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Kentucky Water Resources Research Institute Annual Technical Report FY 2000

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Kentucky Water Resources Research Institute, University of Kentucky

Kentucky Water Resources Research Institute

Annual Technical Report

FY 2000

Introduction

The FY 2000 Annual Technical Report for Kentucky consolidates the reporting requirements of the Section 104(b) base grant and previous regional competitive grant awards in a single technical report that includes: 1) a synopsis of each ongoing research project and each project completed during the period, 2) a list of related reports published, 3) a description of information transfer activities, 4) a summary of student support during the reporting period, and 5) notable achievements and awards during the year.

Research Program

The activities suported by Section 104(b) and the required matching funds are interwoven into the Kentucky Water Resources Research Institute's total program. Other elements of the program during FY 2000 included: 1) the Environmental Systems Certificate graduate program, 2) the Environmental Protection Scholarship program, and 3) Research and Service activities funded by other sources.

Memorandum of Agreement projects with the Kentucky Division of Water included: 1) Continued development of a watershed- based water quality assessment and management methodology for the Kentucky River, 2) Kentucky TMDL development, 3) Evaluation of the impacts of gravel dredging on Buck Creek, and 4) Graphic design and production of a poster for public education to protect groundwater in karst areas of Kentucky.

Several additional projects were funded by the Kentucky Cabinet for Health Services (CHS), the Kentucky Department of Military Affairs (DMA), the Kentucky River Authority (KRA), the National Institute of Environmental Health (NIEH), and Kentucky PRIDE (Personal Responsibility in a Desirable Environment): 1) Technical support for the Maxey Flats Disposal Site (CHS) 2) Technical support for the Paducah Gaseous Diffusion Plant (CHS) 3) Technical support for environmental construction (DMA) 4) Kentucky River Basin management coordination (KRA) 5) Superfund outreach program for Kentucky (NIEH) 6) Kentucky PRIDE water quality assessment (PRIDE)

Synopses of projects supported during FY 2000 by Section 104 awards follow:

Basic Information

Title:	Natural attenuation of trichloroethene in wetland soils and paleowetland sediments
Project Number:	C03
Start Date:	9/1/1997
End Date:	8/31/2000
Research Category:	Water Quality
Focus Category:	Water Quality, Groundwater, Wetlands
Descriptors:	biodegradation, sorption, trichloroethene, wetalnds, ground water
Lead Institute:	Kentucky Water Resources Research Institute
Principle Investigators:	Alan Ernest Fryar, Mark Steven Coyne, Anastasios Karathanasis

Publication

1. Etienne, Nadege, David Butler, Alan Fryar, and Mark Coyne, 2001, Trichloroethene Biodegredation Potential in Wetland Soils and Paleowetland Sediments, Bioremediation Journal, 5(1), 27-50.
2. Sweat, Christofer, 2000, The Role of Organic Carbon in Natural Attenuation of a Trichloroethene-Contaminated Aquifer System, Paducah, Kentucky, MS Thesis, Department of Geological Sciences, College of Arts and Sciences, University of Kentucky, Lexington, Kentucky, 132 p.
3. Fryar, Alan, and Christofer Sweat, 2000, Similar Sorption of Trichloroethene to Alluvial Soils and Cretaceous Sediments from the Lower Ohio Valley, in Geological Society of America Abstracts with Programs, 32(7), A-484.

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 have conducted laboratory experiments to assess TCE degradation and sorption in soils and sediments. We collected soils from wetlands in the West Kentucky Wildlife Management Area (WKWMA) and Metropolis Lake State Nature Preserve; McNairy sediments from PGDP and a gravel pit north of Brookport, Illinois; and lignite and pyrite from a McNairy outcrop near Hico, Kentucky. 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 the mass fraction of organic carbon (OC), analyzed grain size and mineralogy, and enumerated sulfidogenic, methanogenic, and methanotrophic bacteria (which have been implicated in TCE degradation elsewhere). Soil, sediment, and lignite samples were split and treated with methyl isobutyl ketone to extract humic substances or with hydrofluoric acid (HF) to dissolve minerals. Humic substances, HF-treated whole samples, and untreated lignite were analyzed by solid-state ^{13}C nuclear magnetic resonance (NMR) spectroscopy to infer organic functional-group compositions. 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

Sorption could be a significant mechanism of TCE attenuation where contaminated ground water moves into wetland soils or the McNairy Formation. TCE sorption approached steady state in batch experiments over periods of 7 to 12 days. Preliminary values of the Freundlich sorption coefficient (K_F) were 13.4 to 30.5 $(\mu g/kg)/(\mu g/L)^n$ for soils, 34.1 to 47.7 $(\mu g/kg)/(\mu g/L)^n$ for sediments, and 371 $(\mu g/kg)/(\mu g/L)^n$ for lignite. Values of n, a measure of sorption isotherm nonlinearity, ranged from 0.857 to 0.890 for four of five samples (n was 0.953 for one soil). Preliminary values of K_F normalized relative to the fraction of OC (K_{oc}) ranged from 358 to 2040 $(\mu g/kg)/(\mu g/L)^n$, with soils representing both the highest and lowest K_{oc} values. The range of K_{oc} values overlaps the ranges reported elsewhere for shales and low-rank coals. HF-treated soils were marked by aliphatic, carbohydrate, and carboxylic functional groups. HF-treated sediments, lignite, and lignite humic substances (humic acid and humin) were marked by aliphatic and aromatic functional groups. Total aromaticity was lower, and the fraction of polar OC was higher, for soil and soil humin than for sediment

and sediment humin. As observed in other recent studies, K_{oc} appears to increase as the fraction of polar OC decreases.

