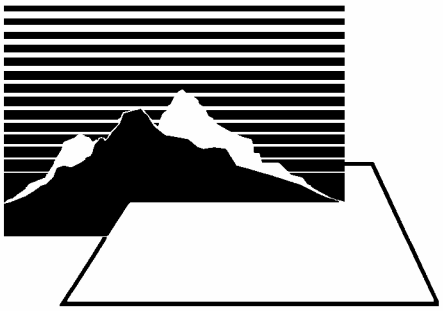
ANNUAL REPORT

of the

Great Plains/Rocky Mountain Hazardous Substance Research Center



December 2001

CONSORTIUM MEMBERS

Colorado State University
Haskell Indian Nations University
Kansas State University
Lincoln University
Montana State University
Montana Tech of the University of Montana
South Dakota State University
University of Iowa
University of Missouri
University of Montana
University of Nebraska
University of Northern Iowa
University of Utah
University of Wyoming
Utah State University

Edited by
Wendy M. Griswold, Terrie K. Boguski, Larry E. Erickson, Mary M. Rankin, and Lakshmi N. Reddi
Great Plains/Rocky Mountain Hazardous Substance Research Center
Kansas State University
104 Ward Hall
Manhattan, KS 66506-2502

Published by
Great Plains/Rocky Mountain
Hazardous Substance Research Center
Available electronically at
http://www.engg.ksu.edu/HSRC/

GREAT PLAINS/ROCKY MOUNTAIN

HAZARDOUS SUBSTANCE RESEARCH CENTER

Director

Dr. Larry E. Erickson
Great Plains/Rocky Mountain Hazardous Substance Research Center
104 Ward Hall
Kansas State University
Manhattan, KS 66506-2502
Phone: (785) 532-4313/2380
Fax: (785) 532-5985
E-mail: lerick@ksu.edu

Associate Director

Dr. Lakshmi N. Reddi
Great Plains/Rocky Mountain Hazardous Substance Research Center
104 Ward Hall
Kansas State University
Manhattan, KS 66506-2502
Phone: (785) 532-1586
Fax: (785) 532-5985
E-mail: reddi@ksu.edu

Technology Transfer Director

Dr. Richard B. Hayter
Engineering Extension
133 Ward Hall
Kansas State University
Manhattan, KS 66506-2508
Phone: (785) 532-6026
Fax: (785) 532-6952
E-mail: rhayter@ksu.edu

Participants

Consortium Members

Colorado State University
Haskell Indian Nations University
Kansas State University
Lincoln University
Montana State University
Montana Tech of the University of Montana
South Dakota State University
University of Iowa
University of Missouri–
Columbia, Kansas City, and Rolla
University of Montana
University of Nebraska
University of Northern Iowa
University of Utah
University of Wyoming
Utah State University

Other Participants

Colorado School of Mines
University of Colorado
Iowa State University

TABLE OF CONTENTS

THE CENTER AT A GLANCE **4**

CENTER DIRECTOR'S REPORT **9**

HIGHLIGHTS **9**

ENVIRONMENTAL CHALLENGES AND SOLUTIONS: A REVIEW OF RESEARCH AND TECHNOLOGY TRANSFER ACTIVITIES **13**

FUTURE DIRECTIONS **17**

PROGRAM SUMMARY **19**

RESEARCH PROJECT DESCRIPTIONS **27**

Nanoscale Metal Oxide Particles as Reagents for Destruction and Immobilization of Hazardous Substances in Air, Water, and/or an Alternative to Incineration 27

Simultaneous Transformation of Atrazine and Nitrate in Contaminated Water, Sediment, and Soil by Zero-Valent Iron-Promoted Processes 29

Iron-Enhanced Bioremediation of Aquifers Contaminated with Chlorinated Solvents, Hexavalent Chromium, and Nitrate 31

Plant-Assisted Remediation of Soil and Groundwater Contaminated by Hazardous Organic Substances: Experimental and Modeling Studies 33

Non Aqueous-Phase Liquid Waste Products in the Subsurface: Tools for Remediation Design, Regulation, and Site Characterization 36

Changes in the Speciation and Biological Volatilization of Environmental Arsenic as a Result of Phytoremediation of Hazardous Waste Sites 38

Data Management and Horticultural Evaluation of Field Sites for the RTDF Phytoremediation Field Test of Petroleum Hydrocarbon Contaminated Soils (RTDF) 40

Transformation Mechanisms of High Molecular Weight Polycyclic Aromatic Hydrocarbons in the Rhizosphere 42

TRAINING AND TECHNOLOGY TRANSFER PROJECT DESCRIPTIONS **44**

HSRC Technology Transfer Program 44

Conference on Hazardous Waste Research 46

Virtual Library: Transferring HSRC Research Results through the Internet 47

Technical Outreach Services to Communities (TOSC) Program 48

Collaborative Environmental Seminar Series 50

Field Validation of an Optimal Design Methodology for Vegetative Remediation of Sediments from the Central Vehicle Wash Facility, Custer Hill, Fort Riley, Kansas—A Technology Transfer Project 52

BIBLIOGRAPHY **54**

A. REFEREED JOURNAL ARTICLES 54

B. ARTICLES SUBMITTED OR IN PRESS 72

C. BOOKS AND BOUND PROCEEDINGS 74

D. CHAPTERS IN OTHER BOOKS OR BOUND PROCEEDINGS 75

E. PROJECT REPORTS 109

F. THESES/DISSERTATIONS 119

G. BULLETINS AND SPECIAL PUBLICATIONS 131

H. CONFERENCES AND WORKSHOPS 132

INDEX **147**

THE CENTER AT A GLANCE

Kansas State University (KSU) leads the consortium comprising the Great Plains/Rocky Mountain Hazardous Substance Research Center, which serves Environmental Protection Agency (EPA) Regions VII and VIII. Other member universities are Colorado State University, Haskell Indian Nations University, Lincoln University, Montana State University, Montana Tech, South Dakota State University, Utah State University, and the Universities of Iowa, Missouri, Montana, Nebraska, Northern Iowa, Utah, and Wyoming. All are located in EPA Regions VII and VIII. The center was established in February 1989 to conduct research pertaining to the identification, treatment, and reduction of hazardous substances resulting from agriculture, forestry, mining, mineral processing, and other activities of local interest. In 1994, efforts of center principal investigators were broadened to include programs for minority academic institutions, technical outreach services for communities, and research and re-education for displaced military and Department of Defense personnel.

The center is headed by Dr. Larry E. Erickson, professor of chemical engineering at Kansas State University (KSU). Dr. Erickson is responsible for coordinating all of the center's activities. He is assisted by Dr. Lakshmi N. Reddi, who is the associate director, and by Dr. Richard B. Hayter, associate dean for extension and outreach and director of engineering extension programs, who oversees the conduct of the center's training and technology transfer program. The center benefits from guidance supplied by a 16-person Science Advisory Committee and a 14-person Training and Technology Transfer Advisory Committee. Members of these committees are listed in Tables 1(A) and 1(B).

Table 1(A): Science Advisory Committee

Member	Affiliation	Expertise
Robert Ahlert, Ph.D.	RAMS Env. Consultants	chemical engineering
Terry Baxter***, Ph.D.	Northern Arizona Univ.	environmental engineering
Tim Canfield	U.S. EPA	biology
Ramesh Chawla, Ph.D.	Howard University	chemical engineering
David Constant, Ph.D.	Louisiana State University	hazardous waste engineering, chemical engineering
Carol L. Dona, Ph.D.	U.S. Army Corps of Engineers	environmental engineering
Mitchell Erickson**, Ph.D.	U.S. Department of Energy	chemistry
Felix Flechas	U.S. EPA, Region VIII	environmental engineering
Randy Freeman*, Ph.D.	ABS Group, Inc.	chemical engineering
Craig McFarlane, Ph.D.	U.S. EPA	plant physiology
Michael Norland	South Florida Natural Resource Center	plant science
Catherine A. Peters	Princeton University	environmental engineering
Robert Peters, Ph.D.	University of Alabama at Birmingham	chemical/environmental engineering
Steven Rock	U.S. EPA	phytoremediation
Thomas B. Stauffer	U.S. Air Force	chemistry
Michael Tucker	U.S. EPA, Region VII	biology

*Chair, 1992-1994
**Chair, 1995-1998
***Chair, 1998-Present

Table 1(B): Training and Technology Transfer Advisory Committee

Member	Affiliation	Expertise
Martha Boss	industry	certified industrial hygienist
David Carty	industry	remediation and soil chemistry
Ronald Hammerschmidt	govt/state	environmental chemistry
Stephen Hoffman	govt/EPA	environmental management
Caren Johannes	govt/state	hazardous waste corrective action
Michael Kukuk	industry	environmental engineering
Jim Lehr	govt/EPA	environmental management
Jack Lonsinger*	industry	industrial processes
Dale Manty (ex officio)	govt/EPA	federal program management
Edward Mead**	govt/Corps of Engineers	industrial processes
Robert Mournighan	govt/EPA	environmental engineering
Ella Mulford	industry	industrial processes
Dennis Murphey	govt/city	professional training
Tim Ward	University of New Mexico	environmental engineering

*Chair, 1989-2000
**Chair, 2001-present

Researchers and extension faculty from various academic programs interact through the center, bringing a diversity of perspectives to address complex problems associated with hazardous substances. Table 2 lists key personnel from each participating consortium institution and related non-consortium universities.

Key investigators at non-consortium institutions include Tissa H. Illangasekare, Colorado School of Mines; Joseph B. Hughes, Rice University; Carl G. Johnston, Mycotech Corporation; and Joel R. Coats, Iowa State University.

Table 2: Key Personnel in the Center

Haskell Indian Nations University
Jamison O. Bear
Brenda Brandon
George L. Godfrey
Daniel R. Wildcat

Lincoln University
Frieda Eivazi
Mary Wyatt

University of Northern Iowa
Barbara A. Hetrick
Catherine Zeman

Kansas State University
Philip L. Barnes
Bertram R. Biles
Terrie K. Boguski
Brenda Brandon
Lawrence C. Davis
Vernon Deines
Larry E. Erickson
L.T. Fan
William G. Fateley
Richard E. Faw
Steven J. Galitzer
Larry A. Glasgow
Wendy M. Griswold
William J. Hankley
Richard B. Hayter
Prasanta K. Kalita
Kenneth J. Klabunde
Peter Kulakow
Michael W. Lambert
Blase A. Leven
Alexander P. Matthews
Gene M. Meyer
Frederick W. Oehme
Gary M. Pierzynski
Lakshmi N. Reddi
Charles W. Rice
John R. Schlup
James C. Shanteau
J. Kenneth Shultis
James M. Steichen
Daniel W. Sweeney
Walter P. Walawender
LaBarbara Wigfall

University of Missouri
John Atkinson
Stephen H. Anderson
Daniel W. Armstrong
Rakesh K. Bajpai
Shankha K. Banerji
V.M. Boddu
Joel G. Burken
P.C.-H. Chan
Thomas E. Clevenger
T.L. Feldbush
Daniel Forciniti
Syed E. Hasan
Shubhender Kapila
S.K. Loyalka
Stanley E. Manahan
Deborah J. Mossman
Thomas J. O'Keefe
R. Lee Peyton
Richard Potter
George Preckshot
Ravi K. Puri
Robert L. Segar
Dabir S. Viswanath
John L. Watson

Montana State University
Anne Camper
J. William Costerton
Al B. Cunningham
Douglas J. Dollhopf
John Goering
William P. Inskeep
Stuart R. Jennings
Warren L. Jones
Zbigniew Lewandowski
Frank F. Munshower
Dennis R. Neuman
Paul J. Sturman
Robert V. Thurston
Bryan K. Warwood
Jon M. Wraith
Nick Zelver

University of Nebraska
Istvan Bogardi
Stephen D. Comfort
Mohamed F. Dahab
Bruce Dvorak
Robert D. Grisso
Larry Hammer
Herb Hoover
D. Lewis
Dennis L. McCallister
Shirley M. Niemeyer
William L. Powers
Patrick J. Shea
David P. Shelton
Wayne E. Woldt
Tian C. Zhang

University of Utah
Sam Ghosh
Andrew P. Hong
Jan D. Miller
Robert W. Okey
Russ Price
H.Y. Sohn

Colorado State University
Harry W. Edwards
Elizabeth Pilon-Smits
Kenneth F. Reardon

Utah State University
Carolyn Abbot
Bruce Bugbee
William J. Doucette
R. Ryan Dupont
Conly L. Hansen
Joan E. McLean
Russ Price
Judith L. Sims
Ronald C. Sims
Darwin L. Sorenson
Daniel Smith
David K. Stevens
Stephen B. Turcotte

South Dakota State University
Suzette Burckhard
Susan A. Gibson
James A. Rice
Vernon R. Schaefer
John C. Tracy

University of Iowa
Pedro J.J. Alvarez
David T. Gibson
Craig Just
Burt C. Kross
Gene F. Parkin
Barbara Pies
Michele Scherer
Jerry L. Schnoor
M.I. Selim
Josef Simeonsson
Richard L. Valentine

University of Montana
Jerry J. Bromenshenk
Chris Heyer
D.G. Klarup

Montana Tech
Karl Burgher
Kevin Mellott

University of Wyoming
Lee A. Bulla
Benito M. Chen
P.S. Colberg
Jerry J. Cupal
William P. Iverson
Robert F. Kubichek
K. J. Reddy
Quentin D. Skinner
John P. Turner
George F. Vance
Roger Wilmot

EPA Regions VII and VIII have a curious diversity of interests resulting from the grouping of mineral-rich states such as Colorado, Montana, and Utah, with the states of the Great Plains whose economic foundations rest on agriculture and animal husbandry. The center defined its original mission in terms of these wide-ranging activities and has undertaken research in the following areas:

- Studies of soil and water contamination by heavy metals and mining wastes.
- Research on soil and groundwater contamination from a variety of sources.
- Development of incineration, biodegradation, and immobilization technology.
- Development of simplified and inexpensive methods for analyzing contaminated soil.
- Hazardous waste minimization.
- Determination of safe concentration levels of hazardous substances in soils and in water.

A decision was made in May 1990 to assign the highest priority to risk-reduction research on soil and processes to clean up contaminated soil. Research proposals were requested based on the following needs and problems, listed here in order of their priority based on the center's current mission:

- Soil and water contamination by heavy metals such as cadmium, chromium, copper, lead, and zinc associated with mining wastes and other industrial activities. Mine tailings from past mining operations have resulted in contaminated surface and groundwater. The heavy metals listed are very similar to the heavy metals that contaminate Department of Energy (DOE sites, except that DOE must also deal with some heavier metals.
- Soil and groundwater contamination by organic chemicals from a variety of sources. Wood preservatives, including pentachlorophenol and creosote, polynuclear aromatic hydrocarbons, carbon tetrachloride, trichloroethylene, vinyl chloride, and other chlorinated aliphatic hydrocarbons, polychlorinated biphenyls (PCBs), and dioxin have been identified as priority substances contaminating groundwater. Numerous pesticides have been identified to be hazardous substances; the fate and transport of pesticides are of particular interest because of the agricultural orientation of Regions VII and VIII. A general need exists for research to develop treatment technologies to clean up contaminated soil.
- Development of improved technologies and methods for characterization and analysis of contaminated soil. Simple inexpensive methods are desired. DOE is interested in developing improved and innovative technologies, including real-time and non-intrusive evaluation and characterization of sites.
- Development of innovative treatment technologies for remediation of contaminated soil and groundwater and for rendering wastes nonhazardous. Technologies that will lead to an *in situ* resolution of the problem are emphasized.
- Development of waste minimization and pollution prevention methods and technologies. The highest priority in this category is assigned to application of these methods to site characterization and remediation processes.

The center has supported research projects at non-consortium institutions through contracts. Less than 10% of the center's funds are allocated for projects at non-consortium institutions.

Diversity of interests in Regions VII and VIII and the large geographic area represented are further reflected in the training and technology transfer program the center currently supports. Much of the center's efforts are dedicated to support of activities that can reach large audiences with a minimum of resources. For example, issues of the center newsletter, *HazTech Transfer,* have been widely disseminated across the nation; an information clearinghouse at the Kansas State University Hale Library has been established and contains over 1,000 publications, including center-funded theses, dissertations, reports, and videos; the center has held annual conferences on hazardous waste research since 1986 with more than 70 papers presented at each conference; and general public environmental information activities are ongoing. Proceedings of the 1995-2001 conferences have been published on the Internet and in print form. Many center publications are now available on the World Wide Web at http://www.engg.ksu.edu/HSRC/. These activities, augmented by some carefully selected special audience functions, appear to provide the most effective means of disseminating necessary technical information across this large and varied area. In recent years electronic mail has been used to distribute information as well.

The center's base support comes from EPA. Participating schools have all made substantial contributions as well. The U.S. Departments of Defense and Energy have partially supported several research projects. Contributions in support of the center have been received from individuals. Additional funding is also being sought through private industry and other public sector organizations; Boeing Commercial Airplane Group, Chevron Inc., Conoco Inc., Dupont, and Phytotech have contributed to the center through the Kansas State University Center for Hazardous Substance Research Industrial Partnership Program. Montana State University also has an industrial partnership program. The center's funding is summarized in Table 3.

Table 3: Great Plains/Rocky Mountain Hazardous Substance Research Center Funding

FUNDING SOURCES	CURRENT FUNDING PERIOD (May 18, 1997-Sept. 30, 2001)	SECOND AWARD PERIOD (May 17, 1992-Sept. 30, 1997)	FUNDS TO DATE (Since Feb. 22, 1989)
EPA: Five Centers Progs.	$3,754,189	$5,353,515	$13,592,194
EPA: Other	2,247,633	1,974,470	4,693,848
Other Govt.: Federal			
U.S. Dept. of Defense	2,075,314	3,423,358	5,498,672
U.S. Dept. of Energy	0	365,000	915,000
Other Govt.: State			
Consortium Universities	1,680,026	4,618,552	10,510,240
Nonconsort. Universities	63,947	279,013	608,078
Private Sector	30,000	42,000	104,000
TOTAL	$8,172,886	$16,055,908	$34,177,134

STUDENT SUPPORT	NUMBER	FUNDING*
Undergraduate	10	$59,900
Graduate	24	547,152
Post Doctoral	5	182,695
TOTAL	39	$789,747

*Includes tuition and travel (rounded annual values)

CENTER DIRECTOR'S REPORT

The center provides a focal point for hazardous substance research and training and technology transfer in the Great Plains and Rocky Mountain areas comprising EPA Regions VII and VIII. A long-term goal is to serve the needs of the 10-state area using as many available resources within Regions VII and VIII as possible. For instance, training and technology transfer events offered by consortium universities and other institutions are listed in the quarterly newsletter, *HazTech Transfer*. Information about the center, the annual report, and proceedings of the annual conference are available on the Internet at http://www.engg.ksu.edu/HSRC. Through personal visits, the newsletter, telephone calls, the Internet, and direct mailings, center staff has emphasized inclusiveness and the idea of "working together for a better environment." Center personnel have made visits to all of the consortium universities, several other universities, EPA regional offices, and other state and federal offices. A variety of professional gatherings and conferences have been sponsored and attended. More than 25,000 individuals have benefited directly through center activities.

A large number of the projects funded by the center include a cooperative element. Many of them involve more than one principal investigator; there is cooperation across academic department boundaries as well as institutional cooperation. In some cases, investigators are cooperating with support through two separate projects. Often publications are co-authored by two or more faculty members. Faculty from several universities have participated in workshops offered by the center. These cooperative activities have helped to strengthen environmental research and technology transfer programs at participating universities. Participating students have benefited from working with a team of investigators.

The advisory committees have been most valuable in guiding the center in selecting research and technology transfer areas to pursue and projects to support. On the advice of the Science Advisory Committee in May 1990, the director assigned the highest priority to research involving soil and processes to clean up contaminated soil, thus pursuing a focal area. Many of the new projects reflect the priority on soil-related research. Members of the committee have encouraged research on innovative applications of vegetation in bioremediation and stabilization of soil. Cooperation with other institutions and organizations has been enhanced because of leadership of committee members.

The center's administrative office is in Ward Hall at Kansas State University. Blase Leven, program manager, manages the office and provides a variety of public services, including responding to many requests for information on the activities of the center and other environmental issues. Wendy Griswold, project manager, provides administrative management for the Native American and Other Minority Academic Institutions (NAOMI) Program at Haskell Indian Nations University. Terrie Boguski, project manager, provides outreach services. Brenda Schaffer is the project accountant for the center.

HIGHLIGHTS

February 2001 marked the completion of 12 years of federally funded center activities. During this time, over 100 projects have been funded, with over 250 principal investigators and students working on these projects.

In March 1997, a peer-review panel of environmental professionals reviewed the center's renewal proposal, reports, publications, and other documents. At the conclusion of their site visit, they prepared a report which included the following summary conclusions and recommendations:

> "The Peer Review Panel's opinion of the technical quality and management capabilities of the Great Plains/Rocky Mountain Hazardous

> Substance Research Center's activities over the past eight years was very favorable. The Center's research is considered to have made important contributions to the areas delineated in its proposals; productivity of most of its funded investigators is of high quality; the training and technical transfer program is effective; and the management of the Center is in the hands of a capable and dedicated Director and staff.
>
> "The Panel considers the Center to have been an effective expenditure of EPA funds and the Panel strongly recommends EPA continued funding of the Center. In addition, the timing of such funding should be sensitive to the uninterrupted support of students on the various Center projects."

As a result of this favorable review, the center received a three-year renewal award in 1997. In September 2000, the center received a two-year extension of the project and budget periods to September 30, 2002.

While it is very difficult to follow all of the positive impacts of the research, training, and technology transfer activities of the center, estimates show that cost savings due to technology innovation are more than 10 dollars for each dollar expended through the center. After 12 years of research through the center, utilization of vegetation in the remediation and/or stabilization of contaminated soil are becoming a widely used technology. The number of contractors actively incorporating vegetation into remediation processes is growing rapidly and the number of field sites where vegetation is part of the solution is increasing exponentially. Field studies often show cost savings of more than 60% compared to conventional pump-and-treat technology. This savings has caught the attention of those who are responsible for remediation within federal agencies and the private sector.

Research on the beneficial effects of vegetation in metals-contaminated soils and mine tailings has been applied at several field sites. The influence of mycorrhizal symbiosis on plant growth and heavy metal tolerance in mine tailings has been demonstrated and communicated. Laboratory and field research has demonstrated which soil amendments are essential to revegetate mine tailings because of the need to improve nutrient availability and water-holding capacity. Results have shown that concentrations of arsenic and cadmium in poplar tree leaves are below the level where they would be a health concern for deer and other animals. Vegetation reduces soil erosion and sediment transport to streams and rivers. Center investigators are providing information and advice to those who are revegetating heavy metal-contaminated sites. Vegetative stabilization is often the only cost-effective solution for large acreages of soils and mine tailings containing heavy metals.

Reactive barriers using zero-valent iron and microbial populations to transform contaminants such as chlorinated solvents and nitrate have been investigated and found to provide faster and more complete dechlorination and nitrate removal.

Center investigators have developed new approaches to identify and select chelators for separating heavy metals from soil. Quantitative structure-activity relationships and molecular descriptors can be incorporated into models that allow computers to be used to help identify chelators. These concepts were presented at two workshops.

The comprehensive approach to process synthesis and design developed through the center has been incorporated into spreadsheet software by a commercial firm and is now available for implementation by those who do process synthesis for chemical process industries. This will lead to significant advances in pollution prevention, save design costs, and increase profitability.

Center investigators have demonstrated that Fenton reagent is effective for oxidation of a variety of contaminants, including munitions compounds such as TNT. The work provides new information on the mechanisms of the oxidation process.

Several field projects conducted through the center have demonstrated that bioremediation occurs in the field as predicted by laboratory studies. Availability of oxygen has been shown to be an important consideration for contaminants that must be degraded aerobically. Further research is being conducted to develop cost-effective oxygen-transfer technologies. Several companies have provided partial support for these field studies.

With greater emphasis being placed on risk-based hazardous substance management, the center has supported projects designed to understand the fate of environmental contaminants that are bound strongly to soil organic matter. Analytical methods have been developed and applied to investigate contaminant fate. The new knowledge and methods are important to risk-based decision making.

The Research and Re-education for Displaced Defense Personnel (R2D2) program was in place from 1995 to 1998. The R2D2 program was national in scope, with all five centers receiving funding to involve former defense personnel in research programs working on center-funded research projects at center consortium universities. This program enrolled more than 70 displaced Department of Defense employees at HSRC consortium universities. These students worked on center projects to improve remediation technologies at defense sites. New technologies are now available for field application and graduates of the program have advanced to professional positions. One result of the R2D2 program has been better communication with professionals at defense locations. This has resulted in additional projects to address their research needs.

The Technical Outreach Services for Communities (TOSC) program continues to provide assistance to communities impacted by hazardous waste in EPA Regions VII and VIII. Blase Leven and Terrie Boguski provide leadership for this program and the Technical Assistance to Brownfields (TAB) program. Recent projects include presentations and workshops for citizens in affected communities, and assistance to community groups in South Dakota, Montana, Iowa, Wyoming, Kansas, Colorado, Illinois, and Missouri. This program matches expertise of center professionals with needs of communities to provide customized education and assistance to community groups dealing with hazardous waste cleanups, permitting, and risk-assessment issues.

The Native American and Other Minority Institutions (NAOMI) program has benefited over 60 minority academic institutions (MAIs). Faculty members and students from several MAIs—historically black universities, Native American universities, and predominantly Hispanic universities—have participated in the annual conference and/or the NAOMI Summer Cooperation Program. The NAOMI program has also produced or co-produced several video seminars and satellite-uplinked seminars.

The Technical Outreach Services for Native American Communities (TOSNAC) program has a full-time professional, Brenda Brandon, to provide services to tribal communities. The Oglala Lakota Nation in South Dakota, which has concerns because of the Badlands Bombing Range, is one of many tribal groups being helped through this nationwide program.

A very important event this year was the 2001 Conference on Environmental Research, held at Kansas State University, May 22-24, 2001. The conference, workshops, and tours attracted approximately 100 participants. Conference topics included phytoremediation, metals-contaminated soil, remediation processes, and water quality. The proceedings are being made available in print form and on the Internet at http://www.engg.ksu.edu/HSRC.

Amy Ryser, a high school student from Wamego, Kansas, was honored for her poster "Phytoremediation of Crude Oil-Contaminated Soil" at the 12th Annual Conference. Peter Kulakow, one of the center's investigators, advised Amy in her research.

Louis Licht, University of Iowa bioremediation researcher and CEO of Ecolotree, Inc., was honored in 1996 for utilizing a poplar tree technology developed by Licht and Jerald Schnoor. The American Council of Engineering Consultants selected Ecolotree, Inc., for an Honor Award in the 1996 Engineering Excellence Awards competition for its role in the design, installation, and management of an innovative, engineered plant system project for the Woodburn, Oregon, wastewater treatment plant. Poplar trees have been installed at over 50 sites in 11 states and Europe.

Kenneth Klabunde, distinguished professor of chemistry at Kansas State University and a center researcher since 1990, is behind a Manhattan, Kansas, business, Nanoscale Materials, Inc., which will commercialize the destructive adsorbent technology that has been developed at the laboratory scale. This company received one of the six 1997 Silicon Prairie Technology of the Year Awards.

A team of chemical engineering seniors under the direction of HSRC faculty designed a plant-based landfill leachate treatment process for Riley County, Kansas. Alfalfa and cottonwood trees have been planted at the site. Use of this innovative technology is expected to save Riley County several million dollars.

Joel Burken and Jerry Schnoor won the 1998 Rudolph Hering Medal from the American Society of Civil Engineers for their paper "Phytoremediation: Plant Uptake of Atrazine and the Role of Exudates" in the *Journal of Environmental Engineering* (ASCE).

Since 1997, the center has become more involved in assisting with brownfield projects and remediation activities at contaminated field sites. Center investigators have responded to requests for assistance from consultants, responsible parties, EPA professionals, state regulators, and community leaders. Funding in support of brownfield activities has enabled the center to provide considerable assistance to community leaders. Educational workshops have been offered in several locations.

HazTech Transfer, the center's quarterly newsletter, has been published since 1989. *Centerpoint* and *Newspoint*, joint publications of the five centers, have continued to be published with responsibility for managing and editing of each issue revolving among the HSRCs. *Earth Medicine*, the newsletter of the NAOMI program, was published and distributed from 1995-1999 to minority academic institutions, center consortium universities, tribal offices, government agencies, and other interested individuals. Because of advances in electronic communication, *HazTech Transfer* is being discontinued. Information is now being distributed electronically.

This year the center has added many pages on the World Wide Web, including a wealth of information about the center and its programs. Individuals all over the world can access the center's Web pages and find copies of center publications, conference proceedings, journal papers, funded project descriptions, information about center personnel, and general information about the center. The center's home page can be accessed at http://www.engg.ksu.edu/HSRC. There is also a home page for the national HSRC program and information on the other centers at http://www.hsrc.org. The Magellan Internet Guide recently gave the HSRC Web site a rating of three out of a possible four stars. The center's Internet site has approximately 10,000 hits per month; about 15% of these are from outside the United States.

The popular workshop, "Beneficial Effects of Vegetation in Contaminated Soil," was presented in January 1998 for the sixth time. In May 2000, a new phytoremediation workshop with emphasis on the state of the science and practice was presented in Denver at EPA Region VIII. The center, in cooperation

with Kansas Department of Health and Environment, Interstate Technology and Regulatory Cooperation Working Group, and the Remediation Technologies Development Forum, conducted a workshop on "Natural Attenuation of Chlorinated Solvents in Groundwater," in Kansas City. A workshop on environmental analysis of surface and groundwater contaminants was conducted for members of several Native American tribes by faculty from Sinte Gleska University and the University of Nebraska.

Professionals at Montana State University provided leadership for the 8th Billings Symposium on Disturbed Land Rehabilitation, which was held March 20-24, 2000. This symposium focused on land reclamation and rehabilitation issues relevant to the Great Plains and Intermountain West.

Workshops are being conducted to transfer phytoremediation science and technology to regulators, consultants, and site owners through a cooperative effort which includes EPA, the Interstate Technology and Regulatory Cooperation Working Group (ITRC), the Remediation Technologies Development Forum (RTDF), and center professionals. Faculty associated with the center are working with other professionals on an edited book on plant science and technology applied to phytoremediation.

As shown by the listing of theses and dissertations in the bibliography, many students have helped with center projects while conducting research required for their advanced degrees. Many of these graduates now have important positions with contractors, industry, government, and universities. Their movement from the university to their places of employment has resulted in technology transfer that has enhanced innovation.

The center repository continues to be a resource for researchers nationwide. Publications that result from funded center projects are placed in the repository at Kansas State University's Hale Library and are available through interlibrary loan.

The Great Plains/Rocky Mountain Hazardous Substance Research Center, the National Mine Land Reclamation Center, and the Waste-management Education and Research Consortium have participated in a cooperative effort to address environmental research and technology transfer needs associated with mining and mine lands.

ENVIRONMENTAL CHALLENGES AND SOLUTIONS: A REVIEW OF RESEARCH AND TECHNOLOGY TRANSFER ACTIVITIES

Since the creation of the Great Plains/Rocky Mountain Hazardous Substance Research Center, consortium researchers have been engaged in developing solutions to the most pressing environmental challenges prevalent in EPA regions VII and VIII. Key achievements in developing solutions to challenges presented by contaminated soil and groundwater include developing innovative technologies for managing contaminant plumes and groundwater flow, using phytotechnologies in cleaning up contaminated water and soil, using vegetation to stabilize and restore land covered by mine tailings, and providing environmental training and technical assistance to many communities including tribal communities in Indian country.

Progress in Remediation of Contaminated Soil and Groundwater

Since February 1989, when the Hazardous Substance Research Centers were created, innovative technologies have been developed for remediation of contaminated soil and groundwater.

Alternatives to conventional pump-and-treat technologies have been developed. The center has supported biobarrier technologies that can be used for plume management and containment. This

technology has shown promise in the laboratory, and field testing is now in progress. Biobarrier technology is more flexible and economical than the use of slurry walls or grout curtains in controlling contaminant plumes. Plant systems are being used for plume control, either alone or in combination with conventional pump-and-treat technologies. Vegetation brings contaminated water to the root zone of the plants. Biodegradation occurs when the contaminants can be biodegraded aerobically. Root-zone biodegradation has been observed for compounds such as toluene, phenol, and polynuclear aromatic hydrocarbons. Some volatile compounds, such as chlorinated aliphatic hydrocarbons, diffuse into the atmosphere. These compounds move through the soil and the vegetation. The plants enhance the transport to the atmosphere by removing water from the soil, by transporting contaminated water upward through the roots and stem, and by lowering the water table to expose volatile compounds to an unsaturated environment where gas-phase transport occurs. In the atmosphere, these compounds are degraded by sunlight and chemical processes. Methyl tert-butyl ether (MTBE) can be removed from soil and groundwater and degraded in the atmosphere using plants to facilitate transport. Increased knowledge in the use of plant systems to treat contaminated soil and water has led to increased regulatory acceptance of this innovative technology and widespread use at polluted sites.

Another technology that has been developed for plumes is to allow the contaminated water to flow through a treatment zone where degradation occurs. Zero-valent metal processes and biodegradation processes have been investigated for use in this and other applications. Microbial degradation processes, when combined with zero-valent metal abiotic processes, have been demonstrated to be more effective than either process alone. This technology can potentially enhance the capability of reactive barriers to intercept important exposure pathways, thus reducing public and environmental health risks.

Management of groundwater flow in the subsurface is complex. Center faculty have contributed to a better understanding of contaminant transport at sites where nonaqueous-phase contaminants are present. This includes progress in understanding groundwater flow, dissolution of contaminants which are present in a nonaqueous phase, and entrapment of nonaqueous-phase liquids. The knowledge and insight gained from this research could lead to better design of remediation treatment systems.

Research has advanced our knowledge of the fate of organic compounds when bioremediation and phytoremediation are applied. Some organic contaminants bind to organic matter associated with the soil. By using radio labeling and fractionating, center investigators have shown that most bound organic contaminants are associated with humic acid and the lipid components of humin in soil. In both bioremediation and phytoremediation, some compounds are transformed to other chemical forms. Some contaminants react to form dimers and other higher molecular weight compounds. Others are incorporated into microbial and/or plant biomass. Toxicity tests provide one method of evaluating the reduction of risk associated with a remediation process. New knowledge gained from this research may help researchers to eventually control the fate, transport, and bioavailability of contaminants in natural environments.

Results of center research have been applied by consultants, regulators, and many others. New companies such as Ecolotree, Phytokinetics, and Phytotech have been established to provide professional remediation services. Established companies such as CH2MHill have hired center graduates and employed them in positions where the innovative technologies are applied. Other companies such as Nanoscale Materials, Inc. have been formed to commercialize products that can be used in a variety of environmental applications.

From the Flask to the Field: Vegetative Remediation of Mine Tailings

Since the mid-1980s, the Reclamation Research Unit (RRU) at Montana State University-Bozeman has performed treatability studies and designed land reclamation/restoration techniques for a

complex of Superfund sites in the Butte and Anaconda, Montana, areas. Beginning in 1993, the GP/RM HSRC and the state of Montana funded benchtop, greenhouse, and field-scale development of a mine tailings re-processing and vegetation method. This technique was successfully demonstrated in bench and greenhouse work and is now being field tested at an operating mine. Work to stabilize and prevent the spread of contamination using vegetation has also been funded by the HSRC in other mining areas.

One method involves use of conventional ore-processing techniques (gravimetric or flotation separation) to remove sulfide minerals from mine tailings. This is an alternative or supplementary method to the use of chemical amendments to reduce acids and metals resulting from weathering of sulfide minerals in tailings over time. The goal is to produce soil-like material that can support vegetation for caps placed over large areas of tailings. Suitable topsoil for vegetated caps is usually not available close to tailings.

Reprocessing of sulfide tailings to decrease plant-inhibitory metal and arsenic levels was successfully completed at the bench scale (~200 kg, three different samples) and at the field pilot scale (~200 tons, one site). Analytical results indicate metal levels were typically decreased in cleaned tailings and were concentrated into approximately 10% of the pretreatment mass. Revegetation of the cleaned tailings (approximately 90% of the pretreatment mass) is analogous to revegetation of silicate-dominated sand. Requirements for addition of lime to prevent future acidity in reprocessed tailings are typically reduced by approximately 95%. None of the high-grade concentrates resulting from treatment failed TCLP analysis, and therefore they can be either disposed as non-hazardous waste or further processed to recover metals (when feasible).

Vegetation establishment was successfully demonstrated during greenhouse evaluation of bench-cleaned tailing material. Basin wild rye (*Leymus cinereus*) and Kentucky bluegrass (*Poa pratensis*) grew adequately in reprocessed tailings and in tailings amended with lime and compost, compared to plants grown in greenhouse potting soil. However, when the common sunflower (*Helianthus annus*) was planted in both reprocessed and amended tailings from one site, only the reprocessed tailing supported plant growth.

Treatment effectiveness and cost appear to vary from site to site, but the prevalence and technological maturity of mineral separation equipment in use in the mining industry suggest a strong potential for low-cost adaptation of mining technology to remedial treatment. At the Anaconda, Montana, Superfund site, use of chemical amendments to create vegetated caps alone will save more than $150 million over the use of topsoil. Stabilization of contaminated materials with vegetated caps, instead of removal and disposal of all tailings, will save over $1.0 billion.

Work has also been underway at Superfund sites along Whitewood Creek in South Dakota and in southeast Kansas to stabilize and prevent the spread of contamination from streamside tailings and smelter wastes, respectively, using poplar trees, grasses, and other forms of vegetation. In the Galena, Kansas, area, researchers are evaluating effectiveness of vegetation treatments on chat tailings to prevent erosion and ground / surface water quality impacts. Much work remains to understand how to establish self-sustaining vegetative ecosystems and their effects on preventing the spread or transport of contaminants, and to evaluate the permanence of this approach.

Technology Transfer in Indian Country

To improve the ability of tribal nations to address their environmental issues, the Great Plains/Rocky Mountain Hazardous Substance Research Center (GP/RM HSRC) provides environmental training, technology transfer services, and public education to tribal communities. The main thrust of the HSRC's Native American programs has been provided by Haskell Indian Nations University through the

Haskell Environmental Research Studies Center (HERS). Haskell, a GP/RM HSRC consortium member, is a keystone institution for education, research, and extension in environmental science for American Indian tribal nations and Alaska Native communities.

Currently, there are over 771 federally recognized American Indian tribes and Alaska Native villages. This number represents a broad range of diversity with respect to cultural, economic, and environmental issues. Examples of these issues include several related to hazardous wastes. Wastes from gold mining (Fort Belknap Reservation, Montana; Cheyenne River, South Dakota) and coal mining (Northern Cheyenne Tribes, Montana) have possibly led to contamination of drinking water supplies. Closure of uranium mines and stored tailings are only some of the environmental challenges facing the Navajo Nation in Arizona and New Mexico. Unexploded ordnance and unknown contaminants on gunnery ranges in the Oglala Lakota Nation (Pine Ridge, South Dakota) and Cheyenne River Reservation (South Dakota) threaten soil and water contamination. In addition to hazardous waste issues, many tribes have brownfield properties within their borders. Issues of concern for these tribes are varied, ranging from remediation of abandoned rail yards to contamination from coal-burning residue and asbestos releases.

While many tribes in the U.S. are faced with serious environmental challenges, their ability to address them is hindered by several issues. Many tribal governments lack the funds and, consequently, the infrastructure to adequately protect their natural resources. HERS assessments of several tribes revealed that some of the reservations had environmental professionals who could quickly pinpoint the environmental degradation on their lands and its causes, while in other cases, responsibility for environmental activities fell to those with little training in this area–the tribal real estate agent or the tribal treasurer. Staff in tribal environmental programs play many roles. Environmental issues can lose focus due to political and financial situations. There is also a high turnover rate for environmental professionals in many tribal programs due to tribal political structure. In addition, there are a limited number of Native American environmental professionals from which tribes can draw qualified environmental staff.

With funding provided from the Native American and Other Minority Institutions (NAOMI) program, the HSRC was able to support a collaborative training effort between Sinte Gleska University (a tribally controlled college) and the University of Nebraska-Lincoln (a GP/RM HSRC consortium member) in 1996. A workshop was developed that focused on water quality parameters, basic environmental analysis techniques, data, and use of field sampling and environmental analysis equipment. This type of training benefits tribes in many ways. With proper training in water quality monitoring, tribal water resources offices can become more self-sufficient. Although the GP/RM HSRC provided funding for SGU and UNL to offer one workshop, Ben Whiting (SGU) and Bruce Dvorak (UNL) were able to obtain subsequent funding from EPA to offer the workshop for additional tribes. A modified version of the workshop was also presented at the Kickapoo Nation of Kansas in summer 1997 with support from Haskell's natural resources program. Throughout successive years, HERS has coordinated the delivery of other technical training to tribal environmental professionals. Topics include air quality management, environmental cleanup and compliance issues, and field-based site characterization and analytical and sampling technologies.

In addition to providing training opportunities for tribal environmental professionals, the GP/RM HSRC has established programs to provide personalized, on-site assistance to tribal environmental programs and communities dealing with hazardous waste and brownfield issues. The Technical Outreach Services for Native American Communities (TOSNAC) program was officially established in March 1998. The goal of this program is to provide educational resources to individuals, community groups, and environmental programs in affected tribal communities, concerning hazardous substance. TOSNAC draws upon the expertise of several HSRC consortium members to provide assistance to tribal communities throughout the U.S.

The TOSNAC program has provided assistance to more than 45 tribal nations and pueblos. One of the tribal nations assisted is the Passamoquody Nation in Maine. The tribe is dealing with PCB contamination of rivers and lakes on tribal land from a nearby Army surplus salvage yard. TOSNAC has provided education to the tribe on the impacts of PCB contamination, conducted ecological and cultural risk assessments, and helped the tribe to compile its comments to the Environmental Protection Agency on this issue. At this particular site, TOSNAC worked with the Technical Outreach Services for Communities (TOSC) staff from the Northeast HSRC to provide the Passamoquody with technical assistance.

In order to provide resources for future and current tribal environmental professionals, the GP/RM HSRC funds the Haskell Environmental Seminar Series (HESS). The purpose of HESS is to provide resources on environmental issues relevant to Indian country, tribal colleges, environmental offices, and community programs. Of the 129 participants in the seminar program, approximately 50 members are based at a tribal college or environmental program. Throughout its history, HERS has produced more than 20 video and satellite uplink programs in support of the seminar series. The seminar programs are used in classrooms at tribal colleges as teaching aids and are also used by tribal environmental offices as continuing education materials. These videos supplement the limited resources that feature Native American environmental professionals presenting information relevant to tribal environmental issues.

While tribal nations have great needs with respect to environmental challenges, the GP/RM HSRC framework has provided a mechanism for beginning to address them. Combining the cultural knowledge of a Native American educational institution with the technical knowledge of HSRC consortium institutions has opened a door to providing technical assistance to Indian country.

FUTURE DIRECTIONS

With the ever-increasing number of users of the Internet and, more specifically, the World Wide Web, center personnel plan to increase availability of center resources through this medium. Many center publications have already been put on the Web, including electronic publishing of the center's conference proceedings. Peer-reviewed papers are published in the electronic *Journal of Hazardous Substance Research*. Hypertext Markup Language (HTML) and Adobe Acrobat are utilized to publish the journal. Through use of electronic media, this document can be published quickly and inexpensively and has the capability to provide hyperlinks to references as well as graphics, video, and sound. These features can be used to allow users to run simulation models.

During the past 12 years, significant progress has been made in developing the capability of the consortium faculty to conduct research in support of Superfund and problems associated with contaminated soil. As a result, many more consortium faculty are actively conducting hazardous substance research now than before the center was established. Many of these faculty are supported with funds from other sources. Because of technological developments associated with the research and growth in faculty expertise, there are more opportunities for site-specific projects.

Research activities conducted by center investigators are expected to have a positive impact on environmental/geoenvironmental curricula at the consortium universities. Center investigators are planning to integrate findings from past research activities into graduate and undergraduate curricula. Efforts to secure extramural funding to aid integration of research and education are underway.

Several new hazardous substance research centers were established by EPA in 2001 in order to involve new investigators and universities in the EPA Hazardous Substance Research Centers program. EPA support through the Great Plains/Rocky Mountain Center is being reduced in order to provide

funding through the new centers. Many of the faculty who have participated in the research activities of the center have ongoing research efforts which continue to be supported from multiple sources. Some faculty who have participated in the Great Plains/Rocky Mountain HSRC will be faculty participants in one of the new centers. Professionals associated with the new centers are working cooperatively with center faculty to continue to serve communities with contaminated sites and/or brownfields.

PROGRAM SUMMARY

February 22, 1989 - September 30, 2001

HEAVY METAL CONTAMINATION OF SOIL/WATER

Principal Investigator(s)	Budget Total/Current	Project No./ Completion Date	Project Title
Keefer	$54k/$0k	3 1990	Metal Recovery and Reuse Using an Integrated Vermiculite Ion Exchange-Acid Recovery System
Hansen, Stevens	$167k/$0k	89-09 1991	Optimal Bioreactor Design for Biological Removal of Mercury
O'Keefe, Watson	$129k/$0k	17 1991	Characterization and Treatment of Hazardous Materials from Metal Mineral Processing Wastes
Walton	$150k/$0k	89-19 1992	An Electrochemical Method for Acid Mine Drainage Remediation and Metals Recovery
Lewandowski	$96k/$0k	89-22 1992	Heavy Metals Removal from Dilute Aqueous Solutions Using Biopolymers
Faw	$78k/$0k	89-29 1992	Neutron Activation Analysis for Heavy Metal Contaminants in the Environment
Clevenger, Hinderberger	$224k/$0k	2 1992	Reclamation of Metal- and Mining-Contaminated Superfund Sites Using Sewage Sludge/Fly Ash Amendments
Pierzynski, Schwab	$94k/$0k	89-30 1992	Reducing Heavy Metal Availability to Perennial Grasses and Row Crops Grown on Contaminated Soils and Mine Spoils
Ghosh	$140k/$0k	4 1992	Removal of Heavy Metals from Hazardous Wastes by Protein Complexation for Their Ultimate Recovery and Reuse
Dollhopf	$132k/$0k	89-21 1992	Sulfide Size and Morphology Identification for Remediation of Acid-Producing Mine Wastes
O'Keefe, Cole, Watson	$206k/$0k	90-16 1994	Development of Electrochemical Processes for Improved Treatment of Lead Wastes
Banks, Hetrick, Schwab	$306k/$0k	90-11 1994	Impact of Soil Microflora on Revegetation Efforts in Southeast Kansas
Schnoor, Licht	$213k/$0k	90-05 1994	Innovative Treatment and Bank Stabilization of Metals-Contaminated Soils and Tailings Along Whitewood Creek, South Dakota
Pierzynski, Davis, Reddi, Erickson, Schnoor	$247k/$0k	92-05 1997	Use of Poplar Trees in Remediating Heavy Metal-Contaminated Sites
Lewandowski, Geesey, Roe	$283k/$0k	92-08 1997	Heavy Metals Removal from Contaminated Water Solutions
Schnoor, Licht, St. Clair, Just, Erickson	$214k/$0k	92-11 1996	Metals Soil Pollution and Vegetative Remediation

HEAVY METAL CONTAMINATION OF SOIL/WATER (cont.)

Principal Investigator(s)	Budget Total/Current	Project No./ Completion Date	Project Title
Munshower, Jennings	$270k/$0k	93-12 1999	Acid-Producing Metalliferous Waste Reclamation by Material Reprocessing and Vegetative Stabilization
Hong, Okey, Banerji	$239k/$0k	93-22 1997	Chelating Extraction of Heavy Metals from Contaminated Soils
Schwab, Banks, Erickson, Tracy	$401k/$0k	93-06 1998	Fate and Transport of Heavy Metals and Radionuclides in Soil: The Impacts of Vegetation
Hetrick, Pierzynski, Erickson, Govindaraju, Sweeney	$419k/$21k	93-07 2000	Vegetative Interceptor Zones for Containment of Heavy Metal Pollutants
O'Keefe	$336k/$23k	94-05 2000	Design and Development of an Innovative Industrial-Scale Process to Economically Treat Waste Zinc Residues

ORGANIC CHEMICAL CONTAMINATION OF SOIL/WATER

Principal Investigator(s)	Budget Total/Current	Project No./ Completion Date	Project Title
Hunter, Culver	$28k/$0k	15 1990	Computer Method to Estimate Safe-Level Water Quality Concentrations for Organic Chemicals
Schlup	$60k/$0k	18 1991	Adsorption of Hazardous Substances onto Soil Constituents
Kross	$160k/$0k	16 1991	Removal of Nitrogenous Pesticides from Rural Well Water Supplies by Enzymatic Ozonation Process
Dickey, Shelton, Steichen, Barnes	$338k/$0k	89-31 1993	Alachlor and Atrazine Losses from Runoff and Erosion in the Blue River Basin
Ghosh	$218k/$0k	89-06 1992	Biodetoxification of Hazardous Solid Wastes by Staged Anaerobic Fermentation Conducted at Separate Redox and pH Environments
Parkin	$84k/$0k	90-04 1992	Biotransformation of Alachlor and Atrazine Under Denitrifying Conditions in Soil-Water Systems
Erickson, Fan	$224k/$0k	6 1992	Development of *In Situ* Biodegradation Technology
Illangasekare	$196k/$0k	89-01 1992	Distribution and Recovery of Refinery Waste Products in Groundwater Aquifers: Experimental Study and Model Evaluation

ORGANIC CHEMICAL CONTAMINATION OF SOIL/WATER (cont.)

