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## Kentucky Water Resources Research Institute Annual Technical Report FY 1998

Kentucky Water Resources Research Institute, University of Kentucky

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# Kentucky Water Resources Research Institute

## Annual Technical Report

**FY 1998**

### Introduction

### Research Program

TRANSMITTAL LETTER TO: Pansy R. Yeatts Contracting Officer, Procurement Branch A Office of Acquisition and Federal Assistance FROM: James A. Kipp, Assistant Director SUBJECT: Kentucky Water Resources Research Institute Annual Program Report March 1, 1998 through February 28, 1999 Award Number: 1434-HQ-96-GR-02672 The Annual Program Report for Kentucky follows. This document consolidates the reporting requirements of the base grant and regional competitive grant awards in a single technical report which includes: 1) a synopsis of each ongoing research project and of each research project completed during the period, 2) a list of reports published, 3) a brief description of information transfer activities, 4) a summary of student support during the reporting period, and 5) notable achievements and awards during the year. Financial reports for the base grant and the regional competitive grant program awards have been provided separately.

#### Basic Project Information

Basic Project Information	
Category	Data
Title	Development of a novel in vitro screening assay for analysis of bioavailable metal
Project Number	C-04
Start Date	07/01/1997
End Date	06/30/1999
Research Category	Water Quality
Focus Category #1	Methods
Focus Category #2	Water Quality
Focus Category #3	Toxic Substances
Lead Institution	University of Kentucky

#### Principal Investigators

Principal Investigators			
Name	Title During Project Period	Affiliated Organization	Order
Christer Hogstrand	Assistant Professor	University of Kentucky	01

## **Problem and Research Objectives**

Bioreactive metal represents the fraction of accumulated metal that can interact with intracellular machinery. The Metal Biosensor exploits the metal responsiveness of the metallothionein (MT) gene, the light-generation of the firefly luciferase gene product, and a newly developed technique to reconstitute a "tight" gill epithelium on a permeable support. It is constructed from freshly isolated bluegill or rainbow trout gill cells transfected with the pGL-6MRE plasmid and reconstructed into a tight epithelium. Unmodified water samples are directly introduced to the apical side. If inducing metals or metal-ligand complexes are present and enter the cell in a bioreactive form, the MT promoter is turned on and luciferase synthesis initiated.

## **Methodology**

A truncated segment (the first 793 base-pairs) of the 5' flanking region of the rainbow trout MT-A gene was used to increase metal specificity. This abbreviated MT-A promoter contained six metal responsive elements (MRE), while all other known cis-acting elements were removed [1-3]. The metal responsive promoter was fused upstream of a luciferase reporter gene and cloned in a plasmid vector, pGL-6MRE [3, 2]. This gene construct was transfected (i.e., packed) into fish gill epithelial cells where it can be activated by bioreactive intracellular Cu, Zn, Cd, Hg, or Ag [1-3, 4]. The production of luciferase is detected with high sensitivity, precision, and speed using scintillation counting. The dose-dependent metal sensitivity of the pGL-6MRE plasmid has been well established in several immortal cell lines [1-3, 4]. We have tested four commercially available cationic liposomes (i.e., Cellfectin, DMRIE-C, Lipofectin, Lipofectamine) for optimal transfection efficiency. Freshly isolated gill cells from bluegill and rainbow trout were transfected over a range of lipid:DNA ratios (1-100:1) and incubated 24-h in 100 mmol Zn/L in culture media. The epithelium is grown on a permeable support with unprocessed sample water maintained on the apical side (facing water column), and the blood plasma surrogate (growth media) maintained on the basolateral side (facing blood plasma). Upon exposure to apical freshwater, the transepithelial resistance increases drastically [6, 7] and a transepithelial potential develops with the basolateral side negative, as in the intact fish [5]. This is in agreement with other studies [5, 6, 7-9]. Ultrastructural characterization using laser confocal and electron microscopy has revealed that the artificial gill has the same cellular constitution, organization, and polarity as the gill lamellae in vivo.

