed. Among these is the importance of wetting phase wedge flows. The CA related experiments have revealed several experimental design flaws which also being addressed. For etched glass micromodels these include sagging pore body 'ceilings', while for large Lucite models there are capillary instabilities due to model imperfections. The CA experiments are currently aimed at validating continuum transport model mixing rules for pore bodies, using colloid particles as tracers.

CONDITIONAL SIMULATION APPLIED TO CONTAMINANT FLOW MODELING

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ABSTRACT

Models for joint conditioning in stochastic flow analysis are presented in this paper. Conditioning of the flow model on both head and transmissivity data are presented for steady state two-dimensional flow.

The model assumes linearization and conditioning is carried out in the spectral domain. A Fast Fourier Transform Spectral approach is used to carry out the simulations and a discussion of that procedure is included. The model developed allows incorporation of measurement errors in addition to the presumed stochastic behavior.

The model was applied to generated fields where the flow equation was solved without linearization using a multi-grid procedure. The effect of conditioning on predictions of travel times are presented and the combined linearized and conditioned models are compared with the non-linearized solution.

To get good agreement of the linearized conditioned model with the non-linear model one needs approximately one point per correlation length. However, travel time variances are considerably reduced even for a modest number of observations.

EVALUATION OF UNSATURATED ZONE CONTAMINANT TRANSPORT MODELS FOR WASTE MANAGEMENT

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ABSTRACT

A simple volume-balance water transport, mixing cell solute transport model was compared to the advection dispersion equation for solute transport and the solution of the Richards' equation for water transport to determine under which conditions the simpler model could be used. When the mixing cell model is parameterized correctly resulting in the proper velocity of water flow through the mixing cell, it calculates solute dispersion identical to the analytical solution of the advection dispersion equation. However, as water increment amounts exceed the cell size, the mixing cell model deviates from the advection dispersion equation and then the process is approximate by assuming piston flow.

The water velocity in the mixing cell model is calculated using an empirical SCS infiltration function. When this equation is parameterized using a finite-difference solution to the Richards' equation then it describes very closely the water velocity and infiltration function predicted by the Richards' equation. Water re-distribution with depth calculated by the Richards' equation after 24 hour is also the same as that calculated by the volume-balance method. If the simple and complex models are not parameterized using equations that interrelate the two methods then the expected results of water and solute transport as predicted by the two models will not be the same. If the two model are parameterized the same results are similar.

EFFICIENT ALGORITHMS FOR MODELING THE WIPP SITE

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ABSTRACT

There are many important physical systems that can be modeled using differential equations with discontinuous coefficients, in particular, porous media flow and heat transfer in composite materials problems. The coefficients in the diffusion term in the partial differential equation for the pressure in a porous-media flow make up the conductivity matrix or tensor. This matrix has large entries when it is easy for the liquid to flow through the material, and has small entries when it is difficult for the liquid to flow through the material. In ground-water modeling and reservoir simulation, this coefficient changes abruptly when the geology that determines the flow changes. The distances over which the changes occur are so small that it is frequently reasonable to model the coefficient as discontinuous. Similar problems occur in heat transfer problems in layered media where the conductivity matrix is discontinuous between materials. If such problems are approximated numerically, then the usual analysis of accuracy fails because of the discontinuous coefficients. The present work provides an alternative analytic analysis of the error for certain critical model problems involving one-dimensional steady-state flow. This analytic technique and numerical experiments are used to compare seven numerical methods, five finite difference methods: Linear Average; Harmonic Average; Geometric Average; Mixed; and Rose; and two finite element methods: Galerkin; and Mixed. The work on higher-dimensional flows is in progress.

Two different models of material interfaces are considered. In the first model, it is assumed that the position of the interface is known with a precision that is significant relative to the grid spacing in the discretization, while in the second, it is assumed that the position of the interface is only known to be some place in a given computational cell. In the first situation, several methods produce the exact analytic answer for the model problem and the error in the methods behaves smoothly with small errors in the position of the interface. In the second situation, most methods produce the same error and thus the simplest methods are the best.

MOBILITY OF RADIOACTIVE COLLOIDAL PARTICLES IN GROUNDWATER

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ABSTRACT

Radiocolloids are a major factor in the rapid migration of radioactive waste in groundwater. At two Los Alamos National Laboratory sites, researchers have shown that groundwater colloidal particles were responsible for the rapid transport of radioactive waste material in groundwater. Similar reports of facilitated plutonium transport by colloids has been reported for several other DOE facilities, e.g., INTEL, NTS, and Maxey Flats. On an international scale, a review of reported field observations, laboratory column studies, and carefully collected field samples provide compelling evidence that colloidal particles enhance both radioactive and toxic waste migration. In this 34 month project, a team of researchers, scientists, and engineers (from UNM, NMSU, LANL, EPA and industry) are addressing the problem of colloid contaminant migration in groundwater. The objective is to understand and predict colloid-contaminant migration through fundamental mathematical models, water sampling, and laboratory experiments. Using this information, the team will develop an effective and scientifically based colloid immobilization strategy. The research is focusing on solving the radiocolloid transport problems at LANL's Mortandad Canyon site.