Principal Investigator(s)	Budget Total/Current	Project No./ Completion Date	Project Title
Parkin, Gibson	$259k/$0k	5 1992	Feasibility of *In Situ* Anaerobic Bioreclamation of Mixtures of Toxic Chemicals: Feasibility of Using Genetically Engineered Bacteria to Degrade Trichloroethylene in Activated-Sludge Systems
Characklis, Jones, Cunningham, Lewandowski	$394k/$0k	89-23 1992	*In Situ* Bioremediation of Organic Groundwater Contaminants
Banerji, Bajpai	$323k/$0k	7 1992	Migration and Biodegradation of Pentachlorophenol in Soil Environment
Schnoor, Parkin	$349k/$0k	10 1992	Modeling Dissolved Oxygen, Nitrate, and Pesticide Contamination in the Subsurface Environment
Yanders, Kapila	$327k/$0k	9 1992	Time-Dependent Movement of Dioxin and Related Compounds in Soil
Glasgow	$141k/$0k	11 1992	Vadose Zone Decontamination by Air Injection
Schnoor, Licht	$246k/$0k	89-10 1994	Deep-Rooted Poplar Trees as an Innovative Treatment Technology for Pesticide and Toxic Organics Removal from Groundwater
Schnoor, Licht	$39k/$0k	R-1 1993	The Role of Deep-Rooted Poplar Trees in Adding Organic Carbon to the Soil for Pesticides and Toxic Organics Removal
Parkin	$135k/$0k	91-08 1994	The Effect of Redox Conditions on Transformations of Carbon Tetrachloride
Kapila, Armstrong, Puri	$282k/$0k	91-04 1994	Laboratory and Field Evaluation of Upward Mobilization and Photodegradation of Polychlorinated Dibenzo-P-Dioxins
Cunningham, Costerton	$306k/$0k	91-25 1994	Microbial Transport in Porous Media
Tracy, Davis, Erickson, Schnoor	$367k/$0k	90-13 1995	Modeling the Use of Plants in the Remediation of Soil and Groundwater Contaminated by Hazardous Organic Substances
Licht, Schnoor	$349k/$0k	91-03 1995	Riparian Poplar Tree Buffer Impact on Non-Point Source Surface Water Contamination
Parkin	$214k/$0k	91-07 1995	Formation and Transformation of Pesticide Degradation Products Under Various Electron Acceptor Conditions
Illangasekare	$477k/$0k	91-10 1997	Modeling for Design and Testing of Treatment and Remediation Technologies for Aquifer Soils Contaminated with Organic Waste Chemicals
Erickson, Fan	$269k/$0k	91-29 1996	Remediation of Soil Contaminated with an Organic Phase

ORGANIC CHEMICAL CONTAMINATION OF SOIL/WATER (cont.)

Principal Investigator(s)	Budget Total/Current	Project No./ Completion Date	Project Title
Coats, Anderson	$152k/$0k	93-05 1997	Use of Vegetation to Enhance Bioremediation of Surface Soils Contaminated with Pesticide Wastes
Kapila, Forciniti, Armstrong	$142k/$0k	93-16 1996	Laboratory and Field Evaluation of Upward Mobilization and Photodegradation of Polychlorinated Aromatics in Soil
Bajpai, Banerji, Puri, Zappi	$281k/$0k	94-08 1998	Remediation of Soils Contaminated with Wood-Treatment Chemicals (PCP and Creosote)
Gibson, Tracy, Kennedy	*	NCIBRD 1 1997	Use of C_2 to C_{18} Organic Acids and Selected Surfactants to Enhance Bioremediation of DNAPL-Contaminated Aquifers
Parkin, Schnoor, Alvarez	$416k/$21k	93-02 2001	The Role of Metallic Iron in the Biotransformation of Chlorinated Xenobiotics
Parkin	$198k/$13k	93-24 2001	Application of Anaerobic and Multiple-Electron-Acceptor Bioremediation to Chlorinated Aliphatic Subsurface Contamination
Segar	$204k/$11k	94-07 2000	Trichloroethene (TCE) Cometabolism in Fluidized-Bed Bioreactors
Schnoor, Burken	$475k/$21k	94-25 2000	Uptake of BETX Compounds and Metabolites by Hybrid Poplar Trees in Hazardous Waste Remediation
Davis, Erickson	$345k/$16k	94-27 2000	Plant-Assisted Remediation of Soil and Groundwater Contaminated by Hazardous Organic Substances: Experimental and Modeling Studies
Illangasekare	$521k/$26k	94-29 2000	Extension of Laboratory-Validated Treatment and Remediation Technologies to Field Problems in Aquifer Soil and Water Contamination by Organic Waste Chemicals
Miller	$158k/$0k	94-15 1998	Removal of Chlorinated Hydrocarbons from Contaminated Water Using Air-Sparged Hydrocyclone Technology
Doucette, Bugbee, Stevens	$504k/$124k	95-10 2000	Fate of Trichloroethylene (TCE) in Plant/Soil Systems: Evaluating Phytoremediation
Zhang, Comfort, Shea	$394k/$33k	95-32 2001	Simultaneous Transformation of Atrazine and Nitrate in Contaminated Water, Sediment, and Soil by Zero-Valent Iron-Promoted Processes
Schnoor	$323k/$24k	95-29 2001	Plant Enzyme Systems for the Phytoremediation of Chlorinated Aliphatics in Contaminated Soils
O'Connor, Brazos	$61k/$0k	89-17 1991	The Response of Natural Groundwater Bacteria to Groundwater Contamination by Gasoline in a Karst Region

*Funded through the Great Lakes/Mid-Atlantic Hazardous Substance Research Center

ORGANIC CHEMICAL CONTAMINATION OF SOIL/WATER (cont.)

Principal Investigator(s)	Budget Total/Current	Project No./ Completion Date	Project Title
Alvarez, Parkin, Schnoor	$150k/$150k	98-01 2001	Iron-Enhanced Bioremediation of Aquifers Contaminated with Chlorinated Solvents, Hexavalent Chromium, and Nitrate
Erickson, Davis	$180k/$180k	98-03 2002	Plant-Assisted Remediation of Soil and Groundwater Contamination by Hazardous Organic Substances: Experimental and Modeling Studies
Illangasekare	$114k/$114K	98-05 2001	Non Aqueous-Phase Waste Chemicals in the Subsurface: Site Characterization and Remediation
Simeonsson	$77k/$77k	98-08 2001	Changes in the Speciation and Biological Volatization of Environmental Arsenic as a Result of Phytoremediation of Hazardous Waste Sites
Reardon	$200k/$200k	SP99-1 2002	Transformation Mechanisms of High Molecular-Weight Polycyclic Aromatic Hydrocarbons in the Rhizosphere
Schwab, Banks, Leven	$84k/$84	SP96-Riley 2002	Field Validation of an Optimal Design Methodology for Vegetative Remediation of Sediments from the Central Vehicle Wash Facility, Custer Hill, Fort Riley, Kansas
Erickson	$150K/$50K	RTDF 2002	Data Management and Horticultural Evaluation of Field Sites for the RTDF Phytoremediation Field Test of Petroleum Hydrocarbon-Contaminated Soils

ANALYSIS/TREATMENT OF CONTAMINATED SOIL

Principal Investigator(s)	Budget Total/Current	Project No./ Completion Date	Project Title
Walawender, Fan	$149k/$0k	12 1991	Thermochemical Treatment of Hazardous Wastes
Viswanath, Kapila, Clevenger	$462k/$0k	13 1992	Development, Characterization, and Evaluation of Adsorbent Materials for Waste Streams
Fan	$153k/$0k	1 1992	Experimental Study of Stabilization/Solidification of Hazardous Substances
Peyton, Anderson	$154k/$0k	89-14 1992	Simulation of Three-Dimensional Transport of Hazardous Chemicals in Heterogeneous Porous Media Using X-Ray Computer Tomography
Valentine	$172k/$0k	89-11 1994	*In Situ* Soil and Aquifer Decontamination Using Hydrogen Peroxide and Fenton's Reagent
Klabunde	$394k/$0k	92-03 89-26 1996	Nanoscale Metal Oxide Particles as Reagents for Destruction and Immobilization of Hazardous Substances

ANALYSIS/TREATMENT OF CONTAMINATED SOIL (cont.)

Principal Investigator(s)	Budget Total/Current	Project No./ Completion Date	Project Title
Comfort, Shea, McCallister, Powers	$294k/$0k	92-24 1997	Fate and Transport of Munitions Residues in Contaminated Soils
Dupont, Sorensen, Doucette	$439k/$0k	93-20 1998	Evaluation of Biosparging Performance and Process Fundamentals for Site Remediation
Faw, Shultis	$134k/$0k	94-02 1997	Application of PGNAA Remote-Sensing Methods to Real-Time, Non-Intrusive Determination of Contaminant Profiles in Soil
Dupont, Sorensen, Kemblowski, Smith	$62k/$0k	SP95-TCE 1996	TCE Attenuation in Groundwater in Severe Northern Climates
R.C. Sims	$430k/$13k	93-21 2000	Field-Scale Bioremediation: Relationship of Parent Compound Disappearance to Humification, Mineralization, Leaching, and Volatilization of Transformation Intermediates
Inskeep, Johnston, Wraith	$264k/$0k	94-09 1999	Effects of Surfactants on the Bioavailability and Biodegradation of Contaminants in Soils
Rice	$242k/$0k	94-11 1999	Contaminant Binding to the Humin Fraction of Soil Organic Matter
Tracy, Van Lent, Schaefer	$196k/$18k	94-12 2000	Development of a Systematic Methodology for Optimally Designing Vegetative Systems for Remediating Contaminated Soil and Groundwater
Kubichek, Iverson, Cupal	$329k/$0k	94-24 1999	Identifying Groundwater Threats from Improperly Abandoned Boreholes
Turner, Bulla, Skinner	$229k/$0k	94-26 1998	Biofilm Barriers for Waste Containment
Cunningham, Chen	$399k/$20k	93-11 94-28 2000	Evaluation and Modeling of Subsurface Biobarrier Formation and Persistence
Klabunde	$354k/$117k	95-04a 2002	Nanoscale Metal Oxide Particles as Reagents for Destruction and Immobilization of Hazardous Substances in Air, Water, and/or as an Alternative to Incineration

WASTE MINIMIZATION

Principal Investigator(s)	Budget Total/Current	Project No./ Completion Date	Project Title
Fan	$194k/$0k	14 1992	Computer-Aided Design and Control of Systems for Treatment of Hazardous Waste and Minimization of Waste Production
Fan	$179k/$0k	91-36 1996	Intelligent Process Design and Control for the Minimization of Waste Production and Treatment of Hazardous Waste

TRAINING AND TECHNOLOGY TRANSFER

Principal Investigator(s)	Budget Total/Current	Project No./ Completion Date	Project Title
Gilliland, Kelly	$128k/$0k	1991	Hazardous Waste Management in Rural Communities in EPA Regions VII and VIII
Harbourt	$265k/$0k	1992	Introduction to Hazardous Waste Management
Hiskey	$68k/$0k	1992	Introduction to Waste Minimization Technology and Applications
Kross	$31k/$0k	1992	Remediation of Pesticide Spills: Technology Transfer to Volunteer Firefighters
Biles	$45k/$0k	1992	Technology Database
Edwards	$20k/$0k	1992	Transfer of Manufacturing Pollution Prevention Technology
Hayter	$52k/$0k	1992	Video Conference
Hayter	$35k/$0k	1993	Five-Center HSRC Training and Technology Transfer Conference
Grant	$65k/$0k	PRP	Superfund PRP Conference
Kelly, Keefer, Rohde, Woldt	$77k/$0k	TR92-03a 1995	A Short Course on Remediation of Contaminated Soils and Sediments
Dahab, Woldt	$78k/$0k	TR92-03b 1995	Development of Pollution Prevention Programs for Small Quantity Generators in EPA Regions VII and VIII
Niemeyer, Woldt, Dahab, Grisso	$38k/$0k	TR92-04 1995	Waste Management: Development of Pollution Prevention Educational Materials for Farms and Small Acreages
Grant	$141k/$0k	TR92-PI 1995	HSRC Technology Transfer Public Information Services
R.C. Sims	$212k/$0k	TR-LIBBY 1997	Libby, Montana, Superfund Site: Prepared-Bed Bioremediation in Buried Lifts as Affected by Oxygen Concentration in Soil Gas
Thurston	$54k/$0k	TR94-02 1995	Training to Advance Environmental Research in Lithuania
Cunningham, Warwood, Zelver	$53k/$0k	TR93-02 1996	Engineering Scaleup of *In Situ* Bioremediation Processes: A Workshop on Biotreatability

TRAINING AND TECHNOLOGY TRANSFER (cont.)

Principal Investigator(s)	Budget Total/Current	Project No./ Completion Date	Project Title
Grant, Griswold	$804k/$0k	NAOMI 1998	Native American and Other Minority Institutions Program
Erickson, Leven	$404k/$8k	TR-01 2002	Conferences and Workshops
Hayter, Leven	$134k/$3k	TR-01 2002	HSRC Contribution Repository and Information Clearinghouse
Reddi, Leven	$360k/$14k	TR-01 2002	HSRC Newsletter, *HazTech Transfer*
J.L. Sims, R.C. Sims	$182k/$0k	TR93-07 1997	Guidance for the Use of Prepared-Bed Land Treatment as a Bioremedial Technology
Banks, Schwab, Govindaraju	$301k/$0k	D93-01 1997	Bioremediation of Petroleum-Contaminated Soil Using Vegetation
McDonald, Leven, Deines, Wigfall	$402k/$150k	SP93-01 2002	Technical Outreach Services to Communities Program, Technical Support to Brownfields
Leven, Grant	$638k/$0k	R2D2 1998	Research and Re-Education for Displaced Defense Personnel Program
Erickson	$37k/$0k	TR95-10 1998	Virtual Library
Reddi	$18k/$0k	TR95-11 1997	Environmental Data Technology Transfer Project
Leven, Godfrey, Griswold	$142k/$10k	TR96-05 2002	Collaborative Environmental Seminar Series
Griswold, Brandon	$662k/$403k	TOSNAC 2002	Technical Outreach Services to Native American Communities
J.L. Sims	$81k/35k	TR97-07 2001	Development of a "State-of-the-Science and Technology" Report on Site-Characterization Technologies

RESEARCH PROJECT DESCRIPTIONS

May 18, 1995 – September 30, 2001

Title: Nanoscale Metal Oxide Particles as Reagents for Destruction and Immobilization of Hazardous Substances in Air, Water, and/or an Alternative to Incineration

Investigators: K.J. Klabunde, Kansas State University

Institution: Great Plains/Rocky Mountain Hazardous Substance Research Center, Kansas State University

Project Number: 95-04a

Project End Date: September 30, 2002

Period Covered by Report: October 2000-September 2001

EPA Project Officer: Dale Manty

Project Amount: $354,000

Research Category: Analysis/Treatment of Contaminated Soil

Goals and Objectives: The goal of this project is to develop a one-step process that uses ultra-high-surface-area metal and metal oxide particles for destroying hazardous substances, including chlorocarbons, chlorofluorocarbons, organophosphorus, nitrogen, and sulfur compounds.

Rationale: Zinc is an effective metal in the dehalogenation of chlorocarbons that contaminate groundwater. This reagent can help efficiently remove chlorinated hydrocarbons with high capacity. Trichloroethylene (TCE), one of the most common pollutants, was found to be degraded by zero-valent zinc in aqueous solutions under neutral pH conditions.

Approach: To gain more insight into the dominant pathway and general mechanism involved, important intermediates of different systems were investigated. A variety of techniques were used to analyze the gaseous, aqueous, and solid phases. Ethylene, ethane, and monchlorinated hydrocarbons were identified as the hydrogenation or elimination products. Dehydrochlorination or beta-elimination was also evident by acetylene appearance. Other related C_1 or C_2 compounds were produced in much smaller yields. Under similar conditions, experiments were also performed to assess the mass balance and carbon distribution. Both kinetic and mechanistic aspects were explored. In anaerobic environments, zinc generally provides electrons to organic molecules and further promotes the hydrocarbon formation. In a separate study, pH changes in Zn and Sn reductive systems were measured and compared. The catalytic effects of Ag^0 and Pd^0 promoters were studied, also.

Project Findings: A new technology was devised for the one-step destruction of hazardous substances, including chlorocarbons, chlorofluorocarbons, organophosphorous-, nitrogen-, and sulfur compounds.

This new technology is based on nanoparticles and porous pellets formed by pressing these powders. Important properties of these nanoparticles are their ability to destructively absorb the toxins in high capacity.

Technology Transfer: The investigators are working in partnership with a small start-up company to transfer the technology to the private sector. Investigators continue to present papers at meetings and technical conferences, publish papers, and answer many inquiries regarding this technology.

CURRENT PERIOD PUBLICATIONS AND PRESENTATIONS

PUBLICATIONS

Carnes, C.L., and K.J. Klabunde, "Synthesis, Isolation, and Chemical Reactivity Studies of Nanocrystalline Zinc Oxide," *Langmuir,* Vol. 16, pages 3764-3772, 2000.

Richards, R., W. Li, S. Decker, C. Davidson, O. Koper, V. Zaikovski, A. Volodin, T. Rieker, and K.J. Klabunde, "Consolidation of Metal Oxide Nanocrystals. Reactive Pellets with Controllable Pore Structure that Represent a New Family of Porous, Inorganic Materials," *Journal of American Chemistry Society*, 122, pages 4921-4925, 2000.

Klabunde, K.J., S. Decker, E. Lucas, O. Koper, "How the Shape of Nanoparticles Affects Their Adsorption Properties," *Cluster and Nanostructure Interfaces*, P. Jena, S.N. Khanna, B.K. Rao (Eds.), World Scientific Publishers, London, pages 577-582, 2000.

PRESENTATIONS

None reported.

Supplemental Keywords: nanoscale, nanoparticle, DAT, destructive adsorption technology, metal oxide.

Relevant Web Sites: http://www.engg.ksu.edu/HSRC

Title: Simultaneous Transformation of Atrazine and Nitrate in Contaminated Water, Sediment, and Soil by Zero-Valent Iron-Promoted Processes

Investigators: T.C. Zhang, P.J. Shea, and S.D. Comfort, University of Nebraska

Institution: Great Plains/Rocky Mountain Hazardous Substance Research Center, University of Nebraska

Project Number: 95-32

Project End Date: September 30, 2001

Period Covered by Report: October 2000-September 2001

EPA Project Officer: Dale Manty

Project Amount: $394,000

Research Category: Organic Chemical Contamination of Soil/Water

Goals and Objectives: The objectives of this project are to 1) develop and test zero-valent iron-promoted processes for simultaneous remediation of atrazine and nitrate in contaminated ground and surface water, sediment, and soil; 2) investigate the technical and economic feasibility of the iron-promoted systems for above ground and *in situ* remediation of ground and surface water, sediment, and soil contaminated with atrazine and nitrate; and 3) elucidate mechanisms of transformation and determine kinetics associated with the proposed processes.

Rationale: Preliminary studies demonstrate the potential use of iron-promoted processes to remediate ground and surface waters contaminated with atrazine and nitrate.

Approach: Investigators are using zero-valent iron-promoted processes, employing fine-grained iron metal as a reducing agent, to simultaneously transform atrazine and nitrate found in contaminated water, sediment, and soil.

Project Findings: Results of this research indicate that iron-promoted processes are viable approaches to simultaneously reduce residues of chlorotriazines and nitrate in contaminated water, sediment, and solids. Results obtained from technology transfer activities indicate that iron-promoted processes are simple, reliable, and cost-effective remediation technologies that can be used by non-professionals with little experience in hazardous waste treatment to control pesticide and nitrate pollution at cooperatives, farmsteads, and other contaminated sites.

Technology Transfer: Investigators have published articles in peer-reviewed scientific journals, presented results at numerous technical conferences, and incorporated the technology into university classroom instruction. In addition, the investigators are disseminating the project findings within EPA Regions VII and VIII.

CURRENT PERIOD PUBLICATIONS AND PRESENTATIONS

PUBLICATIONS

Comfort, S.D., P.J. Shea, T.A. Machacek, H. Gaber, and B.-T. Oh, "Field-Scale Remediation of a Metolachlor-Contaminated Spill Site Using Zerovalent Iron," *J. Environ. Qual.,* Vol. 30, pages 1636-1643, 2001.

Huang, Y.H., and T.C. Zhang, "Kinetics of Nitrate Reduction by Iron at Near Neutral pH," *J. Environ. Eng.* (ASCE), In press, 2001.

PRESENTATIONS

Huang, Y.H., and T.C. Zhang, "Effects of Selected Cations and Aqueous Ferric Iron on Nitrate Reduction with Metallic Iron Powder," Oral presentation for the 2001 Conference on Hazardous Waste Research, Manhattan, Kansas, May 21-24, 2001.

Huang, Y.H., and T.C. Zhang, "Mechanisms of Nitrate Removal by Zerovalent Iron Powder," Poster presentation for the 45th Annual Great Plains Waste Management Conference," Omaha, Nebraska, March 28-29, 2001.

Comfort, S.D., Invited presentation on project at Nebraska Fertilizer and Agricultural Chemical Institute Research Symposium.

Supplemental Keywords: atrazine, nitrate, groundwater, surface water, contamination, zero-valent iron-promoted processes.

Relevant Web Sites: http://www.engg.ksu.edu/HSRC

Title: Iron-Enhanced Bioremediation of Aquifers Contaminated with Chlorinated Solvents, Hexavalent Chromium, and Nitrate

Investigators: G.F. Parkin, M.M. Scherer, and P.J.J. Alvarez, University of Iowa

Institution: Great Plains/Rocky Mountain Hazardous Substance Research Center, University of Iowa

Project Number: 98-01

Project End Date: September 30, 2001

Period Covered by Report: October 2000-May 2001

EPA Project Officer: Dale Manty

Project Amount: $150,000

Research Category: Organic Chemical Contamination of Soil/Water

Goals and Objectives: This project continues the work completed in project 93-02. Research objectives are as follows:

1. to explore the applicability and limitations of zero-valent iron barriers to manage groundwater plumes containing mixtures of common pollutants;
2. to evaluate combined zero-valent iron and microbial treatment systems to determine how environmental factors, system upsets, and substrate interactions affect treatment efficiency, and to evaluate the effect of microbial growth on the performance of zero-valent iron (Fe(0)) barriers.

Rationale: Experiments performed to date suggest that an integrated microbial-Fe(0) system holds great promise for treating a variety of redox-sensitive contaminants, including mixtures; that indigenous microorganisms can colonize Fe(0) surface, presumably to exploit cathodic depolarization, Fe(III) respiration, and bioremediation as metabolic niches; and that the Fe(0) surface area concentration is an important design variable to optimize microbial activity and prevent inhibitory effects when multiple contaminants compete for sites on the Fe(0) surface.

Approach: Column experiments were started in December 1999. Bromide tracer studies were done to establish a baseline for future determination of changes in porosity and permeability as a result of different treatments, bioaugmentation or colonization by indigenous microbes. The columns have been continuously fed by a mixture of TCE, sulfate, hexavalent chromium, and nitrate since March 4, 2000. The contaminants are dissolved in synthetic groundwater. These columns are being used to investigate how adding iron reducers or sulfate reducers to Fe(0) affects treatment efficiency. This effect will also be compared to the effect of microbial colonization by indigenous micobes that may colonize Fe(0). Six columns packed with different layers of porous media are being used.

Project Findings: Column experiments suggest that reactive iron barriers can effectively intercept and degrade mixtures of priority pollutants and those microorganisms might enhance the removal efficiency in some instances. Bioaugumentation with specialized strains can also increase the range of the pollutants that can be treated in iron barriers. Nonetheless, the effect of microorganisms on the long-term permeability and reactivity of the barrier is not well understood. Microorganisms may be able to mediate mineral dissolution or precipitation reactions that affect the availability of reactive sites, reduce barrier

permeability by biofilm formation, or alleviate pore volume reduction caused by the formation and entrapment of hydrogen gas. In related work, an anaerobic microbial culture enriched on lactate demonstrated the ability to rapidly degrade perchlorate after an acclimation period of approximately 200 hours. Abiotic reduction of perchlorate by Fe(0) did not occur even after 1300 hours, even though such reduction is thermodynamically favorable. The addition of Fe(0) inhibited the culture's ability to degrade perchlorate. Removal of Fe(0) allowed the culture to subsequently degrade perchlorate. This work, although preliminary, indicates that permeable reactive barriers containing Fe(0) will not work for waters contaminated with perclorate.

Technology Transfer: Investigators have made numerous presentations of this research at technical conferences. Results have been published in peer-reviewed journals.

CURRENT PERIOD PUBLICATIONS AND PRESENTATIONS

PUBLICATIONS

Oh B.-T., C.L. Just, and P.J.J. Alvarez, "Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) Mineralization by Zero-Valent Iron and Mixed Anaerobic Cultures," *Environmental Science and Technology*, submitted.

Williams, A.G.B., and M.M. Scherer, "Kinetics of Cr(VI) Reduction by Carbonate Green Rust," *Environmental Science and Technology*, in press.

PRESENTATIONS

Gander, J.W., G.R. Parkin, and M.M. Scherer, "Geomicrobial Interactions Among Iron Sulfide Minerals and Methanogenic Consortia," Poster presentation for Byproducts of Biotechnology Consortium Conference, Cedar Rapids, Iowa, October 2000.

Smith, S. and M.M. Scherer, "Catalytic Activity of Survace FE (II) Sites on Lepidocrocite," Oral presentation for Byproducts of Biotechnology Consortium Conference, Cedar Rapids, Iowa, October 2000.

Williams, A., and M. Scherer, "An Introduction to Mossbauer Spectroscopy, from Minerals to Molecules," Iowa Microscopy Society, Iowa City, Iowa, October 13, 2000.

Supplemental Keywords: dechlorination, xenobiotics, heavy metals, iron.

Relevant Web Sites: http://www.engg.ksu.edu/HSRC

Title: Plant-Assisted Remediation of Soil and Groundwater Contaminated by Hazardous Organic Substances: Experimental and Modeling Studies

Investigators: L.C. Davis and L.E. Erickson, Kansas State University

Institution: Great Plains/Rocky Mountain Hazardous Substance Research Center, Kansas State University

Project Number: 98-03

Project End Date: September 30, 2002

Period Covered by Report: October 2000-September 2001

EPA Project Officer: Dale Manty

Project Amount: $180,000

Research Category: Organic Chemical Contamination of Soil/Water

Goals and Objectives: There are four main objectives for this project. Experimental systems to improve oxygen availability for enhanced aerobic biodegradation will be developed. Transfer of contaminants through plants will be monitored. A mathematical model to describe fate of water, contaminant, root exudates, plants, microbes, and oxygen in laboratory and field systems will be applied. This technology will be applied to one or more field sites by working with professionals elsewhere. New funding since May 1998 emphasizes issues of concern during aircraft operations and deicing.

Rationale: Much of the population in U.S. EPA Regions VII and VIII relies on groundwater for its potable water, but many groundwater aquifers within this region have been contaminated with hazardous organic chemicals. Such chemicals may be by-products of agricultural and industrial production or may have leaked from fuel storage tanks or ruptured soil liners at disposal sites. Soil contamination involved in these types of problems is often very dispersed so that conventional soil and groundwater remediation techniques would be very expensive or, in some cases, impractical. Plants can play an important role in remediating soil and groundwater contaminated with organic substances. To put this new technology to effective use, we need to better understand and predict effects that plants have on soil and groundwater remediation, so that effective planting and management plans can be developed.

Approach: Previously a prototype system has been built by these researchers and used for study of bioremediation of groundwater assisted by plants. Based on experience with the prototype system, a new system has been constructed with more but shorter path length channels and a depth of 60 cm. It will permit introduction of controlled amounts of air into the soil, either above or below the water table, in two of the channels. By use of evolutionary operation design, performance of the system will be optimized to minimize air input and maximize degradation of target substances. Material balance measures are used to determine the fate of target substances. Potential intermedia transfer will be monitored by FTIR measurements on the gas phase above the growing plants. Changes in contaminant concentration in the groundwater are monitored by headspace gas chromatography or FT-IR of aqueous samples. The groundwater flow and transport model is used to model behavior of contaminants in the new system under several experimental conditions. The model will be further refined to improve the fit of predicted and observed behavior. It will then be applied to field situations where monitoring wells are in place, such as near landfills.

Project Findings: Three years of experiments on treating TCE-contaminated water with alfalfa showed decreasing levels of TCE escaping to the atmosphere through the soil. Similar results were achieved with sunflowers and a simple model was presented at the 1999 annual conference explaining these results, which were consistent with other studies treating TCE with poplar cuttings. Three cycles of experiments with MTBE have been completed. Research has shown that adsorption of contaminants within the plant must be considered to accurately describe transient contaminant fluxes through plants. Studies on the jet fuel JP-8 and on deicers have been done. Jet fuel experiments were done with alfalfa and horseradish plants. De icer experiments were done with hydroponically grown sunflowers. Corrosion inhibitors in deicing fluids appear to inhibit root growth of plants.

Technology Transfer: Results have been presented to consultants, regulators, and other researchers at workshops and conferences. The investigators have visited field sites and provided recommendations to responsible parties and regulators regarding applications of vegetation for specific problems. Publications have been prepared for peer-reviewed scientific journals and for regulators and consultants.

CURRENT PERIOD PUBLICATIONS AND PRESENTATIONS

PUBLICATIONS

Zhang, Q., L.C. Davis, and L.E. Erickson, "Plant Uptake of Methyl Tert-Butyl Ether (MTBE) from Groundwater," *Practice Periodical of Hazardous, Toxic and Radioactive Waste Management,* Vol. 5, 136-140, 2001. Project no. 94-27, 98-03.

Zhang, Q., L.C. Davis, and L.E. Erickson, "Transport of Methyl Tert-Butyl Ether (MTBE) Through Alfalfa Plants," *Environmental Science and Technology,* Vol. 35, 725-731, 2001. Project no. 94-27, 94-27A, 98-03.

Zhang, Q., L.C. Davis, and L.E. Erickson, "An Experimental Study of Phytoremediation of Methyl Tert-Butyl Ether (MTBE) in Groundwater," *Journal of Hazardous Substance Research,* Vol. 2. No. 4, 2000. URL: www.engg.ksu.edu/HSRC/JHSR/v2_no4.pdf. Project no. 94-27, 98-03.

Castro, S., L.C. Davis, and L.E. Erickson, "Phytodegradation Kinetics of Methyl Benzotriazole," *Proceedings of the 2001 Conference on Environmental Research,* Kansas State University, In Press, 2001. Project no. 98-03.

Davis, L.C., C. Pitzer, S. Castro, and L.E. Erickson, "Henry's Constant, Darcy's Law, and Contaminant Loss," *Proceedings of the 2001 Conference on Environmental Research,* Kansas State University, In Press, 2001. Project no. 98-03.

Castro, S., L.C., Davis, and L.E. Erickson, "Use of Vegetation for the Environmental Management of Deicing Formulations and Volatile Solvents," *Proceedings of the Third International Congress in Environmental Microbiology and First International Symposium in Agricultural Biotechnology,* Pontificia Universidad Javeriana, Bogota, D.C., Colombia, pages 246-253, 2001.

Pitzer, C.R., S. Castro, L.C. Davis, and L.E. Erickson, "Diffusion of MTBE Through Alfalfa," *Proceedings of the 30th Annual Biochemical Engineering Symposium,* D.S. Kompala, Editor, University of Colorado, pages 75-78, 2000.

Castro, S., L.C. Davis, and L.E. Erickson, "Experimental Study of Phytodegradation Kinetics of Methyl Benzotriazole," *Proceedings of the 30th Annual Biochemical Engineering Syposium*, D.S. Kompala, Editor, University of Colorado, pages 33-42, 2000.

Castro, S., L.C. Davis, and L.E. Erickson, "Plant-Enhanced Remediation of Glycol-Based Aircraft Deicing Fluids," *Practice Periodical of Hazardous, Toxic and Radioactive Waste Management,* Vol 5, 141-152, 2000. Project no. 94-27, 98-03.

Erickson, L.E., and Q. Zhang, "Plant-Based Remediation of MTBE and Other Compounds in Gasoline," *Underground Tank Technology Update,* Vol. 15: No. 2, pages 7-10, 2001. Project no. 94-27, 94-27A, 98-03.

Castro, S., L.C. Davis, and L.E. Erickson, "Experimental Study of Phytodegradation Kinetics of Methyl Benzotriazole," *Proceedings of the 30th Annual Biochemical Engineering Syposium*, D.S. Kompala, Editor, University of Colorado, pages 33-42, 2000.

Pitzer, C.R., S. Castro, L.C. Davis, and L.E. Erickson, "Diffusion of MTBE Through Alfalfa," *Proceedings of the 30th Annual Biochemical Engineering Symposium,* D.S. Kompala, Editor, University of Colorado, pages 75-78, 2000.

Karthikeyan, R., L.E. Erickson, L.C. Davis, and K.R. Mankin, "Fate and Transport of Jet Fuel in Soils with Plants: Experiments and Modeling," *Proceedings of the 7th International Petroleum Environmental Conference,* K.L Sublette, Editor, University of Tulsa, pages 469-503, 2000.

PRESENTATIONS

Castro, S., L.C. Davis, and L.E. Erickson, "Plant Uptake and Transformation of Benzotriazoles," 31st Annual Biochemical Engineering Symposium, Kansas State University, September 8, 2001.

Young, K., L.C. Davis, and L.E. Erickson, "Microbial Degradation of Methyl Benzotrazole," 31st Annual Biochemical Engineering Symposium, Kansas State University, September 8, 2001.

Karthikeyan, R., "Fate and Transport of Petroleum Hydrocarbons in Soils with Plants," National Ground Water Board, Rajaji Bhavan, Chennai, Tamil Nadu, India, 2001.

Karthikeyan, R., "Phytoremediation of Petroleum Hydrocarbons," Workshop for Bioremediation, College of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore, India, 2001.

Karthikeyan, R., "Remediation of Contaminated Soil and Water Using Plants," Auroville Water Technology Center, Auroville, Tamil Nadu, India, 2001.

Castro, S., "Introduction to Phytoremediation," Chemical Engineering Seminar, National University of Colombia, Bogota, D.C. Columbia, May 8, 2001.

Karthikeyan, R., L.E. Erickson, L.C. Davis, and K.R. Mankin, "Fate and Transport of Jet Fuel in Soils with Plants: Experiments and Modeling," 7th Annual International Petroleum Environmental Conference, Albuquerque, New Mexico, November 7-10, 2000.

Supplemental Keywords: plants, soil, groundwater, alfalfa, poplar trees.

Relevant Web Sites: http://www.engg.ksu.edu/HSRC

Title: Non Aqueous-Phase Liquid Waste Products in the Subsurface: Tools for Remediation Design, Regulation, and Site Characterization

Investigators: T.H. Illangasekare, Colorado School of Mines

Institution: Great Plains/Rocky Mountain Hazardous Substance Research Center, Colorado School of Mines

Project Number: 98-05

Project End Date: September 30, 2002

Period Covered by Report: October 2000-September 2001

EPA Project Officer: Dale Manty

Project Amount: $114,000

Research Category: Organic Chemical Contamination of Soil/Water

Goals and Objectives: The goal of this project is to compile and evaluate existing information on the behavior of non aqueous-phase liquid (NAPL) chemical wastes in the subsurface. The objectives are to develop methods for characterization of sites for the purpose of obtaining the necessary data for accurate simulation of contaminant fate and transport, and to validate multiphase models that can be used in EPA's regulatory programs, for remediation design and site characterization.

Rationale: Compiling and evaluating existing information will improve the effectiveness and efficiency of future research efforts.

Approach: The project is organized with eight tasks: compilation of existing knowledge, assembly of a set of multimedia test codes, surveying and compiling laboratory data sets, generating a laboratory data set for code validation, compiling field data for demonstration case studies, developing standard procedure for validation/verification, development of characterization methods, and development of a state-of-the-science report on validation/verification.

Project Findings: This study is aimed toward reaching closure for the PI's center-funded research utilizing state-of-knowledge data based on the findings. The center-funded research has resulted in the completion of three field studies involving NAPLs: a mass transfer study at a gasoline-contaminated site in Cincinnati (Chevron oil refinery), a diesel-contaminated site in Oregon (railroad yard in La Grande), and an Air Force site where the potential use of vegetable oil as a co-solvent will be investigated. The knowledge, models, and experimental methods developed in the center-funded research were used in these investigations. Future research plans include compiling existing knowledge, developing a laboratory data set for code validation, and the use of tracer methods to characterize NAPL entrapment under complex morphologies.

Technology Transfer: Investigators have published several articles in peer-reviewed journals. They have written articles for the proceedings of many conferences and made presentations about this work.

CURRENT PERIOD PUBLICATIONS AND PRESENTATIONS

PUBLICATIONS

Barranco, F.T. Jr., D. Dai, and T.H. Illangasekare, "Partitioning and Interfacial Tracers for Differentiating NAPL Entrapment Configuration: Column-Scale Laboratory Results," *Environmental Science and Technology,* 2001.

Davis, C.A., T. Cort, D. Dai, T.H. Illangasekare, and J. Marr, "Effects of Heterogeneity and Saturation on Diesel Biodegradation Respirometry," *Groundwater*, 2001.

Cort, T., and T.H. Illangasekare, "Biological Metabolotes as Tracers to Determine NAPL Saturation," *Environmental Science and Technology*, 2001.

Dai, D., S. Saenton, Q.R. Moore, and T.H. Illangaskare, "Upscaling of Multiple Tracer Techniques for Characterizing Subsurface NAPL Zones—Laboratory Experiments and Numerical Simulation," *Environmental Science and Technology,* In press, 2001.

Dai, D., F.T. Barranco, and T.H. Illangasekare, "Partitioning and Interfacial Tracers for Differentiating NAPL Entrapment Configuration: Column-Scale Laboratory Results," *Environmental Science and Technology,* In press, 2001.

Barth, G., T.H. Illangasekare, H. Rajaram, and M. Hill, "Tracer Response to NAPL Entrapment," *Water Resour. Res.,* In press, 2001.

Barth, G.R., T.H. Illangasekare, M.C. Hill, and H. Rajaram, "Analysis of Intermediate-Scale Tracer Experiments for the Development of Tracer Density Guidelines," *Water Resour. Res.*, 37(1), pages 21-32, 2001.

PRESENTATIONS

Saenton, D., D. Dai, and T.H. Illangasekare, "Upscaling of Multiple Tracers Technique for Characterizing NAPL Entrapment Zones: Intermediate-Scale Testing and Numerical Modeling," 2001 Environmental Research Conference, Kansas State University, Manhattan, Kansas, May 22-23, 2001.

Cort, T., C.A. Davis, D. Dai, and T.H. Illangasekare, "Intermediate-Scale Evaluation of Bioremediation Technologies in Hetergeneous, LNAPL-Contaminated Soil," 2001 Environmental Research Conference, Kansas State University, Manhattan, Kansas, May 22-23, 2001.

Illangasekare, T.H., D. Dai, Q.R. Moore, and S. Saenton, "Intermediate-Scale Experiments for Validation of Models for NAPL Dissolution and Multiple Tracer Behavior," Geological Society of America, Reno, Nevada, 2000.

Supplemental Keywords: NAPL, remediation, site characterization, regulation

Relevant Web Sites: http://www.engg.ksu.edu/HSRC

Title: Changes in the Speciation and Biological Volatilization of Environmental Arsenic as a Result of Phytoremediation of Hazardous Waste Sites

Investigators: J.B. Simeonsson, University of Iowa

Institution: Great Plains/Rocky Mountain Hazardous Substance Research Center, University of Iowa

Project Number: 98-08

Project End Date: September 30, 2001

Period Covered by Report: October 2000-September 2001

EPA Project Officer: Dale Manty

Project Amount: $77,000

Research Category: Organic Chemical Contamination of Soil/Water

Goals and Objectives: The main objectives of this project are to determine whether phytoremediation of arsenic contaminated soils results in a significant change in arsenic speciation and specifically whether volatilization of arsenic species is a significant outcome. Hybrid poplars are the plants under investigation in this study. If arsenic volatilization is determined to be significant, the secondary objectives of the study are to determine the chemical and physical conditions that either enhance or inhibit volatilization processes.

Rationale: Scientific information is needed on the speciation of arsenic as a result of phytoremediation efforts.

Approach: Investigators developed procedures for collecting and measuring atmospheric particulate and vapor sample, procedures to determine the analytical figures of merit for the arsenic measurement methods, and procedures for measuring the performance of plant growth experiments to study the effects of arsenic contamination.

Project Findings: The major accomplishments to date have been the development of an air-sampling system, development of analytical procedures suitable for measurement and speciation of ultratrace levels of arsenic in environmental samples, and performance of plant growth experiments and analysis of samples from the test environments.

Technology Transfer: Investigators have published an article. The work is part of a thesis for two students. They have made presentations about this work at several conferences.

CURRENT PERIOD PUBLICATIONS AND PRESENTATIONS

PUBLICATIONS

Simeonsson, J.B., "A Comparison of Continuous-Flow Hydride Generation Laser-Induced Fluorescence and Laser-Enhanced Ionization Spectrometry Approaches for Parts Per Trillion Level Measurements of Arsenic, Selenium, and Antimony," *Journal of Analytical Atomic Spectrometry*, 16, pages 152-158, 2001.

PRESENTATIONS

None reported.

Supplemental Keywords: arsenic, phytoremediation

Relevant Web Sites: http://www.engg.ksu.edu/HSRC

Title: Data Management and Horticultural Evaluation of Field Sites for the RTDF Phytoremediation Field Test of Petroleum Hydrocarbon-Contaminated Soils (RTDF)

Investigators: L.E. Erickson and P. Kulakow, Kansas State University

Institution: Great Plains/Rocky Mountain Hazardous Substance Research Center, Kansas State University

Project Number: RTDF

Project End Date: September 30, 2002

Period Covered by Report: October 2000-September 2001

EPA Project Officer: Dale Manty

Project Amount: $150,000

Research Category: Organic Chemical Contamination of Soil/Water

Goals and Objectives: The goal of this project is to test phytoremediation of contaminated soils at six to 12 locations to gather data in support of the use of phytoremediation and its acceptance by the regulatory community. The trials will compare petroleum hydrocarbon dissipation in vegetated soils and unvegetated soils for a three-year period and optimize a system for zinc recovery and reuse from plating wastewaters or contaminated groundwater.

Rationale: The EPA-sponsored Research Technology Development Forum (RTDF) for Phytoremediation, Total Petroleum Hydrocarbon (TPH) Subgroup has developed a protocol for a nationwide field test of phytoremediation of petroleum hydrocarbon-contaminated soils. This project will enter appropriate field sites into a testing program and develop a database of the field test results. Results of this project will provide valuable scientific information about the use of phytoremediation to clean up soils contaminated with petroleum hydrocarbons.

Approach: Data will be collected from the field sites and laboratories and sent to Kansas State University (KSU). The data will be cataloged, stored, and distributed in accordance with the data sharing and site confidentiality agreements arranged for this program. KSU will format all of the data into a common format to support data summary, statistical analysis, and reporting. Annual visits by KSU researchers will be made to several locations for the purpose of evaluating plant growth and development. Plant growth parameters will include vegetation coverage, species composition, aboveground biomass production, and plant rooting characteristics such as root length and diameter. Soil analyses will be performed at each field site as needed. Analyses will include pH, nitrogen, potassium, and phosphorus. Initial sampling will also include soil texture, organic matter, available zinc, available iron, cation exchange capacity, and salt alkali. An annual report of research progress will be prepared for internal use by the RTDF. A separate public report will be prepared following recommendations from the RTDF.

Project Findings: There are now 13 RTDF field sites with the addition of two new field sites located at oil production sites in Saskatchewan and Alberta, Canada. Considered as a group, it appears some field sites will show significantly enhanced hydrocarbon degradation with vegetative treatments while other field sites may not show enhanced treatment during the time of field trials. Differences among field sites

may be related to differences in hydrocarbon composition and weathering. Several indicators of hydrocarbon weathering are discussed in the report.

Technology Transfer: Technology transfer for this project has included regular interaction with all project participants, including representatives from EPA, DoD, industry, and universities. The first annual report for use by the RTDF participants was completed in March 2000. A public release version of the annual report is posted on the Internet. This report was sited of a number of technical outreach publications. The second annual report was completed in September 2001. This will be posted to the Internet in January 2002.

CURRENT PERIOD PUBLICATIONS AND PRESENTATIONS

PUBLICATIONS

Kulakow, P., Annual Report of the RTDF Phytoremediation Action Team TPH Subgroup Cooperative Field Trials, Remedial Technologies Development Forum, 85 pages, September 2001.

Kulakow, P., Annual Report of the RTDF Phytoremediation Action Team TPH Subgroup Cooperative Field Trials, Remedial Technologies Development Forum, 132 pages, URL: http://www.engg.ksu.edu/HSRC/RTDFtphrp1.html.

PRESENTATIONS

Kulakow, P., and L.E. Erickson, "RTDF Cooperative Phytoremediation Field Trials," Environmental Research Conference, Kansas State University, Manhattan, Kansas, May 2001.

Supplemental Keywords: phytoremediation, vegetation, soil, fate and transport.

Relevant Web Sites: http://www.engg.ksu.edu/HSRC

Title: Transformation Mechanisms of High Molecular Weight Polycyclic Aromatic Hydrocarbons in the Rhizosphere

Investigators: K.F. Reardon and E. Pilon-Smits, Colorado State University

Institution: Great Plains/Rocky Mountain Hazardous Substance Research Center, Colorado State University

Project Number: SP99-01

Project End Date: September 30, 2001

Period Covered by Report: October 2000-September 2001

EPA Project Officer: Dale Manty

Project Amount: $200,000

Research Category: Organic Chemical Contamination of Soil/Water

Goals and Objectives: The main objectives of this project are to elucidate the mechanisms for enhanced removal of PAHs in the rhizosphere of certain plants, to understand the roles of plants and microorganisms, and ultimately to devise remediation strategies based on these findings.

Rationale: Attention needs to be focused on chemicals released by plant roots. Root exudate and root lysate are both considered a potentially important source of chemicals for rhizosphere microorganisms. The term "root-released chemicals" is used to include both mechanisms.

Approach: Specific tasks for this project include identifying plants with higher rates of PAH degradation; assessment of the relative importance of plants, microorganisms, and plant-microbe interactions; and assessment of root exudate effects on microbial PAH degradation and identification of highly active exudates for further testing. Research activities have been organized into the following three tasks: screen rhizospheres of 12 plants for enhanced PAH removal, assess contributions of potential PAH removal mechanisms (microbial growth, stimulation, gene induction, and enhanced PAH bioavailability), and develop a molecular biological method to test gene induction by exudate compounds.

Project Findings: Thirty-two plants of each of seven species were planted in 12-inch pots in PAH-contaminated soil from Texas City. After 12 months, no PAH removal occurred in either the control or planted soil. This lack of PAH removal may be due to the unusual nature of the soil. GC analysis of total extractable and bioavailable PAHs will occur for samples taken after 18 months. A separate set of greenhouse experiments are underway with PAH-contaminated soil from Alameda NAS. The soil from Alameda is also being used in greenhouse experiments to compare the effects of agronomic practices on PAH removal in nutrient-poor soil. Preliminary data after seven months indicates differences in the number of PAH-degrading microorganisms as a result of treatments.

Technology Transfer: Papers have been presented at numerous conferences. Personnel at the Naval Facilities Engineering Service Center are being kept informed of the progress of the project. The Navy may be interested in conducting field trials if promising plant species are identified.

CURRENT PERIOD PUBLICATIONS AND PRESENTATIONS

PUBLICATIONS

None reported.

PRESENTATIONS

Olson, P.E., E. Pilon-Smits, N.M. DuTeau, K.L. Hale, J. Lowell, B.R. Page, and K.F. Reardon, "Rhizosphere Bioremediation of Organic and Metal-Contaminated Environments," 7th International Petroleum Environmental Conference, Albuquerque, New Mexico, November 7-10, 2000.

Olson, P.E., J. Lowell, K.F. Reardon, E. Pilon-Smits, N.M. DuTeau, and D.A. Klein, "Stimulation of Microbial Polycyclic Aromatic Hydrocarbon Biodegradation by Plant Chemicals," Annual Meeting of the American Institute of Chemical Engineers, Los Angeles, California, November 12-17, 2000.

Olson, P.E., J. Lowell, K.F. Reardon, E. Pilon-Smits, K. Hale, N.M. DuTeau, and D.A. Klein, "Plant-Enhanced Biodegradation of Mixed Polycyclic Aromatics," NIEHS Conference on Application of Technology to Chemical Mixture Research, Fort Collins, Colorado, January 9-11, 2001.

Reardon, K.F., P.E. Olson, J. Lowell, K. Hale, E. Pilon-Smits, N.M. DuTeau, and D.A. Klein, "Plant-Enhanced Microbial Degradation of Polycyclic Aromatic Hydrocarbons," Environmental Biotechnology Institute's Bioremediation Symposium II, San Luis Obispo, California, February 8-10, 2001.

Reardon, K.F., P.E. Olson, J. Lowell, E. Pilon-Smits, K. Hale, B. Page, N.M. DuTeau, and D.A. Klein, "Stimulation of Microbial Polycyclic Aromatic Hydrocarbon Biodegradation by Plant Chemicals," 221st National Meeting of the American Chemical Society, San Diego, California, April 1-5, 2001.

Reardon, K.F., P.E. Olson, J. Lowell, E. Pilon-Smits, K. Hale, B. Page, M. Joern, N.M. DuTeau, and D.A. Klein, "Plant-Enhanced Biodegradation of Polycyclic Aromatic Hydrocarbons," Environmental Research Conference, Kansas State University, Manhattan, Kansas, May 21-24, 2001.

Lowell, J., P.E. Olson, K.F. Reardon, E. Pilon-Smits, K. Hale, N.M. DuTeau, and D.A. Klein, "Induction of Genes for PAH Degradation by Plant Root Compounds," 6th International Symposium on *In Situ* and On-Site Bioremediation, San Diego, California, June 4-7, 2001.

Reardon, K.F., P.E. Olson, E. Pilon-Smits, K. Hale, J. Lowell, B. Page, M. Joern, N.M. DuTeau, and D.A. Klein, "Plant Rhizosphere Screening for Enhanced Polycyclic Aromatic Hydrocarbon Removal," 6th International Symposium on *In Situ* and On-Site Bioremediation, San Diego, California, June 4-7, 2001.