## **Principal Findings and Significance**

Transfected gill cells from each species were responsive to metal. At 100 mmol Zn/L, peak promoter activity, as measured by luciferase, was elevated 2-fold (bluegill) and 3-fold (rainbow trout) above background. For each species, DMRIE-C and Lipofectamine provided the greatest promoter response. Currently, all biosensor components (pGL-6MIRE plasmid, transfections, metal induction, reconstructed bluegill/trout epithelia) are operational and the functional unit is undergoing final laboratory characterization and field validation in Big Bayou Creek. We have found that the artificial gill has permeability and electrical properties similar to intact gills and closely mimics in vivo exposure conditions (water chemistry) in the target tissue. Epithelia constructed from bluegill are being explored because they can be cultured at room temperature and are amenable for use in both cold and warm water systems (bluegill are naturally abundant in most of the U.S., whereas rainbow trout have a more limited distribution). The completed Metal Biosensor will provide a useful test system that accurately measures metal bioreactivity in natural waters by quantifying only the toxic fraction of bioavailable metals in the water column. References 1. Olsson, P.E., Kling, P., Hogstrand, C. 1998. Mechanisms of heavy metal accumulation and toxicity in fish. In: E.W. Taylor, ed. Toxicology and Aquatic Pollution -

Physiological, Molecular and Cellular Approaches. Society for Experimental Biology Seminar Series 57. Cambridge University Press, UK. 2. Olsson, P.E., Kille, P. 1997. Functional comparison of the metal-regulated transcriptional control regions of metallothionein genes from cadmium sensitive and tolerant fish species. *Biochim Biophys Acta* 1350:325-334. 3. Olsson, P.E., Kling, P., Erkell, L.J., Kille, P. 1995. Structural and functional analysis of the rainbow trout (*Oncorhynchus mykiss*) metallothionein-A gene. *Eur J Biochem* 230:344-349. 4. Mayer, G.D., Leach, D.A., Olsson, P.E., Hogstrand, C. 1996. Transcriptional activation of the rainbow trout metallothionein-A gene by Zn and Ag. In: Andren, A.W. ed. Proceedings of the 4th International conference on the Transport, Fate and Effects of Silver in the Environment. Madison, WI, USA. 5. Wood, C.M., Part, P. 1997. Cultured branchial epithelia from freshwater fish gills. *J Exp Biol* 200: 1047-1059. 6. Fletcher, M. 1997. Electrophysiological and ion transport characteristics of cultured branchial epithelia from freshwater rainbow trout. M.S. Thesis. McMaster University, Hamilton, ON. 7. Shaw, J.R., Birge, W.J., Wood, C.M., Hogstrand, C. 1998. Metal specific biosensor for quantification of bioavailable and bioreactive metals. Abstracts 19th Annual Society of Environmental Toxicology and Chemistry Meeting, Charlotte, NC, USA. Nov 15-19, 1998, p224. 8. Wood, C.M., Gilmour, K.M., Part, P. 1998. Passive and active transport properties of a gill model, the cultured branchial epithelium of the freshwater rainbow trout (*Oncorhynchus mykiss*). *Comp Biochem Physiol.* 119:87-96. 9. Part, P., Wood, C.M. 1996. Na<sup>+</sup>/H<sup>+</sup> exchange in cultured epithelial cells from fish gills. *J Comp Phys B* 166:37-45.

## **Descriptors**

bioavailability, biosensor, heavy metals, water quality, gill epithelium

## **Articles in Refereed Scientific Journals**

Birge, W.J., D.J. Price, J.R. Shaw, J.A. Spromberg, A.J. Wigginton, and C.H. Hogstrand, accepted 1999, Metal Bodyburden and Biological Sensors as Ecological Indicators, *Environmental Toxicology and Chemistry*.