Results from this study are providing a fundamental understanding and predictive capability of contaminated colloid migration in groundwater. Using this information we are developing an effective and scientifically based colloid immobilization strategy and technology; thus providing DOE a solution to key environmental problem which is very important to New Mexico and to potentially other DOE facilities. To date we have established a state of the art radiocolloid characterization laboratory. Researchers at NMSU have completed preliminary numerical simulations of the groundwater and contaminant transport for Mortandad Canyon. Findings confirm that unusual and facilitated transport of plutonium and other radionuclides is occurring. Laboratory experiments using natural groundwater colloids from Mortandad Canyon, show that

these colloids are easily flocculated and removed from the goundwater using a standard cationic polyelectrolyte. Column studies are used to simulate and test the polyelectrolyte type colloid remediation concept. Column tests using commercial latex microspheres have shown that the polyelectrolyte induced flocculation can be adversely affected by artificially introduced surfactants that are contained in the commercial latex colloid samples. Surfactant free latex colloids will be investigated in the current Phase III of the project.

NUCLEAR WASTE STORAGE VAULT CLOSURE DETERMINATION

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Collaborators:

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ABSTRACT

Nuclear waste storage vaults, carved from bedded salt, close in on themselves, eventually encapsulating waste placed therein. This process requires an unknown amount of time. Also unknown is the extent to which temperature variations, moisture or faults evident in the walls, will affect the waste barrels or their contents. This is principle among the objections to opening the DOE's Waste Isolation Pilot Project (WIPP) in Carlsbad, NM. Critics cite the recent rockfall events, when slabs of salt rock released suddenly from vault ceilings, as evidence of poor mining practice. Rockfall is part of the waste encapsulation mechanism, which the present research aims to characterize. In particular, a comprehensive mathematical model and computer algorithm is being developed to predict the action of the encapsulating mechanism.

One important difficulty in the larger problem has been the inability to make precise experimental measurements of *whole-field* displacements or strain-rates in existing vaults. Such measurements are needed to guide the thinking of theoreticians as well as to check the predictions of their models. We have employed an experimental mechanics technique, based in coherent optics, called speckle photography. The method is non-invasive and non-intrusive and yields surface displacement information over arbitrarily short gage lengths.

Engineering analysis, coupled with the experimental program, has, to date, provided some answers to the dynamics of the encapsulating mechanism. In summary, we have demonstrated that accurate predictions of salt behavior are possible. We continue our study of the properties of salt formations, the forces that work in them, and the response of salt in the form of flow dynamics. We have used first principles as well as phenomenological relationships to generate a mathematical model of salt deformation. Now, our goal is to 'tune' the model and to develop the appropriate numerical implementation.

CALIBRATION OF NEAR-FIELD STABILITY INSTRUMENTATION AT THE WASTE ISOLATION PILOT PLANT

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Collaborators:

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ABSTRACT

Time domain reflectometry (TDR) laboratory experiments have been conducted using cylindrical rock salt cores from the WIPP site. The chief objective in applying TDR techniques to rock mechanics is to quantify the type and magnitude of rock mass deformation. Coaxial TDR cables, grouted in rock salt samples subjected to extension loads, were monitored to record changes in reflected voltage signals during rock deformation. Both foam and air dielectric cables were used in 1/2 and 7/8 inch diameters to evaluate cable and signal performance under tension. Cables were crimped to produce local cable faults and thereby reflection (reference) points in order to track cable displacements. Radial and axial extensometers were used to measure circumferential and vertical rock sample strains. LVDT's were used to determine average total displacement of the sample during testing.

An MTS servo-controlled hydraulic testing and data acquisition system was used to control stroke (displacement) during extension tests and capture instrumentation data. Cable deformation data was captured and stored using a Tektronix cable tester and computer serial interface. Reflected wave forms of voltage pulses were digitized and analyzed with regard to changes in characteristic shapes and rock deformations in extension. Evaluation of changes in wave form characteristics shows a good correlation of cable deformation rate to rock mass movement in extension. This was evident from changes in crimp separation distance and to a limited extent, wave form amplitudes. Preliminary analysis for the air dielectric coaxial cables showed that a rock deformation range of 0.07 to 0.15 inches in extension corresponded to a 1% change between two crimp separation distances as detected on the cable tester. At cable failure, a range of 0.03 to 0.05 inch rock deformation per 1% crimp separation was recorded. The air dielectric cables produced consistent results with little or no cable-grout interface slippage.

DEFORMATION MECHANISMS OF WIPP BACKFILL

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ABSTRACT

A fundamental understanding of the deformation mechanisms of backfill is crucial in predicting the long-term creep performance of salt-based radioactive waste repository. It is desirable to have the salt consolidate and become impermeable as rapidly as possible. But, an unacceptably long time is required for dry crushed rock salt to attain the low porosity necessary for the backfill to have the permeability approaching that of the surrounding natural formation. However, natural rock salt always contains some brine (0.1 to 1.0% by weight). This small amount of brine will "weaken" the grain boundary of rock salt and consequently accelerate the consolidation rate under low stress conditions.

Water was found to have a significant influence on the consolidation rate of WIPP crushed rock salt. The results of consolidation tests and SEM (Scanning Electron Microscope) observations show that an optimum value of water content exists (under certain pressure, temperature, consolidation time, gradation, etc) for which the crushed rock salt has the fastest consolidation rate.

Four groups of consolidation tests of WIPP crushed rock salt were conducted under different conditions with water content varying from 0.12% to 5.00%. Two of the four groups, with particle sizes uniformly distributed between the fines (0.075 mm) and an upper limit of 10 mm, were performed using floating ring consolidometers, under pressure and temperature of 1 MPa and 20 °C, 3 MPa and 25 °C, respectively. The other two groups with a 0.15 mm upper limit of particle size were consolidated using a pelletizer, under 20 MPa and 20 °C, 69 MPa and 30 °C, respectively.