Supplemental Keywords: bioremediation, PAH , rhizosphere

Relevant Web Sites: http://www.engg.ksu.edu/HSRC

TRAINING AND TECHNOLOGY TRANSFER PROJECT DESCRIPTIONS

May 18, 1994 – September 30, 2001

Title: HSRC Technology Transfer Program

Investigators: L.N. Reddi, R.B. Hayter, and B.A. Leven, Kansas State University

Institution: Great Plains/Rocky Mountain Hazardous Substance Research Center, Kansas State University

Project Number: TR-01

Project End Date: September 30, 2002

Period Covered by Report: October 2000-September 2001

EPA Project Officer: Dale Manty

Project Amount: $360,000

Category: Training and Technology Transfer

Goals and Objectives: Core training and technology transfer activities integrate new information and technology, primarily from HSRC research activities, into use by public and private organizations. The center accomplishes this by hosting annual conferences and workshops; publishing newsletters, proceedings, and other documents; developing and maintaining an HSRC information repository; responding to requests for information and educational services; and administering competitively selected training and technology transfer projects. Center staff provide support to several special HSRC programs with important technology transfer components to ensure integration of results from concurrent HSRC activities and to learn of technology needs for future HSRC research efforts.

Rationale: Many barriers to rapid, cost-effective implementation of environmental research results and new technologies exist due to unique regulations, liabilities, and specific issues associated with environmental cleanup sites. A variety of technology transfer and training activities are necessary to adequately address the full spectrum of issues and audiences involved in cleanup situations.

Approach: The center maintains communication with its consortium members, more than 90 principal investigators, non-consortium institutions, government offices, and interested businesses and individuals through newsletters, press releases, the Internet, workshops, and conferences. To keep pace with changing issues, resources, and the need for technology transfer, greater emphasis is being placed on information exchange systems that will allow centers to address specific on-the-ground needs for this broad audience.

Project Status: Principal investigators on essentially all HSRC research and technology transfer projects continue to publish papers in technical journals, books, and conference proceedings. The center publishes this information in a less technical format for quick review by consultants, industry, and regulators in newsletters such as *HazTech Transfer* and *Centerpoint*, as well as in periodic e-mail bulletins (*E-Briefs*), guidebooks, and video productions. *HazTech Transfer* was published quarterly for 11 years and distributed in hard copy to more than 5,000 addressees, with readership estimated at 20,000 per issue. The

last issue of *HazTech Transfer* was published in October 2000. Many of these center and other non-center publications are maintained in the HSRC Information Repository at KSU, and can be accessed through the GP/RM HSRC World Wide Web site (http://www.engg.ksu.edu/HSRC). Every week the center receives many requests for information from individuals and groups of stakeholders. Responses to these requests range from simple verbal and e-mail messages to oral presentations on the collective thoughts of several HSRC researchers on specific technical issues. Center staff frequently make informational presentations to program managers in state and EPA regional offices.

Recent and future technology transfer activities include the following:

- Cooperating with the Interstate Technology Regulatory Cooperation (ITRC) Workgroup to develop and deliver a series of workshops — Phytoremediation: The State of the Science and Practice. The first of these workshops was offered in May 2000.
- A workshop on the use of phytoremediation at brownfield sites was presented at the EPA Brownfields 2000 Conference in October 2000.
- A workshop for oil and gas producers was delivered in November 2000. This workshop is being developed in partnership with the Petroleum Technology Transfer Council.

Technology Transfer: The entire purpose of this program is to transfer technology developed by the HSRC to practicing environmental professionals in government agencies, businesses, interested individuals, and other researchers. This is accomplished through the various communication methods discussed above.

Supplemental Keywords: collaborative problem solving, partnerships, technology transfer, newsletter, repository, communication, training, World Wide Web.

Relevant Web Sites: http://www.engg.ksu/HSRC

Title: Conference on Hazardous Waste Research

Investigators: L.N. Reddi, L.E. Erickson, and B.A. Leven, Kansas State University

Institution: Great Plains/Rocky Mountain Hazardous Substance Research Center, Kansas State University

Project Number: TR-01

Project End Date: September 30, 2002

Period Covered by Report: October 2000-September 2001

EPA Project Officer: Dale Manty

Project Amount: $404,000

Category: Training and Technology Transfer

Goals and Objectives: The goal of this project is to hold an annual research conference on hazardous substance research, and to provide opportunities for individuals from public and private sectors to share technical information regarding the management of hazardous substances.

Rationale: Conferences provide good opportunities for the exchange of information. The conference serves as a mechanism of technology transfer by bringing together researchers, regulators, and industry to discuss relevant and timely research impacting everyday government and business decisions.

Approach: Kansas State University's approach has been to expand the Conference on Hazardous Waste Research to include issues of technology transfer and training. Other universities host the conference in alternate years.

Project Status: The 16th Annual Conference on Hazardous Waste Research was held at Kansas State University in Manhattan, Kansas, May 21-24, 2001, with approximately 100 people participating. Researchers from around the country and abroad attended the conference to present and hear papers, participate in panel discussions, and view posters and exhibits. The 2001 conference involved several co-sponsors and cooperating supporters, including the U.S. Environmental Protection Agency, Waste-management Education and Research Consortium, National Institute of Environmental Health Sciences, National Mine Land Reclamation Center, American Society of Civil Engineers Geo-Institute, Colorado School of Mines, Integrated Petroleum Environmental Consortium, Mine Waste Technology Program-U.S. EPA, and Petroleum Technology Transfer Council. The 2001 conference proceedings are being prepared for publication on the Internet and in print form.

Technology Transfer and Outreach: This annual conference brings together researchers, regulators, and industry for the express purpose of exchanging information and transferring technology.

Supplemental Keywords: conference, information exchange, research.

Relevant Web Sites: http://www.engg.ksu.edu/HSRC/

Title: Virtual Library: Transferring HSRC Research Results Through the Internet

Investigators: L. E. Erickson, Kansas State University

Institution: Great Plains/Rocky Mountain Hazardous Substance Research Center, Kansas State University

Project Number: TR 95-10

Period Covered by Report: October 2000-September 2001

EPA Project Officer: Dale Manty

Project Amount: $37,000

Category: Training and Technology Transfer

Goals and Objectives: The goal of this project is to publish the *Journal of Hazardous Substance Research*, an electronic, peer-reviewed journal distributed via the Internet.

Rationale: Investigators believe distributing this journal via the Internet will improve delivery time of HSRC findings and information about related research. It should also provide an inexpensive alternative to library subscriptions and offer a means for evaluating the Internet as a vehicle for the delivery of refereed research results.

Approach: The journal publishes selected papers on hazardous substance research. Manuscripts are selected for publication by a team of editors following peer review by members of the editorial board, HSRC advisory committees, and other qualified individuals. The journal is freely accessible via the Internet to industry as well as the public at large. Interested parties are able to easily follow up with researchers by electronic mail or other means of communication.

Project Status: An editorial team and advisory board have been established and a Web site created at http://www.engg.ksu.edu/HSRC/JHSR. Manuscript submission information is on-line, and a call for papers has been distributed. A number of manuscripts have been submitted and peer reviewed, and 21 articles posted on the Web site. The articles are posted in portable document format (pdf) with searchable abstracts also available in HTML. Print copies of Volumes I and II of the journal have been published. Future plans include marketing research and studies to identify reliable methods for indexing, cataloging, and archiving the journal. Efforts to identify funding sources continue. This project is in its fifth year.

Technology Transfer: This form of virtual publishing offers tremendous cost/benefit potential to industry, academia, and the general public by providing more fluid access and distribution of scientific and technological information.

Supplemental Keywords: *Journal of Hazardous Substance Research*, publishing, Internet, World Wide Web, Web site, manuscripts, editorial.

Relevant Web Sites: http://www.engg.ksu.edu/HSRC/JHSR

Title: Technical Outreach Services to Communities (TOSC) Program

Investigators: B.A. Leven, T.K. Boguski, V. Dienes, L.J. Wigfall, B. Brandon, Kansas State University

Institution: Great Plains/Rocky Mountain Hazardous Substance Research Center, Kansas State University

Project Number: SP93-01/TOSNAC

Project End Date: September 30, 2001

Period Covered by Report: October 2000-September 2001

EPA Project Officer: Dale Manty

Project Amount: $402,000/$662,000

Category: Training and Technology Transfer

Goals and Objectives: Technical Outreach Services for Communities (TOSC) provides technical assistance to communities, groups, and individuals affected by hazardous substances at EPA Superfund/RCRA, brownfield, former defense, and tribal sites. This includes providing information on underlying issues related to the cleanup and reuse of sites with real or perceived environmental impacts

Rationale: EPA and Congress have shown increasing interest in the level of community involvement in the decision-making process at hazardous waste sites in general, and specifically under the Superfund process. In 1986, Congress strengthened requirements for community participation in Superfund when it passed the Superfund Amendments and Re-authorization Act. These requirements were further strengthened when the revised National Oil and Hazardous Substances Contingency Plan (NCP) was released in 1990. One effort in support of furthering community involvement is EPA's Technical Assistance Grants program, where EPA provides community groups up to $50,000 per site for the purpose of obtaining outside technical assistance. This program has had success, but has been hampered by administrative burdens placed on community groups to obtain the grants and is limited to sites designated on the NPL.

Approach: The program provides a variety of services to interested citizens in the 10-state region:

- Toll-free telephone access to the TOSC program office.
- In-community presentations, workshops, and handouts on health risk and remediation issues. A listing of workshops appears in the final section of this report.
- In-community technical assistance at a basic level and from researchers in a variety of technical areas ranging from toxicology to engineering.
- Assistance with review of technical documents including site characterization reports, risk assessments, feasibility studies, and remedial designs.
- Attendance at public hearings and assistance in preparing written comments.
- Public education on hazardous substance issues.

Project Status: This is an update to highlight recent and upcoming GP/RM TOSC related activities, inside and outside of Regions 7 and 8. This includes recent efforts to transition support to communities from initial to new regional Hazardous Substance Research Center programs, in Regions V, VII, and VIII.

In Regions VII and VIII support provided to TOSC communities has remained at 12 sites, including six Superfund, one RCRA, two former defense, and three other sites. In addition, we are currently providing support to seven Technical Assistance to Brownfields (TAB) communities, and are on call to support others. Technical Outreach Services for Native American Communities (TOSNAC) is providing support to 13 communities. To aid the transition effort, we have reached a stopping point for focused work at approximately 10 communities and are only supporting on an on-call basis.

Technology Transfer: This program assists in technology transfer of university research projects by providing information and technical assistance to communities in a format that is more easily understood. A greater level of understanding sometimes increases remediation options that can be considered.

Supplemental Keywords: communities, outreach services, Technical Assistance Grants, National Priority List.

Relevant Web Sites: http://www.engg.ksu.edu/HSRC
http://www.engg.ksu.edu/HSRC/Tosc/toschome.html

Title: Collaborative Environmental Seminar Series

Investigators: G.L. Godfrey, Haskell Indian Nations University; and W.M. Griswold and B.A. Leven, Kansas State University

Institution: Great Plains/Rocky Mountain Hazardous Substance Research Center, Kansas State University and Haskell Indian Nations University

Project Number: TR96-05

Project End Date: July 31, 2002

Period Covered by Report: October 2000-September 2001

EPA Project Officer: Dale Manty

Project Amount: $142,000

Category: Training and Technology Transfer

Goals and Objectives: The goal of this project is to produce a series of seminars primarily for audiences at Haskell Indian Nations University (HINU) and other American Indian Higher Education Consortium (AIHEC) colleges and universities. The seminars provide technical information to students, faculty, and tribal environmental professionals throughout the U.S. through quality videotaped seminars, and to students and faculty at HINU through traditional seminars on campus.

Rationale: Although NAOMI program funds expired in December 1997, the most successful elements of this program receive continued support through center funds awarded in open competition. Seminars produced under the NAOMI program are distributed to approximately 130 participants at AIHEC colleges and universities, tribal environmental offices, other minority academic institutions, Kansas colleges, and HSRC consortium institutions. In a survey, these participants indicated that the videos are the most effective delivery method and that they are used primarily as classroom tools and staff development tools.

Approach: The HINU Environmental Seminar Series will produce four high-quality video programs, companion on-campus seminar presentations at HINU, and semi-annual publications of the *Earth Medicine* newsletter. Video topics include panel discussions of tribal environmental justice issues, tribal environmental planning and management, pollution prevention opportunity assessments, and a demonstration on microscale chemistry for the classroom. A peer review of the program scripts has been implemented.

Project Findings: In previous years, the Haskell Environmental Seminar Series (HESS) produced two video seminar programs and filmed four lectures at HINU. In May 2001, a panel discussion on environmental management planning was filmed at HINU. Also, a video seminar on pollution prevention will be completed in spring 2002.

Technology Transfer: This program resembles the TOSC program in that it assists in technology transfer by providing information and technical assistance to Native American communities in an easily understood format.

Supplemental Keywords: Native American, minority colleges, seminar, training.

Relevant Web Sites: http://www.engg.ksu.edu/HSRC

Title: Field Validation of an Optimal Design Methodology for Vegetative Remediation of Sediments from the Central Vehicle Wash Facility, Custer Hill, Fort Riley, Kansas—A Technology Transfer Project

Investigators: A.P. Schwab, P. Kulakow, B.A. Leven, Kansas State University; M.K. Banks, Purdue University; and S.R. Burckhard, South Dakota State University

Institution: Great Plains/Rocky Mountain Hazardous Substance Research Center, Kansas State University, Purdue University, South Dakota State University

Project Number: SP96-Riley

Project End Date: September 30, 2002

Period Covered by Report: October 2000-September 2001

EPA Project Officer: Dale Manty

Project Amount: $84,000

Category: Training and Technology Transfer

Goals and Objectives: The goals of this project are to develop an optimal remediation design using vegetative systems to obtain regulatory approval for use of this technique to treat sediments on an ongoing basis, and to transfer this technology through computer software, demonstrations, and involvement of environmental professionals.

Rationale: The Central Vehicle Wash Facility concrete sedimentation basin at Fort Riley produces petroleum hydrocarbon-contaminated sediments on an ongoing basis. Vegetative remediation is potentially an inexpensive and acceptable innovative technique for treating these contaminated sediments. Results from this study could lead to feasibility evaluations and design of vegetative treatment systems for contaminated materials from other locations such as wastewater lagoons and UST sites, or for on-site treatment of miscellaneous petroleum spills.

Approach: This research involves establishing several vegetative treatment plots at the site, monitoring and comparing results, and calibrating evolving computer models and design tools. Additional field tests of this technology are being conducted at other unique cleanup sites, or for other waste types as funds become available. Technology transfer is an ongoing part of this project.

Project Findings: The RTDF cooperative trials include both common datasets based on the RTDF protocol and unique research conducted independently at each location. Total amount of information being generated on the mechanisms and response of phytoremediation is extensive and will bolster the conclusions from the field trials. Some of research areas include characterization of microbial populations, tree growth analysis, plant root exudate studies, phytoremediation modeling, phytoremediation treatment from natural vegetation, and bioavailability assays.

Technology Transfer: Technology transfer activities include simultaneous involvement of environmental professionals at Fort Riley, the Army Environmental Center, and state regulatory and private contractors throughout this project. A written guide and Internet-based software product are being developed to assess the feasibility and help implement phytoremediation of washrack sediments. Broad

dissemination of project protocols and results is planned through workshops and platform presentations at various conferences. Participants in this study are also participating in the Remediation Technologies Development Forum (RTDF) involving EPA, DoD, industry, and university collaborators to validate and promote regulatory acceptance of phytoremediation of TPH-contaminated soils.

Supplemental Keywords: vegetation, phytoremediation, petroleum hydrocarbons.

Relevant Web Sites: http://www.engg.ksu.edu/HSRC

BIBLIOGRAPHY

February 22, 1989 - September 30, 2001

A. REFEREED JOURNAL ARTICLES

Abbas, J.D., B.A.D. Hetrick, and J.E. Jurgenson, "Isolate Specific Detection of Mycorrhizal Fungi Using Genome-Specific Primer Pairs," *Mycologia*, Vol. 88, No. 6, pages 939-946, 1996. Project no. 93-07.

Abdel-Saheb, I., A.P. Schwab, M.K. Banks, and B.A.D. Hetrick, "Chemical Characterization of Heavy Metal-Contaminated Soil Transects in Southeast Kansas," *Water*, *Air, and Soil Pollution*, Vol. 78, No. 1-2, pages 73-82, 1995. Project no. 93-06.

Adamson, D.T., and G.F. Parkin, "Biotransformation Kinetics of Mixtures of Chlorinated Aliphatic Hydrocarbons by a Mixed Methanogenic Enrichment Culture," *Journal of Water Research*, Vol. 33, pages 1482-1494, 1998. Project no. 93-24.

Adamson, D.T., and G.F. Parkin, "Impact of Mixtures of Chlorinated Aliphatic Hydrocarbons on a High-Rate, PCE-Dechlorinating Enrichment Culture," *Environmental Science and Technology*, Vol. 34, pages 1959-1965, 2000. Project no. 93-24.

Anderson, S.H., R.L. Peyton, J.W. Wigger, H. Wang, and C.J. Gantzer, "Influence of Aggregate Size on Solute Transport Measured Using Computed Tomography," *Geoderma*, Vol. 53, pages 387-398, 1992.

Anderson, T.A., and J.R. Coats, "Screening Rhizosphere Soil Samples for the Ability to Mineralize Elevated Concentrations of Atrazine and Metolachlor," *Journal of Environmental Science and Health*, Vol. 30, pages 473-484. Project no. 93-05.

Arthur, E.L., B.S. Perkovich, T.A. Anderson, and J.R. Coats, "Degradation of an Atrazine and Metolachlor Herbicide Mixture in Pesticide—Contaminated Soils from Two Agrochemical Dealerships in Iowa," *Water, Air, and Soil Pollution*, Vol. 119, pages 75-90, 2000.

Atteya, M., and K.J. Klabunde, "Nanoscale Metal Oxide Particles as Chemical Reagents. Heats of Adsorption of Heteroatom Organics on Heat-Treated Magnesium Oxide," *Chemistry of Materials*, Vol. 3, pages 182-187, 1991.

Bajpai, R.K., and S.K. Banerji, "Bioremediation of Soils Contaminated with Pentachlorophenol," *Biochemical Engineering VII. Annals of the NY Academy of Sciences*, Vol. 665, pages 423-434, 1991.

Banerji, S.K., R.K. Bajpai, and S.M. Wei, "Pentachlorophenol Interactions with Soil," *Water*, *Air, and Soil Pollution*, Vol. 69, pages 149-163, 1993.

Banerji, S.K., and R.K. Bajpai, "Cometabolism of Pentachlorophenol by Microbial Species," *Journal of Hazardous Materials*, Vol. 39, pages 19-31, 1994.

Banks, M.K., G.R. Fleming, A.P. Schwab, and B.A. Hetrick, "Effects of the Rhizosphere Microflora on Heavy Metal Movement in Soil," *Chemosphere,* Vol. 29, No. 8, pages 1691-1699, 1994.

Banks, M.K., C.Y. Waters, and A.P. Schwab, "The Influence of Organic Acids on Leaching of Heavy Metals from Contaminated Mine Tailings," *Journal of Environmental Science and Health,* Vol. A29, No. 5, pages 1045-1056, 1994.

Barrera, J.A., and T.J. O'Keefe, "A Continuous-Flow Evaluation of the Galvanic Stripping Process," *Separation Science and Technology,* Vol. 34, No. 12, pages 2395-2405, 1999. Project no. 94-05.

Barth, G.R., T.H. Illangasekare, M.C. Hill, and H. Rajaram, "Analysis of Intermediate-Scale Tracer Experiments for the Development of Tracer Density Guidelines, *Water Resour. Res.*, 37(1), pages 21-32, 2001. Project no 98-05.

Barth, G., M.C. Hill, T.H. Illangasekare, and H. Rajaram, "Predictive Modeling of Flow and Transport in a Two-Dimensional Intermediate-Scale, Heterogeneous Porous Media," *Water Resources Research*, 2000. Project no. 94-29.

Boronina, T., and K.J. Klabunde, "Destruction of Organohalides in Water Using Metal Particles: Carbon Tetrachloride/Water Reactions with Magnesium, Tin, and Zinc," *Environmental Science and Technology*, Vol. 29, pages 1511-1517, 1995. Project no. 89-26, 92-03.

Boronina, T., K.J. Klabunde, and G.B. Sergeev, "Dechlorination of Carbon Tetrachloride in Water on Activated Zinc," *Mendeleev Community,* pages 154-155, 1998. Project no. 95-04a.

Boronina, T., K.J. Klabunde, and G. Sergeev, "Rebuttal to Comment on 'Destruction of Organohalides in Water Using Metal Particles: Carbon Tetrachloride/Water Reactions with Magnesium, Tin, and Zinc'," *Environmental Science and Technology*, Vol. 30, page 3645, 1996. Project no. 95-04a.

Boronina, T., I. Lagadic, and K.J. Klabunde, "Zinc-Silver, Zinc-Palladium, and Zinc-Gold as Active Bimetallic Systems for Carbon Tetrachloride Dechlorination in Water," *Journal of Hazardous Substance Research,* URL: http://www.engg.ksu.edu/HSRC/JHSR/v1_no6.pdf. Project no. 95-04a.

Boronina, T., I. Lagadic, G. Sergeev, and K.J. Klabunde, "Activated and Non-Activated Forms of Zinc Powder. Reactivity Towards Chlorocarbons in Water and AFM Studies of Surface Morphologies," *Environmental Science and Technology,* Vol. 32, pages 2614-2622, 1998. Project no. 95-4a.

Burckhard, S.R., A.P. Schwab, and M.K. Banks, "The Effects of Organic Acids on the Leaching of Heavy Metals from Mine Tailings," *Journal of Hazardous Materials*, Vol. 41, pages 135-145, 1996. Project no. 93-06.

Burken, J.G., and J.L. Schnoor, "Predictive Relationships for Uptake of Organic Contaminants by Hybrid Poplar Trees," *Environmental Science and Technology*, Vol. 32, pages 3374-3385, 1998. Project no. 94-25.

Burken, J.G., and J.L. Schnoor, "Phytoremediation: Plant Uptake of Atrazine and the Role of Root Exudates," *ASCE Journal of Environmental Engineering*, Vol. 122, No. 11, pages 958-963, 1995. Project no. 94-25.

Burken, J.G., and J.L. Schnoor, "Predictive Relationships for Uptake of Organic Contaminants by Hybrid Poplar Trees," *Environmental Science and Technology,* Vol. 32, No. 21, pages 3379-3385, 1997. Project no. 94-25.

Burken, J.G., and J.L. Schnoor, "Distribution and Volatilization of Organic Compounds Following Uptake by Hybrid Poplar Trees," *International Journal of Phytoremediation,* Vol 1, No. 2, 1999. Project no. 94-25.

Burken, J.G., and J.L. Schnoor, "Uptake and Metabolism of Atrazine by Poplar Trees," *Environmental Science and Technology*, Vol. 31, No. 5, pages 1399-1406, 1997. Project no. 94-25.

Cady, J.C., S. Kapila, S.E. Manahan, D.W. Larsen, and A.F. Yanders, "Evaluation of a Novel Carbon Adsorbent for Fractionation and Treatment of Halogenated Organic Wastes," *Chemosphere*, Vol. 20, pages 1959-1966, 1990.

Camper, A., J.T. Hayes, P.J. Sturman, W. Jones, and A.B. Cunningham, "The Effects of Motility and Adsorption Velocity on the Transport of Bacteria Through Saturated Porous Media," *Applied and Environmental Microbiology*, Vol. 59, page 3455, 1993.

Carnes, C.L., and K.J. Klabunde, "Synthesis, Isolation, and Chemical Reactivity Studies of Nanocrystalline Zinc Oxide," *Langmuir,* Vol. 16, pages 3764-3772, 2000. Project no. 95-4a.

Castro, S., L.C. Davis, and L.E. Erickson, "Plant-Enhanced Remediation of Glycol-Based Aircraft Deicing Fluids," *Practice Periodical of Hazardous, Toxic and Radioactive Waste Management,* Vol 5, 141-152, 2001. Project no. 94-27, 98-03.

Chang, D., K. Fukushi, and S. Ghosh, "Stimulation of Activated Sludge Cultures for Enhanced Heavy Metal Removal," *Water Environment Research*, Vol. 67, pages 822-827, 1995.

Chen, B., "Numerical Simulation of Biofilm Growth in Porous Media," *Journal of Computational and Applied Mathematics,* Vol. 103, pages 55-66, 1999. Project no. 94-28.

Chen, B., A. Cunningham, R. Ewing, R. Peralta, and E. Visser, "Two-Dimensional Modeling of Microscale Transport and Biotransformation in Porous Media," *Numerical Methods for Partial Differential Equations,* Vol. 10, pages 65-83, 1994.

Chen, B.M., and H.V. Kojouharov, "Non-Standard Numerical Methods Applied to Subsurface Biobarrier Formation Models in Porous Media," *Bulletin of Mathematical Biology,* Vol. 61, pages 779-798, 1999. Project no. 94-28.

Chen, D., Z. Lewandowski, F. Roe, and P. Surapaneni, "Diffusivity of CU^{+2} in Calcium Alginate Gel Beads," *Biotechnology and Bioengineering*, Vol. 41, pages 755-760, 1993.

Chen, T.-C., and A. Hong, "Chelating Extraction of Lead and Copper from an Authentic Contaminated Soil Using N-(2-acetamido) iminodiacetic Acid and S-carboxymethyl-L-cysteine," *Journal of Hazardous Materials*, Vol. 41, pages 147-160, 1995. Project no. 93-22.

Chen, T.-C., E. Macauley, and A. Hong, "Selection and Test of Effective Chelators for Removal of Heavy Metals from Contaminated Soils," *Canadian Journal of Civil Engineering*, " Vol. 22, pages 1185-1197, 1995. Project no. 93-22.

Chew, C.F., and T.C. Zhang, *"In Situ* Remediation of Nitrate-Contaminated Groundwater by Electrokinetics/Iron Wall Processes," *Water Science and Technology,* Vol. 38, No. 7, pages 135-142. Project no. 95-32.

Chew, C.F., and T.C. Zhang, "Abiotic Degradation of Nitrate Using Zero-Valent Iron and Electrokinetic Processes," *Environment Engineering and Sciences,* Vol 16, No. 5, pages 389-401, 1999. Project no. 95-32.

Clevenger, T.E., "Use of Sequential Extraction to Evaluate the Heavy Metals in Mining Wastes," *Journal of Air*, *Water*, *and Soil Pollution*, Vol. 50, pages 241-254, 1990.

Coffin, D., and L. Glasgow, "Effective Gas Flow Arrangements in Soil Venting," *Water*, *Air, and Soil Pollution*, Vol. 62, pages 303-324, 1992.

Comfort, S.D., P.J. Shea, L. Hundal, Z. Li, B.L. Woodbury, J.M. Martin, and W. Powers, "TNT Transport and Fate in Contaminated Soils," *Journal of Environmental Quality*, Vol. 24, pages 1174-1182, 1995. Project no. 92-24.

Comfort, S.D., P.J. Shea, T.A. Machacek, H. Gaber, and B.-T. Oh, "Field-Scale Remediation of a Metolachlor-Contaminated Spill Site Using Zerovalent Iron," *J. Environ. Qual.,* Vol. 30, pages 1636-1643, 2001. Project no. 95-32.

Coyle, C.G., G.F. Parkin, and D.T. Gibson, "Aerobic, Phenol-Induced TCE Degradation in Completely Mixed, Continuous-Culture Reactors," *Biodegradation*, Vol. 4, pages 59-69, 1993.

Cunningham, A.B., "Engineering Scaleup of *In Situ* Bioremediation Processes: A Review," *Journal of Contaminant Hydrology*, Vol. 19, pages 171-203, 1995.

Cunningham, A.B., W.G. Characklis, F. Abedeen, and D. Crawford, "Influence of Biofilm Accumulation on Porous Media Hydrodynamics," *Environmental Science and Technology*, Vol. 25, No. 7, pages 1305-1310, 1991.

Davis, L.C., L.E. Erickson, E. Lee, J.F. Shimp, and J.C. Tracy, "Effects of Plants on the Bioremediation of Contaminated Soil and Groundwater," *Environmental Progress*, Vol. 12, No. 1, pages 67-75, 1993.

Davis, L.C., M. Narayanan, V.P. Visser, C. Chaffin, W.G. Fateley, L.E. Erickson, and R.M. Hammaker, "Alfalfa Plants and Associated Microorganisms Promote Biodegradation Rather than Volatilization of Organic Substances from Groundwater," *Bioremediation Through Rhizosphere Technology,* T.A. Anderson and J.R. Coats (Eds.), ACS Symposium Series No. 563, Washington, DC, pages 112-122, 1994.

Davis, L.C., S. Vanderhoof, J. Dana, K. Selk, K. Smith, B. Goplen, and L.E. Erickson, "Chlorinated Solvent Movement Through Plants Monitored by Fourier Transform Infrared (FT-IR) Spectrometry," *Journal of Hazardous Substance Research*, Vol. 1, No. 4, pages 1-26, 1998. URL: http://www.engg.ksu.edu/HSRC/JHSR/v1_no4.pdf. Project no. 94-27.

Decker, S., and K.J. Klabunde, "Enhancing Effect of Fe_2O_3 on the Ability of Nanocrystalline Calcium Oxide to Adsorb SO_2," *Journal of the American Chemical Society*, Vol. 118, pages 12465-12466, 1996. Project no. 95-04a.

Dennis, M.L., and J.P. Turner, "Hydraulic Conductivity of Compacted Soil Treated with Biofilm," *ASCE Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 124, No. 2, pages 120-127, 1998. Project no. 94-26.

Dhawan, S., L.T. Fan, L.E. Erickson, and P. Tuitemwong, "Modeling, Analysis, and Simulation of Bioremediation of Soil Aggregates," *Environmental Progress*, Vol. 10, pages 251-260, 1991.

Dhawan, S., L.E. Erickson, and L.T. Fan, "Model Development and Simulation of Bioremediation in Soil Beds with Aggregates," *Journal of Groundwater*, Vol. 31, No. 2, pages 271-284, 1993.

Doucette, W.J., B.J. Orchard, J.K. Chard, and B. Bugbee, "Uptake of Trichloroethylene by Hybrid Poplar Trees Grown Hydroponically in Flow-Through Plant Growth Chambers.," *Environmental Toxicology and Chemistry,* 1999. Project no. 95-10.

Erickson, L.E., "An Overview of Research on the Beneficial Effects of Vegetation in Contaminated Soil," *Annals of the New York Academy of Sciences,* Vol. 829, pages 30-35, 1997. Project no. 94-27.

Erickson, L.E., J.P. McDonald, L.T. Fan, S. Dhawan, and P. Tuitemwong, "Bioremediation: A Challenging Application of Biochemical Engineering Principles," *Biochemical Engineering VII*, *Annals of the N.Y. Academy of Sciences*, Vol. 665, pages 404-411, 1991.

Erickson, L.E., M.K. Banks, L.C. Davis, A.P. Schwab, M. Narayanan, K. Reilley, and J.C. Tracy, "Using Vegetation to Enhance *In Situ* Bioremediation," *Environmental Progress*, Vol. 13, pages 226-231, 1994.

Erickson, L.E., L.C. Davis, and M. Narayanan, "Bioenergetics and Bioremediation of Contaminated Soil," *Thermochimica Acta,* Vol. 250, pages 353-358, 1995.

Figge, D.H., B.A.D. Hetrick, and G.W.T. Wilson, "Role of Expanded Clay and Porous Ceramic Amendments on Plant Establishment in Mine Spoils," *Environmental Pollution*, Vol. 88, No. 2, pages 161-165, 1995.

Friedler, F., L.T. Fan, and B. Imreh, "Process Network Synthesis: Problem Definition," *Networks*, Vol. 31, pp. 119-124, 1996.

Friedler, F., K. Tarján, Y.W. Huang, and L.T. Fan, "Graph-Theoretic Approach to Process Synthesis: Axioms and Theorems," *Chemical Engineering Science*, Vol. 47, pages 1973-1988, 1991.

Friedler, F., K. Tarján, Y.W. Huang, and L.T. Fan, "Combinatorial Algorithms for Process Synthesis," *Computers and Chemical Engineering*, Vol. 16, suppl. 313-320, 1992.

Friedler, F., K. Tarján, Y.W. Huang, and L.T. Fan, "Graph-Theoretic Approach to Process Synthesis: Polynomial Algorithm Maximal Structure Generation," *Computers and Chemical Engineering*, Vol. 17, pages 929-942, 1993.

Friedler, F., J.B. Varga, and L.T. Fan, "Algorithmic Approach to the Integration of Total Flowsheet Synthesis and Waste Minimization," *Pollution Prevention via Process and Product*

Modifications, E.L. Gaden, Jr., M.M. El-Halwagi, and D.P. Petrides (Eds.), AIChE Symposium Series, Vol. 90, No. 303, New York, pages 86-97, 1995. Project no. 91-36.

Friedler, F., J.B. Varga, and L.T. Fan, "Decision-Mapping: A Tool for Consistent and Complete Decisions in Process Synthesis," *Chemical Engineering Science*, Vol. 50, pages 1755-1768, 1995. Project no. 91-36.

Gandhi, P., L.E. Erickson, and L.T. Fan, "A Simple Method to Study the Effectiveness of Bioremediation-Aided, Pump-and-Treat Technology for Aquifers Contaminated by Nonaqueous-Phase Liquids, I. Single Component Systems," *Journal of Hazardous Materials,* Vol. 39, pages 49-68, 1994.

Gandhi, P., L.E. Erickson, and L.T. Fan, "A Simple Method to Study the Effectiveness of Bioremediation-Aided, Pump-and-Treat Technology for Aquifers Contaminated by Nonaqueous-Phase Liquids, II. Multi-Component Systems," *Journal of Hazardous Materials,* Vol. 41, pages 185-204, 1995.

Ghosh, S., and S. Bupp, "Stimulation of Biological Uptake of Heavy Metals," *Water*, *Science and Technology*, Vol. 26, No. 1-2, pages 227-236, 1992.

Ghoshal, S., R.K. Bajpai, and S.K. Banerji, "Role of Photodegradation in PCP Decontamination in Soils," *Biochemical Engineering VII*, *Annals of the NY Academy of Sciences*, Vol. 665, pages 412-422, 1991.

Gilliland, M.W., W.E. Kelly, and D. Lokke, "Hazardous Waste Management in Rural Areas," *Journal of Professional Issues in Engineering*, Vol. 117, pages 102-110, 1991.

Ginn, J., R.C. Sims, D.P. Smith, D.L. Sorensen, and W.J. Doucette, "Aerobic Biotransformation of Polycyclic Aromatic Hydrocarbons and Associated Metabolites in Soil," *Journal of Polycyclic Aromatic Compounds*, Vol. 11, pages 43-55, 1996. Project no. 93-21.

Gu, H., C.-M. Chang, J.A. Barrera-Godinez, and T.J. O'Keefe, "Preliminary Design of Solvent Extraction Process for the Galvanic Stripping of Iron from D2EHPA," *Minerals & Metallurgical Processing*, Vol. 17, No. 1, pages 16-22, 2000. Project no. 94-05.

Gu, H., C.M. Chang, J.A. Barrera-Godinez, and T.J. O'Keefe, "Preliminary Design of Solvent Extraction Process for Separating Iron from Zinc by Galvanic Stripping," *Transactions SME,* 1999. Project no. 94-05.

Gu, J., G.W. Preckshot, S.K. Banerji, and R.K. Bajpai, "Effect of Some Common Solubility Enhancers on Microbial Growth," *Annals of the New York Academy of Sciences*, Vol. 829, pages 62-73, 1997.

Hangos, K.M., J.B. Varga, F. Friedler, and L.T. Fan, "Integrated Synthesis of a Process and Its Fault-Tolerant Control System," *Computers and Chemical Engineering*, Vol. 19, pages S465-S470, 1995.

Held, R., and T.H. Illangasekare, "Fingering of Dense Nonaqueous-Phase Liquids in Porous Media: 1. Experimental Investigation," *Water Resources Research,* Vol. 31, No. 5, pages 1213-1222, 1995.

Held, R., and T.H. Illangasekare, "Fingering of Dense Nonaqueous-Phase Liquids in Porous Media: 2. Analysis and Classification," *Water Resources Research,* Vol. 31, No. 5, pages 1223-1231, 1995.

Helland, B.R., P.J.J. Alvarez, and J.L. Schnoor, "Reductive Dechlorination of Carbon Tetrachloride with Elemental Iron," *Journal of Hazardous Materials*, Vol. 41, pages 205-216, 1995.

Hetrick, B.A., G.W.T. Wilson, and D. Hoobler, "The Influence of Mycorrhizal Symbiosis and Fertilizer Amendments on Establishment of Vegetation in Heavy Metal Mine Spoil," *Environmental Pollution*, Vol. 86, pages 171-179, 1994.

Hillier, A.C., and C.W. Walton, "Modeling Electroplating Rinse Systems Using Equation-Solving Software," *Plating and Surface Finishing–Journal of AESF*, Vol. 78, No. 11, pages 72-75, 102, 1991.

Hong, A., T.-C. Chen, and R.W. Okey, "Chelating Extraction of Copper from Soil with S-Carboxymethylcysteine," *Water Environment Research*, Vol. 67, pages 971-978, 1995. Project no. 93-22.

Hong, A., T.-C. Chen, and R.W. Okey, "Chelating Extraction of Zinc from Soil with N-(2-acetamido)iminodiacetic Acid," *ACS Symposium Series*, Vol. 607, pages 210-223, 1995. Project no. 93-22.

Hong, A., and T.-C. Chen, "Extractive Recovery of Cadmium from Soil Using Pyridine-2,6-dicarboxylic Acid," *Water, Air and Soil Pollution*, Vol. 86, pages 335-346, 1996. Project no. 93-22.

Hooker, P.D., and K.J. Klabunde, "Destructive Adsorption of Carbon Tetrachloride on Iron(III) Oxide," *Environmental Science and Technology,* Vol. 28, pages 1243-1247, 1994.

Hsu, S.M., J.L. Schnoor, L.A. Licht, M.A. St. Clair, and S.A. Fannin, "Fate and Transport of Organic Compounds in Municipal Solid Waste Compost," *Compost Science,* Vol. 1, No. 4, pages 36-48, 1993.

Huang, Y.L., and L.T. Fan, "A Distributed Strategy for Integration of Process Design and Control: A Knowledge Engineering Approach to Incorporation of Controllability into Process Synthesis," *Computers and Chemical Engineering*, Vol. 16, pages 497-522, 1992.

Huang, Y.L., and L.T. Fan, "Analysis of a Work-Exchanger Network," *Industrial and Engineering Chemistry Research.*, Vol. 35, pages 3528-3538, 1996. Project no. 91-36.

Huang, Y.L., and L.T. Fan, "Artificial Intelligence for Waste Minimization in the Process Industry," *International Journal of Computers in Industry*, Vol. 22, pages 117-128, 1993.

Huang, Y.L., and L.T. Fan, "HIDEN: A Hybrid Intelligent System for Synthesizing Highly Controllable Exchanger Networks: Implementation of Distributed Strategy for Integration of Process Design and Control," *Industrial and Engineering Chemistry Research,* Vol. 33, pages 1174-1187, 1994. Project no. 91-36.

Huang, Y.L., Y.W. Huang, and L.T. Fan, "A Fuzzy Logic-Based Approach to Building Efficient Fuzzy Rule-Based Expert Systems," *Computers and Chemical Engineering*, Vol. 17, pages 181-192, 1993.

Huang, Y.L., G. Sunder, and L.T. Fan, "MIN-CYANIDE: An Expert System for Cyanide Waste Minimization in Electroplating Plants," *Environmental Progress*, Vol. 10, pages 89-95, 1991.

Hughes, J.B., and G.F. Parkin, "The Effect of Mixtures of Xenobiotics and Primary Electron Donor on the Anaerobic Biotransformation of High Concentrations of Chlorinated Aliphatics," *Water*, *Science and Technology*, Vol. 26, pages 117-126, 1992.

Hundal, L., J. Singh, E.L. Bier, P.J. Shea, S.D. Comfort, and W.L. Powers, "Removal of TNT and RDX from Water and Soil Using Iron Metal," *Environmental Pollution*, Vol. 97, pages 55-64, 1997. Project no. 92-24.

Hundal, L.S., P.J. Shea, S.D. Comfort, W.L. Powers, and J. Singh, "Long-Term TNT Sorption and Bound Residue Formation in Soil," *Journal of Environmental Quality*, Vol. 26, pages 896-904, 1996. Project no. 92-24.

Hurst, C.J., R.C. Sims, J.L. Sims, D.L. Sorensen, and J.W. McLean, "Polycyclic Aromatic Hydrocarbon Biodegradation as a Function of Oxygen Tension in Contaminated Soil," *Journal of Hazardous Materials*, Vol. 51, pages 193-208, 1996. Project no. 93-21.

Hurst, C.J., R.C. Sims, J.L. Sims, D.L. Sorensen, J.W. McLean, and S. Huling, "Soil-Gas Oxygen Tension and Pentachlorophenol Biodegradation," *Journal of Environmental Engineering*, Vol. 123, No. 4, pages 364-370, 1997. Project no. 93-21.

Illangasekare, T.H., J.L. Ramsey, K.H. Jensen, and M. Butts, "Experimental Study of Movement and Distribution of Dense Organic Contaminants in Heterogeneous Aquifers," *Journal of Contaminant Hydrology*, Vol. 20, pages 1-25, 1995.

Illangasekare, T.H., J.H. Brannon, and B. Amadei, "Three-Dimensional Aquifer Flow and Transport by Integral Transforms," *Journal of Hydrology*, 161, Vol. 1, No. 4, pages 109-132, 1993.

Illangasekare, T.H., D.N. Yates, and E.J. Armbruster, "Effect of Heterogeneity on Transport and Entrapment of Nonaqueous-Phase Waste Products in Aquifers: An Experimental Study," *ASCE Journal of Environmental Engineering,* Vol. 121, No. 8, pages 572-579, 1995.

Illangasekare, T.H., D.N. Yates, E.J. Armbruster, and D.D. Reible, "Effect of Heterogeneity on Transport and Entrapment of Nonaqueous-Phase Products in Aquifers: An Experimental Study," *ASCE Journal of Environmental Engineering*, Vol. 121, No. 8, pages 572-579, 1995.

Itoh, H.S., S. Utamapanya, J.V. Stark, K.J. Klabunde, and J.R. Schlup, "Nanoscale Metal Oxide Particles as Chemical Reagents. Intrinsic Effects of Particle Size on Hydroxyl Content and on Reactivity and Acid/Base Properties of Ultrafine Magnesium Oxide," *Chemistry of Materials*, Vol. 5, pages 71-77, 1993. Project no. 89-26, 92-03.

Jennings, S.R., and D.J. Dollhopf, "Acid-Base Account Effectiveness for Determination of Mine Waste Potential Acidity," *Journal of Hazardous Materials*, Vol. 41, pages 161-175, 1995. Project no. 93-12.

Jennings, S.R., D.J. Dollhopf, and W. Inskeep, "Hydrogen Peroxide Oxidation of Sulfide and Sulfate Minerals for Prediction of Mine Waste Acid Generation," *Geological Society of America*, Vol. 27, No. 4, page 16, 1995. Project no. 93-12.

Jones, W.L., J.D. Dockery, C.R. Vogel, and P.J. Sturman, "Diffusion and Reaction Within Porous Packing Media: A Phenomenological Model," *Biotechnology and Bioengineering*, Vol. 41, pages 947-956, 1993.

Jordahl, J.L., L. Foster, J.L. Schnoor, and P.J.J. Alvarez, "Effect of Hybrid Poplar Trees on Microbial Populations Important to Hazardous Waste Bioremediation," *Environmental Toxicology and Chemistry*, Vol. 16, No. 6, pages 1318-1321, 1997. Project no. 94-25.

Kapila, S., R.K. Puri, A.F. Yanders, S. Cerlesi, and A.A. Elseewi, "The Effect of Co-Pollutant Degradation on Partitioning of Polychlorinated Dioxins in Saturated Soils," *Organohalogen Compounds*, Vol. 3, pages 327-330, 1990.

Kapila, S., Y.H. Lo, C.E. Orazio, R.K. Puri, A.F. Yanders, and A.A. Elseewi, "Evaluation of Solvent Flotation Coupled with Photodegradation for Decontamination of Soil," *Organohalogen Compounds*, Vol. 9, pages 111-114, 1992.

Kapila, S., K.S. Nam, M.H. Liu, R.K. Puri, and A.F. Yanders, "Promises and Pitfalls of Supercritical Fluid Extraction in Polychlorinated Compound Analyses," *Chemosphere*, Vol. 25, No. 1-2, pages 11-16, 1992.

Klabunde, K.J., J. Stark, O. Koper, C. Mohs, D.G. Park, S. Decker, Y. Jiang, I. Lagadic, and D. Zhang, "Nanocrystals as Stoichiometric Reagents with Unique Surface Chemistry," *Journal of Physical Chemistry*, Vol. 100, pages 12142-12153, 1996. Project no. 89-26, 92-03.

Klabunde, K.J., A. Khaleel, and D. Park, "Overlayer of Iron Oxide on Nanoscale Magnesium Oxide Crystallites," *High Temperature Materials Science*, Vol. 33, pages 99-106, 1995. Project no. 89-26, 92-03.

Klabunde, K.J, S. Decker, E. Lucas, and O. Koper, "How the Shape of Nanoparticles Affects Their Adsorption Properties," *Cluster and Nanostructure Interfaces*, P. Jena, S.N. Khanna, B.K. Rao (Eds.), World Scientific Publishers, London, pages 577-582, 2000. Project no. 95-4a.

Kohl, S.D., and J.A. Rice, "Binding of PCBs and PAHs to the Humin Fraction of Soil Organic Matter," *Chemosphere*, Vol. 36, pages 251-261, 1998. Project no. 94-11.

Kohl, S.D., and J.A. Rice, "Contribution of Lipids to the Nonlinear Sorption of Polycyclic Aromatic Hydrocarbons to Soil Organic Matter," *Organic Chemistry*, Vol. 30, pages 929-936, 1999. Project no. 94-11.

Kohl, S.D., P.J. Toscano, W. Hou, and J.A. Rice, "Solid-State ^{19}F NMR Investigation of Hexafluorobenzene Sorption to Soil Organic Matter," *Environmental Science Technology*, Vol. 34, pages 204-210. Project no. 94-11.

Kojouharov, H., and B. Chen, "Non-Standard Methods for the Convective Transport Equation with Nonlinear Reactions," *Numerical Methods for Partial Differential Equations,* Vol. 14, pages 467-485, 1998. Project no. 94-28.

Koper, O., I. Lagadic, and K.J. Klabunde, "Destructive Adsorption of Chlorinated Hydrocarbons on Ultrafine (Nanoscale) Particles of Calcium Oxide, 2," *Chemistry of Materials*, Vol. 9, pages 838-848, 1997. Project no. 95-04a.

Koper, O.B., and K.J. Klabunde, "Destructive Adsorption of Chlorinated Hydrocarbons on Ultrafine (Nanoscale) Particles of Calcium Oxide, 3 Chloroform, Tricholoethene, and Tetracholoethene," *Chemistry of Materials*, Vol. 9, pages 2481-2485, 1997. Project no. 95-04a.

Koper, O.B., I. Lagadic, A. Volodin, and K.J. Klabunde, "Alkaline-Earth Oxide Nanoparticles Obtained by Aerogel Methods: Characterization and Rationale for Unexpectedly High Surface Chemical Reactivities," *Chemistry of Materials*, Vol. 9, pages 2468-2480, 1997. Project no. 95-04a.

Koper, O., Y.-X. Li, and K.J. Klabunde, "Destructive Adsorption of Chlorinated Hydrocarbons on Ultrafine (Nanoscale) Particles of Calcium Oxide," *Chemistry of Materials*, Vol. 5, pages 500-505, 1993. Project no. 89-26, 92-03.

Koper, O., E.A. Wovchko, J.A. Glass Jr., J.T. Yates Jr., and K.J. Klabunde, "Decomposition of CCl_4 on CaO," *Langmuir*, Vol. 11, pages 2054-2059, 1995. Project no. 89-26, 92-03.

Kovács, Z., F. Friedler, and L.T. Fan, "Parametric Study of Separation Network Synthesis: Extreme Properties of Optimal Structures," *Computers and Chemical Engineering*, Vol. 19, S107-S112, 1995. Project no. 91-36.

Kovács, Z., F. Friedler, and L.T. Fan, "Recycling in a Separation Process Structure," *American Institute of Chemical Engineers Journal*, Vol. 39, pages 1087-1089, 1993.

Kuiper, L., and T.H. Illangasekare, "Numerical Simulation of NAPL Flow in the Subsurface," *Computational Geo Sciences*, 2(3), 1998. Project no. 94-29, 98-05.

Kuiper, L., and T.H. Illangasekare, "A Three-Dimensional Multiphase Flow Model for Immiscible Fluids in Porous Media: Validation for Heterogeneous Conditions," *Journal of Contaminant Geology,* 1999. Project no. 94-29.

Lambert, M.W., G.M. Pierzynski, L. Erickson, and J. Schnoor, "Remediation of Lead, Zinc, and Cadmium-Contaminated Soils," *Contaminated Land and Its Reclamation, Issues in Environmental Science and Technology*, Royal Society of Chemistry, Cambridge, UK, pages 91-102, 1997. Project no. 93-07.

Langner, H.W., W.P. Inskeep, H.M. Gaber, W.L. Jones, B.S. Das, and J.M. Wraith, "Pore Water Velocity and Residence Time Effects on the Degradation of 2,4-D During Transport," *Environmental Science Technology*, Vol. 32, pages 1308-1315, 1998. Project no. 94-09.

Lewandowski, Z., G. Walser, and W. Characklis, "Reaction Kinetics in Biofilms," *Biotechnology and Bioengineering*, Vol. 38, pages 877-882, 1991.

Lewandowski, Z., S.A. Altobelli, P.D. Majors, and E. Fukushima, "NMR Imaging of Hydrodynamics Near Microbially Colonized Surface," *Water*, *Science, and Technology*, Vol. 26, pages 577-584, 1992.

Li, W., and K.J. Klabunde, "Ultrafine Zinc and Nickel, Palladium, Silver-Coated Zinc Particles Used for Reductive Dehalogenation of Chlorinated Ethylenes in Aqueous Solution," *Croatica Chemica Acta,* Vol. 71, pages 853-872, 1998. Project no. 95-4a.