## **Book Chapters**

None

## **Dissertations**

None

## **Water Resources Research Institute Reports**

None

## **Conference Proceedings**

Hogstrand, C.H., J. Spromberg, J. Shaw, and W. Birge, 1998, Biological Sensors and Chemical Body Burden as Ecological Indicators, in Proceedings Modeling and Measuring the Vulnerability of Ecosystems at Regional Scales for Use in Ecological Risk Assessment and Risk Management, Society of Environmental Toxicology and Chemistry, Environmental Protection Agency, and American Society for Testing and Materials, Seattle, WA, August 17-20, 1998. Shaw, J.R., W.J. Birge, C.M. Wood, and C. Hogstrand, 1998, A Metal Specific Biosensor for Quantification of Bioavailable and Bioreactive

Metals, in Proceedings 19th Annual Society of Environmental Toxicology and Chemistry Meeting, Charlotte, NC, November 15-19, 1998. Shaw, J.R., W.J. Birge, C.M. Wood, and C. Hogstrand, 1998, An In Vitro Monitor of Metal Bioavailability and Bioreactivity, in Proceedings ASLO/ESA conference of the Land-Water Interface: Science for a Sustainable Biosphere, St. Louis, MO, June 7-12, 1998. Shaw, J.R., W.J. Birge, C.M. Wood, and C. Hogstrand, 1998, A Novel Method for Quantifying Metal Bioavailability and Bioreactivity, in Proceedings: Kentucky Water Resources Research Annual Symposium, Kentucky Water Resources Research Institute, Lexington, KY, February 11, 1998, p. 41-42. Shaw, J.R. and C. Hogstrand, 1998, Metallothionein in Fish as a Biomarker: Past, Present, and Future, in Proceedings 8th Annual Society of Environmental Toxicology and Chemistry-Europe Meeting, Bordeaux, France, April 11-14, 1998.

## Other Publications

None

## Basic Project Information

Basic Project Information	
Category	Data
<b>Title</b>	Natural attenuation of trichloroethene in wetland soils and paleowetland sediments
<b>Project Number</b>	C-03
<b>Start Date</b>	09/01/1997
<b>End Date</b>	08/31/2000
<b>Research Category</b>	Water Quality
<b>Focus Category #1</b>	Groundwater
<b>Focus Category #2</b>	Wetlands
<b>Focus Category #3</b>	Water Quality
<b>Lead Institution</b>	University of Kentucky

## Principal Investigators

Principal Investigators			
Name	Title During Project Period	Affiliated Organization	Order
Alan E. Fryar	Assistant Professor	University of Kentucky	01
Mark S. Coyne	Associate Professor	University of Kentucky	02
Anastasios D. Karathanasis	Professor	University of Kentucky	03
David L. Balkwill	Professor	Florida State University	04
Stepahn A. Macko	Professor	University of Virginia	05

## Problem and Research Objectives

We are examining the intrinsic capability of wetland soils and paleowetland sediments in the vicinity of the Paducah Gaseous Diffusion Plant (PGDP) to bind or degrade trichloroethene (TCE), a priority pollutant. Within the Regional Gravel Aquifer (RGA), TCE plumes extend several km from PGDP toward the Ohio River. Ground water discharges to wetlands and streams in the river's flood plain. Beneath PGDP, some seepage occurs from the RGA to the underlying McNairy Formation, which contains lignitic, pyritic silts.

## **Methodology**

We are conducting laboratory experiments to assess TCE degradation and sorption in soils and sediments. Soil from wetlands in the West Kentucky Wildlife Management Area (WKWMA) and Metropolis Lake State Nature Preserve; McNairy cores from PGDP and an abandoned gravel pit north of Brookport, Illinois; and lignite and pyrite from a McNairy outcrop near Hico, Kentucky were collected. We also installed piezometers in a tupelo swamp in the WKWMA and along Metropolis Lake and monitored water levels and temperatures. For soil and sediment samples, students measured organic carbon (OC) and enumerated sulfidogenic, methanogenic, and methanotrophic bacteria, which have been implicated in TCE degradation elsewhere. Students also examined TCE biodegradation in methanogenic enrichment cultures and soil/sediment microcosms and TCE sorption to pulverized samples in batch experiments.