Basic Information

Title:	Using neural networks to identify and quantify significant sources of encysted protozoa in watersheds
Project Number:	C05
Start Date:	8/1/1998
End Date:	12/31/2000
Research Category:	Biological Sciences
Focus Category:	Non Point Pollution, Models, Water Quality
Descriptors:	microbial indicators, encysted protozoa, fecal contamination, land use, agriculture, surface water quality, neural networkss
Lead Institute:	Kentucky Water Resources Research Institute
Principle Investigators:	Gail Montgomery Brion, Srinivasa Lingireddy

Publication

1. Neelakantan, T.R., Gail Brion, and Srinivasa Lingireddy, in press, Neural Network Modeling of Cryptosporidium and Giardia Concentrations in the Delaware River, Water Science and Technology.
2. Brion, Gail, T.R. Neelakantan, and S. Lingireddy, 2000, Using Neural Networks to Predict Peak Cryptosporidium Concentrations, Journal of the American Water Works Association, 93(1), 99-105.
3. Brion, Gail M., H.H. Mao, and S. Lingireddy, 2000, New Approaches to Use of Total Coliform Test for Watershed Management, Water, Science, and Technology, 42(1-2), 65-69.
4. Brion, Gail, and H.H. Mao, 2000, Use of Total Coliform Test for Watershed Monitoring with Respect to Atypicals, Journal of Environmental Engineering, American Society of Civil Engineering, 126(2), 175-181.
5. Brion, Gail M. and Srinivasa Lingireddy, 1999, A Neural Network Approach to Indentifying Sources of Microbial Contamination, Water Research, 33(14), 3099-4007.
6. Brion, Gail M. and Srinivasa Lingireddy, 2000, Identification of Pollution Sources via Neural Networks, in R.S. Govindaraju and A.R. Rao ed., Artificial Networks in Hydrology, Kluwer Academic Publishers, ISBN 0-7923-6226-8.
7. Hougland, Sarah, 2000, A New Microbial Indicator to Predict Fecal Age, MS Thesis, Department of Civil Engineering, Engineering College, University of Kentucky, Lexington, Kentucky.
8. Brion, Gail M. and Srinivasa Lingireddy, 1998, Neural Networks as Source Indexing Tools, in Poceedings Source Water Protection Symposium, jointly sponsored by AWWA, IWSA, USDA, and USEPA, San Francisco, California, October 1998.
9. Brion, Gail M., J.S. Meschke, and M.D. Sobsey, 2000, Male-specific Coliphage: Prevalence, Types, and Survival in Natural Waters, in Poceedings 1st World Congress of International Water Association, Health-Related Water Microbiology Symposium, Paris, France, July 2000.
10. Neelakantan, T., Gail M. Brion and Srinivasa Lingireddy, 2000, Neural Network Modeling of Cryptosporidium and Giardia Concentrations in the Delaware River, in Proceedings 1st World

Congress of the International Water Association, Health-Related Water Mycrobiology Symposium, Paris, France, July 2000.

Problem and Research Objectives

Identification of the sources of fecal pollution in surface water is important for the development of the risk analyses that underlie effective watershed management systems related to protozoa. This research presents an approach to identify sources of fecal pollution by neural network analysis of surrogate parameters in surface waters of Kentucky, and to predict peak loadings of encysted protozoa at a surface water treatment plant. Large loadings of *Giardia* cysts or *Cryptosporidium* oocysts are linked with certain fecal sources, and it is thought that by identifying the predominant fecal sources in surface water, better risk analysis of potable water from that source can be accomplished, and public health protected. Currently, it is undecided what the best surrogates will be to base modeling systems on, and neural networks can assist in the identification of significant surrogate parameters.

This research attempts to utilize neural network based modeling systems to:

- Identify sources of non-point source fecal pollution from surrogate parameters.
- Identify peak concentrations of *Cryptosporidium* and *Giardia* in water sources from surrogate parameters.
- Investigate the relative importance of bacteriophage as indicators of protozoa.

Methodology

In this research, neural network predictive models were trained using multiple observations to create multiple parameters "fingerprints" of conditions that would indicate:

- The most prevalent non-point source of fecal contamination at several points within a local watershed.
- Peak events for waterborne protozoa at the inlet to a water treatment plant.

Neural networks were selected as the modelling tool because of their capability to capture non-linear relationships present in the data as well as the ability to self-train. Feed forward, error backpropagation, neural networks work based on the principle of iterative curve fitting technique. These networks comprise a set of highly interconnected but simple processing units referred to as nodes. Neural networks learn through reviewing examples with known outcomes. As in curve fitting technique, known data is used to train and validate the model before it is used for predictions. Basically, multiple observations of an identified data classification were used to train models to sort human sewage from animal, fresh animal sewage from aged, and peak protozoan events from background. Each observation would have measurements of water quality and indicator organisms, along with an assigned classification (i.e. human, animal, aged animal, peak protozoa event, etc). These observations were randomised and split into training and testing/validation subsets. After training to allow the model to recognise the "fingerprint" of parameter concentrations or measurements that matched the assigned classification, the validation dataset was used to predict the associated classification.

Then the predicted classifications were compared to the known classifications and error around the predictions defined.

Principal Findings and Significance

The neural network based models have been able to identify different classifications of non-point fecal sources of pollution in surface water. In particular, the model was very accurate in identifying raw human sewage from animal contaminated surface water. It was also successful in sorting out fresh animal contamination from aged animal contamination in surface water using six or seven commonly measured water quality input parameters. The neural network models produced good results with great accuracy and errors that were negligible. Key to prediction of fecal age was the ratio of atypical coliform colonies to total coliform colonies. Of lesser importance were bacteriophage that infect *E. coli*.

Neural networks were successfully applied to predict the peaks of *Cryptosporidium* and *Giardia* concentrations in the Delaware River, which serves as a drinking water source. Results show that several surrogate indicators are strongly linked with protozoan presence, with spores of *Clostridia perfringens* being one of the most important surrogates. The relative importance of the surrogate parameters was different for each protozoa. Bacteriophage were not found to be important in predicting peak protozoan events.