Li, Y.-X., and K.J. Klabunde, "Nanoscale Metal Oxide Particles as Chemical Reagents. Destructive Adsorption of a Chemical Agent Stimulant Dimethylmethylphosphonate (DMMP) on Heat-Treated Magnesium Oxide," *Langmuir*, Vol. 7, pages 1388-1393, 1991.

Li, Y.-X., J.R. Schlup, and K.J. Klabunde, "A Fourier Transform Infrared Photoacoustic Spectroscopy (FT-IR-PAS) Study of the Adsorption of Organophosphorus Compounds on Heat-Treated Magnesium Oxide," *Langmuir*, Vol. 7, pages 1394-1399, 1991.

Li, Y.-X., and K.J. Klabunde, "Heterophasic Isotope Exchange in Nanoscale Metal Oxide Particles. Lattice Oxygen and Surface OH Groups with Water Vapor (D_20 and $H_2{}^{18}0$)," *Chemistry of Materials*, Vol. 4, pages 611-615, 1992. Project no. 89-26, 92-03.

Li, Y.-X., O. Koper, M. Atteya, and K.J. Klabunde, "Adsorption and Decomposition of Organophosphorus Compounds on Nanoscale Metal Oxide Particles. *In Situ* GC-MS Studies of Pulsed Microreactions over Magnesium Oxide," *Chemistry of Materials*, Vol. 4, pages 323-330, 1992. Project no. 89-26, 92-03.

Li, Y.X., and K.J. Klabunde, "Destructive Adsorption of Chlorinated Hydrocarbons on Ultrafine (Nanoscale) Particles of Magnesium Oxide and Calcium Oxide," *Environmental Science and Technology*, Vol. 28, pages 1248-1253, 1994.

Li, Z.M., P.J. Shea, and S.D. Comfort, "Destruction of 2,4,6- trinitrotoluene (TNT) by Fenton Oxidation," *Journal of Environmental Quality*, Vol. 26, pages 840-847, 1997. Project no. 92-24.

Li, Z.M., P.J. Shea, and S.D. Comfort, "Fenton Oxidation of 2,4,6-trinitrotoluene in Contaminated Soil Slurries," *Environmental Engineering Science*, Vol. 14, pages 55-56, 1997. Project no. 92-24.

Li, Z.M., M.M. Peterson, S.D. Comfort, G.L. Horst, P.J. Shea, and B.T. Oh, "Remediating TNT-Contaminated Soil by Soil Washing and Fenton Oxidation," *Sci. Tot. Environ.*, Vol. 204, pages 107-115, 1997. Project no. 92-24.

Little, B., R. Ray, P. Wagner, Z. Lewandowski, W.H. Lee, W.G. Characklis, and F. Mansfeld, "Impact of Biofouling on the Electrochemical Behavior of 304 Stainless Steel in Natural Seawater," *Biofouling*, Vol. 3, pages 45-59, 1991.

Liu, M.H., S. Kapila, A.F. Yanders, T.E. Clevenger, and A.A. Elseewi, "Role of Entrainers in Supercritical Fluid Extraction of Chlorinated Aromatics from Soils," *Chemosphere*, Vol. 23, pages 1085-1095, 1991.

Liu, M.H, S. Kapila, R.K. Puri, and A.F. Yanders, "Determination of Chlorinated Phenols by Supercritical Fluid Extraction (SFE)-Coupled Liquid Chromatography (LC) System," *Organohalogen Compounds*, Vol. 8, page 91, 1992.

Liu, M.H., S. Kapila, K.S. Nam, and A.A. Elseewi, "A Tandem Supercritical Fluid Extraction (SFE) and Liquid Chromatography (LC) System for Determination of Chlorinated Phenols in Solid Matrices," *Journal of Chromatography*, Vol. 639, pages 151-157, 1993.

Macauley, E., and A. Hong, "Chelation Extraction of Lead from Contaminated Soil," *Journal of Hazardous Materials*, Vol. 40, pages 257-270, 1995. Project no. 93-22.

Macur, R.E., and W.P. Inskeep, "Effects of a Nonionic Surfactant on Biodegradation of Phenanthrene and Hexadecane in Soil," *Environmental Toxicology,* Vol. 18, pages 1927-1931, 1999. Project no. 94-09.

Madison, M.F., and L.A. Licht, "Agricultural Ecosystems–The World Is Watching," *Agricultural Engineering*, Vol. 71, No. 1, pages 12-15, 1990.

Martin, J.L., S.D. Comfort, P.J. Shea, T.A. Kokjohn, and R.A. Drijber, "Denitration of 2,4,6,-trinitrotoluene (TNT) by *Pseudomonas savastanoi*," *Canadian Journal of Microbiology*, Vol. 43, 447-455, 1996. Project no. 92-24.

Miller, C.M., and R.L. Valentine, "Hydrogen Peroxide Decomposition and Quinoline Degradation in the Presence of Aquifer Material," *Water Research*, Vol. 29, No. 10, pages 2353-2359, 1995.

Miller, C.M., and R.L. Valentine, "Oxidation Behavior of Aqueous Contaminants in the Presence of Hydrogen Peroxide and Filter Media," *Journal of Hazardous Materials*, Vol. 41, pages 105-116, 1995.

Moldan, B., and J.L. Schnoor, "Czechoslovakia's Environmental Problems: A Case Study of Central European Environmental Decline and Plan for Recovery," *Environmental Science and Technology*, Vol. 26, pages 14-21, 1992.

Nachabe, M., and T.H. Illangasekare, "Use of Tension Infiltrometer Data with Unsaturated Hydraulic Conductivity Models," *Groundwater*, Vol. 32, No. 6, pages 1017-1021, 1994.

Nachabe, M., A. Islas, and T.H. Illangasekare, "Analytical Solutions for Water Flow and Solute Transport in the Unsaturated Zone," *Groundwater,* Vol. 33, No. 2, pages 304-310, 1995.

Nair, D.R., and J.L. Schnoor, "Effect of Two Electron Acceptors on Atrazine Mineralization Rates in Soil," *Environmental Science and Technology*, Vol. 26, No. 11, pages 2298-2300, 1992.

Nair, D.R., J.G. Burken, J.L. Schnoor, and L.A. Licht, "Mineralization and Uptake of Triazine Pesticide in Soil-Plant Systems," *Journal of Environmental Engineering*, ASCE, Vol. 119, No. 5, pages 842-854, 1993.

Nair, D.R., and J.L. Schnoor, "Effect of Soil Conditions on Model Parameters and Atrazine Mineralization Rates," *Water Research*, Vol. 28, pages 1199-1205, 1994.

Nam, K.S., S. Kapila, A.F. Yanders, and R.K. Puri, "Supercritical Fluid Extraction and Cleanup Procedures for Determination of Xenobiotics in Biological Samples," *Chemosphere*, Vol. 20, pages 873-880, 1990.

Nam, K.S., S. Kapila, A.F. Yanders, and R.K. Puri, "A Multiple-Sample Extraction and Online System for the Analysis of Chlorinated Compounds," *Chemosphere*, Vol. 23, pages 1109-1116, 1991.

Nam, K.S., S. Kapila, R.K. Puri, A.F. Yanders, and B.R. Larsen, "Evaluation of Supercritical Fluid Extraction for Eliminating Interferences During Multiresidue Pesticide Analysis," *Organohalogen Compounds*, Vol. 8, pages 115-120, 1992.

Narayanan, M., L.C. Davis, and L.E. Erickson, "Fate of Volatile Chlorinated Organic Compounds in a Laboratory Chamber with Alfalfa Plants," *Environmental Science and Technology*, Vol. 29, pages 2437-2444, 1995. Project no. 94-27.

Narayanan, M., L.C. Davis, J.C. Tracy, L.E. Erickson, and R.M. Green, "Experimental and Modeling Studies of the Fate of Organic Contaminants in the Presence of Alfalfa Plants," *Journal of Hazardous Materials,* Vol. 41, pages 229-249, 1995.

Narayanan, M., J.C. Tracy, L.C. Davis, and L.E. Erickson, "Modeling the Fate of Toluene in a Chamber with Alfalfa Plants 1. Theory and Modeling Concepts," *Journal of Hazardous Substance Research*, Vol. 1, No. 5, 1998. URL: www.engg.ksu.edu/HSRC/JHSR/v1_no5a.pdf. Project no. 94-27.

Narayanan, M., L.C. Davis, J.C. Tracy, and L.E. Erickson, "Modeling the Fate of Toluene in a Chamber with Alfalfa Plants 2. Numerical Results and Comparison Study," *Journal of Hazardous Substance Research*, Vol. 1, No. 5, 1998. URL: www.engg.ksu.edu/HSRC/JHSR/v1_no5b.pdf. Project no. 94-27.

Narayanan, M., N.K. Russell, L.C. Davis, and L.E. Erickson, "Fate and Transport of Trichloroethylene in a Chamber with Alfalfa Plants," *International Journal of Phytoremediation,* Vol. 1, pages 387-411, 1999. Project no. 94-27.

Narayanan, M., L.E. Erickson, and L.C. Davis, "Simple Plant-Based Design Strategies for Volatile Organic Polluntants," *Environmental Progress,* Vol. 18, pages 231-242, 1999. Project no. 94-27.

Neira, M., T.J. O'Keefe, and J.L. Watson, "Solvent Extraction Reagent Entrainment Effects on Zinc Electrowinning from Waste Oxide Leach Solution," *Minerals Engineering*, Vol. 5, No. 3-5, pages 521-534, 1992.

Nieman, J.K.C., R.C. Sims, J.L. Sims, D.L. Sorensen, J.E. McLean, and J.A. Rice, "[14C] Pyrene. Bound Residue Evaluation Using MIBK Fractionation Method for Creosote-Contaminated Soil," *Environmental Science and Technology*, Vol. 33, No. 5, pages 776-781, 1999. Project no. 93-21. Project no. 94-11.

Novak, P.J., L. Daniels, and G.F. Parkin, "Enhanced Dechlorination of Carbon Tetrachloride and Chloroform in the Presence of Elemental Iron and *Methanosarcina barkeri, Methanosarcina thermophila,* or *Methanosaeta concillii*," *Environmental Science and Technology*, Vol. 32, pages 1438-1443, 1998. Project no. 93-02.

Novak, P.J., L. Daniels, and G.F. Parkin, "Rapid Dechlorination of Carbon Tetrachloride and Chloroform by Extracellular Agents in Cultures of *Methanosarcina thermophila*," *Environmental Science and Technology*, Vol. 32, pages 3132-3136, 1998. Project no. 93-02.

Novak, P.J., S.C. Christ, and G.F. Parkin, "Kinetics of Alachlor Transformation and Identification of Metabolites Under Anaerobic Conditions," *Water Research*, Vol. 31, pages 3107-3115, 1997. Project no. 93-02.

Orazio, C.E., S. Kapila, R.K. Puri, and A.F. Yanders, "Persistence of Chlorinated Dioxins and Furans in the Soil Environment," *Chemosphere*, Vol. 25, pages 1469-1474, 1992.

Orchard, B.J., W.J. Doucette, J.K. Chard, and B. Bugbee, "A Novel Laboratory System for Determining Fate of Volatile Organic Compounds in Planted Systems," *Environmental Toxicology and Chemistry*, Vol. 19, Issue 4, Part 1, pp 888-894, 2000. Project no. 95-10.

Orchard, B.J., W.J. Doucette, J.K. Chard, and B. Bugbee, "Uptake of Trichloroethylene by Hybrid Poplar Trees Grown Hydroponically in Flow-Through Plant Growth Chambers," *Environmental Toxicology and Chemistry*, Vol. 19, Issue 4, Part 1, pp 895-903, 2000. Project no. 95-10.

Parkin, G.F., "Anaerobic Biotransformation of Chlorinated Aliphatic Hydrocarbons: Ugly Duckling to Beautiful Swan?" *Water Environment Research*, Vol. 71, pages 1158-1164, 1999. Project no. 93-24.

Paterson, K.G., and J.L. Schnoor, "Fate of Alachlor and Atrazine in Riparian Zone Field Site," *Research Journal of the Water Pollution Control Federation*, Vol. 64, pages 274-283, 1992.

Paterson, K.G., and J.L. Schnoor, "Vegetative Alteration of Nitrate Fate in Unsaturated Zone," *Journal of Environmental Engineering*, ASCE, Vol. 119, No. 5, pages 986-993, 1993.

Perkovich, B.S., T.A. Anderson, E.L. Kruger, and J.R. Coats, "Enhanced Mineralization of ^{14}C-atrazine in *Kochia scoparia* Rhizospheric Soil from a Pesticide-Contaminated Site," *Pesticide Science*, Vol. 46, pages 391-396, 1996. Project no. 93-05.

Peterson, M.M., G.L. Horst, P.J. Shea, S.D. Comfort, and R.D.K. Peterson, "TNT and 4amino-2,6-dinitrotoluene Influence on Germination and Early Seedling Development of Tall Fescue," *Environmental Pollution*, Vol. 93, pages 57-62, 1996. Project no. 92-24.

Petrie, R.A., P.R. Grossl, and R.C. Sims, "Controlled-Environment Potentiostat to Study Solid-Aqueous Systems," *Soil Science Society of America Journal*, Vol. 62, pages 379-382, 1998. Project no. 93-21.

Peyton, R.L., B.A. Haeffner, S.H. Anderson, and C.J. Gantzer, "Applying X-Ray CT to Measure Macropore Diameters in Undisturbed Soil Cores," *Geoderma*, Vol. 53, pages 329-340, 1992.

Pierzynski, G.M., and A.P. Schwab, "Bioavailability of Zinc, Cadmium, and Lead in a Metal-Contaminated Alluvial Soil," *Journal of Environmental Quality*, Vol. 22, pages 247-254, 1993.

Puri, R.K., S. Kapila, Y-H. Lo, C. Orazio, T.E. Clevenger, and A.F. Yanders, "Effect of Co-Contaminants on the Disposition of Polychlorinated Dibenzo-P-Dioxins and Polychlorinated Dibenzofurans in Saturated Soils," *Chemosphere*, Vol. 20, pages 1589-1596, 1990.

Puri, R.K., Y. Quiping, C.E. Orazio, A.F. Yanders, S. Kapila, S. Cerlesi, and S. Facchetti, "Transport and Persistence of Chlorinated Organics in Varied Soil Environments," *Organohalogen Compounds*, Vol. 9, pages 187-190, 1992.

Reilley, K., M.K. Banks, and A.P. Schwab, "Dissipation of Polynuclear Aromatic Hydrocarbons in the Rhizosphere," *Journal of Environmental Quality*, Vol. 25, pages 212-219, 1996.

Richards, R., W. Li, S. Decker, C. Davidson, O. Koper, V. Zaikovski, A. Volodin, T. Rieker, and K.J. Klabunde, "Consolidation of Metal Oxide Nanocrystals. Reactive Pellets with Controllable Pore Structure That Represent a New Family of Porous, Inorganic Materials," *Journal of American Chemistry Society*, 122, pages 4921-4925, 2000. Project no. 95-4a.

Ruan, H., and T.H. Illangasekare, "A Model to Couple Overland Flow and Infiltration into Macroporous Vadose Zone," *Journal of Hydrology,* Vol. 210, pages 116-127, 1998. Project no. 94-29.

Ruan, H., and T.H. Illangasekare, "Estimation of Relative Hydraulic Conductivity of Sandy Soils Based on a Sheet-Flow Model," *Journal of Hydrology,* Vol. 218, pages 83-93, 1999. Project no. 94-29.

Ryoo, K., S. Kapila, R.K. Puri, and A.F. Yanders, "Evaluation of Carbon for Removal and Destruction of Polychlorinated Biphenyls (PCBs)," *Chemosphere*, Vol. 25, pages 1569-1573, 1992.

Santharam, S., L.E. Erickson, and L.T. Fan, "Modeling the Role of Surfactant and Biodegradation in the Remediation of Aquifers with Nonaqueous-Phase Contaminants," *Journal of Hazardous Materials*, Vol. 53, pages 115-139, 1997. Project no. 94-27.

Saba, T., and T.H. Illangasekare, "Effect of Groundwater Flow Dimensionality on Mass Transfer from Entrapped Nonaqueous-Phase Liquids," *Water Resources Research*, 36(4), pages 971-979, 2000. Project no. 94-29, 98-05.

Saba, T., T.H. Illangasekare, and J. Ewing, "Surfactant-Enhanced Dissolution of Entrapped NAPLs," *Journal of Contaminant Hydrology,* Vol. 51(1-2), pages 63-82, 2000. Project no. 98-05.

Scherer M.M., S. Richter, R.L. Valentine, and P.J.J. Alvarez, "Chemistry and Microbiology of Permeable Reactive Barriers for *In Situ* Groundwater Cleanup," *Critical Reviews in Environmental Science and Technology,* 30:363-411, 2000. Project no. 98-1.

Schnabel, W.E., A.C. Dietz, J.G. Burken, J.L. Schnoor, and P.J.J. Alvarez, "Uptake and Transformation of Trichloroethylene by Edible Garden Plants," *Water Research*, Vol. 31, pages 816-824, 1997. Project no. 95-29.

Schnoor, J.L., "Degradation by Plants—Phytoremediation," *Biotechnology*, J. Klein (ed.), Wiley-VCH, Vol. 11b, pages 372-384, 2000.

Schnoor, J.L., L.A. Licht, S.C. McCutcheon, N.L. Wolfe, and L.H. Carreira, "Phytoremediation of Organic and Nutrient Contaminants," *Environmental Science and Technology*, Vol. 29, No. 7, pages 318A-323A, 1995. Project no. 94-25.

Schnoor, J.L., and A.C. Dietz, "Phytoremediation: An Overview," *Environmental Health Perspectives,* 2001. Project no. 94-25.

Segar, R.L., S.-Y. Leung, and S.A Vivek, "Treatment of Trichloroethene (TCE)-Contaminated Water with a Fluidized-Bed Bioreactor," *Annals of the New York Academy of Sciences*, Vol. 829, pages 83-96, 1997. Project no. 94-07.

Shetty, K.G., M.K. Banks, B.A.D. Hetrick, and A.P. Schwab, "Biological Characterization of a Southeast Kansas Mining Site," *Water*, *Air and Soil Pollution*, Vol. 78, No. 1-2, pages 169-177, 1994.

Shetty, K.G., B.A.D. Hetrick, D. Hoobler, and A.P. Schwab, "Effects of Mycorrhizae and Other Soil Microbes on Revegetation of Heavy Metal-Contaminated Mine Spoil," *Environmental Pollution*, Vol. 86, pages 181-188, 1994.

Shimp, J.F., J.C. Tracy, L.C. Davis, E. Lee, W. Huang, L.E. Erickson, and J.L. Schnoor, "Beneficial Effects of Plants in the Remediation of Soil and Groundwater Contaminated with Organic Materials," *Critical Reviews in Environmental Control*, Vol. 23, No. 1, pages 41-77, 1993.

Shue, S.L., R.E. Faw, and J.K. Shultis, "Thermal Neutron Intensities in Soils Irradiated by Fast Neutrons from Point Sources," *Chemical Geology*, Vol. 144, pages 47-61, 1998. Project 94-02.

Simeonsson, J.B., "A Comparison of Continuous-Flow Hydride Generation Laser-Induced Fluorescence and Laser-Enhanced Ionization Spectrometry Approaches for Parts-Per-Trillion Level Measurements of Arsenic, Selenium, and Antimony," *Journal of Analytical Atomic Spectrometry*, 16, pages 152-158, 2001. Project no. 98.08

Singh, J., S.D. Comfort, and P.J. Shea, "Long-Term RDX Sorption and Fate in Soil," *Journal of Environmental Quality*, Vol. 27, pages 572-577, 1997. Project no. 92-24.

Singh, J., P.J. Shea, L.S. Hunda, S.D. Comfort, T.C. Zhang, and D.S. Hage, "Iron-Enhanced Remediation of Water and Soil Containing Atrazine," *Weed Science*, Vol. 46, No. 3, pages 381-388, 1998. Project no. 95-32.

Sivils, L.D., S. Kapila, Q. Yan, and A.A. Elseewi, "Application of a Two-Dimensional Chromatography System for Gas-Phase Photodegradation Studies of Polychlorinated Dibenzo-p-Dioxins," *Journal of Chromatography*, Vol. 688, pages 221-230, 1994.

Sivils, L.D., S. Kapila, and Q. Yan, "Photodegradation of Polychlorinated Dibenzo-p-Dioxins (PCDDs) in Vapors and Aerosols," *Organohalogen Compounds*, Vol. 24, pages 368-373, 1995.

Stark, J.V., and K.J. Klabunde, "Nanoscale Metal Oxide Particles/Clusters as Chemical Reagents: Adsorption of Hydrogen Halides, Nitric Oxide, and Sulfur Trioxide on Magnesium Oxide Nanocrystals and Compared with Microcrystals," *Chemistry of Materials*, Vol. 8, pages 1913-1918, 1996. Project no. 89-26, 92-03.

Stark, J.V., D.G. Park, I. Lagadic, and K.J. Klabunde, "Nanoscale Metal Oxide Particles/Clusters as Chemical Reagents: Unique Surface Chemistry of Magnesium Oxide as Shown by Enhanced Adsorption of Acid Gases (Sulfur Dioxide and Carbon Dioxide) and Pressure Dependence," *Chemistry of Materials*, Vol. 8, pages 1904-1912, 1996. Project no. 89-26, 92-03.

Sturman, P.J., W.L. Jones, and W.G. Characklis, "Interspecies Competition in Colonized Porous Pellets," *Water Research*, Vol. 28, No. 4, page 831, 1994.

Sturman, P.J., P.S. Stewart, A.B. Cunningham, E.J. Bouwer, and J.H. Wolfram, "Engineering Scaleup of *In Situ* Bioremediation Processes: A Review," *Journal of Contaminant Hydrology*, Vol. 19, pages 171-203, 1995.

Tilio, R., S. Kapila, and K.S. Nam, "Reduction/Elimination of Sulfur Interference in Organochlorine Residue Determination by Supercritical Fluid Extraction," *Journal of Chromatography*, Vol. 662, pages 191-197, 1994.

Tilio, R., K. Krishnan, S. Kapila, K.S. Nam, and S. Facchetti, "A Simple Analytical Methodology for Multiresidue Pollutant Determinations," *Chemosphere*, Vol. 20, No. 9-11, pages 1849-1858, 1994.

Till, B.A., L.J. Weathers, and P.J.J. Alvarez, "Fe^0-Supported Autotrophic Denitrification," *Environmental Science and Technology*, Vol. 32, pages 634-639, 1997. Project no. 93-02.

Utamapanya, S., K.J. Klabunde, and J. Schlup, "Nanoscale Metal Oxide Particles/Clusters as Chemical Reagents. Synthesis and Properties of Ultra-High Surface-Area Magnesium Oxide," *Chemistry of Materials*, Vol. 3, pages 175-181, 1991.

Vanhoudt, P., Z. Lewandowski, and B. Little, "Iridium Oxide pH Microelectrode," *Biotechnology and Bioengineering*, Vol. 40, pages 601-608, 1992.

Varga, J.B., F. Friedler, and L.T. Fan, "Parallelization of the Accelerated Branch-and-Bound Algorithm of Process Synthesis: Application in Total Flowsheet Synthesis," *Acta Chimica Slovenica*, Vol. 42, pages 15-20, 1995. Project no. 91-36.

Walser, G.S., T.H. Illangasekare, and A.T. Corey, "Retention of Liquid Contaminants in Layered Soils," *Journal of Contaminant Hydrology,* Vol 39, pages 91-108, 1999. Project 94-29, 98-05.

Walton, C.W., and K.J. Loos, "Assessment and Options for Waste Minimization in the Metal Finishing Industry," *Plating and Surface Finishing–Journal of the AESF*, Vol. 79, No. 11, pages 8-14, 1992.

Weathers, L.J., and G.F. Parkin, "Toxicity of Chloroform Biotransformation to Methanogenic Bacteria," *Environmental Science and Technology*, Vol. 34, pages 2764-2767, 2000. Project 93-02.

Weathers, L.J., G.F. Parkin, and P.J.J. Alvarez, "Utilization of Cathodic Hydrogen as Electron Donor for Chloroform Cometabolism by a Mixed, Methanogenic Culture," *Environmental Science and Technology*, Vol. 31, pages 880-885, 1997. Project 93-02.

Wildenschild, D., K.H. Jensen, K.J. Hollenbeck, T.H. Illangasekare, D. Znidarcic, and T. Sonnenborg, "A Two-Stage Procedure for Determining Hydraulic Characteristics Using a Syringe Pump and Outflow Observations," *Journal of Soil Science Society of America*, Vol. 61, No. 2, pages 347-359, 1996. Project no. 94-29.

Woodbury, B.L., S.D. Comfort, and W.L. Powers, "An Automated Sampling System for Large Column Transport Studies," *Transactions of ASAE,* Vol. 39, No. 6, pages 2163-2166, 1996. Project no. 92-24.

Wu, J.C., L.T. Fan, and L.E. Erickson, "Modeling and Simulation of Bioremediation of Contaminated Soil," *Environmental Progress*, Vol. 9, pages 47-56, 1990.

Wu, J.C., L.T. Fan, and L.E. Erickson, "Modeling and Simulation of *In Situ* Neutralization and Bioremediation Processes," *Groundwater Management*, Vol. I, pages 279-293, 1990.

Wu, J.C., L.T. Fan, and L.E. Erickson, "Three-Point Backward Finite Difference Method for Solving a System of Mixed Hyperbolic-Parabolic Partial Differential Equations," *Computers and Chemical Engineering*, Vol. 14, pages 679-685, 1990.

Yan, Q., S. Kapila, R.K. Puri, and A.A. Elseewi, "Effects of Co-Contaminants on Photodegradation Kinetics of OCDD," *Organohalogen Compounds*, Vol. 12, pages 95-98, 1993.

Yan, Q., S. Kapila, R.K. Puri, and A.A. Elseewi, "Effects of Co-Contaminants on Photodegradation Kinetics of Polychlorinated Dibenzo-p-Dioxins," *Chemosphere*, Vol. 20, No. 9-11, pages 2183-2192, 1994.

Yan, Q., S. Kapila, L.D. Sivils, and A.A. Elseewi, "Effects of Sensitizers and Inhibitors on Phototransformation of Polychlorinated Dibenzo-p-Dioxins (PCDDs)," *Chemosphere*, Vol. 31, No. 7, pages 3627-3634, 1995.

Yanders, A.F., S. Kapila, Y.-H. Lo, R.K. Puri, and S. Cerlesi, "Persistence of Tetrachlorodibenzo-P-Dioxin in Soil: Times Beach Case Study," *Chemosphere*, Vol. 25, pages 1569-1572, 1992.

Yang, X., L.E. Erickson, and L.T. Fan, "Dispersive-Convective Characteristics in the Bioremediation of Contaminated Soil with a Heterogeneous Formation," *Journal of Hazardous Materials,* Vol. 38, pages 163-185, 1994.

Yang, X., L.E. Erickson, and L.T. Fan, "A Discrete Blob Model of Contaminant Transport in Groundwater with Trapped Nonaqueous-Phase Liquids," *Chemical Engineering Communications,* Vol. 154, pages 33-57, 1995.

Yang, X., L.E. Erickson, and L.T. Fan, "A Study of Dissolution Rate-Limited Bioremediation of Soils Contaminated by Residual Hydrocarbons," *Journal of Hazardous Materials*, Vol. 41, pages 299-313, 1995.

Yang, X., L.T. Fan, and L.E. Erickson, "A Conceptual Study on the Biowall Technology: Feasibility and Process Design," *Remediation*, Vol. 6, pages 55-67, 1995.

Yang, X., L.E. Erickson, and L.T. Fan, "A Bench-Scale Study on Biodegradation and Volatilization of Ethylbenzoate in Aquifers," *Journal of Hazardous Materials*, Vol. 50, pages 169-182, 1996.

Zawaideh, L.L., and T.C. Zhang, "Effects of pH and Addition of an Organic Buffer (HEPES) on Nitrate Transformation in Fe^0-water System," *Water Science and Technology,* Vol 38, No. 7, pages 107-115, 1998. Project no. 95-32.

Zhang, Q., L.C. Davis, and L.E. Erickson, "Effect of Vegetation on Transport of Groundwater and Nonqueous-Phase Liquid Contaminants," *Journal of Hazardous Substance Research,* Vol. 1, No. 8, 1999. URL: www.engg.ksu.edu/HSRC/JHSR/v1_no8.pdf. Project no. 94-27.

Zhang, Q., L.C. Davis, and L.E. Erickson, "An Experimental Study of Phytoremediation of Methyl Tert-Butyl Ether (MTBE) in Groundwater," *Journal of Hazardous Substance Research,* Vol. 2. No. 4, 2000. URL: www.engg.ksu.edu/HSRC/JHSR/v2_no4.pdf. Project no. 94-27, 98-03.

Zhang, Q., L.C. Davis, and L.E. Erickson, "Plant Uptake of Methyl Tert-Butyl Ether (MTBE) from Groundwater," *Practice Periodical of Hazardous, Toxic and Radioactive Waste Management,* Vol. 5, 136-140, 2001. Project no. 94-27, 98-03.

Zhang, Q., L.C. Davis, and L.E. Erickson, "Transport of Methyl Tert-Butyl Ether (MTBE) Through Alfalfa Plants," *Environmental Science and Technology,* Vol. 35, 725-731, 2001. Project no. 94-27, 94-27A, 98-03.

B. ARTICLES SUBMITTED OR IN PRESS

Adamson, D.T., and G.F. Parkin, "Product Distribution During Transformation of Multiple Contaminants by a High-Rate, PCE-Dechlorinating Enrichment Culture," *Environmental Science and Technology,* April 2000. Project no. 93-24.

Barranco, F.T. Jr., D. Dai, and T.H. Illangasekare, "Partitioning and Interfacial Tracers for Differentiating NAPL Entrapment Configuration: Column-Scale Laboratory Results," *Environmental Science and Technology,* 2001. Project no. 94-29, 98-05.

Barrera-Godinez, J.A., and T.J. O'Keefe, "The Galvanic Stripping Treatment of Zinc Residues for Marketable Iron Product Recovery, *TMS Pb-Zn 2000 Symposium*, 2000. Project no. 94-05.

Barth, G., T.H. Illangasekare, H. Rajaram, and M. Hill, "Tracer Response to NAPL Entrapment," *Water Resour. Res.,* 2001. Project no. 98-05.

Bielefeldt, A.R., C. McEachern, and T.H. Illangasekare, "Hydrodynamic Changes in Sand Due to Biodegradation of Naphthalene and Decane," *ASCE Journal of Environmental Engineering*, 2000. Project no. 94-29.

Cort, T., and T.H. Illangasekare, "Biological Metabolotes as Tracers to Determine NAPL Saturation," *Environmental Science and Technology*, 2001. Project no. 98-05.

Dai, D., S. Saenton, Q.R. Moore, and T.H. Illangaskare, "Upscaling of Multiple Tracer Techniques for Characterizing Subsurface NAPL Zones—Laboratory Experiments and Numerical Simulation," *Environmental Science and Technology,* 2001. Project no. 98-05.

Dai, D., F.T. Barranco, and T.H. Illangasekare, "Partitioning and Interfacial Tracers for Differentiating NAPL Entrapment Configuration: Column-Scale Laboratory Results," *Environmental Science and Technology,* 2001. Project no. 98-05.

Davis, C.A., T. Cort, D. Dai, T.H. Illangasekare, and J. Marr, "Effects of Heterogenity and Saturation on Diesel Biodegradation Respirometry, *Groundwater*, 2001. Project no. 98-05.

Davis, L.C., L.E. Erickson, M. Narayanan, and Q. Zhang, "Modeling and Design of Phytoremediation Processes," *Phytoremediation: Transformation and Control of Contaminants,* S.C. McCutcheon and J.L. Schnoor (Eds.), Wiley, New York, 2000. Project no. 94-27, 94-27A, 98-03.

DeJournett, T.D., and P.J.J. Alvarez, "Combined Microbial-Fe(0) System to Treat Nitrate-Contaminated Water," *Bioremediation Journal*, 2000. Project no. 93-02.

Dietz, A.C., and J.L. Schnoor, "Phytotoxicity Screening of Chlorinated Aliphatics," *Environmental Toxicology and Chemistry*, 2000. Project no. 95-29.

Erickson, L.E., L.C. Davis, Q. Zhang, and M. Narayanan, "Transport of Contaminants in Plant and Soil Systems," *Proceedings of the Phytoremediation State of the Science Conference*, 2000. Project no. 94-27, 94-27A.

Gregory, K., B-T Oh, M. Scherer, G.F. Parkin, and P.J.J. Alvarez, "Biogeochemical Degradation of Redox-Sensitive Compounds Using Iron Oxide and *Geobacter metallireducens* GS-15," *220th American Chemical Society National Meeting*, Washington, D.C. August 20-25, 2000. Project no 98-1.

Huang, Y.H., and T.C. Zhang, "Kinetics of Nitrate Reduction by Iron at Near Neutral pH," *J. Environ. Eng.* (ASCE), 2001. Project no. 95-32.

Huang, Y.H., T.C. Zhang, S.D. Comfort, and P.J. Shea, "Effect of Magnetite and Metallic Cations on Nitrate Reduction by Zerovalen Iron," 2001. Project no. 95-32.

Karthikeyan, R., K.R. Mankin, L.C. Davis, and L.E. Erickson, "Experimental Investigation of Fate and Transport of Jet Fuel (JP-8) in Soils with Plants," *International Journal of Phytoremediation,* 2001. Project no. 98-03.

Karthikeyan, R., K.R. Mankin, L.C. Davis, and L.E. Erickson, "Modeling Jet Fuel (JP-8) Fate and Transport in Soils and Plants, *International Journal of Phytoremediation,* 2001. Project no. 98-03.

Kechavarzi, C., K. Soga, and T.H. Illangasekare, "Laboratory Investigation of LNAPL Migration in a Homogeneous Unsaturated Sand," *Proceedings of Int. Symp. on Physical Modeling and Testing in Environmental Geotechnics*, Network of European Centrigues for Environmental Geotechnic Research (NECER), 15-17 May, 2000. La Baule, France. Ed. J. Garnier, L. Thorel, and E. Haze, 285-292. Project no. 93-12, 98-05.

Lambert, M., G. Pierzynski, B. Hetrick, L. Erickson, and D. Sweeney, "Effects of Revegetation on Heavy Metal Content of Mine Tailings," *5th International Conference on the Biogeochemistry of Trace Elements,* Project no. 93-07.

Oh, B.-T., C.L. Just, and P.J.J. Alvarez, "Hexahydro-1,3,5-triazine (RDX) Mineralization by Zero-Valent Iron and Mixed Anaerobic Cultures," *Environmental Science and Technology*, 2001. Project no. 98-01.

Wildman, M., and P.J.J. Alvarez, "RDX Degradation Using an Integrated Fe(0)-Microbial Treatment Approach," *Water Science and Technology*, 2000. Project no. 93-02.

Williams, A.G.B., and M.M. Scherer, "Kinetics of Cr(VI) Reduction by Carbonate Green Rust," Environmental Science and Technology, 2001. Project no. 98-01.

Winnike-McMillan, S.K., Q. Zhang, L.C. Davis, L.E. Erickson, L. Newman, and J.L. Schnoor, "Phytoremediation of MTBE," *In Phytoremediation: Transformation and Control of Contaminants,* Wiley, New York, Submitted, 2001. Project no. 98-03.

C. BOOKS AND BOUND PROCEEDINGS

Characklis, W.G., and K.C. Marshall (Eds.), *Biofilms*, Wiley, New York, 1990.

Erickson, L.E. (Ed.), *Proceedings of the Conference on Hazardous Waste Research*, Kansas State University, Manhattan, Kansas, May 23-24, 1989.

Erickson, L.E. (Ed.), *Proceedings of the Conference on Hazardous Waste Research*, Kansas State University, Manhattan, Kansas, May 21-22, 1990.

Erickson, L.E. (Ed.), *Proceedings of the Conference on Hazardous Waste Research*, Kansas State University, Manhattan, Kansas, May 29-30, 1991.

Erickson, L.E., S.C. Grant, and J.P. McDonald (Eds.), *Proceedings of the Conference on Hazardous Waste Research*, University of Colorado, Boulder, Colorado, June 1-2, 1992.

Erickson, L.E., D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, Kansas State University, Manhattan, Kansas, May 25-26, 1993.

Erickson, L.E., D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), *Proceedings of the 9th Annual Conference on Hazardous Waste Remediation*, Montana State University, Bozeman, Montana, June 8-10, 1994.

Erickson, L.E., D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), *Proceedings of the 10th Annual Conference on Hazardous Waste Research*, Kansas State University, Manhattan, Kansas, May 23-24, 1995. URL: http://www.engg.ksu.edu/HSRC/95Proceed/home.html.

Erickson, L.E., D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), *Proceedings of the 1996 HSRC/WERC Joint Conference on the Environment*, Albuquerque, New Mexico, May 21-23, 1996. URL: http://www.engg.ksu.edu/HSRC/96Proceed.

Erickson, L.E., M.M. Rankin, S.C. Grant, and J.P. McDonald (Eds.), *Proceedings of the 12th Annual Conference on Hazardous Waste Research,* Kansas City, Missouri, May 19-22, 1997. URL http://www.engg.ksu.edu/HSRC/97Proceed/proc97.html.

Erickson, L.E., M.M. Rankin, L.N. Reddi, and C.A. Wolfe (Eds.), *Proceedings of the 13th Annual Conference on Hazardous Waste Research*, Snowbird, Utah, May 18-21, 1998. URL http://www.engg.ksu.edu/HSRC/98Proceed/index.html.

Erickson, L.E., M.M. Rankin, L.N. Reddi, W.M. Griswold, and C.A. Wolfe (Eds.), *Proceedings of the 14th Annual Conference on Hazardous Waste Research*, St. Louis, Missouri, May 25-27, 1999. URL http://www.engg.ksu.edu/HSRC/99Proceed/index.html.

Erickson, L.E., M.M. Rankin, L.N. Reddi, and W.M. Griswold (Eds.), *Proceedings of the 15th Annual Conference on Hazardous Waste Research*, Denver, Colorado, May 23-25, 2000. URL: http://www.engg.ksu.edu/HSRC/00Proceed/index.html.

Erickson, L.E., M.M. Rankin, L.N. Reddi, and W.M. Griswold (Eds.), *Proceedings of the 16th Annual Conference on Hazardous Waste Research*, Manhattan, Kansas, May 21-24, 2001.

Jennings, S.R., and D.J. Dollhopf, "Geochemical Characterization of Sulfide Mineral Weathering for Remediation of Acid-Producing Mine Wastes," Reclamation Research Publication #9502, Montana State University, Bozeman, Montana, 1996. Project no. 93-12.

Kruger, E.L., T.A. Anderson, and J.R. Coats, *Phytoremediation of Soil and Water Contaminants*, American Chemical Society Symposium Series, ACS Books, Washington, DC, 1997. Project no. 93-05.

Lehr, J.H. (Ed.), *Groundwater Management: Proceedings of the 1990 Cluster of Conferences*, Water Well Publishing Company, Dublin, Ohio, February 20-21, 1990.

Leven, B.A., D.J. Carty, G.P. Spurlin, and P.A. Kulakow, *Cost-Effective Maintenance and Surface Remediation Strategies for Oil and Gas Producers, Workshop Proceedings*, Midwest Petroleum Technology Transfer Council - Illinois State Geological Survey, November 16, 2000.

Munshower, F.F., and S.E. Fisher (Eds.), "Planning, Rehabilitation, and Treatment of Disturbed Lands," *Proceedings Seventh Billings Symposium,* Reclamation Research Publication #9603, Montana State University, Bozeman, Montana, March 17-23, 1996.

Schnoor, J.L. (Ed.), *Fate of Pesticides and Chemicals in the Environment*, John Wiley & Sons, New York, 1992.

D. CHAPTERS IN OTHER BOOKS OR BOUND PROCEEDINGS

Adamson, D.T., and G.F. Parkin, "Biotransformation of Mixtures of Carbon Tetrachloride, Perchlorethylene, and 1,1,1 Trichloroethane," *In Situ and On-Site Bioremediation*, B.C. Alleman and A. Leeson (Eds.), Battelle Press, Columbus, Ohio, Vol. 3, pages 15-20, 1997. Project no. 93-24.

Al-Sheriadeh, M., and T.H. Illangasekare, "Modeling of Transport of Nonaqueous-Phase Contaminants in Heterogeneous Aquifers," *Proceedings of 1993 Groundwater Modeling Conference*, International Groundwater Modeling Center, Colorado School of Mines, Golden, Colorado, pages 3.1-3.19, 1993.

Alvarez, P.J.J., G.F. Parkin, J.L. Schnoor, and J. Fang, "Biogeochemical Interactions in Zero-Valent Iron Walls," *U.S. EPA 1996-1998 Bioremediation Research Program Review September 23-24*, EPA/600/F-98/122, page 32, 1998. Project no. 93-02.

Anderson, T.A., and J.R. Coats, "An Overview of Microbial Degradation in the Rhizosphere and Its Implications for Bioremediation," *Bioremediation, Science and Applications*, SSSA, ASA, and CSS, Madison, Wisconsin, pages 135-143, 1995. Project no. 93-05.

Anderson, T.A., E.L. Kruger, and J.R. Coats, "Rhizosphere Microbial Communities of Herbicide-Tolerant Plants as Potential Bioremedients of Soils Contaminated with Agrochemicals," *Bioremediation of Pollutants in Soil and Water*, B.S. Schepart (Ed.), ASTM, Philadelphia, Pennsylvania, pages 149-157, 1995. Project no. 93-05.

Anhalt, J.C., E.L. Arthur, A. Chouhy, T.A. Anderson, and J.R. Coats, "Pesticide-Contaminated Soil Studies: Effects of Aging Herbicide Mixtures on Herbicide Degradation, Soil Respiration, and Plant Survival and Phytoremediation Study with Native Prairie Grasses," *Proceedings of the*

12th Annual Conference on Hazardous Waste Research, Kansas State University, Manhattan, Kansas, pp. 542-555, May 19-22, 1997. Project no. 93-05.

Arthur, E.L., and J.R. Coats, "Phytoremediation," *Pesticide Remediation in Soils and Water*, P.C. Kearney and T.R. Roberts (Eds.), John Wiley and Sons, Ltd., UK, pages 251-283, 1998. Project no. 93-05.

Atteya, M., and K.J. Klabunde, "Nanoscale Metal Oxide Particles as Chemical Reagents. Heats of Adsorption of Heteroatom Organics on Heat-Treated Magnesium Oxide," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 230-256, 1990.

Baldwin, C.A., J.P. McDonald, and L.E. Erickson, "Effect of Hydrocarbon Phase on Kinetic and Transport Limitations for Bioremediation of Microprobes Soil," *Proceedings of the 22nd Annual Biochemical Engineering Symposium*, P.J. Reilly (Ed.), Iowa State University, Ames, Iowa, pages 1-10, 1992.

Baldwin, C.K., B.L. Hall, and R.R. Dupont, "*In Situ* Instrumentation for Evaluating Air-Injection Remediation Technologies," *Proceedings of the HSRC-WERC Joint Conference on the Environment,* Albuquerque, New Mexico, pages 408-423, 1996. URL: http://www.engg.ksu.edu/HSRC/96Proceed/.

Banks, M.K., B.A.D. Hetrick, A.P. Schwab, K.G. Shetty, I. Abdelsaheb, and G. Fleming, "Characterization of a Heavy Metal-Contaminated Site," *Proceedings of the Environmental Engineering Division*, ASCE Water Forum, Baltimore, Maryland, pages 463-467, 1992.

Barth, G., T.H. Illangasekare, H. Rajaram, and H. Ruan, "Model Calibration and Verification for Entrapped NAPL Using Tracer Tests in a Large, Two-Dimensional Tank with Heterogeneous Packing," *Proceedings of Model CARE 96 (Calibration and Reliability in Groundwater Modeling)*, IAHS Publications, Vol. 237, pages 169-178, 1996.

Barth, G., T.H. Illangasekare, and H. Rajaram, "Use of Tracers for the Characterization of Scale-Dependent Subsurface Properties: Initial Evaluation," *Proceedings of the HSRC-WERC Joint Conference on the Environment,* Albuquerque, New Mexico, pages 433-442, 1996. URL: http://www.engg.ksu.edu/HSRC/96Proceed/.

Barth, G.R, M.C. Hill, T.H. Illangasekare, and H. Rajaram, "Predictive Modeling of Flow in a Two-Dimensional Intermediate-Scale, Heterogeneous Porous Media," *Proceedings of the 1999 ModelCARE Conference,* Zurich, F. Stauffer, W. Kinzelback, K. Kovar, and E. Hoehn (Eds.), IAHS Publication No. 265, IAH Press, Wallingford, UK, 2000. Project no. 94-29.

Berry, N., and J. Schlup, "Initial FTIR Studies of the Adsorption of Polycyclic Aromatic Hydrocarbons onto Soil Constituents," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 347-356, 1989.

Bielefeldt, A.R., and T.H. Illangasekare, "Biodegradation of Airplane Deicing Fluids Under Simulated Aquifer Conditions," *Proceedings of Groundwater 2000 International Conference on Groundwater Research,* Copenhagen, Denmark, June 6-8, 2000. Project no. 98-05.

Bielefeldt, A.R., T.H. Illangasekare, M. Grant, and T. Butler, "Biodegradation of Deicing Compounds in Columns Simulating a Range of natural Conditions," *Proceedings of the 14th Annual Conference on Hazardous Waste Research*, L.E. Erickson, and M.M. Rankin (Eds.), St. Louis, Missouri, pages 186-191, 1999. Project no. 94-29.

Bondugula, R., and T.E. Clevenger, "Heavy Metal Contamination in Southwest Missouri," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 46-54, 1991.

Boronina, T., and K.J. Klabunde, "Destruction of Organohalides in Water Using Metal Particles: Carbon Tetrachloride/Water Reactions with Magnesium, Tin, and Zinc," *Proceedings of the 9th Annual Conference on Hazardous Waste Remediation,* L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Bozeman, Montana, pages 81-98, 1994. Project no. 89-26, 92-03.

Bouwer, E.J., H.H.M. Rijnaarts, A.B. Cunningham, and R. Gerlach, "Biofilms in Porous Media," *Biofilms II: Process Analysis and Applications*. Bryers, J.D. (Ed.), Wiley-Liss, Inc., pages 123-135, 2000. Project no. 94-28.

Burckhard, S.R., M. Narayanan, V.R. Schaefer, P.A. Kulakow, and B.A. Leven, "Design of a Graphical User Interface Decision Support System for a Vegetated Treatment System," *Proceedings of the 14th Annual Conference on Hazardous Waste Research*, L.E. Erickson and M.M. Rankin (Eds.), St. Louis, Missouri, pages 196-202, 1999. Project no. 94-12.

Burckhard, S.R., K. Thompson, V.R. Schaefer, P. Kulakow, and B.A. Leven, "Vegetated Treatment of Vehicle Wash Sediments: Development of a Decision Support Tree," *Proceedings of the 2000 Conference on Hazardous Waste Research*, Denver, Colorado, pages 168-176, May 2000. Project no. SP-96.

Burckhard, S.R., K. Thompson, V.R. Schaefer, P. Kulakow, B.A. Leven, and A.P. Schwab, "Vegetated Treatment of Vehicle Wash Sediments: Design of a Multimedia Aid Decision Support System," *Proceedings of the 2000 Conference on Hazardous Waste Research*, Denver, Colorado, pages 154-158, May 2000. Project nos. 94-29, SP-96.

Burken, J.G., and J.L. Schnoor, "Atrazine Phytoremediation and Metabolism by Poplar Trees," *Proceedings of the 69th Annual Water Environment Federation Conference*, Dallas, Texas, 1996. Project no. 94-25.

Burken, J.G., and J.L. Schnoor, "Hybrid Poplar Tree Phytoremediation of Volatile Organic Compounds," *Proceedings of the ACS National Meeting*, Orlando, Florida, 1996. Project no. 94-25.

Burken, J.G., and J.L. Schnoor, "Uptake and Fate of Organic Contaminants by Hybrid Poplar Trees," *Proceedings of the 213th American Chemical Society Convention*, San Francisco, California, 1997. Project no. 94-25.

Burken, J.G., A.C. Dietz, J.L. Jordahl, B.E. Schnabel, P.L. Thompson, L.A. Licht, P.J.J. Alvarez, and J.L. Schnoor, "Phytoremediation of Hazardous Waste," *Proceedings of the 69th Annual Water Environment Federation Conference*, Dallas, Texas, 1996. Project no. 94-25.

Butts, M.B., K.H. Jensen, D. Szlag, and T.H. Illangasekare, "Fate of the Miscible and Immiscible Components Following a Light Oil Spill: An Experimental Study," *Proceedings of 1993*

Groundwater Modeling Conference, International Groundwater Modeling Center, Colorado School of Mines, Golden, Colorado, page 3.13.9, 1993.

Cady, J.D., S. Kapila, S.E. Manahan, and D.S. Viswanath, "Evaluation of Counterflow Oxidation for Regeneration of Granular Carbon Adsorbents," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. II, pages 739-750, 1990.

Callender, T., and L.C. Davis, "Environmental Behavior of Methyl Tert-Butyl Ether: A Study of Henry's Law Constant and the Dispersion of MTBE Through River Bottom Sand and Soil," *Proceedings of the 2001 Conference on Environmental Research,* Kansas State University, pages 136-146, 2001. Project no. 98-03.

Campbell, J.A., and T.H. Illangasekare, "Experimental Study and Modeling of Preferential Flow of Immiscible Fluids in Groundwater Aquifers," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 66-85, 1992.

Castro, S., L.C. Davis, and L.E. Erickson, "Phytodegradation Kinetics of Methyl Benzotriazole," *Proceedings of the 2001 Conference on Environmental Research,* Kansas State University, pages 68-82, 2001. Project no. 98-03.

Castro, S., L.C. Davis, and L.E. Erickson, "Phytoremediation of Aircraft Deicer and Antifreeze Formulations," *Proceedings of the 2000 Conference on Hazardous Waste Research,* pages 141-152, 2000. Project no. 94-27, 94-27A.

Castro, S., L.C. Davis, and L.E. Erickson, "Experimental Study of Phytodegradation Kinetics of Methyl Benzotriazole," *Proceedings of the 30th Annual Biochemical Engineering Syposium*, D.S. Kompala, Editor, University of Colorado, pages 33-42, 2000. Project no. 98-03.