The results of the consolidation tests show that water could accelerate the consolidation rate of the crushed rock salt under low stress conditions, if the water content is sufficient. Furthermore, the effect of water is influenced by consolidation pressure, time and particle gradation. High pressure and small particle size increase the optimum value of water content. On the other hand, the optimum value of water content shifts slowly to smaller values as the consolidation time elapses.

From SEM micrographs of the consolidated specimens, it is shown that the water content affects interparticle contact, void and porosity. High pressure and long consolidation time make the grain size increase. Solution transfer, diffusion and recrystalization seem to be important mechanisms contributed to the densification of the crushed rock salt. In addition, TEM (Transmission Electron Microscope) observations show that the crystal structure of wet WIPP crushed rock salt remains unchanged after consolidated, in comparison to the original sample.

Finally, a consolidation model of WIPP crushed rock salt is under developed. X-ray techniques and ESEM (Environmental Scanning Electron Microscope) are employed for further research works.

PERFORMANCE OF ROCK REINFORCEMENT SYSTEMS AT ELEVATED TEMPERATURE

Principal Investigator:

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Co-Principal Investigators:

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New Mexico Tech

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Collaborator:

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Sandia National Laboratories

ABSTRACT

The Department of Energy began work on siting, designing, and considering for the operation of geologic repositories for disposal of spent nuclear fuel as far back as the early 1970's. One of the concerns was the effects of heat generated by the high level waste on the repository substructure. The over 200°C temperature, such as that anticipated at the Yucca Mountain Project site, may cause adverse stress changes in the rock mass and also in the rock reinforcing systems. The results of a study performed to estimated the damage zone around an underground opening excavated by the smooth-blasting technique, and also the effects of elevated temperature on the mechanical rock bolting system are reported here. Excavation by blasting is considered here because it may be an easier method but at the same time may cause the most damage. A three dimensional elastic wave propagation code (GDBSWC) was developed by New Mexico Tech for this purpose of determining blast damage. A finite-element code, GEOT2D, which was developed at the University of New Mexico was enhanced to simulate pre-stressing in rock-bolts. It was then used to determine the effectiveness of a mechanical rock bolt installed through this damaged zone and also the undamaged zone. A temperature change of 300°C was also simulated. The damage zone around the underground opening excavated by the smooth-blasting technique was found to be between 0.45 m (1.5 ft) to 2 m (6.5 ft) depending on different firing patterns, blast-hole size and explosives used. Results of the finite element analysis suggested that for a 0.6 m (2 ft) to 1.2 m (4 ft) damage layer thickness, the effective zone of influence of the rock bolt is about 2.5 m (8.2 ft) to 1.75 m (5.75 ft) away from the rock bolt. However, that temperature increase of 300°C was found to more than release the 10,000 lb prestress applied to the rock bolt at the time of installation. At this point the rock bolt became totally ineffective.

NUCLEAR WASTE REPOSITORY VENTILATION SYSTEM STUDIES

Principal Investigator:

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ABSTRACT

The ventilation studies of the Waste Isolation Pilot Plant described in this report were performed by personnel from New Mexico State University in collaboration with Sandia National Laboratories, Los Alamos National Laboratory and Westinghouse Corporation. The following research tasks were performed. High efficiency particulate air filters of the type in use at the Waste Isolation Pilot Plant were loaded with salt aerosol provided from that site. The structural strength of salt loaded high efficiency filters was investigated by subjecting the filters to pressure transients of the types expected from fires, explosions and tornadoes for two humidity levels, high (73%RH) and low (13-14%RH). Filters loaded under the high humidity condition proved to have a greater structural strength than did the filters loaded under the low humidity conditions, when both types were subjected to tornado-like pressure pulses. A filter pre-conditioned with a 100%RH airflow for 4 hours prior to structural testing prove weakest of all. CALAMITY, a transient computer code, was developed at NMSU especially for simulation of the WIPP site ventilation systems for eventual use as part of a model-based control of the ventilation systems. It was shown to very closely predict the steady state operation of the underground portion of the current WIPP ventilation system.

CHARGED AEROSOL SCRUBBER FOR AIR PURIFICATION

Principal Investigators:

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ABSTRACT

The critical waste management problem to be addressed by this project is air pollution caused by industry and automobiles. Acid rain has become not just a local problem, but an international problem. For example, a good deal of Canada's acid rain is generated in the United States. In Europe, where a comparable industrial base is contained within a much smaller land area, air pollution is causing forests to die all over the continent. But air pollution form industrial smoke stacks and automobile exhausts affect the health of people as well as trees, lakes and animals. The problem continues to become worse and solutions are sorely needed.

The purpose of this project is to design and develop a new type of scrubber which would help to solve the air pollution problem. The design, which is based upon a method for creating sub-micron charged liquid aerosol, should result in a highly compact and efficient scrubber.

In 1992, the specific task will be to fabricate and field test two prototype charged aerosol scrubbers.