The results of this study show that genetic algorithm training is marginally superior compared to other feed-forward neural network training algorithms.

Basic Information

Title:	A full-scale plant evaluation of the removal of mycrocystin from drinking water
Project Number:	B-01
Start Date:	3/1/1999
End Date:	2/28/2001
Research Category:	Water Quality
Focus Category:	Toxic Substances, Treatment, Water Quality
Descriptors:	microcystin, Microcystis, cyanobacteria, drinking water, hepatotoxin
Lead Institute:	Kentucky Water Resources Research Institute
Principle Investigators:	Mariam Steinitz-Kannan, Judy Westrick

Publication

1. Westrick, Judy, Miriam Steinitz-Kannan, Brian Bertsch, and Heather Millson, 2000, Water Qaulity Differences between the Ohio River and the Storage Reservoir of the City of Newport Drinking Water Plant, in Proceedings American Water Works Association 2000 Water Quality Technology Conference.

Problem and Research Objectives

The objective of the study was to determine the extent of removal of microcystin, a hepatotoxin produced by the cyanobacteria *Microcystis*, from drinking water by full-scale treatment methods at the City of Newport Drinking Water Plant. A conventional treatment system and the Actiflo ballasted flocculation treatment system were to be assessed. Conventional treatment methods for the removal of microcystin were assessed from March 1, 1999 to October 20, 1999. Actiflo assessment began October 21, 1999, and was completed August, 2000 via an extension of the grant.

The City of Newport Drinking Water Plant coagulates water after it is held in a storage reservoir, and has, until recently, considered the reservoir as its source of treatable water. However, the Ohio River is considered its source of treatable water under promulgated federal regulation. The reservoir serves as a barrier against upsets in the river, such as floods, algal blooms, and industrial spills. The reservoir also decreases production costs by acting as a buffer against rapid turbidity changes in the river and decreasing sludge removal during coagulation. Despite these advantages, reservoir water can be difficult to treat due to the proliferation of algae. This problem can be accentuated by the proliferation of cyanobacteria. The objectives of this study were 1) to determine water quality differences between the two sources, 2) to monitor differences in algal densities, especially cyanobacteria, in the river and the reservoir, and 3) to analyze samples from the river and the reservoir for presence of microcystin. Assessing these differences will allow Newport to optimize its water treatment methods.

Methodology

Water samples were collected weekly from the Ohio River and the storage reservoir from March to September of 1999, and monthly from October of 1999 to February of 2000. Turbidity, pH, TOC, and chlorophyll a levels were measured according to Standard Methods (APHA 1998). Paired t-tests were conducted to determine significant differences in each parameter. Samples were also analyzed for dissolved microcystin using an Enzyme Linked Immunosorbent Assay (Chu, 1990). The ELISA method uses polyclonal antibodies against different microcystin variants. ELISA kits were purchased from EnviroGard and have a detection limit of .2 ppb. Samples were filtered through a 0.45 μm membrane filter, assayed, and read on a spectrophotometer.

Algal counting was conducted biweekly from March to September of 1999, and monthly from September 1999 to February 2000. Samples were placed in a settling chamber for 24 hours. Single and colonial units of algae were then counted on an inverted microscope to determine amounts of cyanobacteria, diatoms, and green algae in one liter of water (Wetzel, 1991). Due to algal preservation problems, there is no algal counting data from March or April 1999.

Principal Findings and Significance

Total algal densities, including those of cyanobacteria, were higher in the reservoir on the majority of sampling dates. Chlorophyll a levels were also monitored. A paired t-test determined that chlorophyll a levels were significantly higher in the reservoir than in the river. Turbidity, pH, and TOC were measured in the river and reservoir according to Standard Methods (APHA 1998). Paired t-tests were conducted for each parameter and determined that pH was higher in the storage reservoir than in the river. This data supports the algal density and chlorophyll a data for the reservoir. Water samples from the river and the reservoir were tested for dissolved microcystin using the ELISA method, and results were negative. Frozen Microcystis cells were lysed and microcystin was not detected.

High levels of cyanobacteria, high levels of chlorophyll a, and high pH measurements in the reservoir suggest that the City of Newport should cater its water treatment methods to the water quality parameters of the reservoir, and not to the river. However, monitoring the above factors will enable government agencies to more effectively perform risk benefit analyses of storage reservoirs.

Basic Information

Title:	Measurement and prediction of solute transport parameters for Kentucky soils
Project Number:	B-02
Start Date:	3/1/1999
End Date:	12/31/2000
Research Category:	Ground-water Flow and Transport
Focus Category:	Solute Transport, Water Quality, Agriculture
Descriptors:	soil water, water retention curve, dispersion coefficient, dispersivity
Lead Institute:	Kentucky Water Resources Research Institute
Principle Investigators:	Edmund Perfect, Edmund Perfect