Castro, S., L.C. Davis, and L.E. Erickson, "Interactions of Benzotriazoles with Upland Plants," *Proc. Convergence*, Environmental and Pipeline Engineering Conference, ASCE, Kansas City, pages 118-125, 2000. Project no. 98-03.

Castro, S., L.C. Davis, D. Lupher, and L.E. Erickson, "Phytoremediation of Corrosion Inhibitors in Aircraft Deicer Formulations," *Proceedings of the 29th Annual Biochemical Engineering Symposium,* University of Oklahoma, Norman, Oklahoma, pages 6-15, 1999. Project no. 94-27, 94-27A.

Castro, S., L.C., Davis, and L.E. Erickson, "Use of Vegetation for the Environmental Management of Deicing Formulations and Volatile Solvents," *Proceedings of the Third International Congress in Environmental Microbiology and First International Symposium in Agricultural Biotechnology,* Pontificia Universidad Javeriana, Bogota, D.C., Colombia, pages 246-253, 2001. Project no. 98-03.

Chang, C.M., H. Gu, T.J. O'Keefe, and S.E. James, "Galvanic Stripping of Iron from Solvent Extraction Solutions from Zinc Residue Leaching," *Second International Symposium on Iron Control in Hydrometallurgy*, J.E. Dutrizac and G.B. Harris (Eds.), Canadian Institute of Mining, Metallurgy, and Petroleum, Iron Control and Disposal, pages 417-430, 1996. Project no. 94-05.

Chang, C.M., and T.J. O'Keefe, "The Electrochemical Behavior of Zn-Pb (1.7%) in Galvanic Stripping," *EPD Congress 1998 Adsorption, Ion Exchange and Solvent Extraction TMS*, pages 393-405, 1998. Project no. 94-05.

Chang, C.M., H. Gu, and T.J. O'Keefe, "Review of Galvanic Stripping Process for Use in Treating Oxidized Metal Wastes," *Proceedings HSRC/WERC Joint Conference on the Environment*, pages 164-175, 1996. URL: http://www.engg.ksu.edu/HSRC/96Proceed.

Chen, B., and A.B. Cunningham, "Modeling of Subsurface Biobarrier Formation and Persistence," *Proceedings of the 12th Annual Conference on Hazardous Waste Research,* L.E. Erickson, M.M. Rankin, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, pages 159-166, 1997. Project no. 94-28.

Chen, B., A.B. Cunningham, and E. Visser, "Numerical Simulation of Biofilm Growth on Porous Media and the Microscale," *Proceedings of the 11th International Conference on the Computational Methods in Water Resources*, Cancun, Mexico, 1996. Project no. 94-28.

Chen, B., and H. Kojoharov, "Accurate Numerical Simulation of Biobarrier Formation in Porous Media," *Proceedings of the 13th Annual Conference on Hazardous Waste Research,* L.E. Erickson and M.M. Rankin (Eds.), Kansas State University, Manhattan , Kansas, 1999.

Chen, B., and Y. Li, "Numerical Simulation of Flow and Transport at the Pore Scale," *Proceeding of the XII International Conference on Computational Methods in Water Resources,* V.N. Buganos et al. (Eds.), Computational Mechanics Publications, Southampton, United Kingdom, 1998.

Chen, D., Z. Lewandowski, F. Roe, and P. Surapaneni, "Diffusivity of Metal Ions in Biopolymer Gels," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 1-19, 1992.

Chew, C.F., and T.C. Zhang, "Remediation of Nitrate-Contaminated Groundwater by Electrokinetics/Iron Wall Processes," *Water Quality International: Proceedings of the IAWQ 19th Biennial International Conference*, Vancouver, Canada, Book 7, pages 133-140, 1998. Project no. 95-32.

Chew, C.F., and T.C. Zhang, "Nitrate Removal Using Electrokinetic/Iron Wall Processes," *Proceedings of the 1998 National Conference on Environmental Engineering*, Chicago, Illinois, pages 639-644, 1998. Project no. 95-32.

Chew, C.F., and T.C. Zhang, "Nitrate Removal Using Electrokinetic/Iron Wall Processes," *Proceedings of the 12th Annual Conference on Hazardous Waste Research*, L.E. Erickson, M.M. Rankin, S.C. Grant, and J.P. McDonald (Eds.), Kansas City, Missouri, pages 99-111, May 19-22, 1997. Project no. 95-32.

Chew, C.F., and T.C. Zhang, "Removal of Nitrate Using Industrial Iron Powder," *HSRC/WERC Abstracts Book,* pages 42-43, 1999. Project no. 95-32.

Chew, C.F., and T.C. Zhang, "Simultaneous Transformation of Nitrate and Atrazine by Metal Iron Powder," *Proceedings of the WEF 71st Annual Conference and Exposition*, Orlando, Florida, 1998. Project no. 95-32.

Chew, C.F., and T.C. Zhang, "Removal of Nitrate/Atrazine Contamination with Zero-Valent-Iron Promoted Processes," *Proceedings of the 13th Annual Conference on Hazardous Waste Research*," L.E. Erickson et al. (Eds.) University of Utah, pages 335-346, 1998. Project no. 95-32.

Cho, I.H., V.M. Boddu, D.S. Viswanath, S. Kapila, and R.K. Puri, "Adsorption of Benzene, Phenol, and a Mixture of XAD-4 and Coal Char," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 298-309, 1990.

Chou, S.T., and L.T. Fan, "Stabilization/Solidification of Low-Level Radioactive Liquid from a BWR Nuclear Power Plant with Pozzolan-Based Fixation Process," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 452-466, 1989.

Chou, S.T., and L.T. Fan, "Solidification of K061 Waste," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 385-394, 1990.

Chou, S.T., and L.T. Fan, "Influence of the Type and Amount of Binding Agent on the Characteristics of Solidified Arsenic Waste," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. II, pages 866-876, 1990.

Chou, S.T., and L.T. Fan, "Stabilization/Solidification of Arsenic-Contaminated Soil: Effect of Type and Composition of Soil," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 423-431, 1991.

Chou, S.T., and L.T. Fan, "Characteristics of Solidified Samples of Arsenic-Containing Soil: Influence of Acidity," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 493-501, 1992.

Clevenger, T.E., E. Hinderberger, D.W. Roberts, A. Bush, and P. Phillips, "Lead, Cadmium, and Zinc Contamination in Southwest Missouri," *Proceedings of the 25th Annual Conference on Trace Substances in Environmental Health*, Delbert Hemphill (Ed.), pages 85-93, 1991.

Coffin, D., and L.A. Glasgow, "Some Engineering Considerations in the Application of Soil Venting," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 257-297, 1990.

Coffin, D., and L.A. Glasgow, "Effective Gas Flow Arrangements in Soil Venting," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 388-416, 1991.

Coumoulos, H., K. Soga, and T.H. Illangasekare, "1G and Centrifuge Tests on a DNAPL Migration in Saturated Porous Media with Inclined Layers-Modeling Techniques," *Proceeding of International Symp. on Physical Modeling and Testing in Environmental Geotechnics,* Network of European Centrifuges for Environmental Geotechnic Research (NECER), 15-17 May, 2000. La Baule, France. Project 94-29, 98-05.

Cunningham, A.B., "Hydrodynamics and Solute Transport at the Fluid-Biofilm Interface," *Structure and Function of Biofilms*, W.G. Characklis and P.A. Wilderer (Eds.), John Wiley and Sons, Dahlem Workshop Report Series, Life Science Research Report No. 46, pages 19-31, 1989.

Cunningham, A.B., F. Abedeen, W.G. Characklis, and E.M. Bouwer, "Influence of Microbial Transport on the *In Situ* Bioremediation of Organic Groundwater Contaminants," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 1-12, 1989.

Cunningham, A.B., E.J. Bouwer, and W.G. Characklis, "Biofilms in Porous Media," *Biofilms*, W.G. Characklis and K.C. Marshall (Eds.), John Wiley, New York, pages 692-732, 1990.

Cunningham, A.B., and O. Wanner, "Modeling Biofilm Accumulation and Activity in Porous Media," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 71-81, 1991.

Cunningham, A.B., "Effects of Biocolloids on Hydrodynamic Properties of Porous Media," *Proceedings of the Mantaeo III Conference: Concepts in Manipulation of Groundwater Colloids for Environmental Restoration*, John F. McCarthy (Ed.), Lewis Publishers, pages 103-109, 1993.

Cunningham, A.B., and O. Wanner, "Modeling Microbial Processes in Porous Media with Application to Biotransformation," *Hydrological, Chemical, and Biological Processes of Transformation and Transport of Contaminants in Aquatic Environments: Proceedings of the Rostov-on-Don Symposium*, IAHS Publication No. 217, 1993.

Cunningham, A.B., and O. Wanner, "Modeling Microbial Processes in Porous Media with Application to Biotransformation," *Proceedings Hydrochemistry 1993: International Symposium on Hydrological*, *Chemical*, *and Biological Processes of Transformation and Transport of Contaminants in Aquatic Environments*, Rostov-on-Don, Russia, IASH Publication No. 21. 1993.

Cunningham, A.B., B.K. Warwood, P.J. Sturman, K. Horrigan, G. James, and J.W. Costerton, "Biofilm Processes in Porous Media—Practical Applications," *Microbiology of the Terrestrial Subsurface*, Amy and Halderman (Eds.), CRC Press, Inc., Chapter 17, 1997. Project no. 94-28.

Cunningham, A.B., and B. Chen, "Evaluation and Modeling of Subsurface Biobarrier Formation and Persistence," *Proceedings of the 12th Annual Conference on Hazardous Waste Research*, L.E. Erickson, M.M. Rankin, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Kansas City, Kansas, 1997. Project no. 94-28.

Cunningham, A.B., B.K. Warwood, and G. James, "Containment of Heavy Metal and Chlorinated Organic Solvent Contamination Using Subsurface Biobarriers," *Proceedings of the Joint Conference on the Environment*, L.E. Erickson (Ed.), Albuquerque, New Mexico, 1996. Project no. 94-28.

Cunningham, A.B., and P.J. Sturman, *"In Situ* Bioremediation Process Engineering Concepts," *Bioremediation: Principles and Practice*, Technomics Publishers, Vol. 1, 1998. Project no. 94-28.

Dave, S., T.E. Clevenger, and E. Hinderberger, "Effect of Cover Material on Leachability of Lead Mine Tailings," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 395-416, 1990.

Davis, L.C., C. Pitzer, S. Castro, and L.E. Erickson, "Henry's Constant, Darcy's Law, and Contaminant Loss," *Proceedings of the 2001 Conference on Environmental Research,* Kansas State University, pages 2-15, 2001. Project no. 98-03.

Davis, L.C., "Long-Term Monitoring to Observe Natural Attenuation in the Laboratory," *Proceedings of the 2000 Conference on Hazardous Waste Research,* pages 105-110, 2000. Project no. 94-27.

Davis, L.C., C. Chaffin, M. Narayanan, V.P. Visser, W.G. Fateley, L.E. Erickson, and R.M. Hammaker, "Monitoring the Beneficial Effects of Plants in Bioremediation of Volatile Organic Compounds," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 236-249, 1993.

Davis, L.C., D. Lupher, Q. Zhang, J. Hu, and L.E. Erickson, "Transport of Organic Chemicals Through Living Plant Tissues," *Proceedings of the 29th Annual Biochemical Engineering Symposium, University of Oklahoma, Norman, Oklahoma, pages 108-113, 2000.* Project no. 94-27, 94-27A.

Davis, L.C., M. Narayanan, V.P. Visser, C. Chaffin, W.G. Fateley, L.E. Erickson, and R.M. Hammaker, "Alfalfa Plants and Associated Microorganisms Promote Biodegradation Rather than Volatilization of Organic Substances from Groundwater," *Microbial Degradation of Organic Bioremediation through Rhizosphere Technology*, T.A. Anderson and J.R. Coats (Eds.), ACS Symposium Series, No. 563, pages 112-122, 1994.

Davis, L.C., M.K. Banks, A.P. Schwab, M. Narayanan, L.E. Erickson, and J.C. Tracy, "Plant-Based Bioremediation," *Bioremediation: Principles and Practice*, R.L. Irvine and S.K. Sikdar (Eds.), Technomic, Lancaster, PA, 1995. Project no. 94-12.

Davis, L.C., and N.C. Chou, "Metabolism of TNT Associated with Roots of Higher Plants," *Proceedings of the HSRC-WERC Joint Conference on the Environment*, Albuquerque, New Mexico, pages 569-576, 1996. URL: http://www.engg.ksu.edu/HSRC/96Proceed. Project no. 94-27.

Davis, L.C., S. Vanderhoof, and D. Lupher, "Sorption of Trichloroethylene and Other Halogenated Aliphatics on and in Plant Material," *Proceedings of the 13th Annual Conference on Hazardous Waste Research*, Snow Bird, Utah, 1998, pages 319-325. Project no. 94-27.

Davis, L.C., D. Lupher, J. Hu, and L.E. Erickson, "Transport of Trichloroethylene Through Living Plant Tissues," *Proceedings of the 1999 Conference on Hazardous Waste Research,* St. Louis, Missouri, pages 203-209, 1999. Project no. 94-27.

Davis, L.C., D. Lupher, Q. Zhang, J. Hu, and L.E. Erickson, "Transport of Organic Chemicals Through Living Plant Tissues," *Proceeding of the 29th Annual Biochemical Engineering Symposium*, University of Oklahoma, Norman, Oklahoma, pages 108-113, 1999. Project no. 94-27, 94-27A.

Dietz, A.C., and J.L. Schnoor, "Phytotoxicity Screening of Chlorinated Aliphatics," *Proceedings of the Battelle Conference on Remediation of Chlorinated and Recalcitrant Compounds*, Monterey, California, 1998. Project no. 95-29.

Dhawan, S., L.E. Erickson, L.T. Fan, P. Tuitemwong, and R. Mahadevaiah, "Microcosm Techniques for Investigating the Biodegradation Potential of Light Nonaqueous-Phase Liquids and Dense Nonaqueous-Phase Liquids," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 578-599, 1989.

Dhawan, S., L.E. Erickson, and L.T. Fan, "Modeling the Bioremediation of Contaminated Soil Aggregates: A Phenomenological Approach," *Proceedings of the Twentieth Annual Biochemical Engineering Symposium*, Kansas State University, Manhattan, Kansas, pages 77-86, 1990.

Dhawan, S., L.E. Erickson, and L.T. Fan, "Modeling and Simulating Bioremediation in Soil Beds with Aggregates," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 432-446, 1991.

Erickson, L.E., "Waste Minimization and Process Safety in Process Development, Design, Construction, and Start-Up," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 525-527, 1989.

Erickson, L.E., L.C. Davis, and P.A. Kulakow, "Phytoremediation," *Vadose Zone Science and Technology Solutions,* B.B. Looney and R.W. Falta, (Eds.), Battelle Press, Columbus, Ohio, pages 1090-1097, 2000. Project no. 94-27, 94-27A.

Erickson, L.E., L.T. Fan, S. Dhawan, and P. Tuitemwong, "Modeling, Analysis, and Simulation of Bioremediation of Soil and Water," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 17-46, 1990.

Erickson, L.E., P.A. Kulakow, and L.C. Davis, "Phytoremediation of Petroleum-Contaminated Soil," *In Vadose Zone Science and Technology Solutions,* B.B. Looney and R.W. Falta, (Eds.), Battelle Press, Columbus, Ohio, pages 1234-1237, 2000. Project no. 94-27, 94-27A.

Erickson, L.E., and P. Tuitemwong, "Growth Yields, Productivities, and Maintenance Energy of Methylotrophs," *Biology of Methylotrophs*, I. Goldberg and J.S. Rokem (Eds.), Butterworths, Stoneham, Massachusetts, pages 149-172, 1991.

Erickson, L.E., L.C. Davis, S.K. Santharam, S.C. Kim, M. Narayanan, and C.W. Rice, "Biodegradation in the Rhizosphere: Analysis of the Beneficial Effects of Vegetation," *87th Annual Meeting, AWMA,* Cincinnati, Ohio, Paper No. 94-WA86.04, 1994.

Erickson, L.E., and L.C. Davis. "Beneficial Effects of Vegetation in Bioremediation of Contaminated Soil," *Proceedings of the International Symposium on Environmental Biotechnology,* pages 7-12, Korean Society of Applied Microbiology, Pusan National University, Pusan, South Korea, 1996. Project no. 94-27.

Erickson, L.E., Q. Zhang, and L.E. Erickson, "Plant-Based Remediation of MTBE and Other Compounds in Gasoline," *Underground Tank Technology Update,* Vol. 15: No. 2, pages 7-10, 2001. Project no. 94-27, 94-27A, 98-03.

Erickson, L.E., "Soil Remediation," 2000 *Yearbook of Science and Technology*, McGraw-Hill, New York, pages 394-396, 1999. Project no. 94-27.

Fan, L.T., and Y.L. Huang, "HIDEN: A Hybrid Intelligent Computer-Aided System Towards Process Design Automation," *Proceedings of the 2nd International Conference on Automation, Robotics, and Computer Vision*, Singapore, Vol. 2, pages IA-8.2.1, 1992.

Friedler, F., K. Tarján, Y.W. Huang, and L.T. Fan, "Graph-Theoretic Approach to Process Synthesis: Application to Waste-Minimization," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. II, pages 877-892, 1990.

Friedler, F., K. Tarján, Y.W. Huang, and L.T. Fan, "An Accelerated Branch-and-Bound Method for Process Synthesis," *Proceedings at the 4th World Congress of Chemical Engineering*, Karlsruhe, Germany, Vol. 4, pages 12.2-5, 1991.

Friedler, F., K. Tarján, Y.W. Huang, and L.T. Fan, "Process Synthesis by Exploiting the Combinatorial Properties of Feasible Process Structures," *Proceedings at the 4th World Congress of Chemical Engineering*, Karlsruhe, Germany, Vol. 4, pages 12.2-3, 1991.

Friedler, F., K. Tarján, Y.W. Huang, and L.T. Fan, "Waste-Minimizing Synthesis of a Process for Production of Perchloromethyl Mercaptan: Systematic Approach," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 248-261, 1991.

Friedler, F., and L.T. Fan, "Process Synthesis Incorporating In-Plant Waste Treatment: Algorithmic Approach," *Book of Abstracts for the Special Symposium on Emerging Technologies for Hazardous Waste Management*, Atlanta, Georgia, Vol. I, pages 325-328, 1992.

Friedler, F., Z. Kovács, and L.T. Fan, "Unique Separation Networks for Improved Waste Elimination," *Book of Abstracts for the Special Symposium on Emerging Technologies for Hazardous Waste Management*, Atlanta, Georgia, Vol. II, pages 457-460, 1992.

Friedler, F., K. Tarján, Y.W. Huang, and L.T. Fan, "Accelerated Branch-and-Bound Method for Process Network Synthesis," *Preprints of the Department of Mathematics*, University of Veszprém, Hungary, Vol. 3/5, pages 1-7, 1992.

Friedler, F., K. Tarján, Y.W. Huang, and L.T. Fan, "Computer-Aided Waste Minimizing Design of a Chemical Process," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 107-116, 1992.

Friedler, F., K. Tarján, Y.W. Huang, and L.T. Fan, "A Systematic Approach to Waste-Minimizing Synthesis of a Chemical Process: Production of Perchloromethyl Mercaptan," *Proceedings of the Conference on Process Technology for Waste Reduction*, AIChE National Meeting, Pittsburgh, Philadelphia, pages 93-98, 1992.

Galitzer, S.J., "Utilization of Waste Exchanges in a Waste-Minimization Program," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 528-536, 1989.

Gandhi, P., X. Yang, L.E. Erickson, and L.T. Fan, "In-Well Aeration: An Innovative Subsurface Remediation Technology," *Proceedings of the 24th Annual Biochemical Engineering Symposium*, R.H. Davis (Ed.), University of Colorado, Boulder, pages 1-10, 1994.

Ghosh, S., S. Bupp, and L.M. DeBirk, "Removal of Heavy Metals by Biopolymers," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 449-476, 1990.

Ghosh, S., and S. Bupp, "Uptake of Heavy Metals by Unacclimated Aerobic Cultures," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 30-45, 1991.

Ghosh, S., D. Chang, K. Fukushi, and A. Chan, "Biostimulation of Cadmium and Copper Removal in the Presence of Special Nutrients," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 20-38, 1992.

Ghosh, S., and M.L. Sun, "Anaerobic Biodegradation of Benzene Under Acidogenic Fermentation Condition," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 208-218, 1992.

Ghosh, S., K. Fukushi, D. Chang, and S. Bupp, "Enhanced Heavy Metal Uptake by Activated Sludge Cultures Grown in the Presence of Metallothionein Stimulators," *Proceedings of the Symposium I&EC*, Atlanta, Georgia, 1993.

Ghoshal, S., S.K. Banerji, and R.K. Bajpai, "Photodegradation of PCP," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. II, pages 806-816, 1990.

Ghoshal, S., S.K. Banerji, and R.K. Bajpai, "Photodegradation of Pentachlorophenol," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 197-215, 1991.

Ghoshal, S., S.K. Banerji, and R.K. Bajpai, "A Strategy for Decontamination of Soils Containing Elevated Levels of PCP," *Proceedings of the 21st Annual Biochemical Engineering Symposium*, Colorado State University, Fort Collins, Colorado, pages 104-120, 1991.

Gilliland, M.W., W.E. Kelly, and D. Lokke, "Hazardous Waste Management in Rural Communities in EPA Regions VII and VIII," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 478-481, 1989.

Glasgow, L.A., "Some Engineering Considerations in the Venting of Vadose Zone Soils," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 600-620, 1989.

Govindaraju, R.S., and L.E. Erickson, "Modeling of Overland Flow Contamination Due to Heavy Metals in Shallow Soil Horizons," *Proceedings of the 10th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 289-302, 1995. URL: http://www.engg.ksu.edu/HSRC/95Proceed/home.html.

Grant, S.C., "Citizens, Risk, and Hazardous Substances," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 190-199, 1993.

Green, R., L. Roig, R.S. Govindaraju, and L.E. Erickson, "Effects of Vegetation on Contaminant Transport in Surface Flows," *Proceedings of the HSRC-WERC Joint Conference on the Environment,* Albuquerque, New Mexico, pages 126-141, 1996. URL: http://www.engg.ksu.edu/HSRC/96Proceed/.

Green, R.M., L.E. Erickson, R. Govindaraju, and P. Kalita, "Modeling the Effects of Vegetation on Heavy Metals Containment," *Proceedings of the 12th Annual Conference on Hazardous Waste Research*, L.E. Erickson, M.M. Rankin, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, pages 476-496, 1997. Project no. 93-07.

Green, R.M., L. E. Erickson, P. Kalita, and G. Pierzynski, "Utilization of the Kinematic Runoff and Erosion Model in Predicting the Effects of Vegetation on Heavy Metal Containment in Southeast Kansas," *Proceedings of the 14th Annual Conference on Hazardous Waste Research*, L.E. Erickson and M.M. Rankin (Eds.), St. Louis, Missouri, pages 257-274, 1999. Project no. 93-07.

Griswold, W.M., G.L. Godfrey, S.C. Grant, and D.L. Tillison, "The NAOMI Program and HERS: Working to Create Lasting Links*," Proceedings of the 10th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 336-340, 1996. URL: http://www.engg.ksu.edu/HSRC/95Proceed/home.html.

Griswold, W.M., G.L. Godfrey, S.C. Grant, and P.T. Yazzie, "HERS: A Center for Research, Education, and Communication*," Proceedings of the HSRC/WERC Joint Conference on the Environment,* pages 683-687, 1996. URL: http://www.engg.ksu.edu/HSRC/96Proceed/.

Griswold, W.M., G.L. Godfrey, S.C. Grant, and J. Yazzie, "HERS: An Expanding Program in a Shrinking World," *Proceedings of the 12th Annual Conference on Hazardous Waste Research*, L.E. Erickson, M.M. Rankin, S.C. Grant, and J.P. McDonald (Eds), Kansas State University, pages 536-541, 1997.

Griswold, W.M., G.L. Godfrey, and P.T. Yazzie, "HERS Supports Connection Between Technology and Native American Cultures," *Proceedings of the 13th Annual Conference on Hazardous Waste Research*, L.E. Erickson et al. (Eds.), University of Utah, pages 404-408, 1998. Project no. TR96-05.

Hamdi, S., J.M. Steichen, A.P. Schwab, and P.L. Barnes, "Freundlich Adsorption and Its Impact on Solution of the Non-Linear Chemical Transport Model," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 286-306, 1992.

Hangos, K.M., Friedler, F., J.B. Varga, and L.T. Fan, "Integration of Waste Minimization into Total Flowsheet Synthesis," *Proceedings of the 5th European Symposium on Computer-Aided Process Engineering*, Bled, Slovenia, 1995. Project no. 91-36.

Hansen, C.L., D.K. Stevens, S. Zhang, and D.N. Warner, "Biologically Enhanced Removal of Mercury from Contaminated Soil," *Proceedings of the Air and Waste Management Association 1992 Annual Meeting and Exhibition*, Paper # 92-25.03, 1992.

Hanson, R.S., and B.S. Mattox, "Educational Aspects of Hazardous Waste Management Training," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 187-201, 1992.

Hartford, S.A., and T.H. Illangasekare, "Use of a Solute Transport Model as a Computer-Aided Management and Design Tool," *Proceedings of the Colorado Water Management Conference*, Denver, Colorado, 1992.

Helland, B.R., J.L. Schnoor, and P.J.J. Alvarez, "Oxygen-Controlled Product Formation of CCl_4 Dechlorination Using Zero-Valent Iron," *Preprints of Papers, 209th ACS National Meeting*, American Chemical Society, Anaheim, California, page 732-733, 1995.

Hettiarachchi, G., Pierzynski, J. Zwonitzer, and M. Lambert, "Phosphorus Source and Rate Effects on Cadmium, Lead, and Zinc Bioavailability," *Extended Abstracts of the Fourth International Conference on the Biogeochemistry of Trace Elements*, Berkeley, California, pages 463-464, 1997. Project no. 93-07.

Hettiarachchi, G., and G. Pierzynski, "Effects of Phosphorus and Other Soil Amendments on Soil Lead, Cadmium, and Zinc Bioavailability," *Proceedings of Extended Abstracts of the 5th International Conference on the Biogeochemistry of Trace Elements,* Vienna, Austria, pages 514-515, 1998. Project no. 93-07.

Hillier, A.C., and C.W. Walton, "A Demonstration of the Application of an Equation-Solving Program for Modeling Rinse and Recovery Systems," *Proceedings of the 12th Annual AESF/EPA Environmental Control Conference for the Metal Finishing Industry*, T.V. Tran (Ed.), American Electroplaters and Surface Finishers Society, Orlando, Florida, pages 192-219, 1991.

Hoffman, R.M., V.P. Visser, L.C. Davis, L.E. Erickson, M. Narayanan, R.M. Hammaker, and W.G. Fateley, "Monitoring Plant Bioremediation of Volatile Organic Compounds (VOCs) Using Open-Path Fourier Transform Infrared (FT-IR) Spectrometry," *Proceedings of the 9th Annual Conference on Hazardous Waste Remediation,* L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Bozeman, Montana, pages 108-116, 1994.

Holmes, J.L., R.L. Peyton, and T.H. Illangasekare, "Spatial Distribution of Nonaqueous-Phase Liquids in Sand Cores Using X-Ray Computed Tomography," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 35-43, 1993.

Hooker, P.D., and K.J. Klabunde, "The Destructive Adsorption of Carbon Tetrachloride on Iron (III) Oxide," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 151-164, 1993. Project no. 89-26, 92-03.

Hooker, P.D., and K.J. Klabunde, "The Destructive Adsorption of Carbon Tetrachloride on Iron (III) Oxide," *Environmental Science and Technology*, Vol. 28, pages 1243-1247, 1994. Project no. 89-26, 92-03.

Hsieh, M., R.K. Bajpai, and S.K. Banerji, "Degradation of PCP by Ligninase Produced by *Phanerochaete chrysosporium*," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. II, 797-805, 1990.

Hsieh, M., R.K. Bajpai, and S.K. Banerji, "Biodegradation of Pentachlorophenol by *Phanerochaete chrysosporium* in Soil," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 521-536, 1991.

Hsieh, C.M., R.K. Bajpai, and S.K. Banerji, "Influence of Carbon Source on Pentachlorophenol Degradation by *P. chrysosporium* in Soil," *Proceedings of the 21st Annual Biochemical Engineering Symposium*, Colorado State University, Fort Collins, Colorado, pages 195-205, 1991.

Hu, J., L.C. Davis, and L.E. Erickson, "Modeling Contaminant Transport in Plants," *Proceedings of the Conference on Hazardous Waste Research,* Snow Bird, Utah, pages 285-295, 1998. Project no. 94-27.

Hu, J., L.C. Davis, and L.E. Erickson, "Uptake of Trichloroethylene by Plants," *Proceedings of the 28th Annual Biochemical Engineering Symposium,* Iowa State University, Ames, Iowa, pages 93-100, 1998. Project no. 94-27.

Hu, J., M. Narayanan, L.C. Davis, and L.E. Erickson, "Modeling Root Uptake and Transport of Trichloroethylene," *Proceedings of the 27th Annual Biochemical Engineering Symposium*, Colorado State University, Fort Collins, Colorado, pages 13-121, 1998. Project no. 94-27.

Huang, Y.W., L.T. Fan, and W.W. Olson, "Potential Application of Neural Networks to Hazardous Waste Processing," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 147-167, 1989.

Huang, Y.L., Y.W. Huang, and L.T. Fan, "An Artificial Intelligence Approach to the Synthesis of a Mass Exchanger Network for Hazardous Waste Minimization and Treatment," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 483-499, 1989.

Huang, Y.L., Y.W. Huang, and L.T. Fan, "A Knowledge-Based System for Synthesizing Highly Controllable Heat Exchanger Networks," *Proceedings of the 3rd Oklahoma Symposium on Artificial Intelligence*, Tulsa, Oklahoma, pages 270-271, 1989.

Huang, Y.L., G. Sunder, and L.T. Fan, "An Expert System for Cyanide Waste Minimization in Electroplating Plants," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. II, pages 500-522, 1990.

Huang, Y.L., and L.T. Fan, "A Framework of Plant-Wide Hierarchical Control for Waste Minimization and Management," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 237-247, 1991.

Huang, Y.L., and L.T. Fan, "A Novel Approach for Synthesizing a Robust Controller with Decoupling Capability for a Complicated Multivariable Process System," *Proceedings of the 4th World Congress of Chemical Engineering*, Karlsruhe, Germany, Vol. 4, pages 12.2-21, 1991.

Huang, Y.L., Y.W. Huang, and L.T. Fan, "A Neural Network for Guiding Stream Matching in Heat Exchanger Network Synthesis," *Proceedings of the 4th World Congress of Chemical Engineering*, Karlsruhe, Germany, Vol. 4, pages 12.2-13, 1991.

Huang, W., E. Lee, J.F. Shimp, L.C. Davis, L.E. Erickson, and J.C. Tracy, "Effect of Plants and Trees on the Fate, Transport, and Biodegradation of Contaminants in the Soil and Groundwater," *Proceedings of the Twenty-First Annual Biochemical Engineering Symposium*, Colorado State University, Ft. Collins, Colorado, pages 167-176, 1991.

Huang, Y.L., and L.T. Fan, "Expert Systems Techniques in Waste Minimization," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 86-92, 1992.

Huang, Y.L., and L.T. Fan, "Intelligent Design and Control for In-Plant Waste Minimization," *Waste Minimization through Process Design,* A.P. Rossiter (Ed.), Mc-Graw Hill, New York, New York, 1994. Project no. 91-36.

Hughes, J.B., and G.F. Parkin, "The Effect of Influent Acetate Concentration on the Transformation of Chlorinated Aliphatic Compounds in Fixed-Film Anaerobic Filters," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 1-16, 1990.

Hughes, J.B., and G.F. Parkin, "The Effect of Electron Donor Concentration on the Transformation of Chlorinated Aliphatics," *In Situ and On-Site Bioreclamation*, Butterworths, Inc., pages 55-79, 1991.

Hughes, J.B., and G.F. Parkin, "The Effect of Mixtures of Xenobiotics and Primary Electron Donor on the Anaerobic Biotransformation of High Concentrations of Chlorinated Aliphatics," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 82-91, 1991.

Hurst, C.J., R.C. Sims, J.L. Sims, D.L. Sorensen, J.E. McLean, and S. Huling, "Polycyclic Aromatic Hydrocarbon Biodegradation as a Function of Oxygen Tension in Contaminated Soil," *Proceedings of the 10th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 20-32, 1995. URL: http://www.engg.ksu.edu/HSRC/95Proceed/home.html.

Illangasekare, T.H., D. Dai, T. Saba, F.T. Barranco, Jr., "The Influence of Heterogeneity on NAPL-Zone Detection with Subsurface Multiple Tracers: Column and Intermediate-Scale Laboratory Results," *Proceedings of Groundwater 2000 International Conference on Groundwater Research,*" 6-8 June, 2000. Copenhage, Denmark. Project no. 98-05.

Illangasekare, T.H., and D. Reible, "Pump-and-Treat Design for Plume Containment: Processes, Applications, and Limitations," *ASCE Manuals and Reports on Engineering Practice No. 100.* "Groundwater Contamination by Organic Pollutant-Analysis and Remediation," J.J. Kaluarachchi, (Ed.) pages 79-119, 2000. Project no. 94-29, 98-05.

Illangasekare, T.H., S. Saenton, T. Saba, and C.S. Willson, "Upscaling of NAPL Dissolution from Entrapped Sources: Implications of End Points for Risk Assessment," *Proceedings of 2000 Contaminated Site Remediation Conference,* 4-8 December, 2000. Melbourne, Australia. Project no. 98-05.

Illangasekare, T.H., and T. Saba, "Intermediate-Scale Modeling to Investigate Upscaling Issues Related to Mass Transfer from Non-Aqueous Phase Waste Chemicals in Heterogeneous Aquifer," *Proceedings of Groundwater 2000 International Conference on Groundwater Research,* 6-8 June, 2000. Copenhagen, Denmark. Project no 98-05.

Illangasekare, T.H., and T. Saba, "Intermediate-Scale Physical Model Testing to Investigate Upscaling of Dissolution of Nonaqueous-Phase Liquids in Aquifers," *Proceedings of International Symposium on Physical Modeling and Testing in Environmental Geotechnics,* 15-17 May, 2000. La Baule, France. J. Garnier, L. Thorel, and E. Haze, (Eds.) 261-268. (Invited Keynote Presentation.) Project no. 94-29, 98-05.

Illangasekare, T.H., and T. Saba, "Upscaling of Contaminant Transport in Heterogeneous Aquifers: Dissolution of Entrapped Separate-Phase Organic Chemicals," *Proceedings of Jubilee Congress*, Engineering of Perdeniya, Vol (2), pages 127-132, 2000. Project no. 94-29, 98-05.

Illangasekare, T.H., "Flow and Entrapment of Nonaqueous-Phase Liquids in Heterogeneous Formations," *Physical Nonequillibrium in Soils: Modeling and Application*, H.M. Selima and L. Ma (Eds.), Ann Arbor Press, pages 417-435, 1998. Project no. 94-29.

Illangasekare, T.H., E.J. Armbruster, D.N. Yates, D. Szlag, and D. Reible, "Effect of Heterogeneity on Transport and Entrapment of Nonaqueous-Phase Waste Products in Aquifers," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. II, pages 523-540, 1990.

Illangasekare, T.H., H. Rajaram, H.-S. Chao, and R. Compos, "An Experimental Database for the Evaluation of Theories for Upscaling in Modeling of Groundwater Flow, Solute Transport, and Multiphase Flow in Aquifers," *Proceedings of Selected Research in Environmental Quality*, Joint USAF/Army Contractor/Grantee Meeting, Panama City, Florida, 1997. Project no. 94-29.

Illangasekare, T.H., D. Szlag, J. Campbell, J. Ramsey, M. Al-Sheriadeh, and D. Reible, "Effects of Heterogeneities and Preferential Flow on Distribution and Recovery of Oily Wastes in Aquifers," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 216-236, 1991.

Illangasekare, T., D. Znidarcic, and M. Al-Sheriadeh, "Multiphase Flow in Porous Media," *Proceedings of the International Conference Centrifuge 1991*, H.Y. Ko, F.G. McLean, and A.A. Balkema (Eds.), Rotterdam, pages 517-523, 1991.

Illangasekare, T.H., E.J. Armbruster, D.N. Yates, and J. Wald, "Laboratory Evaluation of Conventional Multiphase Flow Models," *Computational Methods in Water Resources XI*, *Vol. 2: Mathematical Modeling in Water Resources*, Russel, Ewing, Brebbia, Gray, and Pinder (Eds.), Elsevier Applied Science, pages 289-296, 1992.

Illangasekare, T.H., "Transport and Entrapment Behavior of Immiscible Organic Waste Chemicals in Heterogeneous Aquifers: Implications on Modeling, Recovery, and Remediation," *Proceedings of 9th Annual Hazardous Waste Research Symposium,* Cincinnati, Ohio, 1993.

Illangasekare, T.H., and D. Szlag, "Use of a Three-Dimensional Groundwater Model for Retrospective Evaluation of Bioremediated Aquifer Contaminated with Organic Chemicals," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L.

Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 1-11, 1993.

Illangasekare, T.H., "Process Upscaling of Nonaqueous-Phase Liquid Behavior in Heterogeneous Aquifers," *Proceedings of Nonaqueous-Phase Liquids in the Subsurface Environment: Assessment and Remediation*, *1996* A*SCE Annual Convention and Exposition,* Washington, D.C., Ed. L.N. Reddi, pages 25-45, 1996.

Isbell, L., S. Kapila, K.S. Nam, A.F. Yanders, and R.K. Puri, "Application of Support-Bonded Siloxanes and Supercritical Carbon Dioxide for Trace Analysis of Organic Compounds," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 113-122, 1990.

Itoh, H., K.J. Klabunde, and Y.-X. Li, "A Fourier Transform Infrared Photoacoustic Spectroscopy (FT-IR-PAS) Study of the Adsorption of Organophosphorus Compounds on Heat-Treated Magnesium Oxide," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 588-608, 1991.

James, G.A., B.K. Warwood, A.B. Cunningham, P.J. Sturman, R. Hiebert, and J.W. Costerton, "Evaluation of Subsurface Biobarrier Formation and Persistence," *Proceedings of the 10th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 82-91. URL: http://www.engg.ksu.edu/HSRC/95Proceed/home.html.

Jennings, S.R., and J. Kruegar, "Clean Tailing Reclamation: Tailing Processing for Sulfide Removal and Vegetation Establishment," *Proceedings of the 12th Annual Conference on Hazardous Waste Research*, pages 62-75, 1997. Project no. 93-12.

Jennings, S.R., "Review of Acid-Base Account as a Predictive Tool in Drastically Disturbed Land Reclamation," *Seventh Billings Symposium on Disturbed Land Rehabilitation*, Montana State University, Bozeman, Montana, Reclamation Research Publication #9603, pages 2-8, 1996. Project no. 93-12.

Jones, W.L., K.B. Bucklin, A.K. Camper, and P. Stoodley, "Optimization of *In Situ* Biodegradability of Subsurface Soil Contaminants," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 29-43, 1989.

Jordan, R.M., and A.B. Cunningham, "Surfactant-Enhanced Bioremediation: A Review of the Effects of Surfactants on the Bioavailability of Hydrophonic Organic Chemicals in the Soils," *Bioavailabilty of the Organic Xenobiotics in the Environment*, Baveye-Ph., et al. (Eds.), Kluwer Academic Publishers, pages 463-496, 1999. Project no. 94-28.

Kapila, S., J. Byun, K.S. Nam, M.H. Liu, R.K. Puri, and A.A. Elseewi, "A Supercritical Fluid Extraction-Based Closed-Loop System for Decontamination of Soil," *Organohalogen Compounds*, Vol. 8, page 263, 1992.

Karthikeyan, R., L.C. Davis, K.R. Mankin, L.E. Erickson, and P. Kulakow, "Biodegradation of Jet Fuel (JP-8) in the Presence of Vegetation," *Proceedings of the 14th Annual Conference on Hazardous Waste Research,* L.E. Erickson and M.M Rankin (Eds.), St. Louis, Missouri, pages 243-256, 1999. Project no. 94-27.

Karthikeyan, R., L.C. Davis, K.R. Mankin, L.E. Erickson, and P. Kulakow, "Biodegradation of Jet Fuel (JP-8) in the Presence of Vegetation," *Proceedings of the 29th Annual Biochemical Engineering Symposium,* University of Oklahoma, Norman, Oklahoma, pages 15-25. Project no. 94-27, 94-27A.

Karthikeyan, R., L.E. Erickson, L.C. Davis, and K.R. Mankin, "Fate and Transport of Jet Fuel in Soils with Plants: Experiments and Modeling," *Proceedings of the 7th International Petroleum Environmental Conference,* K.L. Sublette, (Ed.), University of Tulsa, pages 469-503, 2000. Project no. 98-03.

Karthikeyan, R., P.A. Kulakow, B.A. Leven, K.R. Mankin, and G. Pierzynski, "Vegetated Treatment of Vehicle Wash Sediments: A Field Demonstration," *Proceedings of the 2000 Conference on Hazardous Waste Research*, Denver, Colorado, pages 159-166, May 2000. Project no. 94-29, 98-05, SP-96.

Keefer, G.B., and G.J. Thies, "Metal Recovery and Reuse Using an Integrated Vermiculite Ion Exchange-Acid Recovery System," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 417-437, 1990. Project no. 3.

Khaleel, A., and K.J. Klabunde, "Iron Oxide on Magnesium Oxide Support as a New Decomposition Adsorbent for Chlorinated Hydrocarbons," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 146-150, 1993. Project no. 89-26, 92-03.

Khaleel, A., and K.J. Klabunde, "Iron Oxide on Magnesium Oxide Support as a New Decomposition Adsorbent for Chlorinated Hydrocarbons," *Proceedings of the NATO Advanced Study Institute on Nanophase Materials: Synthesis, Properties, and Applications*, Kluwer Academic Publishers, G.C. Hadjipanayis and R.W. Siegel (Eds.), Corfu, Greece, Vol. 260, pages 785-788, 1994. Project no. 89-26, 92-03.

Klabunde, K.J., J.V. Stark, O. Koper, C. Mohs, A. Khaleel, G. Glavee, D. Zhang, C.M. Sorenson, and G.C. Hadjipanayis, "Chemical Synthesis of Nanophase Materials," *Proceedings of the NATO Advanced Study Institute on Nanophase Materials: Synthesis, Properties, and Applications*, Kluwer Academic Publishers, G.C. Hadjipanayis and R.W. Siegel (Eds.), Corfu, Greece, Vol. 260, pages 1-19, 1994.

Klabunde, K.J., D.G. Park, J.V. Stark, O. Koper, S. Decker, Y. Jiang, and I. Lagadic, "Nanoscale Metal Oxides as Destructive Adsorbents: New Surface Chemistry and Environmental Applications," *NATO Meeting on Fine Particles Science and Technology*, Kluwer Academic Pub., pages 691-706, 1996. Project no. 89-26, 92-03.

Kohl, S.D., and J.A. Rice, "The Binding of Organic Contaminants to Humin," *Proceedings of the HSRC-WERC Joint Conference on the Environment,* Albuquerque, New Mexico, pages 364-368, 1996. URL: http://www.engg.ksu.edu/HSRC/96Proceed/. Project no. 94-11.

Koper, O., Y.-X. Li, and K.J. Klabunde, "Destructive Adsorption of Chlorinated Hydrocarbons on Ultrafine (Nanoscale) Particles of Calcium Oxide," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 265-285, 1992.

Koper, O., and K.J. Klabunde, "Comparison of Nanoscale Calcium Oxide Versus Commercial Calcium Oxide with Respect to Decomposition of Carbon Tetrachloride," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 122-126, 1993. Project no. 89-26, 92-03.

Koper, O., and K.J. Klabunde, "Comparison of Nanoscale Calcium Oxide Versus Commercial Calcium Oxide with Respect to Decomposition of Carbon Tetrachloride," *Proceedings of the NATO Advanced Study Institute on Nanophase Materials: Synthesis, Properties, and Applications*, Kluwer Academic Publishers, G.C. Hadjipanayis and R.W. Siegel (Eds.), Corfu, Greece, Vol. 260, pages 789-792, 1994. Project no. 89-26, 92-03.

Kross, B.C., and B. Pies, "Remediation of Pesticide Spills: Technology Transfer to Volunteer Firefighters," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 202-207, 1992.

Kruger, E.L., T.A. Anderson, and J.R. Coats, "Degradation of Atrazine in Pesticide-Contaminated Soils: Phytoremediation Potential," *Phytoremediation of Soil and Water Contaminants*, E.L. Kruger, T.A. Anderson, and J.R. Coats (Eds.), American Chemical Society Symposium Series, ACS Books, Washington, DC, 1997. Project no. 93-05.

Kruger, E.L., T.A. Anderson, and J.R. Coats (Eds.), "Phytoremediation of Pesticide-Contaminated Soils," *Proceedings of the 89th Annual Meeting of the Air and Waste Management Association*, paper #96-RP141.03, 1996. Project no. 93-05.

Kubicheck, R., J. Cupal, W. Iverson, S. Choi, and M. Morris, "Identifying Groundwater Threats from Improperly Abandoned Boreholes," *Proceedings of the Wyoming Water Conference*, Casper, Wyoming, 1997. Project no. 94-24.

Kubicheck, R., J. Cupal, W. Iverson, S. Choi, and M. Morris, "Identifying Groundwater Threats from Improperly Abandoned Boreholes," *Wyoming Water Conference,* Casper, Wyoming, April, 1997.

Kulakow, P.A., R. Karthikeyan, B.A. Leven, and L.E. Erickson, "Vegetated Treatment of Vehicle Wash Sediments: a Field Demonstration," *Proceedings of the Seventh International Petroleum Environmental Conference,* Albuquerque, New Mexico, November 2000, Project no. SP96-1.

Kulakow, P., R. Karthikeyan, B.A. Leven, K.R. Mankin, and L.E. Erickson, "Phytoremediation of Wash Water Sediments Contaminated with Petroleum Hydrocarbons," *Proceedings of the Twenty-Eighth Annual Biochemical Engineering Symposium,* Iowa State University, Ames, Iowa, 1998. Project no. SP-96.

Lambert, M.W., G. Pierzynski, and G. Hettiarachchi, "The Use of Phosphorus in Sequestration of Lead and Cadmium in a Smelter Slag," *Proceedings of the 12th Annual Conference on Hazardous Waste Research*, L.E. Erickson, M.M. Rankin, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, pages 439-449, 1997. Project no. 93-07.

Lambert, M.W., G. Pierzynski, and G. Hettiarachchi, "Phosphorus Remediation of a Lead/Zinc Smelter Slag," *Extended Abstracts of the Fourth International Conference on the*

Biogeochemistry of Trace Elements, Berkeley, California, pages 465-466, 1997. Project no. 93-07.

Lambert, M.W., G. Pierzynski, B. Hetrick, L.E. Erickson, and D. Sweeney, "Revegetation of Pb/Zn Mine Tailings (chat) in the Tri-State Mining Region, U.S.A.," *Extended Abstracts of the Fifth International Conference on the Biogeochemistry of Trace Elements,* Vienna, Austria, pages 912-913, 1998. Project no. 93-07.

Lambert, M.W., G. Pierzynski, G. Hettiarachchi, L.E. Erickson, and D. Sweeney, "Revegetation of Heavy Metal-Contaminated Mine Tailings," *Proceedings of the 14th Annual Conference on Hazardous Waste Research,* L.E. Erickson and M.M. Rankin (Eds.), St. Louis, Missouri, pages 114-120, 1999. Project 93-07.

Lelinski, D., and J.D. Miller, "Removal of Volatile Organic Compounds from Contaminated Water Using Air-Sparged Hydrocyclone Stripping Technology," *Proceedings of the International Conference on Analysis and Utilization of Oily Wastes*, Gdansk, Poland, pages 53-62, 1996. Project no. 94-15.

Lewandowski, Z., "Biosorption of Metals from Aqueous Solutions," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. II, pages 477-499, 1990.

Lewandowski, Z., G. Walser, R. Larsen, B. Peyton, and W.G. Characklis, "Biofilm Surface Positioning," *Environmental Engineering Proceedings 1990*, ASCE, pages 17-23, 1990.

Lewandowski, Z.L., and A.B. Cunningham, "Biofilm Process Fundamentals," *Bioremediation: Principles and Practice*, Technomics Publishers, Vol. 1, 1998. Project no. 94-28.

Li, Y.-X., O. Koper, and K.J. Klabunde, "Adsorption and Decomposition of Organophosphorus Compounds on Nanoscale Metal Oxide Particles. *In Situ* GC-MS Studies of Pulsed Microreactions over Magnesium Oxide," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 159-184, 1991.

Li, Y.-X., O. Koper, and K.J. Klabunde, "Nanoscale Metal Oxide Particles as Chemical Reagents: Destructive Adsorption of a Chemical Agent Simulant, Dimethylmethylphosphonate (DMMP) on Heat-Treated Magnesium Oxide," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 120-142, 1991.

Li, Y.-X., J.R. Schlup, and K.J. Klabunde, "A Fourier Transform Infrared Photoacoustic Spectroscopy (FT-IR-PAS) Study of the Adsorption of Organophosphorus Compounds on Heat-Treated Magnesium Oxide," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 588-608, 1991.

Li, Y.-X., H. Li, and K.J. Klabunde, "Destructive Adsorption of Chlorinated Benzene on Ultrafine (Nanoscale) Particles of Magnesium Oxide and Calcium Oxide," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 127-145, 1993. Project no. 89-26, 92-03.

Li, Y.X., H. Li, and K.J. Klabunde, "Destructive Adsorption of Chlorinated Benzene on Ultrafine (Nanoscale) Particles of Magnesium Oxide and Calcium Oxide," *Proceedings of the NATO Advanced Study Institute on Nanophase Materials: Synthesis, Properties, and Applications*, Kluwer Academic Publishers, G.C. Hadjipanayis and R.W. Siegel (Eds.), Corfu, Greece, Vol. 260, pages 793-796, 1994. Project no. 89-26, 92-03.