## **Principal Findings and Significance**

Hydraulic gradients indicated ground-water throughflow at the tupelo swamp and discharge along Metropolis Lake (when not flooded). Among bacterial groups of interest, only methanogens were culturable in McNairy sediments, while sulfidogens, methanogens, and methanotrophs were culturable in surface soils. Biodegradation of TCE over periods as long as 17 months was not statistically significant except in surface soil from the tupelo swamp. OC ranged from 0 to 3.8% in surface soils and from 0.92 to 2.79% in McNairy sediments (excluding a lignite sample, with OC = 48.5%). Sorption is probably dominated by partitioning to solid OC in soils and sediments, and sorption appears to be more rapid for sedimentary (aged) OC than for soil OC. Determination of TCE partitioning coefficients for soils and sediments, DNA analyses of bacteria, and studies of TCE degradation by pyrite and carbon-13 fractionation during TCE attenuation still remain to be completed.

## **Descriptors**

biodegradation, sorption, trichloroethene, geochemistry, wetlands, ground water

## **Articles in Refereed Scientific Journals**

None

## **Book Chapters**

None

## **Dissertations**

None

## Water Resources Research Institute Reports

None

## Conference Proceedings

Fryar, A., D. Butler, N. Etienne, C. Sweat, and M. Coyne, 1999, Seepage to Metropolis Lake and Implications for Contaminant Fate, in Proceedings Kentucky Water Resources Annual Symposium, Kentucky Water Resources Research Institute, University of Kentucky, Lexington, KY, February 26, 1999, p. 5-6. Butler, D., N. Etienne, A. Fryar, and M. Coyne, 1998, Assessing Potential Biodegradation of Trichloroethene in Wetland Soils and Sediments along the Ohio River, McCracken County, Kentucky, in Eos, Transactions, American Geophysical Union, 79(17), p. S-108 Butler, D., N. Etienne, A. Fryar, and M. Coyne, 1998, Assessing Potential Biodegradation of Trichloroethene in Wetland Soils and Sediments along the Ohio River, McCracken County, Kentucky, in Proceedings West Virginia Nonpoint Source Conference, Charleston, West Virginia, October 2, 1998. Butler, D., N. Etienne, A. Fryar, and M. Coyne, 1998, Natural Attenuation of Trichloroethene in Wetland Soils, in Geological Society of America Abstracts with Programs, 30(4), p. 5-6. Etienne, N., M. Coyne, D. Butler, and A. Fryar, 1998, Characterization of Paleowetland Sediments for TCE Biodegradations, in Agronomy Abstracts, p. 339. Sweat, C., and A. Fryar, 1998, The Role of Organic Carbon in Trichloroethene Sorption to Paleowetland Sediments and Wetland Soils, McCracken County, Kentucky, in Eos, Transactions American Geophysical Union, 79(17) p. S-98. Sweat, C., and A. Fryar, 1998, Natural Attenuation of Trichloroethene in Paleowetland Sediments and Wetland Soils in Western Kentucky: The Role of Organic Carbon, in Geological Society of America Abstracts with Programs, 30(4), p. 62.

## Other Publications

None

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## Basic Project Information

Basic Project Information	
Category	Data
<b>Title</b>	Using Neural Networks to Identify and Quantify Significant Sources of Encysted Protozoa in Watersheds
<b>Project Number</b>	C-05
<b>Start Date</b>	08/01/1998
<b>End Date</b>	07/31/2000
<b>Research Category</b>	Biological Sciences
<b>Focus Category #1</b>	Non Point Pollution
<b>Focus Category #2</b>	Models
<b>Focus Category #3</b>	Water Quality
<b>Lead Institution</b>	University of Kentucky

## Principal Investigators

Principal Investigators			
Name	Title During Project Period	Affiliated Organization	Order
Gail M. Brion	Assistant Professor	University of Kentucky	01
Srinivasa Lingireddy	Assistant Professor	University of Kentucky	02

## Problem and Research Objectives

This investigation seeks to develop a neural-network-based microbial source identification model for different types of fecal sources (pathogen and non-pathogen associated) in surface waters. Sub-objectives include: 1) to discover distinctive microbial fingerprints for different types of non-point source fecal inputs (from horse farms, cattle grazing areas, suburban activities, and human waste releases under normal dry weather and rainfall conditions), 2) to optimize the system of microbial indicators selected to determine the presence and source of fecal inputs in source waters, 3) to define and statistically evaluate the relationships between the selected indicators, pathogenic oo/cysts, land use practices, and fecal sources, 4) to develop an efficient neural network model and to train the model using a state-of-the-art technique such as genetic algorithm, and 5) to define the universality of the locally trained model to other sites in Kentucky and in other southeastern agriculturally-impacted states.