ASSESSING RISK COSTS OF RAM TRANSPORT: A JOINT PROJECT OF THE UNIVERSITY OF NEW MEXICO AND NEW MEXICO STATE UNIVERSITY

Principal Investigator:

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Co-Principal Investigators:

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Co-Principal Investigators:

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ABSTRACT

A perceived and therefore real cost borne by communities along transportation routes or near disposal sites is the risk of radioactive release. For realistic and legitimate cost estimates, it is crucial that monetary value of reducing the perceived risk on affected individuals be measured. With such monetary measures of changes of perceived risk, the benefits of alternative routes can be directly compared to construction and operating costs. The problem, however, is that the present state of the art for estimating values for non-market goods is inadequate for valuing the risk-cost of nuclear waste. The research in the previous two phases developed a new concept with regard to the quantification (valuation) of the difficult public choices inherent with nuclear waste. The concept consists of two simultaneous but complimentary approaches: (1) a contingent valuation method (CVM) that samples a broad representation of New Mexicans' preferences concerning nuclear waste issues; and (2) an experimental inference procedure (EIP) that has direct monetary incentives for the respondents to accurately reveal preferences.

The complimentary approach of CVM and EIP must be shown to eliminate three major measurement biases in the elisticitation of monetary values; (1) separability bias, (2) the difference between estimates of willingness to pay (WTP) and estimates of willingness to accept (WTA) and (3) incentive bias. These issues are briefly described. The goal of this research, third phase, is to develop credible and professionally accepted methods for valuing risk costs associated with transportation of hazardous materials, in general, and nuclear-related activities in particular. The third phase of this research has the objective of developing the CVM/EIP procedure to the point that it can be demonstrated that the simultaneous approach significantly reduces or eliminates separability, incentive and WTA/WTP biases.

Result 1: Demonstrate that a suitable design of the CVM/EIP procedure can systematically eliminate the three sources of bias encountered in estimating monetary values of nuclear waste transportation. If the CVM/EIP procedure can separate nuclear waste transportation issues from other nuclear or environmental issues, DOE can then specifically weigh the benefits of routes, bypasses and other transportation measures against their respective costs.

Result 2: Demonstrate that willingness to pay measures derived using CVM/EIP can be used to obtain accurate willingness to accept valuation. This will assist DOE in a critical question in negotiations with New Mexico concerning transportation routes; the extent that risk/cost values differs depending on what is assumed about state rights vis-a-vis federal domain.

UNDERSTANDING CHANGE IN PUBLIC PERCEPTIONS OF NUCLEAR WASTE

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Collaborator:

Leo Gomez
Sandia National Laboratories

Richard P. Barke
Georgia Institute of Technology

ABSTRACT

The current WERC project has collected national base-line data on risk perceptions in the form of a random survey of American households; the second national survey in the series (funded through our existing WERC grant) will be administered in December, 1991. The base-line data have made possible the test of numerous hypotheses about the nature and origin of nuclear risk perceptions; the time series will allow analysis of the factors that lead to change in perceived risks over time. The funding requested here will permit collection of random national samples in June and December of 1992 and 1993, thereby extending the time-series dataset to six samples taken over six-month intervals. Despite the importance of understanding the evolution of popular perceptions of critical policies to manage nuclear wastes, no comparable time-series dataset exists anywhere in the United States.

The fundamental problems addressed by this research are the substantial difficulties encountered in attempts to develop and implement acceptable nuclear waste management policies. As recently described by two eminent scholars of risk perceptions, "officials and experts from DOE and the nuclear industry are profoundly puzzled, frustrated, and disturbed by the public and political opposition that they believe is based on irrationality and ignorance" (Slovic, Layman, and Flynn, 1991). Far too little is understood about the patterns of, and reasons behind, public reactions to federal policies designed to safely manage nuclear wastes. In our ignorance -- and despite the expenditure of many billions of dollars -- our efforts to persuade the public or to override public objections may substantially worsen the problem both now and in the future.

Our proposal is designed to increase our understanding of public perceptions of nuclear risk and of trust in those charged with implementing nuclear waste management policies. In particular, our focus on patterns of change in perceived risk and trust over time is intended to provide a basis for improved risk communication and policy planning in the future.

Several specific aspects of the proposal will generate concrete benefits for those charged with developing and implementing nuclear waste policies. First, we will analyze the characteristics of support and opposition to nuclear waste management policies: how widespread is opposition to these policies? What percentage of those opposed are firmly committed to that opposition, and why? To what degree does opposition represent "spill-over" from other policy concerns, such as opposition to development of nuclear weapons, rather than perceived risks? Second, we will examine in considerable detail to origins of perceived risks of nuclear waste management. Does "knowledge" about radiation and technology influence risk perception"? If so, in what ways? To what degree does perceived risk emanate from the level of trust accorded the primary organizations charged with implementing nuclear waste management policy? To what degree does exposure to the various news media influence perceived risk; do specific kinds of media programming convey specific messages about those risks? Finally -- and most importantly -- we will track changes in each of these areas over time. Is perceived risk (and therefore

opposition to nuclear waste management policies) growing, holding steady, or diminishing over time? Once the time-series is of sufficient length, we will be able to analyze the degree to which perception of risk responds to specific events (e.g., events like Chernobyl or the FBI investigation of the Rocky Flats weapons facility).

Understanding the nature of risk perception will allow the organizations charged with formulation and implementation of nuclear waste policies to assess the political feasibility of prospective nuclear waste management policies before they become committed to those policies; it will permit informed assessment of the degree of support and opposition to existing policies (does vocal opposition represent a small group or is it reflective of the broader population?); it will provide information relevant to educational policies that may affect risk perception; and it will allow planning for nuclear waste management in a manner that accounts for current and evolving public perceptions of the risks of nuclear waste policies.