Li, Y.X., H. Li, and K.J. Klabunde, "Destructive Adsorption of Chlorinated Benzene on Ultrafine (Nanoscale) Particles of Magnesium Oxide and Calcium Oxide," *Environmental Science and Technology*, Vol. 28, pages 1248-1253, 1994. Project no. 89-26, 92-03.

Licht, L.A., "Ecolotree™ Poplar Tree Technology Provides Cost and Management Advantages for Landfills," *Proceedings of the Solid Waste Management Association of North America, 34th Annual Solid Waste Exposition,* GRG004, pages 197-204, September 1996.

Licht, L.A., "Poplar Tree Roots for Water Quality Improvement," *Proceedings of the National Conference on Enhancing State's Lake Management Programs*, pages 55-61, 1990.

Licht, L.A., and J.L. Schnoor, "Poplar Tree Buffer Strips Grown in Riparian Zones for Biomass Production and Nonpoint Source Pollution Control," *Proceedings of the American Society of Agricultural Engineers*, Paper 902057, pages 1-21, 1990.

Licht, L.A., "Ecolotree™ Buffer for Landfill Leachate Management: Installation and Operational Summary," *Proceedings of Air and Waste Management Association 87th Meeting*, Cincinnati, Ohio, Paper 94-WA86.03, 1994.

Licht, L.A., "*Populus spp.* (Poplar) Capabilities and Relationships to Landfill Water Management," *Proceedings of Air and Waste Management Association 87th Meeting,* Cincinnati, Ohio, Paper 94-WA86.02, 1994.

Lin, J., and R.S. Govindarajk, "Conductivity of Soils with Preferential Flow Paths," *Proceedings of the HSRC/WERC Joint Conference on the Environment*, pages 117-125, 1996. URL: http://www.engg.ksu.edu/HSRC/96Proceed/.

Liu, M.H., S. Kapila, T.E. Clevenger, D.S. Viswanath, R.K. Puri, and A.F. Yanders, "Evaluation of Supercritical Fluid Extraction for Removal of Organic Contaminants from Soil," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 152-169, 1990.

Lo, Y.-H., A.F. Yanders, R.K. Puri, and S. Kapila, "Effect of Co-Pollutants on the Movement of Polychlorinated Dibenzo-P-Dioxins and Polychlorinated Dibenzofurans in Saturated Soils," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 77-88, 1990.

Lupher, D., L.C. Davis, and L.E. Erickson, "Function and Degradation of Benzotriazole," *Proceedings of the 28th Annual Biochemical Engineering Symposium,* Iowa State University, Ames, Iowa, pages 33-39, 1998. Project no. 94-27.

Lupher, D., L.C. Davis, and L.E. Erickson, "Effect of Benzotriazoles on Sunflowers and Fescue," *Proceedings of the 14th Annual Conference on Hazardous Waste Research,* L.E. Erickson and M.M. Rankin (Eds.), St.Louis, Missouri, pages 210-214, 1999. Project no. 94-27.

Makepeace, V.D., L.C. Davis, J. Dana, K. Selk, K. Smith, R.M. Hammaker, W.G. Fateley, and L.E. Erickson, "Measuring Contaminant Flux Through Plants by Fourier Transform Infrared (FT-IR) Spectrometry," *Proceedings of the HSRC-WERC Joint Conference on the Environment,* Albuquerque, New Mexico, pages 577-582, 1996. URL: http://www.engg.ksu.edu/HSRC/96Proceed.

Marino, M.A., and J.C. Tracy, "Water and Solute Movement in a Rooted Soil," *Trends in Hydrology,* Research Trends, Council of Scientific Information (Ed.), Trivandrum, India, pages 359-371, 1995.

Mazac, O., I. Landa, W.E. Kelly, and J.H. Blaha, "A New Technique for Detecting Petroleum Pollution Around Underground Storage Tanks," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 12-20, 1993.

McDonald, J.P., C.A. Baldwin, and L.E. Erickson, "Practical Considerations for Implementation of a Field-Scale Bioremediation Project," *Proceedings of the 21st Annual Biochemical Engineering Symposium*, Colorado State University, Ft. Collins, Colorado, pages 121-130, 1991.

McDonald, J.P., C.A. Baldwin, and L.E. Erickson, "Rate Limiting Factors for *In Situ* Bioremediation of Soils Contaminated with Hydrocarbons," *Proceedings Fourth International IGT Symposium on Gas*, *Oil*, *and Environmental Biotechnology*, Gas Research Institute, Chicago, Illinois, pages 1-16, 1991.

McDonald, J.P, C.A. Baldwin, L.E. Erickson, and L.T. Fan, "Modeling Bioremediation of Soil Aggregates with Residual NAPL Saturation," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 346-365, 1993.

Miller, M., J. Dana, L.C. Davis, M. Narayanan, and L.E. Erickson, "Phytoremediation of VOC-Contaminated Groundwater Using Poplar Trees," *Proceedings of the 26th Annual Biochemical Engineering Symposium*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 42-51, 1997. Project no. 94-27.

Miller, C.M., R.L. Valentine, J.L. Stacy, M.E. Roehl, and P.J.J. Alvarez, "Chemical Oxidation and Toxicity Reduction of Pesticide-Contaminated Soils," *Bioremediation of Recalcitrant Organics*, R.E. Hinchee, D.B. Anderson, and R.E. Hoeppel (Eds.), Battelle Press, Columbus, pages 175-182, 1995.

Moats, M.S., and T.J. O'Keefe, "Optimization of Ferric Reduction in Di-Ethylehxyl Phosphoric Acid by Separate Galvanic Stripping," *Second International Symposium on Extraction and Processing for the Treatment and Minimization of Wastes*, V. Ramachandran and C.C. Nesbitt (Eds.), pages 673-684, 1996. Project no. 94-05.

Moats, M.S., C.M. Chang, and T.J. O'Keefe, "Recovery of Zinc from Residues by SX-Galvinic Stripping Process," *Third International Symposium on Recycling of Metals and Engineered Materials*, P.B. Queneau and R.D. Peterson (Eds.), pages 545-561, 1995. Project no. 94-05.

Mohs, C., and K.J. Klabunde, "Photocatalytic Oxidation of Chloroform by Titanium Dioxide," *Proceedings of the 9th Annual Conference on Hazardous Waste Research*, Bozeman, Montana, page 103, 1994. Project no. 89-26, 92-03.

Mohs, C., and K.J. Klabunde, "Preparation of Small Particles of Titanium (IV) Oxide," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 165-170, 1993. Project no. 89-26, 92-03.

Mohs, C., and K.J. Klabunde, "Preparation of Small Particles of Titanium (IV) Oxide," *Proceedings of the NATO Advanced Study Institute on Nanophase Materials: Synthesis, Properties, and Applications*, Kluwer Academic Publishers, G.C. Hadjipanayis and R.W. Siegel (Eds.), Corfu, Greece, Vol. 260, pages 121-124, 1994.

Nair, D.R., and J.L. Schnoor, "Modeling of Alachlor and Atrazine at a Small Plot in Amana, Iowa," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 89-112, 1990.

Nam, K.S., S. Kapila, A.F. Yanders, R.K. Puri, and D.S. Viswanath, "Supercritical Fluid Extraction and Cleanup Procedures for Determination of Xenobiotics in Biological Samples," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 138-151, 1990.

Narayanan, M., L.C. Davis, and L.E. Erickson, "Monitoring the Fate of Toluene and Phenol in the Rhizosphere," *Proceedings of the 23rd Annual Biochemical Engineering Symposium*, R. Harrison (Ed.), University of Oklahoma, Norman, Oklahoma, pages 46-53, 1993.

Narayanan, M., R.M. Green, L.E. Erickson, and L.C. Davis, "A Laboratory Study of the Fate of Trichloroethylene and 1,1,1-Trichloroethane in the Presence of Vegetation," *Proceedings of 24th Annual Biochemical Engineering Symposium,* Rob Davis (Ed.), University of Colorado-Boulder, pages 110-118, 1994.

Narayanan, M., L.C. Davis, and L.E. Erickson, "Biodegradation Studies of Chlorinated Organic Pollutants in a Chamber in the Presence of Alfalfa Plants," *Proceedings of the 25th Biochemical Engineering Symposium*, University of Missouri, Columbia, Missouri, pages 11-20, 1995. Project no. 94-27.

Narayanan, M., L.C. Davis, L.E. Erickson, R.M. Hoffman., N.K. Russell, R.M. Hammaker, and W.G. Fateley, "Modeling and Analysis of Transport and Biodegradation in Laboratory Chambers with Plants," *Proceedings of the 5th World Congress of Chemical Engineering*, San Diego, California, AIChE, New York, Vol. 3, pages 694-699, 1996. Project no. 94-27.

Narayanan, M., J. Hu, L.C. Davis, and L.E. Erickson, "Effect of Water Content on Transport of Trichloroethylene in a Chamber with Alfalfa Plants," *Proceedings of the 26th Annual Biochemical Engineering Symposium*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 110-119, 1997. Project no. 94-27.

Narayanan, M., N.K. Russell, L.C. Davis, and L.E. Erickson, "Experimental and Modeling Studies of the Fate of Trichloroethylene in a Chamber with Alfalfa Plants," *Proceedings of the HSRC-WERC Joint Conference on the Environment,* Albuquerque, New Mexico, pages 474-481, 1996. URL: http://www.engg.ksu.edu/HSRC/96Proceed/. Project no. 94-27.

Narayanan, M., J.B. Reddy, D.A. Gustafson, L.E. Erickson, P. Kulakow, B.A. Leven, and S. Burckhard, "Vegetated Treatment of Vehicle Wash Sediments: Designing a Graphical User

Interface, *Proceedings of the 2000 Conference on Hazardous Waste Research*, Denver, Colorado, pages 177-185, May 2000. Project no. SP-96.

Narayanan, M., L.E. Erickson, P. Kulakow, B.A. Leven, and S. Burckhard, "Vegetated Treatment of Vehicle Wash Sediments: Mathematical Modeling of Groundwater and Solute Transport, *Proceedings of the 2000 Conference on Hazardous Waste Research*, Denver, Colorado, pages 186-193, May 2000. Project no. SP-96.

Nedunuri, K.V., R.S. Govindaraju, L.E. Erickson, and A.P. Schwab, "Modeling of Heavy Metal Movement in Vegetated, Unsaturated Soils with Emphasis on Geochemistry," *Proceedings of the 10th Annual Conference on Hazardous Waste Research*, Kansas State University, Manhattan, Kansas, pp. 57-66, 1995. Project no. 93-06.

Nedunuri, K.V., R.S. Govindaraju, A.P. Schwab, and L.E. Erickson, "Geochemical Modeling of Lead in Vadose Zone," *ASCE North American Water and Environment Congress*, CD-ROM, Anaheim, California, 1996. Project no. 93-06.

Neira, M.P., J.L. Watson, and T.J. O'Keefe, "The Effect of Entrained Di-2-Ethylhexyl Phosphoric Acid (D2EHPA) on Zinc Electrowinning," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 55-65, 1991.

Neira, M.P., and T.J. O'Keefe, "Zinc Electrowinning from Waste Oxide Generated Using Ausmelt Pyroprocessing," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 246-264, 1992.

Nieman, J.K., D.O. Kimball, R.C. Sims, and J.A. Rice, "Incorporation of PAH into Soil Components as Affected by Alternate Electron Acceptor Addition During Land Farming," *Proceedings of the 4th International Symposium of In Situ and On-Site Bioremediation*, Vol. 2, Battelle Press, Columbus, Ohio, Vol. 2, pages 181-184, 1997. Project no. 93-21.

O'Connor, J.T., and B.J. Brazos, "The Response of Natural Groundwater Bacteria to Groundwater Contamination by Gasoline in a Karst Region," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 281-293, 1991. Project 89-17.

Okeson, S.J., T.H. Illangasekare, D.C. Szlag, and J.E. Ewing, "Modeling of Dissolution Transport of Nonaqueous-Phase Liquid Wastes in Heterogeneous Aquifers," *Proceedings of the 10th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 146-152, 1995. URL: http://www.engg.ksu.edu/HSRC/95Proceed/home.html.

Orchard, B.J., W.J. Doucette, J.K. Chard, and B. Bugbee, "Laboratory Studies on Plant Uptake of TCE," *Phytoremediation and Innovative Strategies for Specialized Remedial Applications,* pages 127-132, 1999. Project no. 95-10.

Parkin, G.F., L.J. Weathers, P.J. Novak, and P.J.J. Alvarez, "Enhanced Anaerobic Bioremediation Using Elemental Iron," *Water Resources and Urban Environments–1998 Proceedings of the ASCE National Conference on Environmental Engineering*, Chicago, Illinois, pages 128-133, 1998. Project no. 93-02.

Parkin, G.F., D.T. Adamson, and J.B. Hughes, "Anaerobic Biotransformation of Mixtures of Chlorinated Aliphatic Hydrocarbons," *Proceedings of the AGU Annual Meeting*, San Francisco, California, 1997. Project no. 93-24.

Patel, B.B., S.T. Chou, and L.T. Fan, "Simulation of Waste Generation During Start-Up of an Interconnected Process Network," *Proceedings of the 10th Annual Conference on Hazardous Waste Research*, pages 271-280, Kansas State University, Manhattan, Kansas, 1995. Project no. 91-36.

Paterson, K.G., and J.L. Schnoor, "Fate and Transport of Alachlor and Atrazine in an Unsaturated Riparian Zone," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. II, pages 561-591, 1990.

Peyton, R.L., S.H. Anderson, C.J. Gantzer, J.W. Wigger, and H. Wang, "X-Ray Computed Tomography as a Tool in Contaminant Transport Research," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. II, pages 715-732, 1990.

Pierzynski, G.M., "Characterization of Lead and Zinc Mine Tailings and Heavy Metal-Contaminated Soils in Southeast Kansas," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 511-520, 1991.

Pierzynski, G.M., and A.P. Schwab, "Reducing Heavy Metal Availability to Soybeans Grown on a Metal-Contaminated Alluvial Soil," *American Society of Agronomy Meetings*, Minneapolis, Minnesota, page 53, 1992.

Pierzynski, G.M., and A.P. Schwab, "Reducing Heavy Metal Availability to Soybeans Grown on a Metal-Contaminated Soil," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 543-553, 1992.

Pierzynski, G.M., "Strategies for Remediating Trace Element-Contaminated Sites,"*Remediation of Soils Contaminated with Metals*, A.K. Iskandar and D.C. Adriano (Eds.), Science Reviews, Northwood, England, pages 67-84, 1997.

Pierzynski, G.M., G.M. Hettiarachchi, and J.K. Koelliker, "Methods for Assessing the Effects of Soil Degradation on Water Quality," *Methods of Assessment of Soil Degradation, Advances in Soil Science*, R. Lal, W. Blum, C. Valentine, and B.A. Stewart (Eds.), CRC Press, Boca Raton, Florida, pages 513-545, 1997. Project no. 93-07.

Pierzynski, G., G. Hettiarachchi, M.W. Lambert, and L.E. Erickson, "*In Situ* Remediation of Pb in Soils Using Phosphorus," *Proceedings of the 1998 Conference on Hazardous Waste Research,* page 40, 1998. Project no. 93-07.

Pierzynski, G., L. Licht, J.L. Schnoor, and L.E. Erickson, "Revegetation of a Pb/Zn Smelter Site Using Poplar Trees," *Proceedings of the 1998 Conference on Hazardous Waste Research,* pages 46-47, 1998. Project no. 93-07.

Pierzynski, G.M., J.L. Schnoor, M.K. Banks, J.C. Tracy, L.A. Licht, and L.E. Erickson, "Vegetative Remediation at Superfund Sites," *Mining and Its Environmental Impact–Issues in*

Environmental Science and Technology, R.E. Hester and R.M. Harrison (Eds.), Royal Society of Chemistry, Vol. 1, pages 46-69, 1994.

Pierzynski, G.M., G. Hettiarachchi, M.W. Lambert, L.E. Erickson, D. Sweeney, and B. Hetrick, "Remediation of Metal-Contaminated Sites in the Tri-State Mining Region, U.S.A.," *Proceedings of the 16th World Congress of Soil Science*, Montpellier, France, CD-ROM, 1998.

Pitzer, C.R., S. Castro, L.C. Davis, and L.E. Erickson, "Diffusion of MTBE Through Alfalfa," *Proceedings of the 30th Annual Biochemical Engineering Symposium,* D.S. Kompala, Editor, University of Colorado, pages 75-78, 2000. Project no. 98-03.

Rao, D., and T.E. Clevenger, "Effect on the Mobility of Lead from a Landfill Located in a Mine Waste Site," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 495-510, 1991.

Rayavarapu, R., S.K. Banerji, and R.K. Bajpai, "Biodegradation of PCP by *Pseudomonas cepacia*," *Proceedings of the 20th Annual Biochemical Engineering Symposium*, pages 68-76, 1990.

Rayavarapu, R., S.K. Banerji, and R.K. Bajpai, "Biodegradation of PCP by *Pseudomonas cepacia*," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 47-62, 1990.

Rice, J.A., "Contaminant Binding to Humin," *Proceedings of the National Meeting of the American Waste Management Association*, Nashville, Tennessee, Abstract no. 96-RP141.02, 1996.

Roe, F., Z. Lewandowski, D. Chen, and R. Hughes, "Theoretical and Experimental Studies on Diffusion of Metal Ions and Reaction with Biopolymers," *Biohydrometallurgical Technologies: Proceedings of an International Biohydrometallurgy Symposium*, A.E. Torma, M.L. Apel, and C.L. Brierley, (Eds.), Jackson Hole, Wyoming, Vol. 2, pages 145-158, 1993.

Ruan, H., T.H. Illangasekare, B.P. Greimann, and I. Litaor, "Calibration of a Model for Preferential Flow in the Vadose Zone at the Column Scale," *Model CARE 96 (Calibration and Reliability in Groundwater Modeling) Poster Papers*, pages 215-224, 1996.

Ruan, H., and T.H. Illangasekare, "A Model of the Relative Hydraulic Conductivity of Unsaturated Sandy Soils," *Proceedings of the International Workshop on Characterization and Measurement of the Hydraulic Properties of Unsaturated Porous Media,* 1997, pages 43-51, 1999. Project no. 94-29.

Ruan, H., and T.H. Illangasekare, "A Model for Relative Hydraulic Conductivity for Unsaturated Sandy Soils," *Proceedings of the International Workshop on Unsaturated Porous Media*, Riverside, California, pages 43-51, 1997. Project no. 94-29.

Russell, N.K., L.C. Davis, and L.E. Erickson, "A Review of Contaminant Transport to the Gas Phase Above Fields of Vegetation," *Proceedings of the 89th Annual Meeting and Exhibition of the Air and Waste Management Association*, Nashville, Tennessee, paper #96-RP141.01, 1996. Project no. 94-27.

Ryu, S.B., L.C. Davis, J. Dana, K. Selk, and L.E. Erickson, "Evaluation of Toxicity of Trichloroethylene for Plants," *Proceedings of the HSRC-WERC Joint Conference on the Environment,* Albuquerque, New Mexico, pages 583-588, 1996. URL: http://www.engg.ksu.edu/HSRC/96Proceed/. Project no. 94-27.

Santharam, S.K., L.E. Erickson, and L.T. Fan, "Modeling the Fate of Polynuclear Aromatic Hydrocarbons in the Rhizosphere," *Proceedings of the 9th Annual Conference on Hazardous Waste Remediation,* L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Bozeman, Montana, pages 333-350, 1994.

Santharam, S.K., L.E. Erickson, and L.T. Fan, "Modeling the Fate of Pyrene in the Rhizosphere," *Proceedings of the 24th Annual Biochemical Engineering Symposium*, R.H. Davis (Ed.), University of Colorado, Boulder, pages 119-128, 1994.

Santharam, S.K., L.T. Fan, and L.E. Erickson, "Surfactant-Enhanced Extraction and Biodegradation of a Nonaqueous-Phase Liquid in Soil," *Proceedings of the Conference on Nonaqueous-Phase Liquids (NAPLs) in Subsurface Environment: Assessment and Remediation*, L.N. Reddi (Ed.), American Society of Civil Engineers, New York, pages 419-430, 1996. Project no. 94-27.

Satapanajaru, T., C. Gibb, P.J. Shea, S.D. Comfort, and T.A. Machacek, "Aluminum and Ferrous Sulfate Catalyzed Destruction of Metolachlor by Zerovalent Iron," *Abst. Am. Soc. Agron.*, Vol. 92, page 411. Project no. 95-32.

Scherer, M.M., S. Richter, R.L. Valentine, and P.J.J. Alvarez, "Chemistry and Microbiology of Permeable Reactive Barriers for *In Situ* Groundwater Cleanup," *Critical Review of Environmental Science Technology*, Vol. 30, pages 363-411, 2000. Project no. 98-01.

Schnoor, J.L., "Vegetative Remediation of Volatile and Semi-Volatile Organics," *Plant Biotechnological Institute Bulletin,* National Research Council, Canada, September 6-9, 1998.

Schnoor, J.L., and V. Thomas, "Soil as a Vulnerable Environmental System," *Industrial Ecology and Global Change*, R. Socolow (Ed.), Cambridge University Press, Cambridge, United Kingdom, pages 233-244, 1994.

Schwab, A.P., "Chemical and Physical Characterization of Soils," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 326-344, 1992.

Schwab, A.P., and M.K. Banks, "The Impacts of Vegetation on the Leaching of Heavy Metals from Mine Tailings," *Proceedings of Air & Waste Management Association Annual Meeting*, Paper 93-WA-89.06, 1993.

Schwab, A.P., M.K. Banks, and M. Arunachalam, "Influence of the Rhizosphere on Biodegradation of Phenanthrene and Pyrene," *On-Site Bioreclamation*, Hinchee and Olfenbuttel (Eds.), Butterworth and Heinemann, 1995.

Seybert, R.A., W.P. Walawender, and L.T. Fan, "Preliminary Evaluation of Carbon Tetrachloride Destruction in the KSU Bench-Scale Incinerator," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 426-451, 1989.

Shea, P.J., and S.D. Comfort, "Iron-Mediated Remediation of Contaminated Soil and Water," *Proceedings of the Korean Society of Agricultural Chemistry and Biotechnology,* pages 65-86, 2000. Project no. 95-32.

Shea, P.J., and S.D. Comfort, "Remediating Munitions-Contaminated Soils," *Abstracts and Proceedings of the 21st Annual RREL Research Symposium*, E.L. George (Ed.), EPA/600/R-95/012, U.S. EPA, Cincinnati, Ohio, pages 354-358, 1995.

Shimp, J.F., E. Lee, W. Huang, L.E. Erickson, J.C. Tracy, L.C. Davis, and J.L. Schnoor, "Concepts Involved in Developing Soil and Groundwater Remediation Strategies Using Plants," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 629-647, 1991.

Shimp, J.F., L.C. Davis, J.C. Tracy, E. Lee, Y. Huang, and L.E. Erickson, "Predictive Model for Contaminant Degradation in the Rhizosphere," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 317-325, 1992.

Shimp, J.F., J.C. Tracy, E. Lee, L.C. Davis, and L.E. Erickson, "Modeling Contaminant Transport, Biodegradation, and Uptake by Plants in the Rhizosphere," *Proceedings of the Twenty-Second Annual Biochemical Engineering Symposium*, Iowa State University, Ames, Iowa, pages 181-190, 1992.

Shue, S.L., R.E. Faw, and J.K. Shultis, "Fast Neutron Thermalization and Capture Gamma-Ray Generation in Soils," *Proceedings of the HSRC-WERC Joint Conference on the Environment,* Albuquerque, New Mexico, pages 596-613, 1996. URL: http://www.engg.ksu.edu/HSRC/96Proceed/.

Shultis, J.K., R.E. Faw, and F.A. Khan, "Methods for Determining Soil Contaminant Profiles from Prompt-Neutron Gamma Activation Data," *Proceedings of the HSRC-WERC Joint Conference on the Environment,* Albuquerque, New Mexico, pages 614-631, 1996. URL: http://www.engg.ksu.edu/HSRC/96Proceed/.

Sims, J.L., R.C. Sims, D.L. Sorensen, and S.G. Huling, "Prepared-Bed Bioreactors," *Bioremediation of Contaminated Soils*, No. 37*,* D.C. Adriano, J.M. Bollag, W.T. Frankenberger, Jr., and R.C. Sims (Eds.), Soil Science Society of America Publication, pages 559-594, 1999. Project no. 93-21.

Sims, R.C., "Migration of the Major Wood Preservatives and the Potential for Groundwater, Surface Water, and Soil Contamination," *Proceedings of the Workshop on Utility Poles: Environmental Issues*, University of Madison-Madison, Wisconsin, 1997. Project no.93-21.

St. Clair, M.A., C. Mojonnier, and J.L. Schnoor, "Photochemical Treatment Process for Mine-Tailing Leachates," *Preprint Extended Abstracts*, *204th National Meeting of the American Chemical Society*, Environmental Chemistry Division, Washington, D.C., ENVR40, 1992.

Stark, J.V., and K.J. Klabunde, "Nanoscale Magnesium Oxide Used to Adsorb SO_2 and CO_2," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 117-121, 1993. Project no. 89-26, 92-03.

Stark, J.V., and K.J. Klabunde, "Nanoscale Magnesium Oxide Used to Adsorb SO_2 and CO_2," *Proceedings of the NATO Advanced Study Institute on Nanophase Materials: Synthesis, Properties, and Applications*, Kluwer Academic Publishers, G.C. Hadjipanayis and R.W. Siegel (Eds.), Corfu, Greece, Vol. 260, pages 797-800, 1994. Project no. 89-26, 92-03.

Steichen, J.M., P. Barnes, and S. Siegele, "Atrazine Movement in Soil Compared with PRZM and GLEAMS Models," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 12-29, 1991.

Sturman, P.J., W.L. Jones, and W.G. Characklis, "Interspecies Competition in Colonized Porous Pellets," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 66-70, 1991.

Sturman, P.J., W.L. Jones, W.G. Characklis, and A.B. Cunningham, "Interspecies Competition in Colonized Porous Pellets," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 219-245, 1992.

Sturman P.J., A.B. Cunningham, and P. Stewart, "A Scaleup Approach for the Design and Operation of *In Situ* Bioremediation Systems," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan Kansas, pages 85-92, 1993.

Sturman, P.J., P. Stewart, R. Sharp, J. Wolfram, and A.B. Cunningham, "Scaleup Implications of Respirometrically Determined Microbial Kinetic Parameters," *Proceedings of the Second International Symposium on In Situ and On-Site Bioreclamation*, San Diego, California, pages 300-304, 1993.

Szlag, D.C., and T.H. Illangasekare, "Experimental Investigation and Modeling of Immiscible Liquid Entrapment in Porous Media," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 127-143, 1992.

Szlag, D., and T.H. Illangasekare, "Dissolution of Trapped Nonaqueous-Phase Liquids in Heterogeneous Aquifers and Determination of Mass Transfer Coefficients," *Proceedings of the 8th Annual Conference Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 107-115, 1993.

Szlag, D.C., T.H. Illangasekare, T. Fairbanks, D. Znidarcic, D. Kampbell, and J.T. Wilson, "Retrospective Evaluation of a Bioremediated Aquifer Contaminated with Organic Chemicals – Part Model Application," *Proceedings of the 86th Annual Meeting of the Air and Waste Management Association*, Denver, Colorado, Paper No. 83-TP-65.01, 1993.

Szlag, D.C., T.H. Illangasekare, and J.T. Wilson, "Use of a Three-Dimensional Groundwater Model for Retrospective Evaluation of a Bioremediated Aquifer Contaminated with Organic Chemicals," *Proceedings of 1993 Groundwater Modeling Conference*, International Groundwater Modeling Center, Colorado School of Mines, Golden, Colorado, pages 5.21-5.30, 1993.

Szlag, D.C., and T.H. Illangasekare, "Dissolution of NAPLs in Heterogeneous Porous Medium at Greater Residual Saturation," *Proceedings of the 9th Annual Conference on Hazardous Waste*

Remediation, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Bozeman, Montana, pages 25-34, 1994.

Szlag, D.C., and T.H. Illangasekare, "Rate-Limited Dissolution of Entrapped Nonaqueous-Phase Liquids in Heterogeneous Soils," *Proceedings of the 1994 Groundwater Modeling Conference*, J.W. Warner and P. van der Heijde (Eds.), International Groundwater Modeling Center, Ft. Collins, Colorado, pages 425-432, 1994.

Till, B.A., L.J. Weathers, and P.J.J. Alvarez, "Fe^0-based Bioremediation of Nitrate-Contaminated Waters," *In Situ and On-Site Bioremediation, Vol. 3*, B.C. Alleman and A. Leeson (Eds.), Battelle Press, Columbus, Ohio, pages 367-372, 1997. Project no. 93-02.

Tracy, J.C., L.E. Erickson, J.F. Shimp, and L.C. Davis, "Modeling the Beneficial Effects of Vegetation in the Management of Landfill Leachates," *Proceedings of the Air & Waste Management Association's 1991 Annual Meeting and Exhibition*, Paper 92-27.03, pages 1-16, 1992.

Tracy, J.C., and J. Brummer, "Estimation of the Hydraulic Flow Parameters for the Alluvial Aquifer Underlying the Riley County Landfill," *Proceedings of the 1993 International Groundwater Modeling Conference*, International Groundwater Modeling Conference, Golden, Colorado, pages 1-11 to 1-20, 1993.

Tracy, J.C., L.E. Erickson, and L.C. Davis, "Rate-Limited Degradation of Hazardous Organic Contaminants in the Root Zone of a Soil," *Proceedings of the 86th Annual Meeting of the Air and Waste Management Association*, Paper No. 93-WA-89.02, 1993.

Tracy, J.C., H. Ramireddy, L.E. Erickson, and L.C. Davis, "Effects of Climatological Variability on the Performance of Vegetative Systems in Remediating Contaminated Soil," *Proceedings of the 87th Annual Meeting of the Air & Waste Management Association*, Paper No. 94-WA-86.01, 1994.

Tuitemwong, P., B.M. Sly, S. Dhawan, L.E. Erickson, and J.R. Schlup, "Microcosm Treatability of Soil Contaminated with Petroleum Hydrocarbons," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. II, pages 893-925, 1990.

Tuitemwong, P., L.E. Erickson, X. Yang, and L.T. Fan, "Effects of Depth of a Soil Column on the Biodegradation of Palmitate," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 601-615, 1992.

Turner, J.P., M.L. Dennis, Y. Osman, J. Chase, and L.A. Bulla, "Biofilm Treatment of Soil for Waste Containment and Remediation," *Proceedings of the International Containment Technology Conference*, U.S. Department of Energy, DuPont Company, and U.S. Environmental Protection Agency, pages 672-678, 1997. Project no. 94-26.

Utamapanya, S., K.J. Klabunde, and J. Schlup, "Nanoscale Metal Oxide Particles/Clusters as Chemical Reagents. Synthesis and Properties of Ultra-High Surface Area Magnesium Oxide," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 170-203, 1990.

Valentine, R.L., A.H. Wang, and C. Miller, "Hydrogen Peroxide Decomposition and Organic Contaminant Loss in the Presence of Iron Oxides," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 185-196, 1991.

Varga, J.B., F. Friedler, and L.T. Fan, "Risk Reduction Through Waste-Minimizing Process Synthesis," *Proceedings of the 21st Annual Risk Reduction Engineering Laboratory (RREL) Research Symposium*, Cincinnati, Ohio, pages 359-363, 1995. Project no. 91-36.

Venkatraman, A., W.P. Walawender, S.M. Chern, and L.T. Fan, "Applications of Mass Spectrometry in Monitoring Incineration Processes," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 522-542, 1992.

Walser, G.S., T.H. Illangasekare, and A.T. Corey, "Retention of Liquid Contaminants in Layered Soils," *Proceedings of the 9th Annual Conference on Hazardous Waste Remediation,* L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Bozeman, Montana, pages 35-48, 1994. Project no. 94-29.

Walton, C.W., "Material Recovery and Treatment Methods Used in the Chromium Electroplating Process," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. II, pages, 652-672, 1990.

Walton, C.W., A.C. Hillier, and G.L. Poppe, "Process Options for Waste Minimization and Metal Recovery for the Metal Finishing Industries," *Proceedings of the International Conference on Pollution Prevention: Clean Technologies and Clean Products*, EPA/600/9-90/039, U.S. EPA, Washington, DC, pages 703-712, 1990.

Walton, C.W., K.J. Loos, and T.A. Lewis, "Application of Electrodialysis Techniques to Remediation of Heavy Metal-Contaminated Waters," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 552-560, 1991.

Walton, C.W., K. Briggs, and K.J. Loos, "Waste Minimization and Remediation in the Metal Finishing Industries," *Industrial Environmental Chemistry I: Waste Minimization in Industrial Processes and Remediation of Hazardous Wastes*, D.T. Sawyer and A.E. Martell (Eds.), Plenum Publishing Corporation, New York, pages 71-87, 1992.

Wang, H., R.L. Peyton, and S.H. Anderson, "Estimation of Small-Scale Porosity, Velocity, and Hydraulic Conductivity in Porous Media Using X-Ray Computed Tomography: Theory and Model Testing," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 609-623, 1991.

Wang, H., R.L. Peyton, S.H. Anderson, and C.J. Gantzer, "Simulation of Three-Dimensional Transport of Hazardous Chemicals in Heterogeneous Soil Cores Using X-Ray Computed Tomography," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 39-56, 1992. Project no. 89-14.

Wang, J., S.K. Banerji, and R.K. Bajpai, "Migration of Pentachlorophenol Through Soil Columns in Presence of a Nonaqueous Phase," *Proceedings of the Conference on Hazardous Waste*

Research, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 57-65, 1992.

Wang, J., S.K. Banerji, and R.K. Bajpai, "Migration of PCP in Unsaturated and Saturated Soils," *Proceedings of the 22nd Annual Biochemical Engineering Symposium*, Iowa State University, Ames, Iowa, pages 11-20, 1992.

Wang, W., J.L. Schnoor, and J. Doi (Eds.), "Volatile Organic Compounds in the Environment," *ASTM*, West Conshohocken, PA, 1996. Project no. 95-29.

Wang, L., J.R. Foeller, and R.L. Segar, Jr., "Sand Media Type and Charge Effects on TCE Cometabolism in a Fluidized-Bed Bioreactor," *Proceedings of the 14th Annual Conference on Hazardous Waste Research,* L.E. Erickson and M.M. Rankin, (Eds.) St. Louis, Missouri, pages 167-185, 1999. Project no. 94-07.

Watanabe, H., J.M. Steichen, P. Barnes, N.L. Watermeier, P.J. Jasa, D.P. Shelton, and E.C. Dickey, "Water Quality Aspects of Tillage, Soil Type, and Slope. Part II: Atrazine and Alachlor Losses," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 166-181, 1992.

Watermeier, N.L., P.J. Jasa, D.P. Shelton, E.C. Dickey, H. Watanabe, and J.M. Steichen, "Water Quality Aspects of Tillage, Soil Type, and Slope. Part I: Runoff and Soil Erosion," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 149-165, 1992.

Waters, C.Y., M.K. Banks, and A.P. Schwab, "Zinc Movement in Mine Tailings Amended with Organics," *Proceedings of the CSCE-ASCE National Conference, Environmental Division*, Montreal, Canada, pages 237-241, 1993.

Weathers, L.J., and G.F. Parkin, "Metallic Iron-Enhanced Biotransformation of Carbon Tetrachloride and Chloroform Under Methanogenic Conditions," *Third International In Situ and On-Site Bioreclamation Symposium*, R.E. Hinchee, A. Leeson, and L. Semprini (Eds.), Vol. 3, pages 117-122, 1995.

Weathers, L.J., G.F. Parkin, P.J. Novak, and P.J.J. Alvarez, "Methanogens Couple Anaerobic Fe(0) Oxidation and $CHCl_3$ Reduction," *Preprints of Papers, 209th ACS National Meeting*, American Chemical Society, Anaheim, California, 1995.

Wei, S.M., S.K. Banerji, and R.K. Bajpai, "Pentachlorophenol Interactions with Soil," *Proceedings of the 20th Annual Biochemical Engineering Symposium*, pages 159-168, 1990.

Wei, S.M., S.K. Banerji, and R.K. Bajpai, "Pentachlorophenol Interactions with Soil," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, Vol. I, pages 322-346, 1990.

Wetzel, S., M.K. Banks, and A.P. Schwab, "Effects of the Rhizosphere on the Degradation of Pyrene and Anthracene in Soil," *Phytoremediation of Soil and Water Contaminants,* E.L. Kruger, T.A. Anderson, and J.R. Coats (Eds.), American Chemical Society Symposium Series 664, pages 254-263, 1997.

Wildcat, D.R., G.L. Godfrey, M.D. Tosse, D.L. Tillison, S.C. Grant, and L.E. Erickson, "The NAOMI Program: Developing Hazardous Substance Programs at Native American and Other Minority Educational Institutions," *Proceedings of the 9th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Montana State University, Bozeman, Montana, pages 361-365, 1994.

Wildenschild, D., K.H. Jensen, T.H. Illangasekare, and D. Znidarcic, "Identification of Hydraulic Parameters for Unsaturated Flow Using Combined Direct Measurements and Inverse Solution Techniques," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 21-34, 1993.

Willson, C.S., J.W. Weaver, T.H. Illangasekare, and R.J. Charbeneau, "Framework for a Screening Model for DNAPL Contamination of Porous Media," *ASCE Conference on Nonaqueous-Phase Liquids in the Subsurface Environment: Assessment and Remediation,* ed. L.M. Reddi, pages 407-418, Washington, D.C., 1996.

Wu, X., N. Chou, D. Lupher, and L.C. Davis, "Benzotriazoles: Toxicity and Biodegradation," *Proceedings of the 13th Annual Conference on Hazardous Waste Research*, Snowbird, Utah, pages 374-382, 1998. Project no. 94-27.

Wu, X. and L.C. Davis, "Detection of Specific Microorganisms Using the Arbitrary Primed PCR in the Bacterial Community of the Vegetated Soil," *Proceedings of the 26th Annual Biochemical Engineering Symposium*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 120-126, 1997. Project no. 94-27.

Wu, X., L.C. Davis, and L.E. Erickson, "Examining the Fate of Released Pseudomonas putida Fl in Rhizosphere Environments," *Proceedings of the 12th Annual Conference on Hazardous Waste Research*, L.E. Erickson, M.M. Rankin, S.C. Grant and J.P. McDonald (Eds.), Kansas State University, pages 492-499, 1997. Project no. 94-27.

Wu, J.C., L.T. Fan, and L.E. Erickson, "Modeling and Simulation of Bioremediation of Contaminated Soil: A Case Study with Recycle of Nutrient Solution," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 121-146, 1989.

Wu, X., L.C. Davis, and L.E. Erickson, "Examining the Fate of Released Pseudomonas Putida F1 in Rhizosphere Environments," *Proceedings of the 12th Annual Conference on Hazardous Waste Research*, L.E. Erickson, M.M. Rankin, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, pages 492-499, 1997.

Yang, X., L.E. Erickson, and L.T. Fan, "Dispersive-Convective Transport in the Biorestoration of Contaminated Clay Layers," *Proceedings of the Conference on Hazardous Waste Research*, L.E. Erickson, S.C. Grant, and J.P. McDonald (Eds.), University of Colorado, Boulder, Colorado, pages 581-600, 1992.

Yang, X., L.E. Erickson, and L.T. Fan, "Modeling of Dispersive-Convective Characteristics in Bioremediation of Contaminated Soil," *Proceedings of the 22nd Annual Biochemical Engineering Symposium*, P.J. Reilly (Ed.), Iowa State University, Ames, Iowa, pages 191-200, 1992.

Yang, X., L.E. Erickson, and L.T. Fan, "Mass Transfer in the Bioremediation of Soils Contaminated with Trapped Nonaqueous-Phase Liquids," *Proceedings of the 23rd Annual Biochemical Engineering Symposium*, Norman, Oklahoma, pages 110-119, 1993.

Yang, X., L.E. Erickson, and L.T. Fan, "Transport Properties of Toluene as a Nonaqueous-Phase Liquid in Groundwater," *Proceedings of the 8th Annual Conference on Hazardous Waste Research*, L.E. Erickson, D.L. Tillison, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, Manhattan, Kansas, pages 313-330, 1993.

Zawaideh, L.L., and T.C. Zhang, "Effect of pH and Addition of an Organic Buffer (HEPES) on Nitrate Transformation on Fe^0-Water System," *Water Quality International 1998: Proceedings of the IAWQ 19th Biennial International Conference*, Vancouver, Canada, Book 7, pages 108-115, 1998. Project no. 95-32.

Zawaideh, L.L., C.F. Chew, and T.C. Zhang, "Remediation of Nitrate-Containing Water and Soil by Fe^0-Promoted Processes," *Proceedings of the 12th Annual Conference on Hazardous Waste Research*, L.E. Erickson, M.M. Rankin, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, pages 77-97, 1997. Project no. 95-32.

Zhang, Q., L.C. Davis, and L.E. Erickson, "A Microcosm Study on Biodegradation of Methyl-Tert-Butyl Ether (MTBE)," *Proceedings of 29th Annual Biochemical Engineering Symposium,* University of Oklahoma, Norman, Oklahoma, pages 99-107, 1999. Project no. 94-27, 94-27A.

Zhang, Q., L.C. Davis, and L.E. Erickson, "An Experimental Study of Phytoremediation of Methyl-Tertiary-Butyl Ether (MTBE) in Groundwater," *Proceedings of the 1999 Conference on Hazardous Waste Research,* St. Louis, Missouri, pages 227-242, 1999. Project no. 94-27.

Zhang, Q., L.C. Davis, and L.E. Erickson, "An Experimental Study of Trichloroethylene Fluxes into the Atmosphere," *Proceedings of the 27th Annual Biochemical Engineering Symposium*, Colorado State University, Fort Collins, Colorado, 1998. Pages 122-132. Project no. 94-27.

Zhang, Q., L.C. Davis, and L.E. Erickson, "Biodegradation and Remediation of Methyl-Tert-Butyl Ether," *Proceeding of the 28th Annual Biochemical Engineering Symposium,* Iowa State University, Ames, Iowa, 1998. Pages 23-32. Project no. 94-27.

Zhang, Q., L.C. Davis, and L.E. Erickson, "Plant Uptake of Methyl Tert-Butyl Ether (MTBE) from Groundwater," In *Environmental and Pipeline Engineering,* R.Y. Surampalli, Ed., ASCE, Reston, Virgina, pages 166-173, 2000. Project no. 94-27, 94-27A.

Zhang, Q., L.C. Davis, and L.E. Erickson, "Using Vegetation to Treat Methyl-Tert-Butyl Ether Contaminated Groundwater," *Proceedings of the 13th Annual Conference on Hazardous Waste Research*, Snowbird, Utah, 1998. pages 262-272. Project no. 94-27.

Zhang, Q., J. Hu, L.E. Erickson, and L.C. Davis, "Effect of Air Sparging on Fate and Transport of Trichloroethylene in Chambers with Alfalfa Plants," *Proceedings of the 12th Annual Conference on Hazardous Waste Research*, L.E. Erickson, M.M. Rankin, S.C. Grant, and J.P. McDonald (Eds.), Kansas State University, pages 564-573, 1997. Project no. 94-27.

Zhang, Q., B. Goplen, S. Vanderhoof, L.C. Davis, and L.E. Erickson, "Fate and Effect of Trichloroethylene as Nonaqueous-Phase Liquid in Chambers with Alfalfa," *Proceedings of the*

26th Annual Biochemical Engineering Symposium, L.E. Erickson (Ed.), Kansas State University, Manhattan, Kansas, pages 154-163, 1997. Project no. 94-27.

Zhang, S., and C.L. Hansen, "Biological Detoxification of Mercury-Contaminated Soil," *American Society of Agricultural Engineering*, ASAE Summer Meeting, Albuquerque, New Mexico, Paper # 91-6006, 1991.

Znidarcic, D., T.H. Illangasekare, and M. Manna, "Laboratory Testing of and Parameter Estimation for Two-Phase Flow Problems," *Proceedings of the Geotechnical Engineering Congress*, McLean, Campbell, and Harris (Eds.), ASCE, New York, pages 1078-1089, 1991.

E. PROJECT REPORTS

Alvarez, P., G.F. Parkin, and M.M. Scherer, "Iron-Enhanced Bioremediation of Aquifers Contaminated with Chlorinated Solvents, Hexavalent Chromium, and Nitrate," Final Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2001. Project no. 98-1.

Bajpai, R.K., S.K. Banerji, R.K. Puri, and M.E. Zappi, "Remediation of Soils Contaminated with Wood Treatment Chemicals (PCP and Creosote)," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1998. Project no. 94-08.

Balakrishnan, N., "NAOMI Summer Research Cooperation: Speciation of Arsenic," Progress Report, Haskell Environmental Research Studies Center, Haskell Indian Nations University, Lawrence, Kansas, 1994.

Banerji, S., "Biodegradation of Chelating Agents Used in Chelating Extraction of Heavy Metals from Contaminated Soil," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1996.

Banerji, S.K., and R.K. Bajpai, "Migration and Biodegradation of Pentachlorophenol in Soil Environment," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 7.

Banks, M.K., B.A.D. Hetrick, and A.P. Schwab, "Impact of Soil Microflora on Revegetation Efforts in Southeast Kansas," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1994. Project no. 90-11.

Banks, M.K., R.S. Govindaraju, and A.P. Schwab, "Bioremediation of Petroleum-Contaminated Soil Using Vegetation," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995.

Bates, D.K., "Hazardous Substance Research Center Bibliography," Kansas State University, Manhattan, Kansas, 1991.

Boronina, T., and K.J. Klabunde, "Scrubbing Groundwater with Metal Cuts the Contaminants," *Chemecology*, Vol. 24, No. 7, page 7, September 1995. Project no. 89-26, 92-03.

Characklis, W.G., A.B. Cunningham, W.L. Jones, and Z. Lewandowski, "*In Situ* Bioremediation of Organic Groundwater Contaminants," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 89-23.

Clean Sites, Inc., Hazardous Substance Research Center, and EPA Region VIII, "Forum Report on PRP Incentives to Speed Up Settlements and Accelerate Cleanups," Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1993.

Clevenger, T.E., and E.J. Hinderberger, "Reclamation of Metal- and Mining-Contaminated Superfund Sites Using Sewage Sludge/Fly Ash Amendments," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 2.

Coats, J.R., and T.A. Anderson, "Use of Vegetation to Enhance Bioremediation of Surface Soils Contaminated with Pesticide Wastes," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1997. Project no. 93-05.

Comfort, S.D., P.J. Shea, D.L. McCallister, and W.L. Powers, "The Fate and Transport of Munitions Residues in Contaminated Soils," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1997. Project no. 92-24.

Cunningham, A.B., and J.W. Costerton, "Microbial Transport in Porous Media," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1994. Project no. 91-25.

Cunningham, A.B., P.J. Sturman, and B.K. Warwood, "Microbial Process Engineering Concepts," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1994.

Cunningham, A.B., and R. Hiebert, "Subsurface Biofilm Barriers (Biobarriers) for the Containment of Contaminated Groundwater," *Groundwater Currents*, Issue No. 36, 2000. Project no. 94-28.

Cunningham, A.B., and B. Chen, "Evaluation and Modeling of Subsurface Biobarrier Formation and Persistence," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2000. Project no. 94-28, 93-11.

Cunningham, A.B., P.J. Sturman, B.K. Warwood, and N. Zelver, "Engineering Scaleup of *In Situ* Bioremediation Processes: A Workshop on Biotreatability," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995.

Dahab, M.F., and W.E. Woldt, "Development of Pollution Prevention Programs for Small Quantity Generators in EPA Regions VII and VIII," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995.

Davis, L.C., and L.E. Erickson, "Plant-Assisted Remediation of Soil and Groundwater Contaminated by Hazardous Organic Substances: Experimental and Modeling Studies," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2001. Project no. 98-3.

Davis, L.C., and L.E. Erickson, "Plant-Assisted Remediation of Soil and Groundwater Contaminated by Hazardous Organic Substances: Experimental and Modeling Studies," Final

Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2000. Project no. 94-27, 94-27A.

Doucette, W.J., B. Bugbee, and D.K. Stevens, "Fate of Trichloroethylene (TCE) in Plant/Soil Systems: Evaluating Phytoremediation," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1999. Project no. 95-10.

Dupont, R.R., D.L. Sorensen, and W.J. Doucette, "Evaluation of Biosparging Performance and Process Fundamentals for Site Remediation," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995. Project no. 93-20.

Erickson, L.E., and P. Kulakow, "Data Management and Horticultural Evaluation of Field Sites for the RTDF Phytoremediation Field Test of Petroleum Hydrocarbon-Contaminated Soils," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2001. Project no. RTDF.

Erickson, L.E., and L.T. Fan, "Development of *In Situ* Biodegradation Technology," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 6.

Erickson, L.E., A.P. Schwab, M.K. Banks, and B.A. Leven, "Field Validation of an Optimal Design Methodology for Vegetative Remediation of Sediments from the Central Vehicle Wash Facility, Custer Hill, Fort Riley, Kansas," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2001. Project no. SP96-Riley.

Erickson, L.E., and L.T. Fan, "Remediation of Soil Contaminated with an Organic Phase," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1994. Project no. 91-29.

Fan, L.T., "Experimental Study of Stabilization/Solidification of Hazardous Wastes," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 1.

Fan, L.T., "Computer-Aided Design and Control of Systems for Treatment of Hazardous Waste and Minimization of Waste Production," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1993. Project no. 14.

Fan, L.T., "Intelligent Process Design and Control for the Minimization of Waste Production and Treatment of Waste," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1997. Project no. 91-36.

Faw, R.E., J.K. Shultis, B.C. Letellier, S.L. Shue, and F.A. Khan, "Application of PGNAA Remote Sensing Methods to Real-Time, Non-Intrusive Determination of Contaminants Profiles in Soils," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1997. Project no. 94-02.