## Methodology

Samples are being obtained by both grab sampling and in-field filtration collection from several different study sites in selected reservoirs, along the Kentucky River, and in a karst aquifer. Sites suspected of being impacted by human fecal material through bacteriophage results or other observations are sampled for biolipids. Samples are collected year-round during dry and wet weather events in order to capture geographic and temporal (seasonal) distributions of encysted parasites and indicators. Water samples collected during and after major precipitation events are used to examine the impacts of storm water runoff into surface waters and surface water infiltration from agricultural areas into ground water on the occurrence and concentrations of encysted parasites and indicators. Water samples are being analyzed for: total coliforms, fecal coliforms, fecal streptococci, total coliphage, male-specific coliphage, pH, turbidity, alkalinity, hardness, phosphate, and nitrate. The microbial and chemical data from each site is examined individually and as part of larger sets. Sample sites are classified into three land use groups: (i.) primarily agricultural, (ii.) primarily suburban, and (iii) mixtures. A further division of the data is applied to separate human, animal, and mixed fecal sources. The resultant data groups are examined for significant correlations through an all- possible multiple linear regression and Spearman correlation to determine which indicators are most useful in predicting the presence and concentrations of pathogens and in distinguishing between types or sources of fecal contamination from humans and the different animal sources. Indicators are being evaluated on the basis of sensitivity, specificity, accuracy, reliability, technical difficulty, speed, and cost. A robust mathematical model to indicate the nature of a contaminating source (when provided with physical and microbial data at a source of interest), is being developed employing a neural network approach to identify the sources of microbial contamination in water bodies.

## Principal Findings and Significance



New sample sites have been chosen farther away from the reservoir used to train the initial neural network. Preliminary results from coliphage testing do not indicate overt human sewage contamination at these new sites. Data collected from late winter through early summer have been examined utilizing the previously trained neural network which is correctly identifying the new agricultural sites. The new urban sites have shown mixed results. The model correctly identifies sites as urban when the samples are collected from a impoundment. However, when the urban site is a fast flowing stream, the initial model has difficulty identifying the site type. This has led to the inclusion of new training parameters for the neural network model. The model continues to correctly identify the characteristic of the original sample sites from newly collected data. The analytical method for the recovery of *Cryptosporidium* and *Giardia* from turbid environmental samples has been developed and proven (recovers more than 70% of seeded oo/cysts to date). Utilizing the method, oo/cysts have been recovered from all sampling sites within the reservoir. The presence of encysted protozoa is most easily detected at urban ponds where Canadian geese and mallard ducks are observed. Analysis of fecal samples from these waterfowl show large concentrations of encysted protozoa as do water samples from the pond where they swim. Male-specific coliphage continue to be infrequently found at watershed sites impacted primarily by animal pollution. Their usefulness as watershed quality indicators is in question. However, total coliphage, somatic and male-specific, have been utilized with the numbers of atypical coliforms to create a reference indicator that ranks the water quality of a particular site as compared to raw sewage. Identification of the types of organisms that comprise the atypical coliform group have been done. So far, this group is comprised of 3 main groups of bacteria: *Aeromonas*, coliforms, and a mix of salmonella and other lactose fermenters. The relative numbers of *Aeromonas* to coliform may provide further clarification as to site identifications, but this work is preliminary. *Clostridia perfringens* spores are no longer being assayed as review of initial results did not suggest that this parameter was valuable for inclusion into the model. Analysis for phosphate has been initiated as it has been found to vary in concentration from site to site. New media for fecal streptococci are being evaluated in order to reduce the number of false positives.