Publication

1. Bejat, E., E. Perfect, V.L. Quisenberry, M.S. Coyne, and G.R. Haszler, 2000, Solute Tranpsort as Related to Soil Structure in Unsaturated Intact Soil Blocks, Soil Science Society of America Journal, 64,818-826.
2. Perfect, E., and M.C. Sukop, 2001, Models Relating Solute Dispersion to Pore Space Geometry in Saturated Media: A review, in H.M. Selim and D.L. Sparks ed., Physical and Chemical Processes of Water and Solute Transport/Retention in Soil, Special Publ. 56, Soil Science Society of America, Madison, Wisconsin, 77-146.
3. Perfect, E., 2000, Estimating Soil Mass Fractal Dimensions from Water Retention Curves, in Y.A. Pachepsky, J.W. Crawford, and W.J. Rawls eds., Fractals in Soil Science, Developments in Soil Science 27, Elsevier, Amsterdam, the Netherlands, 131-141.
4. Sukop, M.C., 2001, Porosity, Percolation Theshholds, and Water Retention Behavior of Random Fractal Porous Media, Ph.D. Dissertation, Department of Agronomy, College of Agriculture, University of Kentucky, Lexington, Kentucky. http://lib.uky.edu/ETD/ukysosc2001d00009/Sukopdis.pdf
5. Perfect, E. and M.C. Sukop, 2001, Modeling Solute Dispersivity in Irregularly Shaped Soil Pores, in Proceedings 4th Eastern Canada Soil Structure/Carbon Workshop, Leamington, Ontario, Canada, 107-116.
6. Perfect, Edmund, Michael C. Sukop, Gerald R. Haszler, and Riley J. Walton, 2001, Measurement and Prediction of Solute Transport Parameters for Kentucky Soils, Kentucky Water Resources Research Institute, University of Kentucky, Lexington, Kentucky, 28.

Problem and Research Objectives

Dispersivity (α) is a required input parameter in solute transport models based on the advection-dispersion equation. Normally α is obtained from miscible displacement experiments. This dependency on inverse procedures imposes a severe limitation on our predictive capability. If solute breakthrough curves and soil hydraulic properties were measured simultaneously, pedotransfer functions could be developed to predict α from independent measurements.

Methodology

In this study, 6-cm long undisturbed soil columns were employed to investigate the relationship between α and the soil water retention curve as parameterized by the air entry value (ψ_a) and Campbell exponent (b). We worked with 69 samples from 6 soil types ranging in texture from loamy sand to silty clay, conventional- and no-till management practices, steady-state saturated flow conditions, and a step decrease in $CaCl_2$ concentration from 0.009 to 0.001 M. Breakthrough curves were measured by monitoring changes in effluent electrical conductivity using a computerized data acquisition system.

Principal Findings and Significance

Estimates of α (calculated using the method of moments) ranged from 1 to 192 mm for the 6 soils. Conventional tillage on a silt loam soil decreased both the mean and variance of α as compared to no-till. Stepwise multiple regression analysis explained ~50% of the total variation in α, and indicated that dispersion increased as ψ_a and b increased. Since both ψ_a and b increase with increasing clay content, α also increases moving from coarse to fine textured soils. Our regression equation can be used as a pedotransfer function to predict α from existing databases of soil hydraulic properties. Further research is needed to independently validate its predictability. Strategies for upscaling the model predictions also need to be developed.

Basic Information

Title:	Records of Holocene climatic change and hydrologic variability in sping tufa from Kentucky: Will global climate changes affect water availability in karst terrains of the midcontinent?
Project Number:	B-03
Start Date:	3/1/1999
End Date:	2/28/2001
Research Category:	Climate and Hydrologic Processes
Focus Category:	Water Quantity, Climatological Processes, Hydrogeochemistry
Descriptors:	climate change, drought, karst hydrology, isotopes, trace elements
Lead Institute:	Kentucky Water Resources Research Institute
Principle Investigators:	Slawek Tulaczyk

Publication

Problem and Research Objectives

The primary objective was to obtain a sample of mid-Holocene spring tufa or cave speleothems from Kentucky. The samples were to be dated and examined for evidence of drought frequency during the mid-Holocene climatic optimum. We were focused on obtaining proxies of hydrologic activity for this specific time period because it can serve as a reasonable analog of future climate under the scenario of possible global warming. The practical motivation was provided by the fact that karst aquifers are a significant source of water for the population of Kentucky and other neighboring states. At the same time, these aquifers are typified by short residence time of water and their usefulness could be compromised if future climate was characterized by more frequent and/or severe droughts. We planned that the ultimate product of would be a quantitative estimate of drought frequency and severity during the mid-Holocene climatic optimum in Kentucky.

Methodology

The work consisted of four major stages:

1) Collection of two 20-cm cores of tufa from three Hundred Springs and speleothem from the Lost River Cave (both near Bowling Green, Kentucky)
2) Uranium-Thorium dating of the core material
3) Analysis of core internal structure and elemental composition using digital thin-section analysis and electron microprobe/ICP MS
4) Data processing and interpretation

Principal Findings and Significance

After successfully acquiring the two core samples, we proceeded with core dating and petrographic/elemental analysis. Unforeseen circumstances delayed the dating by more than a year, but we were able to quickly analyze the internal structure of the two cores in petrographic thin sections. Preliminary elemental mapping was also done using an electron microprobe. Analysis of the tufa sample from the Three Hundred Springs revealed that the material did not have any microscopic lamination. Similarly, it did not show any systematic along-core variation in elemental composition. This finding represented a significant setback to our scientific objectives, because the ability to investigate past drought frequency and severity hinged on the presence of annual or nearly annual lamination. Therefore, we were forced to discard this material as a possible source of constraints on drought frequency and severity in mid-Holocene. In contrast, the speleothem core from the Lost River Cave contained well-developed, variable laminae. We acquired digital images of this core at the resolution of about 2 microns. The images were processed in ImagePro Plus to better define the microscopic lamination present in the core. Differences in elemental composition of selected lamina were analyzed using an electron microprobe. Unfortunately, subsequent U-Th dating of this material indicated that it is older than the age range of this dating technique (>250 ky), thereby excluding the possibility of using the core to derive proxies of the warm mid-Holocene climate and hydrology in the region. The work involved in analyzing these two core samples consumed all of the resources available for this project. Moreover, the PI has moved to another institution. In spite of the negative experience with the two selected samples, we believe that the proposed scientific approach is

sound and the practical importance of the topic justifies further interest in such research. Significantly more exploration work will have to be done to identify samples of cave speleothem and spring tufa, which will be of the right age and the right internal structure to provide records of mid-Holocene hydrologic and climatic variability in Kentucky.