Ghosh, S., "Biodetoxification of Hazardous Solid Wastes by Staged Anaerobic Fermentation Conducted at Separate Redox and pH Environments," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 89-06.

Ghosh, S., "Removal of Heavy Metals from Hazardous Wastes by Protein Complexation for Their Ultimate Recovery and Reuse," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 4.

Glasgow, L.A., "Vadose Zone Decontamination by Air Injection," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 11.

Godfrey, G.L., W.M. Griswold, and B.A. Leven, "Collaborative Environmental Seminar Series," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1998. Project no. TR96-05.

Godfrey, G.L., "Survey of Environmental Concerns on Native American Tribal Lands," Progress Report, Haskell Environmental Research Studies Center, Haskell Indian Nations University, Lawrence, Kansas, 1994.

Grant, S.C., "Conference on Superfund Settlement Incentives," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1994.

Grant, S.C., "Public Environmental Information Services," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995.

Griswold, W., "The Native American and Other Minority Institutions Program," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1997.

Gruber, W., (science writer) with K.J. Klabunde and S. Mahashwari, "Ultrafine Metal Oxides Dismantle Chlorinated Organics," *Environmental Engineering World*, pages 36-37, July-August, 1995. Project no. 89-26, 92-03.

Hamdi, S., "A Preferential Flow Model, PREF, with User's Manual," Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992.

Hansen, C.L., and D.K. Stevens, "Optimal Bioreactor Design for Biological Removal of Mercury," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 89-09.

Hayter, R.B., and S.C. Grant, "Training and Technology Transfer Programs Management and Operation," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995.

Hetrick, B.A.D., G.M. Pierzynski, R.S. Govindaraju, L.E. Erickson, and D. Sweeney, "Vegetative Interceptor Zones for Containment of Heavy Metal Pollutants," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2000. Project no. 93-07.

Hong, A., R.W. Okey, and S.K. Banerji, "Chelating Extraction of Heavy Metals from Contaminated Soils," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1997. Project no. 93-22.

Hunter, R.S., and F.D. Culver, "Computer Method to Estimate Safe Level Water Quality Content Rations for Organic Chemicals," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1991. Project no. 15.

Illangasekare, T.H., "Distribution and Recovery of Refinery Waste Products in Groundwater Aquifers: Experimental Study and Model Evaluation," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 89-01.

Illangasekare, T.H., "Modeling for Design and Testing of Treatment and Remediation Technologies for Aquifer Soils Contaminated with Organic Waste Chemicals," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1994. Project no. 91-10.

Illangasekare, T.H., D. Znidarcic, G. Walser, and J. Weaver, "An Experimental Evaluation of Two Sharp-Front Models for Vadose Zone Nonaqueous-Phase Liquid Transport," U.S. EPA Report EPA/600/R-94/197, Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma, 1994.

Illangasekare, T.H., and A. Bielefeldt, "Extension of Laboratory-Validated Soil and Groundwater Treatment and Remediation Technologies to Field Problems in Aquifer Soil Contamination by Organic Waste Chemicals," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2000. Project no. 94-29.

Illangasekare, T.H., "Nonaqueous-Phase Liquid Waste Products in the Subsurface: Tools For Remediation Design, Regulation, and Site Characterization," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2001. Project no. 98-05.

Inskeep, W.P., C.G. Johnston, and J.M. Wraith, "Effects of Surfactants on the Bioavailability and Biodegradation of Contaminants in Soils," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1999. Project no. 94-09.

Kapila, S., D.W. Armstrong, and R.K. Puri, "Laboratory and Field Evaluation of Upward Mobilization and Photodegradation of Polychlorinated Dibenzo-P-Dioxins and Furans in Soil," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1994. Project no. 91-04.

Kapila, S., D. Forciniti, and D.W. Armstrong, "Laboratory and Field Evaluation of Upward Mobilization and Photodegradation of Polychlorinated Aromatics in Soil," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995. Project no. 93-16.

Keefer, G.B., and G.J. Thies, "Metal Recovery and Reuse Using an Integrated Vermiculite Ion Exchange-Acid Recovery System," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1990. Project no. 3.

Kelly, W.E., J. Rohde, G.B. Keefer, and W.E. Woldt, "A Short Course on Remediation of Contaminated Soils and Sediments," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995.

Klabunde, K.J., "Nanoscale Metal Oxide Particles as Reagents for Destruction and Immobilization of Hazardous Substances," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1997. Project no. 89-26, 92-03.

Klabunde, K.J., "Nanoscale Metal Oxide Particles as Reagents for Destruction and Immobilization of Hazardous Substances in Air, Water and/or as an Alternative to Incineration," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2001. Project no. 95-04a.

Klabunde, K.J., "Nanoscale Particles Destroy Toxic Substances," *Centerpoint*, Vol. 2, No. 1, pages 1-3, 1994. Project no. 89-26, 92-03.

Kross, B.C., "Removal of Nitrogenous Pesticides from Rural Well Water Supplies by Enzymatic Ozonation Process," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1991. Project no. 16.

Kubichek, R.F., J.J. Cupal, and W.P. Iverson, "Identifying Groundwater Threats from Improperly Abandoned Boreholes," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1999. Project no. 94-24.

Leven, B.A., "Technical Outreach Services for Communities," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1998.

Leven, B.A., and S.C. Grant, "Research and Re-education for Displaced Defense Personnel Program," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995.

Lewandowski, Z., "Heavy Metals Removal from Dilute Aqueous Solutions Using Biopolymers," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 89-22.

Lewandowski, Z., "Heavy Metals Removal from Contaminated Water Solutions," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995. Project no. 92-08.

Licht, L.A., "Riparian Poplar Tree Buffer Impact on Non-Point Source Surface Water Contamination: A Paired Agricultural Watershed Study," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1994. Project no. 91-03.

Logan, R.A., "The News Media Manual: A Guide for Hazardous Substance Research Centers," Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992.

Miller, J.D., "Removal of Chlorinated Hydrocarbons from Contaminated Water Using Air-Sparged Hydrocyclone Technology," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1997. Project no. 94-15.

Munshower, F.F., "Clean Tailing Reclamation, Acid-Producing Metalliferous Waste Reclamation by Material Reprocessing and Vegetative Stabilization," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1998. Project no. 93-12.

Niemeyer, S.M., W.E. Woldt, M.F. Dahab, and R.D. Grisso, "Waste Management: Development of Pollution Prevention Educational Materials for Farms and Small Acreages," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995.

O'Connor, J.T., and B.J. Brazos, "The Response of Natural Groundwater Bacteria to Groundwater Contamination by Gasoline in a Karst Region," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1991. Project no. 89-17.

O'Keefe, T.J., and J.L. Watson, "The Characterization and Treatment of Hazardous Materials from Metal/Mineral Processing Wastes," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 17.

O'Keefe, T.J., "Design and Development of an Innovative Industrial-Scale Process to Economically Treat Waste Zinc Residues," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1999. Project no. 94-05.

Parkin, G.F., and D.T. Gibson, "Feasibility of *In Situ* Anaerobic Bioreclamation of Mixtures of Toxic Chemicals," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 5.

Parkin, G.F., and D.T. Gibson, "Feasibility of Using Genetically Engineered Bacteria to Degrade Trichloroethylene in Activated-Sludge Systems," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992.

Parkin, G.F., and L.J. Weathers, "The Effect of Redox Conditions on Transformations of Carbon Tetrachloride," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1994. Project no. 91-08.

Parkin, G.F., "Application of Anaerobic and Multiple-Electron-Acceptor Bioremediation to Chlorinated Aliphatic Subsurface Contamination," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2000. Project no. 93-24.

Parkin, G.F., "Formation and Transformation of Pesticide Degradation Products Under Various Electron Acceptor Conditions," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995. Project no. 91-07.

Parkin, G.F., P.J. Alvarez, M.M. Scherer, and J.L. Schnoor, "The Role of Microbes in Remediation with Fe(0) Reactive Barriers," *Groundwater Currents*, EPA 542-N-00-002, 35:2-3, 2000. Project no. 98-1.

Parkin, G.F., L.J. Weathers, J.L. Schnoor, and P.J.J. Alvarez, "The Role of Metallic Iron in the Biotransformation of Chlorinated Xenobiotics," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2000. Project no. 93-02.

Peyton, R.L., and S.H. Anderson, "Simulation of Three-Dimensional Transport of Hazardous Chemicals in Heterogeneous Porous Media Using X-Ray Computer Tomography," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 89-14.

Pierzynski, G.M., and A.P. Schwab, "Reducing Heavy Metal Availability to Perennial Grasses and Row Crops Grown on Contaminated Soils and Mine Spoils," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1993. Project no. 89-30.

Pierzynski, G.M., L.E. Erickson, S.C. Grant, L.C. Davis, L.A. Licht, and J.L. Schnoor, "The Use of Poplar Trees in Remediating Heavy Metal-Contaminated Sites," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995. Project no. 92-05.

Reardon, K.F., and E. Pilon-Smits, "Transformation of Mechanisms of High Molecular Weight Polycyclic Aromatic Hydrocarbons in the Rhizosphere," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2001 . Project no. SP99-1.

Reclamation Research Unit, "Geochemical Characterization of Sulfide Mineral Weathering for Remediation of Acid-Producing Mine Wastes," Reclamation Research Publication No. 9203-1, pages 1-167, Montana State University, Bozeman, Montana, 1992.

Rice, J.A., "Contaminant Binding to the Humin Fraction of Soil Organic Matter," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1998. Project no. 94-11.

Schaefer, V.R., and S.R. Burckhard, "Development of a Systematic Methodology for Optimally Designing Vegetative Systems for Remediating Contaminated Soil and Groundwater," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1999. Project no. 94-12.

Schlup, J.R., "Adsorption of Hazardous Substances onto Soil Constituents," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1991. Project no. 18.

Schnoor, J.L., and G.F. Parkin, "Modeling Dissolved Oxygen, Nitrate, and Pesticide Contamination in the Subsurface Environment," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 10.

Schnoor, J.L., and L.A. Licht, "Deep-Rooted Poplar Trees as an Innovative Treatment Technology for Pesticide and Toxic Organics' Removal from Groundwater," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1993. Project no. 89-10.

Schnoor, J.L., and L.A. Licht, "Innovative Treatment and Bank Stabilization of Metals-Contaminated Soils and Tailings Along Whitewood Creek, South Dakota," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1994. Project no. 90-05.

Schnoor, J.L., and J.G. Burken, "Uptake of BTEX Compounds and Metabolites by Hybrid Poplar Trees in Hazardous Waste Remediation," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2000. Project no. 94-25.

Schnoor, J.L., L.A. Licht, and C. Just, "Metals Soil Pollution and Vegetative Remediation," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995. Project no. 92-11.

Schnoor, J.L., "Plant-Enzyme Systems for the Phytoremediation of Chlorinated Aliphatics in Contaminated Soils: Role of P450 and Glutatione S-Transferases in Poplar Trees Detoxification

Cycle," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2000. Project no. 95-29.

Schwab, A.P., M.K. Banks, L.E. Erickson, and J.C. Tracy, "Fate and Transport of Heavy Metals and Radionuclides in Soil: The Impacts of Vegetation," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1998. Project no. 93-06.

Segar, R.L., "Trichloroethene (TCE) Cometabolism in Fluidized-Bed Bioreactors," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1999. Project no. 94-07.

Shue, S.L., "Using BibTeX for PGNAA Reports," Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995.

Shue, S.L., "Use of the Discrete Ordinates Code DANTSYS in Neutron Transport," Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1996.

Shue, S.L., and R.R. Faw, "Penetration of 14-MeV Neutrons into Representative Soils," Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1996.

Shultis, J.K., "Format Style for PGNAA Project Reports: A Special LATEX Style," Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995.

Shultis, J.K., R.E. Faw, and F.A. Khan, "Mathematical Models and Analysis for PGNAA of Soil," Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1996.

Simeonsson, J.B., "Changes in the Speciation and Biolgoical Volatilization of Environmental Arsenic as a Result of Phytoremediation of Hazardous Waste Sites," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, KS, 2001. Project no. 98-8.

Sims, J.L., and R.C. Sims, "Development of a 'State-of-the-Science and Technology' Report on Site-Characterization Technologies," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1999. Project no. TR97-07.

Sims, J.L., and R.C. Sims, "Guidance for the Use of Prepared-Bed Land Treatment as a Bioremedial Technology," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995.

Sims, R.C., "Field-Scale Bioremediation: Relationship of Parent Compound Disappearance to Humification, Mineralization, Leaching, and Volatilization of Transformation Intermediates," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2000. Project no. 93-21.

Sims, R.C., "Libby, Montana, Superfund Site: Prepared-Bed Bioremediation in Buried Lifts as Affected by Oxygen Concentration in Soil Gas," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995.

Steichen, J.M., P.L. Barnes, E.C. Dickey, and D.P. Shelton, "Alachlor and Atrazine Losses from Runoff and Erosion in the Blue River Basin," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1994. Project no. 89-31.

Tosee, M.D., "Report and Assessment of Tribal Environmental Concerns," Progress Report, Haskell Environmental Research Studies Center, Haskell Indian Nations University, Lawrence, Kansas, 1994.

Tracy, J.C., L.E. Erickson, L.C. Davis, and J.L. Schnoor, "Modeling the Use of Plants in Remediation of Soil and Groundwater Contaminated by Hazardous Organic Substances," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1994. Project no. 90-13.

Turner, J.P., L.A. Bulla, and Q.D. Skinner, "Biofilm Barriers for Waste Containment," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1997. Project no. 94-26.

Valentine, R.L., "*In Situ* Soil and Aquifer Decontamination Using Hydrogen Peroxide and Fenton's Reagent," Progress Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 89-11.

Viswanath, D.S., S. Kapila, and T.E. Clevenger, "Development, Characterization, and Evaluation of Adsorbent Regeneration Processes for Treatment of Hazardous Waste," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 13.

Walawender, W.P., and L.T. Fan, "Thermochemical Treatment of Hazardous Wastes," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1991. Project no. 12.

Walser, G., T.H. Illangasekare, J. Weaber, and D. Znidarcic, "An Experimental Evaluation of Two Sharp-Front Models for Vadose Zone Nonaqueous-Phase Liquid Transport," Completion Report, U.S. EPA Kerr Laboratory, EPA/600/R-94/197, 1994.

Walton, C.W., "An Electrochemical Method for Acid Mine Drainage Remediation and Metals Recovery," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 89-19.

Wang, X., "Use of the BUGLE-93 Cross-Section Library," Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1995.

Whiting, B.H.J., "NAOMI Summer Research Cooperation," Progress Report, Haskell Environmental Research Studies Center, Haskell Indian Nations University, Lawrence, Kansas, 1994.

Yanders, A.F., and S. Kapila, "Time-Dependent Movement of Dioxin and Related Compounds in Soil," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 1992. Project no. 9.

Zhang, T.C., P.J. Shea, and S.D. Comfort, "Simultaneous Transformation of Atrazine and Nitrate in Contaminated Water, Sediment, and Soil by Zero-Valent Iron-Promoted Processes," Final Report, Hazardous Substance Research Center, Kansas State University, Manhattan, Kansas, 2001. Project no. 95-32.

F. THESES/DISSERTATIONS

Abedeen, F., "Microbial Processes in Porous Media," M.S. Thesis, Montana State University, Bozeman, 1990.

Adamson, D.T., "Biotransformation of Mixtures of Carbon Tetrachloride, Perchloroethylene, and 1,1,1-Trichloroethane," M.S. Thesis, University of Iowa, Iowa City, 1996. Project no. 93-24.

Adamson, D.T., "Transformation of Mixtures of Highly Chlorinated Aliphatics by Acclimated Anaerobic Enrichment Cultures," Ph.D. Dissertation, University of Iowa, Iowa City, 2000.

Al-Sheriadeh, M.S., "Numerical Modeling of Transport of Nonaqueous-Phase Contaminants in Heterogeneous Aquifers," Ph.D. Dissertation, University of Colorado, Boulder, 1993.

Aoki, D.F., "The Uptake of Arsenic and Cadmium in Mine Tailings by Poplar Trees," M.S. Thesis, University of Iowa, Iowa City, 1992.

Armbruster, E.J., "Study of Transport and Distribution of Lighter-than-Water Organic Contaminants in Groundwater," M.S. Thesis, University of Colorado, Boulder, 1991.

Arunachalam, M., "Microbial Degradation of Polycyclic Aromatic Hydrocarbons in Rhizosphere Soil," M.S. Thesis, Kansas State University, Manhattan, Kansas, 1995.

Atteya, M., "The Use of Magnesium Oxide as a Model Compound for Decomposing Air Pollutants and Other Compounds," M.S. Thesis, Kansas State University, Manhattan, 1990.

Bier, E.L., "Abiotic Remediation of RDX-Contaminated Water and Soil," M.S. Thesis, University of Nebraska, Lincoln, 1997. Project no. 92-24.

Brady, J., "The Design of a Subsurface Irrigation System Utilizing Poplar Trees for Nitrate Removal from Agricultural Drainage Water," M.S. Thesis, University of Iowa, Iowa City, 1990.

Barth, G., "Determination of Effective Parameters at Field Sites Contaminated with Nonaqueous-Phase Organic Wastes," PhD. Dissertation, University of Colorado, Boulder, 1998. Project no. 94-29.

Burckhard, S., "The Impact of Vegetation on the Transport of Heavy Metals from Contaminated Soils," Ph.D. Dissertation, Kansas State University, Manhattan, 1997. Project no. 93-06.

Burken, J.G., "Vegetative Uptake by *Populus* spp. and Mineralization of Atrazine in Variable Soil Types," M.S. Thesis, University of Iowa, Iowa City, 1993.

Butler, T.L., "Effect of Propylene Glycol-Induced Biogrowth on Hydraulic Conductivity and Dispersivity of a Two-Dimensional Homogeneous Porous Media," M.S. Thesis, University of Colorado, Boulder, 1999. Project no. 94-29.

Cady, J.C., "Gasification Techniques in Waste Treatment," Ph.D. Dissertation, University of Missouri, Columbia, 1990.

Campbell, J.A., "Nonaqueous-Phase Liquid (NAPL) Flow Through Heterogeneous Porous Media: Experimental Study and Conceptual Sharo-Front Model Development," M.S. Thesis, University of Colorado, Boulder, 1993.

Chard, J.K., "Phytoremediation Potential for Trichloroethylene: Laboratory Studies," M.S. Thesis, Utah State University, Logan, 1999. Project no. 95-10.

Christ, S.J., "Sequential Transformation of Carbon Tetrachloride, Perchloroethylene, and 1,1,1-Trichloroethane Using Methanogenic and Methanotrophic Conditions," M.S. Thesis, The University of Iowa, Iowa City, 1996.

Choi, S., "Acoustic Plug Detection on Abandoned Boreholes," Ph.D. Dissertation, University of Wyoming, Laramie, May 1999. Project no. 94-24.

Coffin, D., "Considerations in the Design of Cost-Effective Soil-Venting Processes," M.S. Thesis, Kansas State University, Manhattan, 1991.

Coyle, C.G., "Aerobic Phenol-Induced TCE Degradation in Completely Mixed, Continuous-Culture Reactors," M.S. Thesis, University of Iowa, Iowa City, 1990.

Currence, D.W., "Biodegradation of Pentachlorophenol by Mixed Culture," M.S. Thesis, University of Missouri, Columbia, 1992.

Dave, S., "Use of Chemical Speciation to Determine the Leachability of Lead Mine Tailings," M.S. Thesis, University of Missouri, Columbia, 1991.

DeJournett, T.D., "Feasibility of Bioaugmentation of Fe(0) with Autotrophic Denitrifiers," M.S. Thesis, University of Iowa, Iowa City, 1998.

Dennis, M.L., "Hydraulic Conductivity of Compacted Soil Treated with Biofilm," M.S. Thesis, University of Wyoming, Laramie, 1996. Project no. 94-26.

Dhawan, S., "Modeling and Simulating Bioremediation in Aggregated Soils," M.S. Thesis, Kansas State University, Manhattan, 1991.

Dietz, A.C. "Phytotoxicity of Chlorinated Aliphatics," Ph.D. dissertation, University of Iowa, Iowa City, July, 2000. Project 95-29.

Dietz, A.C., "Uptake and Accumulation of Trichloroethylene by Garden Vegetables," M.S. Thesis, University of Iowa, Iowa City, 1996. Project no. 95-29.

Doughten, R.A., "Biodegradation of 2,4-Dichlorophenoxyacetic Acid (2,4-D) and Penta-chlorophenol in Soils," M.S. Thesis, Montana State University, Bozeman, 1997. Project no. 94-09.

Elwood, S.A., "Development and Applications of Laser-Enhanced Ionization, Laser-Induced Fluorescence and Photoionization Detection Systems for Trace Detection of Elements and Compounds of Environmental and Biological Significance," M.S. Thesis, University of Iowa, Iowa City, 2001. Project no. 98-08.

Ewing, J., "Effects of Dimensionality and Heterogeneity on Surfactant-Enhanced Solubilization of Nonaqueous-Phase Liquids in Porous Media," M.S. Thesis, University of Colorado, Boulder, 1996.

Ezer, M., "One-and Two-Color, Laser-Induced Fluorescence Studies of Cadmium, Zinc, Chromium, Antimony, and Other Elements in Electrothermal Atomizers, Inductively Coupled Plasma and Flame," M.S. Thesis, University of Iowa, Iowa City, 2001. Project no. 98-08.

Fairbanks, T., "Light Nonaqueous-Phase Fluid Barriers in Initially Water-Saturated Heterogeneous Porous Media," M.S. Thesis, University of Colorado, Boulder, 1993.

Fleming, R., "Effects of the Rhizosphere Microflora on Leaching of Zinc from Mine Tailings," M.S. Thesis, Kansas State University, Manhattan, 1992.

Foeller, J., "Cometabolism of Trichloroethene (TCE) in a Fluidized-Bed Reactor," M.S. Thesis, University of Missouri-Columbia, Columbia, 1998. Project no. 94-07.

Freier-Coppinger, R., "Sorption of 1,1,1-Trichloroethane, Chloroform, and Dichloromethane into Soil Organic Matter," M.S. Thesis, University of Iowa, Iowa City, 1989.

Gandhi, P., "Role of Biodegradation in Traditional and Innovative Subsurface Remediation Technologies," M.S. Thesis, Kansas State University, Manhattan, 1994.

Ghoshal, S., "Photodegradation of PCP in Aqueous and Soil Systems," M.S. Thesis, University of Missouri, Columbia, 1991.

Ginn, J.S., "Biodegradation and Metabolites of PAHs, Including Phenanthrene and Anthracene, in Soil," Ph.D. Dissertation, Utah State University, Logan, 1997. Project no. 93-21.

Ginner, J., "Effect of Temperature and Mass Transfer on Kinetics of Nitrate and Nitrate Reduction by Iron Metal," M.S. Thesis, University of Iowa, Iowa City, 1999. Project no. 93-02.

Gregory, K.B., "Enhanced Biotransformations of Carbon Tetrachloride, Tetrachloroethene, and 1,1,1-trichloroethane Using Elemental Iron," M.S. Thesis, University of Iowa, Iowa City, 1997. Project no. 93-02.

Green, R., "The Use of Sediment Pollution Models in Predicting the Effects of Vegetation on Surface Flow and Contaminant Transport in Southeast Kansas," M.S. Thesis, Kansas State University, Manhattan, 1998.

Gu, J., "Biodegradation of Some Commercially Used Solubility Enhancers and Their Toxicity on Growth of Microorganisms," M.S. Thesis, University of Missouri, Columbia, Missouri, 1996. Project no. 94-08.

He, Y., "Adsorption and Transport of Zinc and Lead in Soil as Affected by Organic Ligands," Ph.D. Dissertation, Kansas State University, 1997. Project no. 93-06.

Held, R., "Transport of Dense Organic Fluids in Saturated Soils," M.S. Thesis, University of Colorado, Boulder, 1993.

Helland, B.R., "Dechlorination of Carbon Tetrachloride with Zero-Valent Iron," M.S. Thesis, University of Iowa, Iowa City, 1996.

Henderson, C.T., "The Effects of Vegetation on the Mobility and Oxidation State of Chromium in Soil," M.S. Thesis, Kansas State University, 1997. Project no. 93-06.

Hsieh, C.M., "Biodegradation of PCP in Soils by *Phanerochaete Chrysosporium*," M.S. Thesis, University of Missouri, Columbia, 1991.

Hu, J., "Plant Model Interface Design," M.S.E. Portfolio, Kansas State University, Manhattan, Kansas, 1998.

Hu, J., "Study of Fate and Transport of Contaminants in Plants," M.S. Thesis, Kansas State University, Manhattan, Kansas, 1998.

Hughes, J.B., "Anaerobic Biotransformation of Chlorinated Aliphatics: Interactions with Primary Substrate Utilization and Effects of Mixtures," Ph.D. Dissertation, University of Iowa, Iowa City, 1992.

Hundal, L.S., "TNT Sorption and Fate in Munitions-Contaminated Soil: Implications for Abiotic Remediation," Ph.D. Dissertation, University of Nebraska, Lincoln, 1997. Project no. 92-24.

Hurst, C.J., "Prepared-Bed Bioremediation at the Libby, Montana, Superfund Site," M.S. Thesis, Utah State University, Logan , 1996. Project no. 93-21.

Hwang, S.J., "Optimal Removal Conditions of Alachlor in an Ozone-Sparged Reactor," M.S. Thesis, University of Iowa, Iowa City, Iowa, 1990.

Isbell, L., "Evaluation of Coupled Solid-Phase Extraction and Desorption with Supercritical CO_2 for Ultra-Trace Analysis of Xenobiotics in Aquatic Systems," M.S. Thesis, University of Missouri, Columbia, 1990.

Jennings, S.R., "Geochemical Characterization of Sulfide Mineral Weathering for Remediation of Acid-Producing Mine Wastes," M.S. Thesis, Montana State University, Bozeman, Montana, 1993. Project no. 93-12.

Johnson, E., "Dispersion of Volatile Organic Chemical Vapor in Heterogeneous Soils," M.S. Report, University of Colorado, Boulder, 1996.

Kalia, P., "Modeling Cometabolism in Biofilm Reactors," M.S. Thesis, University of Missouri, Columbia, 1996. Project no. 94-07.

Karthikeyan, R., "Experimental and Modeling Studies of Fate and Transport of Petroleum Contaminants in Soils with Plants," Ph.D. Dissertation, Kansas State University, Manhattan, 2001. Project no. 98-03, SP-96.

Khaleel, A., "Iron Oxide on Magnesium Oxide as a New Destructive Adsorbent for Chlorinated Hydrocarbons," M.S. Thesis, Kansas State University, Manhattan, 1993.

Kimball, D., "Assessment of a Creosote-Contaminated Soil Toxicity Associated with the Soil Solid Phase Using the Microtox™ Assay," M.S. Thesis, Utah State University, 1999. Project no. 93-21.

Kimball, D., "Toxicity Reduction and Metabolites of PAH Used as Indicators of Biodegredation During Prepared-Bed Treatment of Contaminated Soil," M.S. Thesis, Utah State University, Logan, 1999. Project no. 93-21.

Kohl, S.D., "Role of Lipids in the Sorption and Binding of Nonpolar Anthropogenic Organic Compounds to Soil Organic Matter," Ph.D. Thesis, South Dakota State University, Brookings, 1999. Project no. 94-11.

Koper, O., "Properties of High-Surface-Area Calcium Oxide and Its Reactivity Towards Chlorocarbons," Ph.D. Thesis, Kansas State University, Manhattan, 1996. Project no. 89-26, 92-03.

Kruger, E.L., "Enhanced Degradation of Herbicide Wastes in Soil: Implications for Bioremediation of Agrochemical Dealer Sites," Ph.D. Dissertation, Iowa State University, Ames, 1996. Project no. 93-05.

Kurimski, L.J., "Physiochemical Factors of Iron Photoproduction and a Metals Removal Process for Mine Tailings," M.S. Thesis, University of Iowa, Iowa City, 1994.

Lay, J., "Surfactant Interaction with Soils," M.S. Thesis, University of Missouri, Columbia, Missouri, 1997. Project no. 94-08.

Lee, E., "The Fate of Polycyclic Aromatic Hydrocarbons in the Rhizosphere of *Fesuca arundinacea*," Ph.D. Dissertation, Kansas State University, Manhattan, Kansas, 1996.

Leung, K., "A Conductivity Tracer Test for Biofilm Reactors," M.S. Thesis, University of Missouri, Columbia, 1996. Project no. 94-07.

Li, W., "Reductive Degradation of Chlorinated Ethylenes by Zero-Valent Zinc in Aqueous Solution," M.S. Thesis, Kansas State University, Manhattan, 1997. Project no. 95-04a.

Li, Z.M., "Remediating TNT-Contaminated Water and Soil by Fenton Oxidation," Ph.D. Dissertation, University of Nebraska, Lincoln, 1996. Project no. 92-24.

Licht, L.A., "Poplar Tree Buffer Strips Grown in Riparian Zones for Biomass Production and Non-Point Source Pollution Control," Ph.D. Dissertation, University of Iowa, Iowa City, 1990.

Liu, M.H., "Evaluation of Supercritical Fluid Extraction for the Removal of Chlorinated Xenobiotics from Soil," Ph.D. Dissertation, University of Missouri, Columbia, 1992.

Lo, Y.-H., "Studies on the Persistence of Polychlorinated Dibenzo-P-Dioxin (PCDD) and Polychlorinated Dibenzofuran (PCDF)," M.S. Thesis, University of Missouri, Columbia, 1990.

Lundman, R.W., "Transport of Substrate and Biomass in a Packed-Bed Reactor," M.S. Thesis, Montana State University, Bozeman, 1992.

Mahashwari, S., "Bench-Scale Process Development Studies for Destructive Adsorption of Chlorocarbons," M.S. Thesis, Kansas State University, Manhattan, 1996. Project no. 89-26, 92-03.

Manna, M., "Suction-Saturation Measurement in Soils Using the Flow-Pump Technique," M.S. Thesis, University of Colorado, Boulder, 1991.

Martin, J.L., "Metabolism of 2,4,6-trinitrotoluene (TNT) by *Pseudomonas savastanoi*," M.S. Thesis, University of Nebraska, Lincoln, 1995. Project no. 92-24.

McDonald, J.P., "Transport Limitations Associated with Traditional and Innovative Sub-Surface Remediation Technologies," M.S. Thesis, Kansas State University, Manhattan, 1994.

McEachern, C., "Upscaling of Flow and Transport of Jet Fuels in Near-Surface Environments Under Conditions of Bioactivity," M.S. Thesis, University of Colorado, Boulder, 1998. Project no. 94-29.

McEachern, C., "Effect of Bacterial Growth by Means of Jet Fuel Constituents on the Hydraulic Conductivity and Dispersivity of Porous Media in One- and Two-Dimensional Systems," M.S. Thesis, University of Colorado, Boulder, 1998. Project no. 94-29.

Menon, R., "Adsorption of Mercury Vapor by Activated Carbon," M.S. Thesis, Utah State University, Logan, 1991.

Miller, C., "Filter Media Surface-Catalyzed Hydrogen Peroxide Decomposition and Oxidation of Selected Contaminants," M.S. Thesis, University of Iowa, Iowa City, 1992.

Mogallapu, S., "Analysis of a Waste Management Option for Titanium Electrochemical Machining," M.S. Thesis, University of Nebraska, Lincoln, 1992.

Moore, Q., "Applicability of Multiphase/Multicomponent Numerical Models to Simulate Mass Transfer of Entrapped NAPLs: Verification of Code," M.S. Thesis, Colorado School of Mines, 2001. Project no. 98-05.

Nair, D.R., "Atrazine Fate Modeling and Mineralization Studies in Soil-Plant Systems," Ph.D. Dissertation, University of Iowa, Iowa City, 1991.

Nam, K.S., "Application of Supercritical Fluid Extraction and Multidimensional Chromatography for Multiresidue Determinations," Ph.D. Dissertation, University of Missouri, Columbia, 1991.

Narayanan, M., "Modeling the Movement and Fate of Contaminants in an Experimental Chamber with Alfalfa Plants," Ph.D. Dissertation, Kansas State University, Manhattan, 1998. Project no. 94-27.

Nieman, J.K.C., "Binding of PAH to Soil Humic Materials During Prepared-Bed Treatment of Contaminated Soil," M.S. Thesis, Utah State University, Logan, 1998. Project no. 93-21.

Novak, P.J., "Formation and Transformation of Alachlor and Atrazine Degradation Products Under Various Electron Acceptor Conditions," M.S. Thesis, University of Iowa, Iowa City, 1994.

Novak, P.J., "Enhanced Dechlorination of Carbon Tetrachloride and Chloroform in the Presence of Elemental Iron and Methanogenic Bacteria," Ph.D. Dissertation, University of Iowa, Iowa City, 1997. Project no. 93-02.

Okeson, S., "A Study of the Dissolution of Multicomponent Nonaqueous-Phase Liquids in a Two-Dimensional Flow Field and Model Development," M.S. Thesis, Dept. of Civil, Envi, and Arch. Engineering, page 169, 1995.

Orazio, C.E., "Persistence and Transport of Organochlorine Contaminants in Soils," Ph.D. Dissertation, University of Missouri, Columbia, 1992.

Orchard, B.J., "Evaluation of the Uptake and Fate of Trichloroethylene by Hybrid Poplar Trees Using a Sealed Plant-Growth Chamber System," M.S. Thesis, Utah State University, Logan, 1998. Project no. 95-10.

Patel, B.B., "Simulation of Waste-Generating Characteristics of a Chemical Reactor Network During Start-Up," M.S. Thesis, Kansas State University, 1996. Project no. 91-36.

Paterson, K.G., "Fate of Alachlor and Atrazine in Small Plot Field Studies," M.S. Thesis, University of Iowa, Iowa City, 1990.

Petrie, R.A., "Oxidation of Pentchlorophenol Affected by Manganese Oxide Under Various Redox Environments," Ph.D. Dissertation, Utah State University, Logan, Utah, 1997. Project no. 93-21.

Picken, H.D., "Sequential Anaerobic-Aerobic Treatment of Chlorinated Aliphatic Hydrocarbons," M.S. Thesis, University of Iowa, Iowa City, 1998. Project no. 93-24.

Pirkl, D.R., "Petroleum Hydrocarbon Residual Product Effects on Soil-Water Retention Curves," M.S. Thesis, South Dakota State University, Brookings, 2000. Project no. 94-12.

Pytte, K., "Dimensionality and Heterogeneous Effects on Enhanced LNAPL Recovery Using Hot Water Flooding," M.S. Thesis, University of Colorado, Boulder, 1996. Project no. 94-29.

Ranf, T., "Assessing the Potential for *In Situ* Bioremediation of Contaminated Aquifers," M.S. Thesis, Montana State University, Bozeman, 1990.

Rao, D., "Mobility of Lead in Mining Wastes Due to Landfill Leachate," M.S. Thesis, University of Missouri, Columbia, 1991.

Rayavarapu, R. "Biodegradation of Pentachlorophenol by *Pseudomonas cepacia* AC 1100," M.S. Thesis, University of Missouri, Columbia, 1991.

Redy, B., "Validation of a Sequential Extraction Method for Lead, Cadmium, and Zinc," M.S. Thesis, University of Missouri, Columbia, 1992.

Regmi, T.P., "Biodegradaton of Chelating Agents Used for Removal of Metals from Contaminated Soils," M.S. Thesis, University of Missouri, Columbia, 1996. Project no. 93-22.

Saba, T.A., "Upscaling of Natural and Enhanced Dissolution of Nonaqueous-Phase Waste Chemicals," PhD. Dissertation, University of Colorado, 1998. Project no. 94-29.

Santharam, S., "The Role of Vegetation and Surfactants in Remediating Soil Contaminated with Polycyclic Aromatic Hydrocarbons," M.S. Thesis, Kansas State University, Madras, India, 1992.

Schwarz, P.G., "Effect of Poplar Trees on Fate of Atrazine in a Model Tree System Through Metabolism, Degradation, and Accumulations," M.S. Thesis, University of Iowa, Iowa City, 1991.

Schwensohn, D., "Petroleum Hydrocarbon Residual Product Effect on the Friction Angle of Ottawa Sand," M.S. Thesis, South Dakota State University, Brookings, 2001. Project no. SP-96.

Seybert, R.A., "Design and Preliminary Evaluation of a Chlorinated Hydrocarbon Incinerator," M.S. Thesis, Kansas State University, Manhattan, 1990.

Shetty, K.G., "Relationship Between Mycorrhizal Symbiosis and Zinc Tolerance in Plants," Ph.D. Dissertation, Kansas State University, Manhattan, 1994.

Shi, Z. "Model Development and Simulation of *In Situ* Remediation in Lead-Contaminated Soils" M.S. Thesis, Kansas State University, Manhattan, 2000.

Shrake, C., "Modeling of Evapotranspiration (ET) Landfill Covers in Sub-Humid Environments," M.S. Thesis, South Dakota State University, Brookings, 2001. Project no. SP-96.

Shurtliff, M.M., "Aerobic Biotransformation of Trichloroethylene by a Phenol-Induced, Mixed Culture," M.S. Thesis, University of Iowa, Iowa City, 1992.

Singh, J., "Natural and Accelerated Detoxification of Atrazine and RDX in Contaminated Soil and Water," Ph.D. Dissertation, University of Nebraska, Lincoln, 1997. Project no. 92-24, 95-32.

Sturman, P., "Effectiveness and Interspecies Competition in Colonized Porous Pellets," M.S. Thesis, Montana State University, Bozeman, 1991.

Syverson, A.E., "Biotransformation of Volatile Chlorinated Organics in Anaerobic Filters with Acetate Enrichment Cultures," M.S. Thesis, University of Iowa, Iowa City, 1989.

Thies, G.T., "Metal Removal and Recovery Using a Vermiculite Ion Exchange System and Acid Extraction," M.S. Thesis, University of Nebraska, Lincoln, 1990.

Thompson, K., "Design of a Phytoremediation Decision Support System," M.S. Thesis, South Dakota State University, Brookings, 2000. Project no. SP-96.

Till, B.A., "Treatment of Nitrate-Contaminated Waters Using Autotrophic Denitrifiers and Zero-Valent Iron," M.S. Thesis, University of Iowa, Iowa City, 1997. Project no. 93-02.

Utamapanya, S., "Investigations of Molecular and Surface Properties of Magnesium Oxide," Ph.D. Dissertation, Kansas State University, Manhattan, 1990.

Vivek, S., "Treatment of Trichloroethene with a Fluidized-Bed Bioreactor," M.S. Thesis, University of Missouri, Columbia, 1996.

Walser, G.S., "Vadose Zone Infiltration, Mobilization, and Retention of Nonaqueous-Phase Liquid," Ph.D. Dissertation, University of Colorado, Boulder, 1995.

Wang, J.C., "Migration of PCP in Soil Columns in Presence of Nonaqueous Phase," M.S. Thesis, University of Missouri, Columbia, 1992.

Wang, J.M., "Migration of Sodium Pentachlorophenol in Unsaturated Soil Columns," M.S. Thesis, University of Missouri, Columbia, 1992.

Wang, Y., "Biodegradation of Chelating Agents Used for Removal of Metals from Contaminated Soils," M.S. Thesis, University of Missouri, Columbia, 1997. Project no. 93-22.

Wang, S.-P., "Application of Supercritical Fluid Extraction and Supercritical Fluid Chromatography for Determination of Steroidal Compounds," M.S. Thesis, University of Missouri, Columbia, 1992.

Watanabe, H., "Alachlor and Atrazine Losses from Runoff and Erosion in the Blue River Basin," M.S. Thesis, Kansas State University, Manhattan, 1993. Project no. 89-31.

Watermeier, N.L., "Impacts of Tillage System and Chemical Incorporation on Surface Losses of Water, Soil, Atrazine, and Alachlor," M.S. Thesis, University of Nebraska, Lincoln, 1993.

Waters, Y., "The Influence of Organic Acids on Leaching of Heavy Metals from Contaminated Mine Tailings," M.S. Thesis, Kansas State University, Manhattan, 1992.

Weathers, L.J., "Biological and Metallic Iron-Promoted Transformation of Carbon Tetrachloride and Chloroform under Methanogenic Conditions," Ph.D. Dissertation, University of Iowa, Iowa City, 1995.

Wei, S.M., "Interactions of Pentachlorophenol on Soils," M.S. Thesis, University of Missouri, Columbia, 1991.

Wetzel, S., "Biodegradation and Analysis of Pyrene in Rhizosphere Soils," M.S. Thesis, Kansas State University, Manhattan, 1995.

Wichman, M.D., "Fate and Toxicity of Volatile Organic Chemicals in a Poplar Plot," M.S. Thesis, University of Iowa, Iowa City, 1991.

Wigger, J.W., "Breakthrough Analysis Using X-Ray Computed Tomography," M.S. Thesis, University of Missouri, Columbia, 1991.

Wilber, G.G., "Kinetics of Alachlor, Atrazine, and Chloroform Transformation Under Various Electron-Acceptor Conditions," Ph.D. Dissertation, University of Iowa, Iowa City, 1991.

Wildman, M.J., "Treatment of RDX-Contaminated Soil Using a Combined Microbial Fe(0) Approach," M.S. Thesis, University of Iowa, Iowa City, 1998. Project no. 93-02.

Wu, J.C., "Modeling of *In Situ* Neutralization and Biodegradation Processes and Numerical Simulation with the Three-Point Backward Finite Difference Method," M.S. Thesis, Kansas State University, Manhattan, 1989.

Wu, X., "Examining the Fate of Released Pseudomonas Putida Fl Through a Microcosm Study," M.S. Thesis, Kansas State University, Manhattan, 1998. Project no. 94-27.

Yang, X., "Characterizing *In Situ* Bioremediation of Organic-Contaminated Soils," Ph.D. Dissertation, Kansas State University, 1995.

Yates, D.N., "The Transport and Distribution of Nonaqueous Organics in Groundwater Aquifers: Experimental Investigation and Numerical Development," M.S. Thesis, University of Colorado, Boulder, 1989.

Ye, Q., "Studies on Uptake and Metabolism of PCBs by Terrestrial Plants," M.S. Thesis, University of Missouri, Columbia, 1991.

Zawaideh, L.L., "Remediation of Nitrate-Contaminated Water by Fe^0-Promoted Processes," M.S. Thesis, University of Nebraska, Lincoln, 1997. Project no. 95-32.

Zhang, S., "Biological Detoxification of Mercury-Contaminated Soil," M.S. Thesis, Utah State University, Logan, 1991.

Zhang, Q., "Phytoremediation of Methyl-Tert-Butyl Ether (MTBE) in Groundwater—Experimental and Modeling Studies," Ph.D. Dissertation, Kansas State University, Manhattan, 1999. Project no 94-27.

Zhu, D., "The Fate and Transport of Heavy Metals in Soil as Affected by Vegetation and Organic Complexing Agents," Ph.D. Dissertation, Kansas State University, Manhattan, 1998. Project no. 93-06.

G. BULLETINS AND SPECIAL PUBLICATIONS

Boguski, T.K., "Collecting Environmental Information Using the Data Quality Objectives Process," Environmental Science and Technology Briefs for Citizens, URL: www.engg.ksu.edu/HSRC/Tosc/dqo.pdf.

Boguski, T.K., "Human Health Risk Assessment," Environmental Science and Technology Briefs for Citizens, URL: www.engg.ksu.edu/HSRC/Tosc/healthrisk.pdf.

Boguski, T.K., "What Are Quality Assurance Project Plans?" Environmental Science and Technology Briefs for Citizens, URL: www.engg.ksu.edu/HSRC/Tosc/quapp.pdf.

Boguski, T.K., "Writing a Request for Proposals: A Primer for Brownfield Pilots," Environmental Science and Technology Briefs for Citizens, URL: www.engg.ksu.edu/HSRC/Tosc/rfp.pdf.

Deines, V., Brownfields Technical Assistance Notes on Economic Development Decision Making; Agribusiness and Other Business Development Resources; Auto Service, Repair, and Salvage Facilities; and Pollution Prevention and Environmental Compliance, URL: www.engg.ksu.edu/HSRC/Tosc/dmbrown.html.

Griswold, W.M, "Science Basics: Exploring the Fundamentals of Science," Environmental Science and Technology Briefs for Citizens, URL: www.engg.ksu.edu/HSRC/Tosc/scibr2.pdf.

Kulakow, P., "A Guide to In-Well Vapor Extraction," Environmental Science and Technology Briefs for Citizens, URL: www.engg.ksu.edu/HSRC/Tosc/vapor.pdf.

Kulakow, P., "A Guide to Thermal Desorption," Environmental Science and Technology Briefs for Citizens, URL: www.engg.ksu.edu/HSRC/Tosc/desorp.pdf. Adapted from EPA Technology Fact Sheet EPA542-F-96-005.

Kulakow, P., Annual Report of the RTDF Phytoremediation Action Team TPH Subgroup Cooperative Field Trials, Remedial Technologies Development Forum, 85 pages, Sept. 2001. Project nos. SP -96, RDTF.

Kulakow, P., Annual Report of the RTDF Phytoremediation Action Team TPH Subgroup Cooperative Field Trials, Remedial Technologies Development Forum, 132 pages, URL: http://www.engg.ksu.edu/HSRC/RTDFtphrp1.html. Project nos. SP -96, RDTF.

Lambert, M.W., B.A. Leven, and R.M. Green, "New Methods of Cleaning Up Heavy Metal in Soils and Water," Environmental Science and Technology Briefs for Citizens, URL: www.engg.ksu.edu/HSRC/Tosc/metals.pdf.

Lambert, M.W., "Unexploded Ordnance: A Reference Guide for the Citizen," Environmental Science and Technology Briefs for Citizens, URL: http://www.engg.ksu.edu/HSRC/Tosc/uxo.pdf.

McGaughey, K.J., "Understanding Statistics: Interpreting Environmental Conditions Through Math," Environmental Science and Technology Briefs for Citizens, URL: www.engg.ksu.edu/HSRC/Tosc/stats.pdf.

"Superfund Technical Assistance Grants," Environmental Science and Technology Briefs for Citizens, URL: www.engg.ksu.edu/HSRC/Tosc/tag.pdf.

H. CONFERENCES AND WORKSHOPS

Three-day workshop — Introduction to Hazardous Waste Management, Sioux Falls, South Dakota, November 9-11, 1989 — University of Missouri, Columbia, Missouri.

Three-day workshop — Introduction to Hazardous Waste Management, Denver, Colorado, January 18-20, 1990 — University of Missouri, Columbia, Missouri.

One-day conference — Hazardous Waste Minimization, Omaha, Nebraska, January 23, 1990 — Iowa Department of Natural Resources, Des Moines, Iowa; and Nebraska Department of Environmental Control, Lincoln, Nebraska.

Three-day workshop — Introduction to Hazardous Waste Management, Overland Park, Kansas, February 15-17, 1990 — University of Missouri, Columbia, Missouri.

Two-day cluster of conferences — Agricultural Impacts on Groundwater Quality; Groundwater Geochemistry; Groundwater Management and Wellhead Protection; Environmental Site Assessments: Case Studies and Strategies, Kansas City, Missouri, February 20-21, 1990 — National Water Well Association and Association of Groundwater Scientists and Engineers, Columbus, Ohio.

Two-day conference — Controlling Water Contamination, Manhattan, Kansas, March 7-8, 1990 — Kansas State University, Manhattan, Kansas.

Three-day workshop — Introduction to Hazardous Waste Management, Helena, Montana, March 15-17, 1990 — University of Missouri, Columbia, Missouri.

Five-day conference — 1990 Billings Reclamation Symposium, Billings, Montana, March 25-30, 1990 — Montana State University, Bozeman, Montana.

Three-day workshop — Introduction to Hazardous Waste Management, Kansas City, Missouri, April 18-20, 1990 — University of Missouri, Columbia, Missouri.

One-day teleconference — Ask the Experts: Third Annual Hazardous Materials and Waste Management Update, Manhattan, Kansas, May 11, 1990 — Oklahoma State University, Stillwater, Oklahoma.

Two-day conference — Conference on Hazardous Waste Research, Manhattan, Kansas, May 21-22, 1990 — Kansas State University, Manhattan, Kansas.

One-day workshop — Minimizing Hazardous Waste: A Workshop for Metal Finishers, Manhattan, Kansas, May 23, 1990 — Kansas State University, Manhattan, Kansas.

Three-day conference — Interfacial Microbial Process Engineering, Bozeman, Montana, July 18-20, 1990 — Montana State University, Bozeman, Montana.

Five-day workshop — Summer Institute on Hazardous Waste Management, Columbia, Missouri, August 6-10, 1990 — University of Missouri, Columbia, Missouri.

Five-day symposium — Mineral and Hazardous Waste Processing Symposium, Butte, Montana, September 30-October 5, 1990 — Montana College of Mineral Science and Technology, Butte, Montana; and the Northern Rocky Mountain Water Congress.

Three-day workshop — Introduction to Hazardous Waste Management, Des Moines, Iowa, October 18-20, 1990 — University of Missouri, Columbia, Missouri.

Three-day conference — 25th Midwest Regional Meeting of the American Chemical Society, Manhattan, Kansas, November 7-9, 1990 — Kansas State University, Manhattan, Kansas.

Three-day workshop — Introduction to Hazardous Waste Management, Salt Lake City, Utah, November 29-December 1, 1990 — University of Missouri, Columbia, Missouri.

Two-day video conference — The Environment: Corporate Stewardship and Business Opportunity in the Decade of Global Awakening, Manhattan, Kansas, December 5-6, 1990 — Business Week and World Resources Institute.

Three-day workshop — Introduction to Hazardous Waste Management, Lincoln, Nebraska, December 14-16, 1990 — University of Missouri, Columbia, Missouri.

Three-day workshop — Introduction to Hazardous Waste Management, St. Louis, Missouri, February 6-8, 1991 — University of Missouri, Columbia, Missouri.

Two-hour video conference — Pollution Prevention in Business: How Small Rural Businesses Can Minimize Their Pollution, Manhattan, Kansas, February 21, 1991 — Kansas State University, Manhattan, Kansas.