APPENDIX M

LIST OF MAJOR PUBLICATIONS RESULTING FROM WERC

1. Angel, E., "User Interfaces and Tele-robots", Technical University of Graz, Graz, Austria, May, 1991.

2. Angel, E., "User interface Tools for Tele-robotic Systems for Handling Hazardous Waste", AI '91, Frontiers in Innovative Computing for the Nuclear Industry, September 1991.

3. Angel, E., "User Interface Tools for Tele-Robots", Visualization Seminar, Computer Science Department, University of Colorado at Boulder, February, 1992.

4. Bandy, D., Bhada, R., Bickel, J., & Morgan, J. D., "The Achievements of a University-National Laboratory Waste-management Education & Research Consortium", WM'91, Tucson, Arizona, February, 1991.

5. Bhada, R., Jacquez, R., Matthews, L., Morgan, D. J., "A Consortium To Address Multidisciplinary Issues of Waste Management", 1st Encuentro Interamericano Sobre Educacion en Ingenieria, June 28, 1991.

6. Bhada, R., Morgan, J. D., "The Achievements of a University-National Lab Waste-Management Education & Research Consortium (WERC)", Annual Meeting of the AIChE, November 16, 1991.

7. Bhada, R. K., "Centrifugal Film Reactor", AIChE National Meeting, Houston, TX, April 1989.

8. Bhada, R. K., "Waste Education & Research Consortium", New Mexico Environmental Forum, Las Cruces, NM, January, 1990.

9. Bhada, R. K., "Multi Disciplinary Issues of Waste Management", ASEE SW Annual Conference Proceedings, pp. 140-147, March 1990.

10. Bhada, R. K., "Opportunities for Minorities in Waste Management", Navajo Community College Forum, Shiprock, NM, March 1990.

11. Bhada, R. K., "Community Involvement in Environment Education and Technology Transfer", New Mexico City Management Conference, Ruidoso, NM, April 1990.

12. Bhada, R. K., "Progress of the University Consortium", Rio Grande Section of AIChE, Las Cruces, NM, April 1990.

13. Bhada, R. K., "The New Mexico Waste Management Consortium", Weapons Complex Monitor, Phoenix, AZ, April 1990.

14. Bhada, R. K., "Waste Management Problems and Opportunities", New Mexico Hispanic Leadership Program, Las Cruces, NM, April 1990.

15. Bhada, R. K., "Waste Management Education and Research", Rio Grande Section of ASCE, Albuquerque, NM, May 1990.

16. Bhada, R. K., "A Consortium to Address Multidisciplinary Issues of Waste Management", Chemical Engineering Education Journal, pp. 180-183, Fall 1990.

17. Bhada, R. K., "A Multidisciplinary Approach to Education & Research in Environment", AIChE National Meeting, Chicago, IL, p. 246e, November 1990.

18. Bhada, R. K., "Opportunities in Environmental Management", 8th Annual Science, Space & Technology Career Expo, Albuquerque, NM, p. 4, April 1991.

19. Bhada, R. K., "New Mexico's Waste Management Consortium", Rotary Club, Albuquerque, NM, June 1991.

20. Bhada, R. K., "New Mexico's Waste Management Consortium", KBIM TV, Roswell, June 1991.

21. Bhada, R. K., "New Mexico Horizons", KDBC TV, El Paso, TX, June 1991.

22. Bhada, R. K., "Foresight", HBCE/MI Meeting, Jackson, MS, June 1991.

23. Bhada, R., Jacquez, R., Kauffman, D., Morgan, J. D., "Lets Move Towards Multi-Disciplinary, Multi-Organizational Education", American Society for Engineering Education Gulf-Southwest Section Annual Meeting, March 15-17, 1992, Albuquerque, NM.

24. Bhada, R., Bickel, J., Bandy, D., Morgan, J. D., "A DOE-University-National Lab Waste-Management Education & Research Consortium (WERC), Status in the Second Year", Environmental Remediation '91, September 8-11, 1991, Pasco, WA.

25. Bhada, R., Morgan, J. D., "A National Environmental Design Contest Capstone Course for Universities", Waste Management '92, March 1-5, 1992, The University of Arizona, Tucson, AZ.

26. Bhada, R., "The New Mexico Waste Education & Research Consortium (WERC)", Waste Management & Cleanup Conference, Phoenix, AZ, April 17.

27. Brookins, D. G., (accepted), "Use of Eh-pH Diagrams to Address the Problem of Contaminant Migration/Retention in Uranium Mill Tailings Impoundments", Cd, Hg, Pb, Sb, As: Hazardous Waste Society of N.M. annual meeting (March 1991).

28. Brookins, D. G., and Persico, J. L., (accepted), "Behavior of Trace Elements in the Poison Canyon Mine Tailing Site, near Grants, New Mexico", Hazardous Waste Soc. N.M. ann. meeting (March 1991).

29. Burness, H. S., Cummings, Harrison, G. W., "Valuing Environmental Goods: A critical Appraisal of the State of the Art", April 1990, Issues in the Economics and Management of Agricultural Drainage Water.

30. Colbaugh, R., & Jamshidi, R., "Robot Manipulator Control for Hazardous Waste Handling Applications", invited paper to special issue on Robots in Unstructured Environments in the Journal of Robotic Systems, Vol. 8, 1991.