Basic Information

Title:	In situ testing of integrated grass filter strip-permeable barrier systems for groundwater protection
Project Number:	B-04
Start Date:	3/1/2000
End Date:	2/28/2001
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Treatment, Water Quality
Descriptors:	watershed management, contaminant transport, soil, erosion, phosphorus, bacteria, sorption, sedimentation
Lead Institute:	Kentucky Water Resources Research Institute
Principle Investigators:	Elisa DAngelo, Mark S. Coyne

Publication

1. D'Angelo, Elisa M., J. Crutchfield, and M. Vandiviere, 2001, Rapid, Sensitive, Microscale Determination of Phosphorus in Water and Soil, Journal of Environmental Quality (accepted).

Problem and Research Objectives

Approximately one-third of rivers and streams in Kentucky are impaired for drinking and recreational purposes as a result of pollution with fecal coliform bacteria and nutrients from primarily nonpoint source discharges such as agricultural runoff, septic tanks, and straight pipes. In many cases, contamination can be attributed to insufficient reaction time or reactivity between pollutants and soils, since many areas have shallow soils, are underlain by impermeable rock and clay barriers, or are located on steep slopes. We propose that integrated grass filter strip-permeable reactive barrier systems (GFS-PRB) would be an effective, low-cost, and low maintenance technology to attenuate phosphorus (P) and bacteria. It was hypothesized that soil mixed with reactive iron, aluminum, and calcium oxide enriched slags, obtained from iron and steel manufacturing, would be effective for sequestering these pollutants by a combination of sorption, precipitation, and filtration mechanisms. The objectives of this study were to quantify P and bacteria treatment capabilities of reactive mixtures, determine the importance of sorption and precipitation as treatment mechanisms, and evaluate installed GFS-PRB systems for pollutant removal.

Methodology

Nine reactive mixtures were prepared in the laboratory, which consisted of different combinations of Maury silt loam (M), limestone, and five types of metal oxide materials (including 3 slags). Batch sorption isotherms were used as an efficient method for comparing potential sorbents for P removal. Optimal mixtures were selected to assess long-term (144 d) P and bacteria attenuation capacities using dynamic column studies amended with poultry manure solution. Chemical fractionation procedures were used to elucidate P retention mechanisms.

Principle Findings and Significance

Phosphorus sorption behavior was well described by the Langmuir model ($C_o \leq 100$ mg P L^{-1})($R^2 \geq 0.90$). Slag materials were found to have sorption maxima (S_{max}) ranging from 223 to 27,473 mg P kg^{-1}; inclusion of these materials at rates of 5 to 8% generally increased S_{max} by up to 4.5 fold over M alone (410 mg P kg^{-1}). Equilibrium P concentrations (EPC_o, the dissolved P concentration at which sorption equals desorption) ranged between 0.04 and 0.8 mg P L^{-1}. None of the sorbents contributed significant amounts of water soluble or exchangeable trace metals (Mn, Cd, Cr, Ni, Pb, Zn, Cu, Co, Mo). Four of the six sorbents selected for column studies showed a 57 to 88% decline in flow velocity over the experimental period, which was attributed to losses of macroporosity through microbial clogging/particle settling/filtration mechanisms. Two remaining sorbents (mixtures containing basic oxygen furnace slag or limestone) showed a 249-411% increase in flow velocity after 9-15 pore volumes, which was due to dissolution of carbonate minerals and development of highly conductive macropores. Initial (<9 pore volumes) retention of bacteria and P by all columns was >95%. After this period, P and bacteria removal was decreased significantly (2-95%) for columns containing high-carbonate materials due to poor pollutant-sorbent interactions, even

though they had the greatest S_{max} in batch isotherms. P recovery by sorbents was -0.2 to 12% in the water/weakly exchangeable pool, 26 to 73% in the Fe and Al bound pool, 11 to 97% in the Ca and Mg bound pool, -23 to 15% as labile organic P. Effluent from carbonate-enriched columns may contribute to water quality problems associated with elevated pH (>8.5). Hence, high carbonate slag materials used alone may not be appropriate choices for PRB materials for treatment of P and bacteria. However it may be possible to take advantage of the sorption and hydraulic characteristics of combinations of reactive mixtures for pollutant attenuation. This hypothesis will be investigated in laboratory and pilot level field experiments in the next phase of the study.

Basic Information

Title:	Fragipan influence on hillslope hydrology and solute transport
Project Number:	B-05
Start Date:	3/1/2000
End Date:	2/28/2001
Research Category:	Ground-water Flow and Transport
Focus Category:	Hydrology, Solute Transport, Non Point Pollution
Descriptors:	perched water table, saturated flow, contaminant transport, soil-water relationships, nitrogen
Lead Institute:	Kentucky Water Resources Research Institute
Principle Investigators:	James Thompson

Publication

Problem and Research Objectives

In western Kentucky many soils contain fragipans--subsurface soil layers characterized by high density and high mechanical strength relative to overlying soil layers. The presence of a fragipan in a soil landscape controls water storage and discharge because it restricts downward water movement and promotes the development of perched water tables above the fragipan. In sloping landscapes, the fragipan encourages lateral subsurface water flow. The movement of dissolved and suspended species (e.g., carbon, nutrients, fertilizers, pesticides) to surface water and groundwater is enhanced through this lateral downslope flow above the fragipan. For example, a common practice for disposal of animal wastes is land application to agricultural land. Once applied to the soil, many factors control the fate of inorganic or organic nitrogen in the animal waste. The widespread occurrence of fragipans may affect the fate and transport of nitrogen and other dissolved or suspended species. To fully understand the effects of different surface management operations on surface water and groundwater systems, especially in complex soil landscapes found in western Kentucky, it is necessary to examine the hydrological processes within the soil.