Two-day conference — Water and the Future of Kansas, Manhattan, Kansas, March 4-5, 1991 — Kansas State University, Manhattan, Kansas.

Three-day workshop — Introduction to Hazardous Waste Management, Kansas City, Missouri, March 6-8, 1991 — University of Missouri, Columbia, Missouri.

Four-day conference — Hydrology Days, Fort Collins, Colorado, April 2-5, 1991 — Colorado State University, Fort Collins, Colorado.

One-day workshop — Underground Storage Tanks, St. Louis, Missouri, April 11, 1991 — University of Missouri, Columbia, Missouri.

One-day workshop — Sampling and Identification of Hazardous Waste, St. Louis, Missouri, April 12, 1991 — University of Missouri, Columbia, Missouri.

One-day conference — Hazardous Waste Management Conference: Remediation Alternatives and Case Studies, Kansas City, Missouri, April 23, 1991 — University of Missouri, Columbia, Missouri.

One-day workshop — Underground Storage Tanks, Kansas City, Missouri, April 25, 1991 — University of Missouri, Columbia, Missouri.

One-day workshop — Sampling and Identification of Hazardous Waste, Kansas City, Missouri, April 26, 1991 — University of Missouri, Columbia, Missouri.

Four-day conference — On-Site Bioremediation Conference, Hickory Corners, Michigan, May 19-22, 1991 — University of Michigan, Ann Arbor, Michigan.

Two-day conference — Conference on Hazardous Waste Research, Manhattan, Kansas, May 29-30, 1991 — Kansas State University, Manhattan, Kansas.

Two-day workshop — Primer in Environmental Initiatives, St. Louis, Missouri, May 30-31, 1991 — University of Missouri, Columbia, Missouri.

Two-day workshop — Primer in Environmental Initiatives, Kansas City, Missouri, June 13-14, 1991 — University of Missouri, Columbia, Missouri.

One-day course — Small Business Hazardous Chemical and Waste Management Course, Cape Girardeau, Missouri, July 9, 1991 — University of Missouri, Columbia, Missouri.

One-day course — Small Business Hazardous Chemical and Waste Management Course, Sikestone, Missouri, July 10, 1991 — University of Missouri, Columbia, Missouri.

One-day course — Small Business Hazardous Chemical and Waste Management Course, Kirksville, Missouri, July 30, 1991 — University of Missouri, Columbia, Missouri.

One-day course — Small Business Hazardous Chemical and Waste Management Course, Hannibal, Missouri, July 31, 1991 — University of Missouri, Columbia, Missouri.

Five-day workshop — Hazardous Waste Management Summer Institute, Columbia, Missouri, August 5-9, 1991 — University of Missouri, Columbia, Missouri.

One-day course — Small Business Hazardous Chemical and Waste Management Course, Kansas City, Missouri, August 20, 1991 — University of Missouri, Columbia, Missouri.

One-day course — Small Business Hazardous Chemical and Waste Management Course, St. Joseph, Missouri, August 21, 1991 — University of Missouri, Columbia, Missouri.

One-day course — Small Business Hazardous Chemical and Waste Management Course, St. Louis, Missouri, September 10, 1991 — University of Missouri, Columbia, Missouri.

Three-day workshop — Beneficial Effects of Vegetation in Contaminated Soils, Manhattan, Kansas, January 7-9, 1992 — Kansas State University, Manhattan, Kansas.

One-day workshop — Bioremediation: The State of Practice in Hazardous Waste Remediation Operations, A Satellite Seminar, held at eight sites in EPA Regions VII and VIII, January 9, 1992 — Air and Waste Management Association, Pittsburgh, Pennsylvania.

Three-day workshop — Hazardous Waste Management, Casper, Wyoming, January 16-18, 1992 — University of Missouri, Columbia, Missouri.

Two-day workshop — Primer in Environmental Initiatives, Columbia, Missouri, January 23-24, 1992 — University of Missouri, Columbia, Missouri.

One-day conference — 42nd Environmental Engineering Conference, Lawrence, Kansas, February 5, 1992 — University of Kansas, Lawrence, Kansas.

Two-day workshop — Our Changing Environment, AGU 1992 Front Range Meeting, Boulder, Colorado, February 10-11, 1992 — Rush Services Technical Communications.

Three-day workshop — Hazardous Waste Management, Columbia, Missouri, February 13-15, 1992 — University of Missouri, Columbia, Missouri.

Four-day workshop — Project Management for the Hazardous Waste Professional, Columbia, Missouri, February 19-22, 1992 — University of Missouri, Columbia, Missouri.

Two-day conference — Waste Management Conference, Logan, Utah, March 4-5, 1992 — Utah State University, Logan, Utah.

Three-day workshop — Hazardous Waste Management, Wichita, Kansas, March 26-28, 1992 — University of Missouri, Columbia, Missouri.

Two-day workshop — Waste Minimization Technology and Applications, Salt Lake City, Utah, April 29-30, 1992 — University of Missouri, Columbia, Missouri.

Two-day seminar — Technical Seminar on Groundwater, Topeka, Kansas, May 12-13, 1992 — Kansas Water Well Association.

Two-day workshop — Waste Minimization Technology and Applications, Wichita, Kansas, May 13-14, 1992 — University of Missouri, Columbia, Missouri.

Two-day conference — Alternate Fuels Conference, Manhattan, Kansas, May 14-15, 1992 — Kansas State University, Manhattan, Kansas.

Two-day conference — 7th Annual Conference on Hazardous Waste Research, Boulder, Colorado, June 1-2, 1992 — Kansas State University, Manhattan, Kansas.

One-day workshop — Impact of Heavy Metals on Mine Land Restoration Workshop, Boulder, Colorado, June 3, 1992 — Kansas State University, Manhattan, Kansas.

Five-day workshop — Hazardous Waste Site Operations Training, Kansas City, Kansas, June 15-19, 1992 — University of Kansas, Lawrence, Kansas.

Four-day conference — Subsurface Restoration Conference, Dallas, Texas, June 21-24, 1992 — Rice University, Houston, Texas.

Six-day workshop — Shaping Our Environmental Heritage, Kansas City, Missouri, June 21-26, 1992 — Air & Waste Management Association, Pittsburgh, Pennsylvania.

Two-day conference — Annual Conference and Exhibition Application of Geostatistics and Kriging to Spatial Estimation Problems in Groundwater, Golden, Colorado, July 16-17, 1992 — Colorado School of Mines, Golden, Colorado.

Five-day workshop — 11th Annual Hazardous Waste Management Summer Institute, Columbia, Missouri, August 10-14, 1992 — University of Missouri, Columbia, Missouri.

Five-day workshop — Principles and Applications of Modeling Chemical Reactions in Groundwater, Golden, Colorado, August 10-14, 1992 — Colorado School of Mines, Golden, Colorado.

Four-day workshop — Transport and Fate of Organic Chemicals in Multimedia Environmental Systems, Golden, Colorado, August 17-20, 1992 — Colorado School of Mines, Golden, Colorado.

Five-day workshop — Fundamentals of Bioremediation of Hazardous Waste-Contaminated Soils, Logan, Utah, August 24-28, 1992 — Utah State University, Logan, Utah.

Five-day workshop — Introduction in Groundwater Modeling, Golden, Colorado, September 14-18, 1992 — Colorado School of Mines, Golden, Colorado.

Four-day workshop — Primer in Environmental Initiatives, Columbia, Missouri, September 20-23, 1992 — University of Missouri, Columbia, Missouri.

One-day workshop — Sampling and Laboratory Analysis of Hazardous Substances, Columbia, Missouri, September 25, 1992 — University of Missouri, Columbia, Missouri.

Two-day workshop — Pollution Prevention Technology and Applications, Columbia, Missouri, October 14-15, 1992 — University of Missouri, Columbia, Missouri.

Three-day workshop — Five-Center Technology Transfer and Training Meeting and Workshop, Excelsior Springs, Missouri, October 14-16, 1992 — Kansas State University, Manhattan, Kansas.

Two-day conference — Total Quality Environmental Management, 6th Annual Colorado Hazardous Waste Management Society Conference and Exhibit, Denver, Colorado, October 22-23, 1992 — Hazardous Waste Management Society, Denver, Colorado.

Two-day workshop — Pollution Prevention Technology and Applications, St. Louis, Missouri, February 17-18, 1993 — University of Missouri, Columbia, Missouri.

Four-day workshop — Project Management for the Hazardous Waste Professional, Kansas City, Missouri, February 23-26, 1993 — University of Missouri, Columbia, Missouri.

Three-day workshop — Introduction to Hazardous Waste Management, Helena, Montana, March 17-19, 1993 — University of Missouri, Columbia, Missouri.

One-day workshop — Remedial Design Issues...Keeping Your Projects on Schedule and Within Budget, Kansas City, Missouri, March 25, 1993 — University of Missouri, Columbia, Missouri.

Two-day conference — Potentially Responsible Parties Superfund Settlement Incentives, Denver, Colorado, April 15-16, 1993 — Kansas State University, Manhattan, Kansas.

One-day workshop — Pollution Prevention Workshop for the Electroplating Industry, Manhattan, Kansas, May 24, 1993 — Kansas State University, Manhattan, Kansas.

Two-day conference — 8th Annual Conference on Hazardous Waste Research, Manhattan, Kansas, May 25-26, 1993 — Kansas State University, Manhattan, Kansas.

One-day workshop — Underground Storage Tank Site Characterization and Remediation Technologies, Manhattan, Kansas, May 27, 1993 — Kansas State University, Manhattan, Kansas.

Two-month workshop — Environmental Biotechnology Workshop for Thai Professors, Manhattan, Kansas, June 7-July 30, 1993 — Kansas State University, Manhattan, Kansas.

Four-day convention — National Groundwater Association's 45th Annual Convention and Exposition, Kansas City, Missouri, October 17-20, 1993 — National Groundwater Association, Dublin, Ohio.

One-day course — The Annual HAZMAT Update, St. Louis, Missouri, November 3, 1993 — University of Missouri, Columbia, Missouri.

One-day course — HAZMAT Employee Training, Testing and Certification, St. Louis, Missouri, November 4, 1993 — University of Missouri, Columbia, Missouri.

One-day course — Hazardous Waste Sampling, St. Louis, Missouri, November 5, 1993 — University of Missouri, Columbia, Missouri.

Four-day course — CHMM Review Course and Exam, St. Louis, Missouri, November 17-20, 1993 — University of Missouri, Columbia, Missouri.

One-day course — Hazardous Waste Sampling, Kansas City, Missouri, November 18, 1993 — University of Missouri, Columbia, Missouri.

One-day course — Advanced Hazardous Waste Management, Columbia, Missouri, November 30, 1993 — University of Missouri, Columbia, Missouri.

Three-day course — Introduction to Hazardous Waste Management, Kansas City, Missouri, December 1-3, 1993 — University of Missouri, Columbia, Missouri.

Three-day course — Three-Day Short Course on Soil Contamination, Kansas City, Missouri, December 2-3, 1993 — University of Nebraska, Lincoln, Nebraska.

Three-day workshop — Beneficial Effects of Vegetation in Contaminated Soils, Manhattan, Kansas, January 5-7, 1994 — Kansas State University, Manhattan, Kansas.

Three-day course — Introduction to Hazardous Waste Management, St. Louis, Missouri, January 5-7, 1994 — University of Missouri, Columbia, Missouri.

One-day course — CHMM Examination, St. Louis, Missouri, January 8, 1994 — University of Missouri, Columbia, Missouri.

One-day course — Air Quality Management Update, Kansas City, Missouri, January 25, 1994 — University of Missouri, Columbia, Missouri.

One-day course — HAZMAT 8-Hour Refresher Course, Kansas City, Missouri, February 3, 1994 — University of Missouri, Columbia, Missouri.

Two-day course — Pollution Prevention Course, Springfield, Missouri, February 3-4, 1994 — University of Missouri, Columbia, Missouri.

One-day course — HAZMAT Transportation Safety, Kansas City, Missouri, February 4, 1994 — University of Missouri, Columbia, Missouri.

Two-day course — Project Management for the Hazardous Waste Professional: Phase I, St. Louis, Missouri, February 8-19, 1994 — University of Missouri, Columbia, Missouri.

One-day course — Air Quality Management Update, St. Louis, Missouri, February 23, 1994 — University of Missouri, Columbia, Missouri.

Two-day course — Pollution Prevention Course, St. Louis, Missouri, February 24-25, 1994 — University of Missouri, Columbia, Missouri.

One-day course — Working Trees—Farming in the 1990s: Ecolotree™ Buffers for Riparian Edge Management, Owatonna, Minnesota, March 3, 1994 — Minnesota Soil & Water Conservation Association, Owatonna, Minnesota.

Two-day course — Project Management for the Hazardous Waste Professional: Phase II, Kansas City, Missouri, March 10-11, 1994 — University of Missouri, Columbia, Missouri.

Two-day course — Pollution Prevention Course, Kansas City, Missouri, March 18-19, 1994 — University of Missouri, Columbia, Missouri.

Two-day course — Advanced Water Treatment, Columbia, Missouri, March 24-25, 1994 — University of Missouri, Columbia, Missouri.

Two-day course — Pollution Prevention Course, Springfield, Missouri, April 7-8, 1994 — University of Missouri, Columbia, Missouri.

Four-day course — CHMM Review and Examination, St. Louis, Missouri, April 20-23, 1994 — University of Missouri, Columbia, Missouri.

One-day course — HAZMAT 8-Hour Refresher Course, Cape Girardeau, Missouri, May 5, 1994 — University of Missouri, Columbia, Missouri.

One-day course — HAZMAT Transportation Safety, Cape Girardeau, Missouri, May 6, 1994 — University of Missouri, Columbia, Missouri.

Five-day course — 40-Hour HAZWOPER, Columbia, Missouri, May 16-20, 1994 — University of Missouri, Columbia, Missouri.

Two-day workshop — Beneficial Effects of Vegetation in Soils Contaminated with Heavy Metals, Denver, Colorado, May 23-24, 1994 — EPA Region VIII, Denver, Colorado; and Kansas State University, Manhattan, Kansas.

Two-day course — Primer in Environmental Initiatives, Columbia, Missouri, May 24-25, 1994 — University of Missouri, Columbia, Missouri.

One-day field trip — Mine Lands Revegetation Field Trip, Butte, Montana, June 7, 1994 — Montana State University, Bozeman, Montana.

One-day workshop — Synergistic Solutions: A Conversation Among Industry, Government, and Academia, Bozeman, Montana, June 7, 1994 — Montana State University, Bozeman, Montana.

Three-day conference — 9th Annual Conference on Hazardous Waste Remediation, Bozeman, Montana, June 8-10, 1994 — Kansas State University, Manhattan, Kansas; and Montana State University, Bozeman, Montana.

One-day field trip — Mine Waste Field Trip, Butte, Montana, June 11, 1994 — Montana State University, Bozeman, Montana.

Five-day course — Hazardous Waste Management Summer Institute, Columbia, Missouri, August 8-12, 1994 — University of Missouri, Columbia, Missouri.

Two-day course — Primer in Environmental Laws and Multimedia Auditing, Columbia, Missouri, September 22-23, 1994 — University of Missouri, Columbia, Missouri.

One-day course — Introduction to Sampling, Columbia, Missouri, September 28, 1994 — University of Missouri, Columbia, Missouri.

One-day course — HazMat Refresher, Springfield, Missouri, October 6, 1994 — University of Missouri, Columbia, Missouri.

One-day course — Introduction to Sampling, Columbia, Missouri, October 12, 1994 — University of Missouri, Columbia, Missouri.

One-day course — ASTM—Risk-Based Corrective Action for Petroleum Sites, Columbia, Missouri, October 19, 1994 — University of Missouri, Columbia, Missouri.

One-day course — Hazardous Waste Sampling, Columbia, Missouri, November 3, 1994 — University of Missouri, Columbia, Missouri.

Seminar — The NAOMI Program and HERS: New Opportunities in Environmental Research, Lawrence, Kansas, November 2, 1994 — Haskell Indian Nations University, Lawrence, Kansas.

Seminar — Comparison of Native American and European Worldviews: A Native American Viewpoint, Lawrence, Kansas, November 4, 1994 — Haskell Indian Nations University, Lawrence, Kansas.

One-day course — Advanced Hazardous Waste Management, St. Louis, Missouri, November 16, 1994 — University of Missouri, Columbia, Missouri.

Three-day course — Introduction to Hazardous Waste Management, Denver, Colorado, December 1-3, 1994 — University of Missouri, Columbia, Missouri.

One-day course — Advanced Hazardous Waste Management, Kansas City, Missouri, January 25, 1995 — University of Missouri, Columbia, Missouri.

Seminar — Environmental Impacts of Gold Mining Operations Near the Fort Belknap Reservation, Lawrence, Kansas, January 26, 1995 — Haskell Indian Nations University, Lawrence, Kansas.

One-day course — Environmental Risk Management, Kansas City, Missouri, January 26, 1995 — University of Missouri, Columbia, Missouri.

One-day course — Eight-Hour HazMat Refresher, St. Louis, Missouri, February 9, 1995 — University of Missouri, Columbia, Missouri.

One-day course — HazMat HM-126/181, St. Louis, Missouri, February 10, 1995 — University of Missouri, Columbia, Missouri.

One-day course — Air Quality Management Update, St. Louis, Missouri, February 22, 1995 — University of Missouri, Columbia, Missouri.

Seminar — Comparison of Native American and European Worldviews: A European Viewpoint, Lawrence, Kansas, March 3, 1995 — Haskell Indian Nations University, Lawrence, Kansas.

One-day course — Air Quality Management Update, Kansas City, Missouri, March 8, 1995 — University of Missouri, Columbia, Missouri.

Three-day course — Introduction to Hazardous Waste Management, St. Louis, Missouri, March 16-18, 1995 — University of Missouri, Columbia, Missouri.

Two-day course — Advanced Water Treatment, Columbia, Missouri, March 23-24, 1995 — University of Missouri, Columbia, Missouri.

Seminar — Basin Creek Mine Closure Reclamation Techniques, Butte, Montana, April 13, 1995 — Mine Waste Technology Program, Butte, Montana; and Haskell Indian Nations University, Lawrence, Kansas.

Seminar — PCBs in Our Environment—The Legacy Continues, Flagstaff, Arizona, April 21, 1995 — Northern Arizona University, Flagstaff, Arizona; and Haskell Indian Nations University, Lawrence, Kansas.

Four-day seminar — A Gathering for the Earth, Washington, DC, April 21-23, 1995 — U.S. Department of Agriculture, Washington, DC; and Haskell Indian Nations University, Lawrence, Kansas.

Seminar — Topics in Pollution Prevention, Lawrence, Kansas, May 2, 1995 — Haskell Indian Nations University, Lawrence, Kansas.

One-day course — Eight-Hour HAZWOPER Refresher Course, Manhattan, Kansas, May 22, 1995 — Kansas State University, Manhattan, Kansas.

One-day workshop — Bioremediation of Munitions-Contaminated Soil, Manhattan, Kansas, May 22, 1995 — Kansas State University, Manhattan, Kansas; and Western Governors' Association Military Munitions Waste Working Group.

Two-day conference — 10th Annual Conference on Hazardous Waste Research, Manhattan, Kansas, May 23-24, 1995 — Kansas State University, Manhattan, Kansas.

Two-day workshop — Chelating Agents Design and Application in Heavy Metals Extraction from Contaminated Soils, Manhattan, Kansas, May 23-24, 1995 — University of Utah, Logan. Project no. 93-22.

One-day workshop — Beneficial Effects of Vegetation in Contaminated Soils, Manhattan, Kansas, May 25, 1995 — Kansas State University, Manhattan, Kansas.

One-day workshop — Designer Chelators: Study of Structure-Activity Relationships to Obtain the Ideal Chelator, Manhattan, Kansas, May 25, 1995 — University of Utah, Salt Lake City, Utah; and Kansas State University, Manhattan, Kansas.

One-day workshop — Environmentally Conscious Printing, Manhattan, Kansas, May 25, 1995 — Kansas State University, Manhattan, Kansas.

Five-day seminar — Freight Pipeline Seminar, Columbia, Missouri, July 10-14, 1995 — University of Missouri, Columbia, Missouri.

Two-week workshop — Technologies in Cleanup and Compliance, Lawrence, Kansas, July 16-29, 1995 — Haskell Indian Nations University, Lawrence, Kansas; Kansas State University, Manhattan, Kansas; and Kansas State University, Salina, Kansas.

Five-day course — Hazardous Waste Summer Institute, Columbia, Missouri, August 7-11, 1995 — University of Missouri, Columbia, Missouri.

Two-day seminar — Phytoremediation of Soil and Water Contaminants, Orlando, Florida, August 25-30, 1996 — 212th National Meeting of the American Chemical Society.

Seminar — Comparison of Native American and European Worldviews: A Roundtable Discussion, Lawrence, Kansas, September 20, 1995 — Haskell Indian Nations University, Lawrence, Kansas.

Five-day workshop — 40-Hour HAZWOPER Training, Missoula, Montana, October 9-13, 1995 —University of Montana, Missoula, Montana.

Seminar — The Badlands Bombing Range Project, Lawrence, Kansas, October 11, 1995 — Haskell Indian Nations University, Lawrence, Kansas.

Five-day workshop — 40-Hour HAZWOPER Training, Missoula, Montana, November 13-17, 1995 — University of Montana, Missoula, Montana.

One-day workshop — Advanced Hazardous Waste Management, St. Louis, Missouri, Nov 29, 1995 — University of Missouri, Columbia, Missouri.

One-day workshop — Annual Hazardous Materials Update (8-Hour Refresher), television simulcast from Kansas City, St. Louis, and Columbia, Missouri, Oct 25, 1995 — University of Missouri, Columbia, Missouri.

One-day workshop — Bioremediation Alternatives, Helena, Montana, December 7, 1995 — Montana State University, Bozeman, Montana.

Five-day workshop — 40-Hour HAZWOPER Training, Missoula, Montana, December 11-15, 1995 — University of Montana, Missoula, Montana.

Five-day workshop — 40-Hour HAZWOPER Training, Manhattan, Kansas, January 15-19, 1996 — Kansas State University, Manhattan, Kansas.

Seminar — Comparison of Native American and European Worldviews: A Roundtable Discussion, Part II, Lawrence, Kansas, January 23, 1996 — Haskell Indian Nations University, Lawrence, Kansas.

One-day workshop — Advanced Hazardous Waste Management Course, Kansas City, Missouri, February 8, 1996 — University of Missouri, Columbia, Missouri.

Two-day workshop — Real Estate Site Assessment, Phase I, Kansas City, Missouri, March 5-6, 1996 — University of Missouri, Columbia, Missouri.

Three-day workshop — Bioremediation Alternatives, Annual UST/LUST National Conference, Chicago, Illinois, March 11-13, 1996 — Montana State University, Bozeman, Montana.

One-week symposium — Billings Reclamation Symposium, Billings, Montana, March 17-23, 1996 — Montana State University, Billings, Montana.

Two-day workshop — Real Estate Site Assessment, Phase I, Omaha, Nebraska, March 19-20, 1996 — University of Missouri, Columbia, Missouri.

Two-hour video conference — An Environmental Legacy for Our Grandchildren, Lawrence, Kansas, April 11, 1996 — Haskell Indian Nations University.

Seminar — Geoscience Education in Native American Communities, Rapid City, South Dakota, April 19, 1996 — South Dakota School of Mining and Technology, Rapid City, South Dakota and Haskell Indian Nations University, Lawrence, Kansas.

One-day exposition — Solvent Alternative Expo, Salina, Kansas, April 25, 1996 — Kansas State University, Manhattan, Kansas.

One-day workshop — Beneficial Effects of Vegetation in Metals-Contaminated Soils, Albuquerque, New Mexico, May 20, 1996.

One-day workshop — HAZWOPER Refresher, Columbia, Missouri, May 21, 1996 — University of Missouri, Columbia, Missouri.

Two-day workshop — Real Estate Site Assessment, Phase I, Salt Lake City, Utah, May 21-22, 1996 — University of Missouri, Columbia, Missouri/ASTM.

One-day workshop — Bioremediation Alternatives, HSRC/WERC Joint Conference on the Environment, Albuquerque, New Mexico, May 21-23, 1996 — Montana State University, Bozeman, Montana.

Three-day conference — HSRC/WERC Joint Conference on the Environment, Albuquerque, New Mexico, May 21-23, 1996 — Great Plains/Rocky Mountain HSRC, Manhattan, Kansas.

Five-day workshop — HAZWOPER 40-Hour Course, Columbia, Missouri, May 20-24, 1996 — University of Missouri, Columbia, Missouri.

One-day workshop — Remediation of Munitions-Contaminated Soil and Water, Albuquerque, New Mexico, May 23, 1996.

Two-day workshop — HAZWOPER 8-Hour Refresher Short Course, Albuquerque, New Mexico, May 23-24, 1996.

Two-day workshop — Selection of Remediation Technologies Short Course, Albuquerque, New Mexico, May 23-24, 1996.

Two-day workshop — Risk-Based Corrective Action, Wichita, Kansas, June 25-26, 1996 — University of Missouri, Columbia, Missouri/ASTM.

Five-day workshop — Hazardous Waste Summer Institute, Columbia, Missouri, July 29-August 2, 1996 — University of Missouri, Columbia, Missouri.

Two-day training — Environmental Analysis Training, Rosebud, South Dakota, November 20-22, 1996 — Sinte Gleska University and University of Nebraska-Lincoln.

Seminar — Biology of the Earth: All Things Are Connected, Lawrence, Kansas, January 28, 1997 — Haskell Indian Nations University, Lawrence, Kansas.

Two-day workshop — Risk-Based Corrective Action (ASTM Standards), Kansas City, Missouri, January 28-29, 1997 — University of Missouri-Columbia, Missouri.

One-day workshop — Air Quality Management Update, St. Louis, Missouri, February 13, 1997 — University of Missouri-Columbia, Missouri.

Two-day workshop — Real Estate Phase I Assessment (ASTM Standards), Memphis, Tennessee, February 25-26, 1997 — University of Missouri-Columbia, Missouri.

Seminar — Biology of the Earth: Our Connection to the Land, Lawrence, Kansas, February 28, 1997 — Haskell Indian Nations University, Lawrence, Kansas.

One-day training — Eight-Hour HAZWOPER Refresher, Columbia, Missouri, March 4, 1997 — University of Missouri-Columbia, Missouri.

One-day workshop — Advanced Hazardous Waste Management, Columbia, Missouri, March 5, 1997 — University of Missouri-Columbia, Missouri.

One-day workshop — Air Quality Management Update, Kansas City, Missouri, March 6, 1997 — University of Missouri-Columbia, Missouri.

Two-day workshop — Department of Transportation Requirements for Hazardous Materials Handling, Columbia, Missouri, March 6-7, 1997 — University of Missouri-Columbia, Missouri.

One-day workshop — Advanced Water Treatment, Columbia, Missouri, March 20, 1997 — University of Missouri-Columbia, Missouri.

Seminar — Biology of the Earth: Water – Going Beneath the Surface of the Issue, Lawrence, Kansas, March 20, 1997 — Haskell Indian Nations University, Lawrence, Kansas.

Two-day workshop — ISO 14000 Auditing for Managers, Kansas City, Missouri, April 8-9, 1997 — University of Missouri-Columbia, Missouri.

Two-day conference — WERC/HSRC Joint Conference on the Environment, Albuquerque, New Mexico, April 22-24, 1997 — Waste-management Education and Research Consortium and the South/Southwest Hazardous Substance Research Center.

Seminar — Biology of the Earth: Air-Ensuring Quality for the Future, Lawrence, Kansas, April 22, 1997 — Haskell Indian Nations University, Lawrence, Kansas.

Six-week video course — Certified Hazardous Materials Manager Review, various locations throughout Missouri, April 24-May 29, 1997 — University of Missouri-Columbia, Missouri.

Test — Certified Hazardous Materials Manager Examination, Columbia, Missouri, April 26, 1997 — University of Missouri-Columbia, Missouri.

Two-day course — Risk-Based Corrective Action: The Standard for Petroleum Release Sites ASTM Standard E 1739, St. Louis, Missouri, April 29-30, 1997 — University of Missouri-Columbia, Missouri.

Two-day course — ISO 14000 for Auditors, Kansas City, Missouri, May 13-14, 1997 — University of Missouri-Columbia, Missouri.

One-day workshop — Eight-Hour HAZWOPER Refresher, Kansas City, Missouri, May 19, 1997 — Kansas State University, Manhattan, Kansas.

One-day workshop — Acid Mine Drainage Short Course, Kansas City, Missouri, May 19, 1997 — West Virginia University.

One-day course — Eight-Hour HAZWOPER Refresher, Columbia, Missouri, May 20, 1997 — University of Missouri-Columbia, Missouri.

Three-day conference — 12th Annual Conference on Hazardous Waste Research, Kansas City, Missouri, May 20-22, 1997 — Great Plains/Rocky Mountain HSRC, Manhattan, Kansas.

One-day workshop — Application of Chelating Agents for Removal of Heavy Metals from Soils, Kansas City, Missouri, May 22, 1997 — Utah State University, Logan, Utah. Project no. 93-22.

One-day workshop — Prepared-Bed Bioremediation of Contaminated Soils, Kansas City, Missouri, May 22, 1997 — Utah State University, Logan, Utah.

One-day workshop — Water Quality Workshop, June 3, 1997 — Haskell Indian Nations University, Lawrence, Kansas.

Three-day conference — EPA Region 7 Pollution Prevention Conference, Kansas City, Missouri, June 3-5, 1997 — Kansas State University, Manhattan, Kansas.

Five-day seminar — 16th Annual Hazardous Waste Summer Institute, Columbia, Missouri, August 4-8, 1997 — University of Missouri-Columbia, Missouri.

Two-day workshop — Environmental Site Assessment Practices for Commercial Real Estate ASTM Standard E 1527 and 1528, St. Louis, Missouri, August 12-13, 1997 — University of Missouri-Columbia, Missouri.

Three-day workshop — Symposium on Science in the Tallgrass, 53rd Southwest Regional Meeting, Tulsa, Oklahoma, October 1-3, 1997 — American Chemical Society, Washington, DC.

Three-day workshop — Certified Hazardous Materials Manager Review, St. Louis, Missouri, October 15-17, 1997 — University of Missouri-Columbia, Missouri.

Seminar — Native American Environmentalism at the Cusp of the Millennium, Lawrence, Kansas, November 5, 1997 — Haskell Indian Nations University, Lawrence, Kansas.

Seminar — Effects of the 1997 Nuclear Waste Policy Act, Lawrence, Kansas, November 10, 1997 — Haskell Indian Nations University, Lawrence, Kansas.

Three-day workshop — Compacted Clay Liners, Columbia, Missouri, November 11-13, 1997 — University of Missouri-Columbia, Missouri.

Five-day workshop — HAZWOPER 40-hour Course, Manhattan, Kansas, January 5-9, 1998 — Kansas State University, Manhattan, Kansas.

One-day workshop — HAZWOPER Refresher, Manhattan, Kansas, January 7, 1998 — Kansas State University, Manhattan, Kansas.

Three-day workshop — Workshop on Beneficial Effects of Vegetation in Contaminated Soil, Manhattan, Kansas, January 7-9, 1998 — Great Plains/Rocky Mountain HSRC, Manhattan, Kansas.

Three-day workshop — Introduction to Hazardous Waste Management, Columbia, Missouri, January 12-14, 1998 — University of Missouri-Columbia, Missouri.

Two-day workshop — Compliance with DOT Regulations Training, Testing, and Certification, Columbia, Missouri, January 15-16 — University of Missouri-Columbia, Missouri.

Seminar — Environmental Justice in Indian Country, Lawrence, Kansas, March 20, 1998 — Haskell Indian Nations University, Lawrence, Kansas.

Nine-day conference — Wetlands Engineering and River Restoration Conference, Denver, Colorado, March 20-29, 1998 — American Society of Civil Engineers, Reston, Virginia; and Society of Wetland Scientists, Lawrence, Kansas.

Three-day conference — Joint Conference on the Environment, Albuquerque, New Mexico, March 31-April 2, 1998 — Waste-management Education and Research Consortium, Las Cruces, New Mexico; Western Region HSRC, Stanford, California; and New Mexico Hazardous Waste Management Society.

Seminar — Microscale Chemistry in the Classroom, Lawrence, Kansas, April 11, 1998 — Haskell Indian Nations University, Lawrence, Kansas.

Three-day workshop — Certified Hazardous Materials Manager Review Course, Columbia, Missouri, April 15-17, 1998 — University of Missouri-Columbia, Missouri.

One-day workshop — On-Site Insights: Innovative Technologies for Site Assessment and Monitoring, Snowbird, Utah, May 18, 1998 — Northeast HSRC, Newark, New Jersey.

One-day workshop — Predictive Modeling of Pitlake Chemistry: Theory, Methods, Application, and Regulatory Issues, Snowbird, Utah, May 18, 1998 — Montana Tech of the University of Montana, Butte, Montana.

One-day workshop — Quantitative Assessment of Natural Attenuation Processes for Site Remediation, Snowbird, Utah, May 18, 1998 — Utah State University, Logan, Utah; and Great Plains/Rocky Mountain HSRC, Manhattan, Kansas.

Three-day conference — 13th Annual Conference on Hazardous Waste Research, Snowbird, Utah, May 19-21, 1998 — Great Plains/Rocky Mountain HSRC, Manhattan, Kansas.

Two-day workshop — Natural Attenuation of Chlorinated Solvents in Groundwater, Salt Lake City, Utah, July 15-16, 1998 — Utah Department of Environmental Quality, Salt Lake City, Utah; Hill Air Force Base, Utah; Utah State University, Logan, Utah.

Four-day conference — Animal Production Systems and the Environment: An International Conference on Odor, Water Quality, Nutrient Management, and Socioeconomic Issues, Des Moines, Iowa, July 19-22, 1998 — Iowa State University, Ames, Iowa.

Seminar — Wetland Ecology and Indian Culture, Lawrence, Kansas, September 10, 1998 — Haskell Indian Nations University, Lawrence, Kansas.

Seminar — Water Resource Protection Programs — A Tribal Perspective, Lawrence, Kansas, September 11, 1998 — Haskell Indian Nations University, Lawrence, Kansas.

Two-day workshop — Natural Attenuation of Chlorinated Solvents in Groundwater, Kansas City, Kansas, September 16-17, 1998 — Kansas Department of Health and Environment, Topeka, Kansas and Great Plains/Rocky Mountain HSRC, Manhattan, Kansas.

Three-day workshop — Fate, Transport, and Remediation of Nonaqueous-Phase Liquids (NAPLs), Helena, Montana, September 22-24, 1998 — Colorado School of Mines, Golden, Colorado; Colorado State University, Fort Collins, Colorado; and University of Nevada, Las Vegas, Nevada.

Five-day workshop — HAZWOPER 40-hour Course, Manhattan, Kansas, January 4-8, 1999 — Kansas State University, Manhattan, Kansas.

One-day workshop — HAZWOPER Refresher, Manhattan, Kansas, January 6, 1999 — Kansas State University, Manhattan, Kansas.

Three-day conference — Tailings and Mine Waste '99 Conference, Ft. Collins, Colorado, January 24-27, 1999 — Colorado State University.

Two-day course — Introduction to Hazardous Waste Management, Columbia, Missouri, January 25-27, 1999 — University of Missouri-Columbia.

Two-day course — Compliance with DOT Regulations: Training, Testing, and Certification, Columbia, Missouri, January 27-29, 1999 — University of Missouri-Columbia.

Four-day conference — Ninth Annual Waste-management Education and Research Consortium Conference on the Environment, Las Cruces, New Mexico, April 26-29, 1999 — WERC.

One-day workshop — Assessment and Cleanup Strategies for Site Redevelopment Based on Intended Land Use and Risk Analysis, Sioux Falls, South Dakota, May 4, 1999 — Great Plains/Rocky Mountain HSRC, Manhattan, Kansas.

One-day workshop — Assessment and Cleanup Strategies for Site Redevelopment Based on Intended Land Use and Risk Analysis, Des Moines, Iowa May 6, 1999 — Great Plains/Rocky Mountain HSRC, Manhattan, Kansas.

One-day workshop — Assessment and Cleanup Strategies for Site Redevelopment Based on Intended Land Use and Risk Analysis, St. Louis, Missouri, May 24,1999 — Great Plains/Rocky Mountain HSRC, Manhattan, Kansas.

Three-day conference — 14th Annual Conference on Hazardous Waste Research, St. Louis, Missouri, May 25-27, 1999 — Great Plains/Rocky Mountain HSRC, Manhattan, Kansas.

One-day workshop — Community Involvement Strategies, Wellston, Missouri, May 27, 1999 — Great Plains/Rocky Mountain HSRC, Manhattan, Kansas.

One-day workshop — Permeable Reactive Barriers, St. Louis, Missouri, May 27, 1999 — Great Plains/Rocky Mountain HSRC, Manhattan, Kansas.

One-day workshop — Assessment and Cleanup Strategies for Site Redevelopment Based on Intended Land Use and Risk Analysis, Salt Lake City, Utah, June 3, 1999 — Great Plains/Rocky Mountain HSRC, Manhattan, Kansas.

Five-day workshop — HAZWOPER 40-hour Course, Manhattan, Kansas, June 14-18, 1999 — Kansas State University, Manhattan, Kansas.

Five-day workshop — Field-Based Site Characterization Technologies Course, Haskell National Training Center, Lawrence, Kansas, June 21-25, 1999, Haskell Environmental Resources Study Center, Lawrence, Kansas.

One-day workshop — HAZWOPER Refresher, Manhattan, Kansas, June 21, 1999 — Kansas State University, Manhattan, Kansas.

One-day workshop — Assessment and Cleanup Strategies Workshop, Denver, Colorado, July 8, 1999 — GP/RM HSRC and EPA Brownfields and Community Involvement Offices.

Three-day tour — Nebraska Summer Water Tour "Opportunities and Alternatives in Water and Agriculture," July 19-21, 1999 —University of Nebraska-Lincoln and other sponsors; Kearney Area Chamber of Commerce.

Three-day course — Introduction to Hazardous Waste Management (Course 2), August 2-4, 1999, Columbia, Missouri — University of Missouri-Columbia.

One-day course — Advanced Hazardous Waste Management, August 5, 1999, Columbia, Missouri — University of Missouri-Columbia.

One-day course — Hazardous Waste Management Update, August 6, 1999, Columbia, Missouri — University of Missouri.

Four-day conference — 5th International Petroleum Environmental Conference, Albuquerque, New Mexico, October 20-23, 1999 — Integrated Petroleum Environmental Consortium and Waste-management Education and Research Consortium.

Five-day symposium — 2000 Billings Land Reclamation Symposium, March 20-24, 2000, Billings, Montana — Montana State University.

One-day workshop — Phytoremediation Workshop: The State of the Science and Practice, May 22, 2000, Denver, Colorado — Great Plains/Rocky Mountain Hazardous Substance Research Center, Manhattan, Kansas.

One-day workshop — Technology Transfer for the Domestic Petroleum Industry: A State Regulator Workshop, May 22, 2000, Denver, Colorado — Great Plains/Rocky Mountain Hazardous Substance Research Center, Manhattan, Kansas.

Three-day conference — 15th Annual Conference on Hazardous Waste Research, May 23-25, 2000, Denver, Colorado — Great Plains/Rocky Mountain Hazardous Substance Research Center, Manhattan, Kansas.

One-day workshop — Workshop on Environmental Disclosure in Real Estate Transactions, May 25, 2000, Denver, Colorado — Great Plains/Rocky Mountain Hazardous Substance Research Center, Manhattan, Kansas.

Three-day course — Introduction to Hazardous Waste Management, August 7-9, 2000, Columbia, Missouri — University of Missouri-Columbia.

One-day course — Advanced Hazardous Waste Management, August 10, 2000, Columbia, Missouri — University of Missouri-Columbia.

One-day course — Hazardous Waste Management Update, August 11, 2000, Columbia, Missouri — University of Missouri-Columbia.

Three-day conference — Central States Agricultural Health and Safety Conference: A Working Conference to Develop a Plan of Action, September 20-22, 2000, Kansas City, Kansas — University of Iowa.

One-day training — Eight-Hour HAZWOPER Refresher Course, May 21, 2001, Manhattan, Kansas — Great Plains/Rocky Mountain Hazardous Substance Research Center, Manhattan, Kansas.

Half-day course — Engineering and Technology: Pollution Prevention Workshop, May 21, 2001, Manhattan, Kansas — Great Plains/Rocky Mountain Hazardous Substance Research Center, Manhattan, Kansas.

Two-day conference — 2001 Conference on Environmental Research, May 22-23, 2001, Manhattan, Kansas — Great Plains Rocky/Mountain Hazardous Substance Research Center, Manhattan, Kansas.

One-day workshop — Cost-Effective Maintenance and Surface Remediation for Oil and Gas Producers, May 24, 2001, Manhattan, Kansas — Great Plains/Rocky Mountain Hazardous Substance Research Center, Manhattan, Kansas.

Two-day workshop — ITRC Phytotechnologies: Mechanisms & Application, September 12-13, 2001, Austin, Texas —Interstate Technology and Regulatory Cooperation Work Group.

Two-day workshop — ITRC Phytotechnologies Classroom Training, October 24-25, 2001, Amherst, Massachusetts — Interstate Technology and Regulatory Cooperation Work Group.

INDEX

A

Adobe Acrobat, 17
Adobe's Acrobat software, 48
alfalfa, 12, 34
Alvarez, P.J.J., 31
analysis/treatment of contaminated soil, 27
annual conference, 8, 47
arsenic, 39
atrazine, 29

B

Banks, M.K., 56
bioremediation, 43
Boguski, T.K., 49
Brandon, B., 49
Burckhard, S.R., 53

C

Center's mission, 8
Centerpoint, 12
collaborative problem solving, 46
Comfort, S.D., 29
communication, 46
communities, 49
contamination, 29

D

DAT, 28
Davis, L.C., 33
dechlorination, 32
dehalogenation, 27
destructive adsorption technology, 28
Dienes, V., 49

E

Earth Medicine, 12
editorial, 48
editorial board, 48
editors, 48
electronic journal, 48
electronic media, 17
EPA Regions VII and VIII, 7
Erickson, L.E., 33, 41, 47, 48

F

fate and transport, 42

funding, 8

G

Godfrey, G.L., 51
graphics, 17
Griswold, W.M., 9, 51
groundwater, 30, 33

H

Hale Library, 13
Haskell Indian Nations University, 51
Hayter, R.B., 45
HazTech Transfer, 18, 12
heavy metals, 32
home page, 12
HTML, 17, 48
http://www.engg.ksu.edu/HSRC, 8, 12, 13
hyperlinks, 17
Hypertext Markup Language (HTML), 17

I

Illangasekare, T.H., 37
information, 47
information exchange, 47
interlibrary loan, 13
Internet, 8, 9, 17, 48
iron, 31
iron-promoted processes, 29

J

Journal of Hazardous Substance Research, 17, 48

K

key investigators, 5
key personnel, 5
Klabunde, K.J., 12, 27
Kulakow, P., 41

L

Leven, B.A., 9, 45, 47, 50, 52, 54
Licht, L., 12

M

Magellan Internet Guide, 13
MAIs, 11
manuscripts, 48
metal oxide, 27
minority colleges, 51

N

nanoparticle, 28
nanoscale, 27
NAOMI, 9, 11, 12, 51
NAPL, 37
National Priority List, 50
Native American, 51
newsletter, 45, 51
Newspoint, 12
nitrate, 29

O

organic chemical contamination of soil/water, 29, 33, 37, 39, 43
outreach services, 49

P

PAH, 43
Parkin, G.F., 31
partnerships, 46
PDF, 48
phytoremediation, 39, 53
Pilon-Smits, E., 43
plants, 33
poplar trees, 35
portable document format, 48
Project numbers
No. 01, 23, 113
No. 02, 19, 112
No. 03, 19, 94, 116
No. 04, 19, 114
No. 05, 21, 117
No. 06, 20, 113
No. 07, 21, 111
No. 09, 21, 121
No. 10, 21, 118
No. 11, 21, 114
No. 12, 23, 120
No. 13, 23, 121
No. 14, 25, 113
No. 15, 20, 115
No. 16, 20, 116
No. 17, 19, 117
No. 18, 20, 118
No. 89-01, 20, 115
No. 89-06, 20, 114
No. 89-09, 19, 114
No. 89-10, 21, 118
No. 89-11, 22, 120
No. 89-14, 23, 108, 118
No. 89-17, 22, 100, 117
No. 89-19, 19, 120
No. 89-21, 19
No. 89-22, 19, 116
No. 89-23, 21, 112
No. 89-26, 23, 56, 63, 64, 65, 70, 71, 78, 89, 94, 95, 96, 97, 98, 99, 105, 112, 114, 116, 125, 126
No. 89-29, 19
No. 89-30, 19, 118
No. 89-31, 20, 120, 129
No. 90-04, 20
No. 90-05, 19, 118
No. 90-11, 19, 111
No. 90-13, 21, 121
No. 90-16, 18
No. 91-03, 21, 116
No. 91-04, 21, 115
No. 91-07, 21, 117
No. 91-08, 20, 117
No. 91-10, 21, 115
No. 91-25, 21, 112
No. 91-29, 21, 113
No. 91-36, 25, 59, 60, 61, 62, 64, 71, 88, 91, 101, 107, 114, 127
No. 92-03, 23, 56, 63, 64, 65, 70, 71, 78, 89, 94, 95, 96, 97, 98, 99, 105, 112, 114, 116, 125, 126
No. 92-05, 19, 118
No. 92-08, 19, 116
No. 92-11, 19, 119
No. 92-24, 24, 58, 62, 65, 66, 68, 70, 72, 112, 121, 124, 125, 126, 128
No. 93-02, 24, 68, 71, 74, 75, 77, 101, 106, 118, 123, 127, 128, 130
No. 93-05, 22, 55, 68, 76, 77, 95, 112, 125
No. 93-06, 21, 57, 58, 102, 121, 124, 126, 132
No. 93-07, 20, 55, 64, 87, 88, 89, 95, 96, 100, 101, 115
No. 93-11, 24, 112
No. 93-12, 20, 63, 74, 93, 117, 124
No. 93-16, 22, 116
No. 93-20, 24, 113
No. 93-21, 24, 60, 62, 67, 68, 100, 104, 120, 123, 124, 125, 127
No. 93-22, 20, 57, 58, 61, 66, 115, 128, 129, 140, 144
No. 93-24, 22, 55, 68, 73, 76, 101, 121, 127
No. 94-02, 24, 39, 114
No. 94-05, 20, 37, 60, 73, 80, 98, 117
No. 94-07, 22, 108, 119, 123, 125
No. 94-08, 22, 111, 124, 125
No. 94-09, 24, 64, 66, 115
No. 94-11, 23, 63, 64, 67, 94, 118, 125
No. 94-12, 24, 78, 84, 118, 127
No. 94-15, 22, 76, 96, 117
No. 94-24, 24, 96, 116, 122
No. 94-25, 22, 56, 57, 70, 79, 119
No. 94-26, 24, 59, 107, 120, 122
No. 94-27, 22, 33, 34, 57, 58, 67, 69, 73, 74, 79, 80, 83, 84, 85, 90, 93, 97, 98, 99, 103, 109, 110, 111, 113, 124, 130
94-27A, 34, 35, 73, 75, 79, 80, 83, 84, 85, 93, 110, 113
No. 94-28, 24, 58, 64, 79, 80, 83, 93, 96, 112
No. 94-29, 22, 37, 56, 64, 69, 71, 72, 73, 78, 79, 82, 92, 94, 102, 107, 115, 121, 125, 126, 127, 128
No. 95-04a, 24, 27, 56, 59, 64, 116, 125
No. 95-10, 22, 59, 68, 100, 113, 122
No. 95-29, 22, 69, 74, 108, 119, 122, 123
No. 95-32, 22, 28, 29, 58, 70, 74, 81, 103, 104, 110, 121, 128, 130
No. 95-4a, 27, 57, 65, 69

No. 98-01, 23, 31, 69, 74, 75, 103, 111, 117
No. 98-03, 23, 33, 34, 35, 58, 73, 74, 75, 79, 80, 83, 85, 94, 102, 113, 125
No. 98-05, 23, 35, 38, 56, 64, 69, 71, 73, 74, 78, 82, 92, 94, 126
No. 98-08, 23, 38, 70, 119, 123
No. D93-01, 26
No. NAOMI, 26
No. NCIBRD 1, 22
No. PRP, 25
No. R-1, 21
No. R2D2, 26
No. RDTF, 41, 113, 131
No. SP -96, 78, 79, 94, 95, 100, 125, 128, 131
No. SP93-01, 26, 49
No. SP95-TCE, 24
No. SP96-1, 95
No. SP96-Riley, 53
No. SP99-01, 23, 42, 118
No. TOSNAC, 26, 49
No. TR-01, 26, 44, 46
No. TR92-03a, 25
No. TR92-03b, 25
No. TR92-04, 25
No. TR92-PI, 25
No. TR93-02, 25
No. TR93-07, 26
No. TR94-02, 25
No. TR95-10, 26, 47
No. TR95-11, 26
No. TR96-05, 26, 51, 88, 114
No. TR97-07, 26, 119
No. TR-LIBBY, 25
publishing, 48

R

R2D2, 11
Reardon, K.F., 43
Reddi, L.N., 45, 47
regulation, 37
remediation, 37
repository, 13, 45
research, 47
rhizosphere, 43
risk-reduction research, 7

S

Scherer, M.M., 31
Schwab, A.P., 54
Science Advisory Committee, 4, 9
seminar, 52
Shea, P.J., 28
Simeonsson, J.B., 39
site characterization, 37
soil, 33, 41
sound, 17
surface water, 29

T

TCE, 27
Technical Assistance Grants, 50
technology transfer, 45
TOSC program, 11
TOSNAC, 11
training, 45
Training and Technology Transfer, 45, 47, 48, 49, 51, 53
Training and Technology Transfer Advisory Committee, 5

V

vegetation, 41, 53
video, 17
virtual publishing, 48

W

waste minimization, 7
Web pages, 12, 46
Web site, 48
Wigfall, L.J., 49
World Wide Web, 8, 12, 17, 46, 48

X

xenobiotics, 32

Z

zero-valent, 29
Zhang, T.C., 29