31. Colbaugh, R., Seraji, H., & Glass, K., "Adaptive Impedance Control of Redundant Manipulators", Proc. 29th IEEE Conference on Decision and Control, December 5 - 7, 1990, Honolulu, Hawaii.

32. Colbaugh, R., Glass, K., & Hensel, E., "Hierarchical Control of Manipulators Operating in Hazardous and Unstructured Environments", Proc. American Nuclear Society 4th Topical Meeting on Robotics and Remote Systems, February 24-28, 1991, Albuquerque, NM.

33. Colbaugh, R., Glass, K., Hensel, E., "Hierarchical Control of Manipulators Operating in Hazardous and Unstructured Environments", Fourth ANS Topical Meeting on Robotics and Remote Systems, pg. 251-257.

34. Colbaugh, R., Glass, K., "On Controlling Robots with Redundancy", Robotics & Computer-Integrated Manufacturing, Vol. 9, No. 2, pp. 00-00, 1992.

35. Colbaugh, R., Glass, K., "On Controlling Robots with Redundancy", 1991 American Control Conference, June 26-28, 1991, Boston, Massachusetts, pg. 2059-2061.

36. Colbaugh, R., Glass, K., Jamshidi, M., "Impedance Control for Hazardous Waste Handling Applications", 30th Conference on Decision and Control, Brighton, England, December 1991, pg. 684-691.

37. Colbaugh, R., Glass, K., Jamshidi, M., "Direct Adaptive Impedance Control of Manipulators", 30th Conference on Decision and Control, Brighton, England, December 1991, pg. 2410-2415.

38. Colbaugh, R., Glass, K., Seraji, H., "An Adaptive Inverse Kinematics Algorithm for Robot Manipulators", International Journal of Modelling & Simulation, Vol. 11, No. 2, 1991, pg. 33-38.

39. Colbaugh, R., Glass, K., "A unified Approach to Controlling Robots with Redundancy", International Journal of Robotics and Automation, Vol. 6, No. 2, 1991, pg. 95-104.

40. Colbaugh, R., Jamshidi, M., "Robot Manipulator Control for Hazardous Waste-Handling Applications", Journal of Robotic Systems 2-9136-Art. 492 Denny 12/5/91, pg. 01-036.

41. Conley, E., Genin, J., "Nuclear Waste Burial Repositories: Analysis and Experiment", Radiological and Mixed Waste, pg. 81-83.

42. Conley, Ed, Genin, J., "Nuclear Waste Vault Closure Analysis", Sixth Annual Hazardous Waste Management Conference, Manhattan, Kansas, May 29-30, 1991.

43. Conley, E., Cloud, G., "Resolution experiments using the white light speckle method", Applied Optics, March 1991, Vol. 30, No. 7, pp. 795-800.

44. Fekete, F. A., Nuttal, H. E., Jain, R., "Production and Partial Characterization of Selenium Colloids", 65th Colloid and Surface Science Symposium, June 17-19, 1991, University of Oklahoma.

45. Fekete, F. A., Barton, L. L., "Effects of iron(III) analogs on growth and pseudobactin synthesis in a chromium-tolerant *Pseudomonas* isolate", Biology of Metals, 1991, pg. 211-216.

46. Fertelli, Y. M., "Colloid Transport in Groundwater Flow Through Saturated and Unsaturated Fractures", Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Chemical Engineering, The University of New Mexico, Albuquerque, New Mexico, December 1990.

47. Gomez, L., Jenkins-Smith, H., Miller, K., "Changes in Risk Perception Over Time", American Association for Advancement of Science, February 6-11, Chicago, IL.

48. Groffman, A. R., Brookins, D. G., and peterson, S. A., (accepted), "The Removal of Lead, Cadmium, Heavy Metals and Trace Element. from Waste Water Streams using Zeolites, Zeocarb and Other Natural Materials as a Sorption Medium", Hazardous Waste Society N. M. annual meeting (March 1991).

49. Jain, R., & Nuttall, H. E., "CTC-Colloid Transport Code & Simulations", Manteo III, Concepts in Manipulating Groundwater Colloids for Environmental Restoration, DOE Sponsored, Manteo, North Carolina, October 15 - 18, 1990.

50. Jenkins-Smith, H., Rouse, A., "Subjective Knowledge, Its Origins and Relationship to Perceptions of Risk", American Association for Advancement of Science, February 6-11, Chicago, IL.

51. Jenkins-Smith, H., Smith, W., "Ideology, Culture and Risk Perception", American Association for Advancement of Science, February 6-11, Chicago, IL.

52. Kauffman, D., "A comprehensive Plan for Continuing Education in Hazardous Waste Management", ACHEMA-91 Meeting, Frankfurt, Germany, Summer 1991.

53. Longmire, P. A., Brookins, D. G., Thomson, B. M., and Eller, P. G., 1990, "Hydrogeochemical Investigations at a Uranium Mill Tailings Site, Maybell, Colorado", Geol. Soc. Amer. Abs. w. Programs, v. 21, n. 7, p, A 160. This paper was presented by Brookins at the 1990 annual meeting of the Geological Society of America in Dallas, TX, Oct. 30, 1990.