Methodology

The direction and magnitude of lateral flow above the fragipan were examined using a tracer study. We installed piezometers directly above the fragipan at 25 locations at the study site. These are used for monitoring water table depth and sampling perched water. Also, continuous water table monitoring systems, each consisting of a pressure transducer and digital data logger in one unit, have been installed in nine piezometers across the study site.

Approximately 1 m upslope of each of the five piezometers in the first row of the grid of piezometers, we will excavate a trench perpendicular to the slope, approximately 2 m long, 0.2 m wide, and 0.2 m deep. A known amount of tracer will be added to each trench, then the trenches will be backfilled with soil to prohibit any movement of tracers in surface flow. Because flow may not be perpendicular to the soil surface, two tracers will be used, Br^- and Cl^-. Different ratios of Br^- to Cl^- in each trench (100/0 $\%Br^-/\%Cl^-$, 75/25, 50/50, 25/75, and 0/100) will be used to detect any deflection of flow paths. If flow is perpendicular to topography, the ratio of Br^- to Cl^- downslope of each trench should be approximately equal to the ratio of Br^- to Cl^- in the trench. Conversely, if flow is not perpendicular to topography, there should be changes in the ratio of Br^- to Cl^- downslope of each trench.

We will collect water samples for analysis of tracer concentrations on a biweekly basis. Following measurement of the depth to water in each piezometer, we will evacuate the water using a portable pump. More frequent observations may be made during critical times during the year, e.g., in the fall when perched saturated conditions return above the fragipan. Flow magnitude on a given sample date will be determined by the amount of tracer found in a given piezometer and the distance traveled from the trench. We will determine the percent recovery of the tracers on a given sample date by multiplying the volume of perched water present by the measured tracer concentration.

We will characterize the hydraulic properties of the soil at each piezometer location by extracting an intact soil core down to the top of the fragipan using a hydraulic probe. These cores will be returned to the lab, and a segment of each core from each major genetic soil horizon will be analyzed to determine saturated hydraulic conductivity and bulk density. Using these results and site characteristics, pore water velocity will be calculated.

To examine tracer movement beyond the study site, we will install two additional water table monitoring systems in a stream that flows along to the base of the slope. These will be used to measure the height of water in the stream and to sample water from the stream for water analysis.

Principal Findings and Significance

Project was not completed due to the departure of Dr. Thompson from the University of Kentucky.

Basic Information

Title:	Defining perennial, intermittent and ephemeral channels in eastern Kentucky: Application to forestry best management practices
Project Number:	B-06
Start Date:	3/1/2000
End Date:	2/28/2001
Research Category:	Climate and Hydrologic Processes
Focus Category:	Non Point Pollution, Water Quantity, Surface Water
Descriptors:	best management practices, geomorphology, stream classification
Lead Institute:	Kentucky Water Resources Research Institute
Principle Investigators:	Randall Karl Kolka, Jeffrey Stringer

Publication

Problem and Research Objectives

Addressing nonpoint source pollution during silvicultural and timber harvesting operations requires that all parties be able to properly determine the types of streams and channels that are being impacted. The type of Best Management Practice (BMP) applied is dependent on whether a channel is classified as ephemeral, intermittent or perennial. For Forestry BMPs, the presence and width of a streamside management zone (SMZ), the level of disturbance allowed within the SMZ, and the distance to major soil disturbances (e.g. roads) are dependent on the stream classification. Incorrect evaluation of stream channel class leads to either increased nonpoint source pollution in the form of sediment and nutrients when actual flow duration is longer than that assessed, or to costly, unneeded BMP implementation when flow duration is shorter than that assessed.

The only method currently available to ascertain stream class is to use USGS Quadrangle topographic maps (where solid blue lines are considered perennial, dotted lines are considered intermittent and channels not defined on the map are considered ephemeral). The reliability of these maps is questionable, especially at the site scale. We propose a site-specific morphological approach to streamflow duration classification.

The specific objectives of this research are:

1. To quantify relationships between streamflow duration in eastern Kentucky and stream and watershed physical/morphological properties.
2. To develop easily measurable parameters that forest operators can use to define stream types in eastern Kentucky, where over one-half of the state's timber reserves lie and over 80% of the land is forested.
3. To help clarify the application of BMP guidelines addressing timber harvesting near streams, assuring that SMZs are properly implemented.

Methodology

We selected 15 sites spanning the continuum from known ephemeral to known perennial streamflow in eastern Kentucky. Semi-continuous stage height recording wells were installed at nine randomly selected ungauged sites. Four additional gauged sites are located on the Department of Forestry's Robinson Forest and two others are located on the State Natures Preserve's Blanton Forest in southeastern Kentucky. Wells were placed upright in the deepest part of the channel and secured with rebar. Semi-continuous stage height recording wells are programmed to take stage readings four-times daily (i.e. every six hours). Physical properties measured or collected at each site include bankfull width, bankfull depth profiles, cross-sectional area, bottom material, flood-prone area, stream slope, and sinuosity. Watershed parameters collected include drainage area, hillslope percent, dominant vegetation, soil types present, surface geology and occurrences of disturbed area.

Principle Findings and Significance

Although the data set is currently incomplete, our study is already showing trends. The width:depth ratio, sinuosity and the slope of the streambed are all appear to have potential at predicting flow duration (Figure 1).