## **Descriptors**

microbial indicators, encysted protozoa, fecal contamination, land use, agriculture, surface water quality, neural networks

## **Articles in Refereed Scientific Journals**

Brion, G.M. and H.H. Mao, accepted 5/99, Use of Total Coliform Test for Watershed Monitoring with Respect to Atypicals, American Society of Civil Engineers Journal of Environmental Engineering.

## **Book Chapters**

Brion, G.M. and S. Lingireddy, in review 5/99, Watershed Management for Improved Water Quality: Preventing Waterborne Disease in R.S. Govindaraju and A.R. Rao eds., Artificial Neural Networks in Hydrology, Kluwer.

## **Dissertations**

None

## **Water Resources Research Institute Reports**

None

### **Conference Proceedings**

Brion, G.M. and S. Lingireddy, 1998, Neural Networks as Source Indexing Tools, in Proceedings American Water Works Association Source Water Protection Symposium, American Water Works Association, San Francisco, CA, October 1998. Brion, G.M. and T. McRay-Higdon, 1998, Male-Specific Coliphage as Indicators of Watershed Pollution, in Proceedings American Water Works Association Source Water Protection Symposium, American Water Works Association, San Francisco, CA, October 1998. Brion, G.M., H.H. Mao and S. Ligireddy, 1999, New Approach to Use of Total Coliform Test for Watershed Management, in Proceedings 7th International Conference for Ecology and Environmental Quality on Environmental Challenges for the Next Millenium, Jerusalem, Israel, June 1999.

### **Other Publications**

None

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## **Information Transfer Program**

The Institute's information transfer program has numerous components: The Environmental Systems Seminar Series is managed with assistance from the Institute. Graduate students working toward the Environmental Systems Certificate are required to attend this seminar, but the presentations and discussion periods are also open to the general public. Speakers address environmental issues that are normally related in some way to water due to a strong emphasis on the systems approach. The Academic Department Seminar Assistance program helps to provide resources to enhance departmental seminar series. During 1998, the Department of Geological Sciences and the Institute cosponsored the Geological Society of America Birdsall-Dreiss Lecture in Hydrogeology (Origin and Migration of Saline Fluids in Sedimentary Basins, Dr. Jeffrey Hanor, Louisiana State University). The Institute also cooperated with the U.S. Geological Survey, Kentucky District in Louisville to cosponsor a Seminar Series as an avenue for outreach and information exchange. Featured speakers included USGS staff from other districts and university faculty members. The Kentucky Water Resources Annual Symposium was held on February 26, 1999. This one-day symposium allowed individuals from universities, government, and the private sector to present information on completed and ongoing research and program activities. Twenty-five platform presentations and one poster presentation were included in the program and the abstracts were printed and distributed as a proceedings volume. There were approximately 150 attendees at this conference. The Institute also served as a co-sponsor for the Kentucky Nonpoint Source Pollution Conference (September 29 - October 1, 1998). The program included a pre-conference field trip (dead poultry and poultry litter composting, 25 participants), 25 platform presentations, 18 poster presentations, 2 workshops (Getting In Step: A Guide to Effective Outreach in Your Watershed; and Grant Management for Nonpoint Source Projects), and a featured banquet speaker (A Holistic Approach to Stream Restoration: The Arteries of Our Lands, Keith Bowers, Biohabitats, Inc.). A total of 105 people registered for the conference. The Institute Newsletter - WATERWORKS continued to provide a forum for the dissemination of research results and water news of interest to researchers, regulators, and the public. A 1998 Annual Report describing all of the activities of the Institute during the calendar year was published and distributed. The Institute maintained a Publications List and research reports are provided to organizations and individuals requesting them. The Institute also maintains a Kentucky Water Resources Research Faculty and Staff Directory to provide a ready reference for Kentucky university water-resource investigators experienced in dealing with specific water resource problems. This directory helps to facilitate information transfer and documents the