54. Longmire, P. A., Brookins, D. G., Thomson, B. M., and Eller, P. G., 1990 in press, "Application of Sphagnum Peat for Immobilizing Radioactive and Hazardous Contaminants in the Subsurface", Sci. Basis for Nuc. Waste Management Int. Symposium, Program w. Abstracts, 1990 annual eastern meeting of the Materials Research Society. Presented by Brookins on Nov. 27, 1990 in Boston, MA.

55. Longmire, P. A., Brookins, D. G., Thomson, B. M., and Eller, P. G., "Application of Sphagnum Peat for Immobilizing Radioactive and Hazardous Contaminants in the Subsurface", in Scientific Basis for Nuclear Waste Management XIV (T.A. Abranjo and L. A. Johnson, Eds.), in press.

56. Longmire, P. A., Eller, P. G., Brookins, D. G., and Thomson, B. M., 1991 (in press), "Application of Sphagnum Peat for Immobilizing Radioactive and Hazardous Contaminants in the Subsurface", in Waste Management 91 (Tucson, AZ, International Meeting), Abstracts volume.

57. Longmire, P. A., Brookins, D. G., Eller, P. G., and Thomson, B. M., "Application of Sphagnum Peat for Immobilizing Radioactive and Hazardous Contaminants in the Subsurface", Waste Management 91 Proceedings Volume, accepted for inclusion.

58. Longmire, P. A., Eller, P. G., Brookins, D. G., and Thomson, B. M., 1991 in press, Surface chemistry studies of sphagnum peat: molecular mechanisms for removal of radioactive and hazardous contaminants: Geol. Soc. Amer. Rocky Mtn.-South Central Sectional Meeting (Albuquerque, NM; April 22-24, 1991).

59. Maji, A. K., Donald, S. & Cone, K., "Mechanical Properties of Porous and Cellular Materials" Ed: Gibson, Green, Sieradzki; Mrs Publication (1990), Testing of Impact Limiters for Transportation Cask Design.

60. Maji, A. K., Schreyer, H. L., Associate Members ASCE, and Neilsen, M., "Development of a Constitutive Model for Impact Limiters", Proc. of Engineering Mechanics Conference, Columbus, OH, 1991.

61. Maji, A. K., Satpathi, D., & Schreyer, H. L., "Testing of Materials and Scale Models for Impact Limiters", Proc. of International High Level Radioactive Waste Management Conference, at Las Vegas, Nevada, April 28-May 2, 1991. Organized by ASCE and ANS.

62. Maji, A. K., and Sahu, R., "Acoustic Emission Monitoring of Reinforced Concrete", to appear in the proceedings of the SEM Spring Conference, Milwaukee, WI, 1991.

63. Majumder, S., Prairie, M., Ondrias, M., Shelnutt, J., "Photocatalytic Degradation of Aromatic Compounds By Porphyrins Adsorbed Onto Al_2O_3 Using Visible Light".

64. Majumder, S., Prairie, M., Ondrias, M., Shelnutt, J., "Enhancement of Solar Photocatalytic Detoxification by Adsorption of Porphyrins onto TiO_2", Detoxification & Bioconversion Session 1992 ASME International Solar Energy Conference, Lahaina, Maui, Hawaii, April 5-9, 1992.

65. Majumder, S., Ondrias, M., Enhancement of Solar Photocatalytic Detoxification by Adsorption of Porphyrins onto TiO_2", presented by SAM at the Student Competition Section of 36th Annual New Mexico Water Conference, Las Cruces, NM, November 7, 1991.

66. Majumder, S., Shelnutt, J., Prairie, M., Ondrias, M., "Enhancement of Solar Photocatalytic Detoxification by Adsorption of Porphyrins onto TiO_2, presented by SAM at the 1991 Waste Management Conference, San Juan, Puerto Rico, April 1991.

67. Martin, F. D., Bretz, R. E., Bowman, R. S., Kieft, T. L., Cadena, F., "The Hobbs Oil & Water Experimental Facility of the Waste-Management Education & Research Consortium", PETRO-SAFE '92 Conference, January 27-29, 1992, Houston, TX.

68. Munson-McGee, Stuart, "Technology for Waste Encapsulation", Superfund Sludge Characterization & Treatment Workshop in Edison, NJ, June 17-19, 1991.

69. Nuttall, H. E., Jain, R., Triay, I. R., "Colloid Remediation in Groundwater by Polyelectrolyte Capture", 65th Colloid and Surface Science Symposium, June 17-19, 1991, University of Oklahoma.

70. Nuttall, H. E., & Jain, R., "Electrokinetic Model for Colloid Transport in Fractures", American Institute of Chemical Engineers, 1990 Annual Meeting, November 11-16, 1990, Chicago, Illinois, Particulate Processes in Porous Media-II(276).

71. Nuttall, H. E., Long, R., Triay, I., "Radiocolloid Migration in Groundwater", 4th Annual Hazardous Waste Management Conference and Exhibition, March 18-21, 1991, Albuquerque, NM.

72. Nuttall, H. E., Jain, R., & Fertelli, Y., "Radiocolloid Transport in Saturated and Unsaturated Fractures", International High Level Radioactive Waste Management Conference, April 28-May 2, 1991, Ceasars Palace, Las Vegas, Nevada, Sponsored by ANS and DOE.

73. Nuttall, H. E., and Triay, I., "Removal of Actinides from Waste Water by Flocculation", 4th World Congress of Chemical Engineering, June 16-21, Karlsruhe, FEDERAL REPUBLIC OF GERMANY.