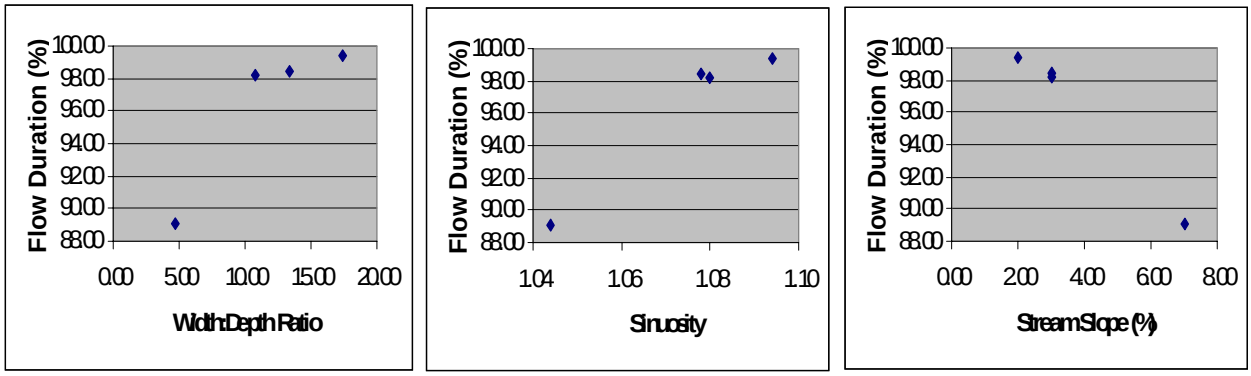

Figure 1. Preliminary flow duration relationships of four Cumberland Plateau stream sites.

The figures presented above do not represent the range of flow duration within the study so we hesitate to draw many conclusions or present mathematical relationships. However, it appears initially that our approach has promise.

Basic Information

Title:	Developmental stability as an indicator of amphibian population health and environmental degradation
Project Number:	B-07
Start Date:	3/1/2000
End Date:	2/28/2001
Research Category:	Biological Sciences
Focus Category:	Conservation, Water Quality, Ecology
Descriptors:	bioindicators, amphibians, pollutants, ponds
Lead Institute:	Kentucky Water Resources Research Institute
Principle Investigators:	Howard H. Whiteman

Publication

Problem and Research Objectives

One of the most important, yet most difficult, tasks associated with conservation of any organism is the identification of populations subject to stress before such stress has a detrimental effect. This is particularly true of amphibians; the global decline of amphibians is considered a disturbing indicator of environmental degradation because it may forebode of cascading ecological effects, as well as raising health concerns about human populations. Amphibians are ideal biological indicators, because their semi-permeable epidermis and complex life cycle expose them to multiple stressors in both aquatic and terrestrial environments. Because of this, amphibians should be among the first vertebrates affected by anthropogenic stressors in either of these environments. Furthermore, some of the same stressors affecting amphibians are known to have negative effects on other species, including humans (e.g., PCBs, UV light, etc). Biologists thus need an early-warning system that could identify environmentally-stressed animals before the stressor causes population and/or regional harm. Such an indicator should be able to measure stress-induced effects before drastic changes in morphology (which would subsequently decrease the organism's survival and reproductive abilities) take place. One such indicator is obtained by measuring developmental stability (DS), the ability of an organism to develop normally under a range of environmental conditions. The objective of the current project is to utilize developmental stability as an indicator of amphibian stress and habitat quality from temporary ponds in Kentucky that vary in land use, water quality and other anthropogenic disturbance.

Methodology

Approximately twenty ponds of varying hydroperiod were chosen for study. At least 25 bullfrog (*Rana catesbiana*) larvae and 12 eastern newt (*Notophthalmus viridescens*) adult males were sampled from as many populations as we could find. After transporting amphibians to MSU, each individual was anesthetized using tricaine methylchloride (MS-222), and measured for snout-vent length (mm) and mass (g). Each individual was then photographed with a Pixera Professional digital camera connected to a PC. After imaging, animals were submerged in aged water to revive them and released back to their pond of capture. Measurements of DS concentrated on morphological structures directly related to amphibian fitness. Each individual was measured three separate times in order to statistically analyze measurement error.

Temperature, pH, conductivity, dissolved oxygen, and alkalinity were measured at each pond with portable meters and orthophosphates and nitrate/nitrite were measured using a Lachet Nutrient Analyzer at Murray State University’s Hancock Biological Station (HBS).

Principal Findings and Significance

Thus far, we have captured images from nine populations of bullfrogs (25 individuals x 2 sides x 9 = 450 images) and ten populations of eastern newts (15 individuals x 2 sides x 10 = 300 images). Initial analyses of bullfrog samples indicate significant differences in DS across populations which correlate with anthropogenic stress, confirming our preliminary work. We are in the process of fully analyzing our bullfrog results, and are also currently processing the newt images. Our initial results suggest that amphibian DS can be used as an indicator of environmental stress.

Basic Information

Title:	A growing season hydroclimatology focusing on soil moisture deficits for Kentucky and surrounding climate divisions
Project Number:	B-08
Start Date:	3/1/2000
End Date:	2/28/2001
Research Category:	Climate and Hydrologic Processes
Focus Category:	Climatological Processes, Drought, Water Quantity
Descriptors:	soil moisture, hydroclimatology, atmospheric processes
Lead Institute:	Kentucky Water Resources Research Institute
Principle Investigators:	Mace Bentley

Publication

1. Bentley, Mace and Andrew Grundstein, 2000, A Growing Season Hydroclimatoloty Focusing on Soil Moisture Deficits for the Ohio Valley Region, in EOS Transactions of the American Geophysical Union, 81(48), Fall Meeting Supplement, Abstract H52A-18.
2. Bentley, Mace L., Andrew J. Grundstein, 2001, A Growing Season Hydroclimatology Focusing on Soil Moisture Deficits for the Ohio Valley Region, Kentucky Water Resources Research Institute, University of Kentucky, Lexington, Kentucky, 24.