vast expertise available in the Commonwealth to address water resource issues and problems. The Institute maintains a Homepage on the Internet that provides electronic access to information such as the Annual Report, newsletters, the Kentucky Water Resources Research Faculty and Staff Directory, and all of the abstracts from the Kentucky Water Resources Annual Symposium: <http://www.uky.edu/WaterResources/> The Internet site documents all of the programs of the Institute (not only activities supported by section 104), provides personnel profiles, and furnishes direct E-mail linkage for those wishing to contact the staff of the Institute. Information Transfer Program Publications: Kentucky Water Resources Research Institute 1998 Annual Report, February 1999, Kentucky Water Resources Research Institute, Lexington, KY, 28 p. Proceedings Kentucky Water Resources Research Annual Symposium, 1999, Kentucky Water Resources Research Institute, February 26, 1999, Lexington, KY, 52 p. Program and Abstracts 1998 Kentucky Nonpoint Source Conference, Kentucky Division of Water Nonpoint Source Section and Kentucky Water Resources Research Institute, September 29-October 1, 1998, Somerset, KY, 98 p.

## USGS Internship Program

### Student Support

Student Support					
Category	Section 104 Base Grant	Section 104 RCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	0	1	0	0	1
Masters	0	4	0	0	4
Ph.D.	0	1	0	0	1
Post-Doc.	0	1	0	0	1
<b>Total</b>	0	7	0	0	7

### Awards & Achievements

Dr. Lyle Sendlein, Director of the Kentucky Water Resources Research Institute, was the recipient of the Kentucky Geological Survey 1998 Distinguished Service Award. The award was granted in recognition of Dr. Sendlein's "contributions to the advancement of earth sciences for the benefit of society through his energy, vision, inspiration, and dedication." The award was presented on May 14th at the 38th Annual Seminar of the Kentucky Geological Survey. Dr. Sendlein retired from the University of Kentucky on August 31, 1998. Over the past several years, the Institute has assembled an ad hoc group known as the Technical Advisory Committee for the Kentucky Interagency Ground Water Monitoring Network. Major goals included assembling existing information and collecting additional baseline data on ambient ground-water resources, characterizing ground-water resources, and disseminating information collected by the cooperative interagency monitoring network. The General Assembly of the Commonwealth of Kentucky enacted legislation in the 1998 regular legislative session formally creating an Interagency Technical Committee on Groundwater charged with the responsibility of establishing a long-term groundwater monitoring network for the purpose of characterizing the quality, quantity, and distribution of Kentucky's ground-water resources. The act (Kentucky Revised Statutes, Chapter 151.00, Sections 151.620, 151.621, 151.625, and 151.629) stipulates that the director of the Kentucky Water Resources Research Institute shall serve as chair of this committee. On July 15, 1998, this group officially became responsible for coordinating the overall characterization of the state's ground water. David Butler and Christofer Sweat of the Department of Geological Sciences received Commonwealth Research Awards from the University of Kentucky Graduate School

in support of their presentations at the Spring 1998 meeting of the American Geophysical Union (Project C-03). Joseph R. Shaw received a Procter and Gamble/Society of Environmental Toxicology and Chemistry pre-doctoral fellowship (\$15,000) to support follow-up work on the Metal Biosensor. The research will include comparing the biosensor, sentinel monitoring, and biotic ligand modeling (Project C-04).

## **Publications from Prior Projects**

### **Articles in Refereed Scientific Journals**

None Reported

### **Book Chapters**

None Reported

### **Dissertations**

Wallin, E.J., 1998, Ground-Water/Stream-Water Interactions in the Vicinity of the Paducah Gaseous Diffusion Plant, McCracken County, Kentucky, M.S. Thesis, Department of Geological Sciences, College of Arts and Sciences, University of Kentucky, Lexington, KY. Project C-02

### **Water Resources Research Institute Reports**

Fryar, A.E., E.J. Wallin, D.L. Brown, D.B. Wenner, and T.C.Rasmussen, 1998, Spatial and Temporal Variability in Seepage Between a Contaminated Aquifer and Tributaries to the Ohio River, Kentucky Water Resources Research Institute Report #203, Kentucky Water Resources Research Institute, University of Kentucky, Lexington, Kentucky, 48 p. Project C-02

### **Conference Proceedings**

None Reported

### **Other Publications**

None Reported