74. Nuttall, H. E., Jain, R., & Triay, I. R., "Colloid Remediation in Groundwater by Polyelectrolyte Capture", 65th Colloid and Surface Science Symposium, June 17 - 19, 1991, The University of Oklahoma.

75. One Ph.D. dissertation in progress; one MS thesis in progress (WERC funded).

76. Pratt, D., Jenkins-Smith, H., "The Role of the Media and Information in Fears of Radiation", American Association for Advancement of Science, February 6-11, Chicago, IL.

77. Rayson, G., Huei-Yang, D., "Investigation of UO^{2+}_2 Binding Sites on *Datura Innoxia* Using UO^{2+}_2 Luminescence".

78. Rayson, G., Huei-Yang, D., "Characterization of Cd Binding Sites on *Datura Innoxia* Using ^{113}Cd NMR Spectrometry".

79. Rayson, G., Huei-Yang, D., Birnbaum, E., Darnall, D., "Characterization of the Carboxyl Groups on *Datura Innoxia* Using EU(III) Luminescence".

80. Rayson, G., Huei-Yang, D., Birnbaum, E., Darnall, D., Jackson, P., "Investigation of Eu(III) Binding Sites on *Datura Innoxia* using Eu(III) Luminescence".

81. Sharp, R., "Preliminary Development of a Method for Correlating the Hydrogenase Activity of Sulfate-Reducing Bacteria to Rates of Microbiologically Induced Corrosion", Thesis, submitted in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering, The University of New Mexico, Albuquerque, NM, December 1991.

82. Sharp, R., Ross, T., Barton, L., "Determination of the Rate of Biocorrosion Via Dehydrogenase Activity", R&D 92, National Research & Development Conference on the Control of Hazardous Materials", February 4-6, 1992, San Francisco, CA.

83. Seraji, H., Colbaugh, R., "Singularity-Robustness and Task-Prioritization in Configuration Control of Redundant Robots", 29th Conference on Decision and Control, Honolulu, Hawaii, December 1990, pg. 3089-3095.

84. Seraji, H., Colbaugh, R., "Improved Configuration Control for Redundant Robots", Journal of Robotic Systems 7(6), 897-928 (1990), pg. 898-928.

85. Triay, I. R., Mitchell, A., Thompson, J., & Nuttall, H. E., "Utilization of a Flocculation Technique to Remediate Waters Contaminated with Actinides", Manteo III, Concepts in Manipulating Groundwater Colloids for Environmental Restoration, DOE Sponsored, Manteo, North Carolina, October 15 - 18, 1990.

86. Townsend, J., "Focus on Haz Mat, APU's - A Hazardous Non-Material", *Industrial Fire World*, August-September 1990.

87. Townsend, J., "Fruit Basket Turnover - Almost", Industrial Fire World, Volume 6, Number 5, pg. 18-19, August/September 1991.

88. Townsend, J. S., "Underground Storage Tanks: Rules & Regulations", Industrial Fire World Exposition, April 16-18, 1991.

89. Townsend, J., "Where There's Smoke There's Fire and Vice Versa", Industrial Fire World, December 1991, pg. 10-11 & 24.

90. Townsend, J., "Arsenic and Old Lace", Industrial Fire World, October/November 1991, pg. 10-11.

91. Wang, M. L., Miao, S. K., Maji, A. K., Hwang, C. L., "Effect of Water on the Consolidation of Crushed Rock Salt".

APPENDIX N

TYPES OF EQUIPMENT AT WERC LABORATORIES

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Flourometer

Constant Pressure Respirometer

Gas Chromatograph/Mass Spectrometers with Accessories including Purge & Trap Concentrator

High Performance Liquid Chromatograph

Inductively Coupled Argon Plasma (ICAP) Spectrometer

Colloidal Particle Counter/Analyzer

Atomic Absorption Spectrophotometers

Fluorescence Detector

Microwave Digestion System

Evaporation Workstation

Silicon Graphics Computational Machine

Ion Chromatograph System

Carbon-Hydrogen-Nitrogen-Sulphur-Oxygen(CHNSO) Analyzer for GC/MS

Fourier-Transform Infra-Red (FTIR) Spectrophotometer

Gas Chromatograph with Nitrogen-Phosphorous Detector (NPD)

Pulsed Neutron Generator System

Safety Equipment

Extractors

Evaporative Concentrators

Centrifuges

Homogenizer

Crusher

Grinder

Incubator with Shaker

Coliform Water Bath

Deionized Water System

Data Acquisition Systems

Drying Oven

Coaxial Detector

Closed Loop Water Circulating System

Fume Hood

Injector Kit

Auto Sampler

Micro-Centrifuge

Orbital Shaker

High Pressure Pumps

Vibration Free Table

Gross Alpha-Beta Counter

Portable Alpha/Gamma Detectors

TLD System

Gas Adapter

Pressure Controller

Two Stage Pressure Regulator

GOW-MAC Gas Leak Detector

Column Leaching System

Harvard 44 Programmable Syringe Pump

Multi-channel Analyzer

Laser Light Source

High Resolution CCD Camcorder with Video Printer

Still Camera and High Resolution Lens System

Metallurgical Microscope with Camera System

WET-Scanning Electron Microscope Upgrade

Portable Environmental Radiation Monitor

Pocket, Self-reading Dosimeters

Low Background Shield and Pop-Top Cryostat for Germanium Detection System