Problem and Research Objectives

Overall, mean monthly precipitation in Kentucky is adequate and consistent enough for considerable agricultural productivity. The economies of many regions within the Commonwealth are intimately tied to agriculture. Therefore, moisture deficits due to interannual precipitation variability can cause major agricultural disruptions and subsequent economic losses. Moreover, portions of eastern Kentucky rely primarily on surface water for consumption and sanitation needs. Deficits in these regions lead to serious water shortages that restrict the supply for normal activities. Developing a growing season hydroclimatology focusing on soil moisture deficits will provide a foundation for the analysis of drought type, severity, and causal mechanisms.

This study developed a hydroclimatology for Kentucky and surrounding climate divisions for the period 1895 through 1999 using the Thornthwaite-Mather water budget model. This technique allows for the calculation of a long time series of soil moisture parameters making it ideal for developing a climatology. Results of the investigation include:

- the identification of long-term trends in soil moisture conditions for the region, including cyclic trends in soil moisture between very dry and moist periods;
- identification of spatial patterns of soil moisture deficit within the 19 climate divisions making up the region;
- determining causal mechanisms leading to soil moisture deficit conditions by examining the inputs and outputs of the water budget model;
- development of conceptual models illustrating meteorological conditions associated with severe soil moisture deficit conditions in the region; and,
- evaluation of relationships between growing season soil moisture deficits and agricultural yield statistics for the region.

Methodology

A climatology of soil moisture drought for Kentucky and the surrounding region was produced using an empirically based water budget technique designed by Thornthwaite and Mather (Mather, 1978). Temperature and precipitation data were obtained from the climate division data set available from the National Climatic Data Center. In addition, the water holding capacity in each climate division was based on estimates by Main (1979). The water budget was run for the four climate divisions within Kentucky as well as the 15 climate divisions that neighbor the Commonwealth from 1895 through 1999. At each climate division, a monthly value for soil moisture was produced. To better analyze soil moisture deficits during the growing season, an aggregate soil moisture deficit value was computed by adding up monthly soil moisture deficits from April through March. The data, software and computer hardware needed to produce the hydroclimatology was housed in the Climatology Research Laboratory at the University of Georgia. An investigation of the relationship between inputs and outputs was then conducted to determine the causes of soil moisture deficits. The relative importance of water budget variables such as precipitation and evapotranspiration on the development of the soil moisture deficit was also evaluated.

Further analysis examined the meteorological conditions that are present during severe droughts. Case studies were developed examining the five worst growing season droughts since 1960. Sea-level pressure, temperature, humidity, and upper-level circulation features were analyzed in order to develop conceptual models of synoptic-scale meteorological conditions associated with severe soil moisture deficits. These data were obtained from a variety of sources contained within the library of the Climatology Research Laboratory at the University of Georgia.

Principal Findings and Significance

Evidence suggests that there is considerable temporal variability but no long-term trend towards either wetter or drier conditions in the Ohio River Valley. The pattern of growing season deficit is characterized by multiyear and multidecadal cycles of wet and dry periods. Deficits in the OhioValley are more closely tied to precipitation variability than to temperature (evapotranspiration). Decreases in precipitation during years with anomalously large growing season deficits, however, are associated more with the reduced frequency of precipitation events than to any changes in intensity. These variations in precipitation frequency and the conditions conducive to droughts appear to be linked with large-scale atmospheric conditions including the low-level and upper-level flow patterns.

Using a case study approach for a “wet” year (1950) and a “dry” year (1953), it was found that soil moisture anomalies were considerably different for wet versus dry events over the Ohio River Valley. Enhanced ridging, especially in the upper-levels was found over the region during 1953. This westward extension of the Bermuda High provided subsidence and weak flow that inhibited convective development during the growing season. As surface heating increased due to the lack of evaporation, the low-level jet intensified and directed moisture northward into the northern Great Plains. During 1950, an upper-level trough was found to have developed over the Central U.S. This enhanced large-scale upward motion over the Ohio Valley and also cooled mid to upper-level temperatures. The low-level jet continued to provide adequate moisture from the Gulf of Mexico into the Central Great Plains. However, instead of advecting moisture into the northern Great Plains, the low-level jet arched into the Ohio Valley enhancing low-level moisture in the region and also producing speed convergence. These conditions produced precipitation leading to soil moisture surpluses.

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 certificate are required to participate in this seminar for two semesters, but the presentations are also open to the general public. Speakers address environmental issues that are normally related in some way to water due to the strong emphasis on the systems approach to environmental problems.

The Kentucky Water Resources Annual Symposium was held on February 23, 2001. This one-day symposium allowed individuals from universities, government, and the private sector to present information on completed and ongoing research and program activities. Forty-two platform presentations and four poster presentations were included in the program and the abstracts were printed and distributed as a proceedings volume. The conference program featured a panel presentation by the Kentucky Watershed Watch volunteer program. There were 181 registrants at the annual symposium.

The Institute also serves as the co-sponsor for the Kentucky Nonpoint Source Conference. The 2000 conference was held May 23-25, 2000 in Bowling Green, Kentucky. The program planning committee arranged two field trips (karst features, constructed wetlands for swine waste management), two workshops (319 grant management, newcomers introduction to the 319 program), 3 invited speakers (cave biota, Kentucky legislative update, phosphorus management), 20 platform presentations, 22 poster presentations, and numerous exhibits.

The Institute newsletter - WATERWORKS continued to provided a forum for the dissemination of research results and water news of interest to researchers, regulators, and the general public. A 2000 Annual Report describing all of the activities of the Institute during the calendar year was also published and distributed.

The Institute maintained a Publications List and research reports were 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.

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. 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:

http://www.uky.edu/WaterResources/

General Information Transfer Program Publications:

Kentucky Water Resources Research Institute 2000 Annual Report, March 2001, Kentucky Water Resources Research Institute, Lexington, KY, 28 p.

Proceedings Kentucky Water Resources Research Annual Symposium, 2001, Kentucky Water Resources Research Institute, February 23, 2001, Lexington, KY, 76 p. Information Transfer Presentations (Platform or Poster) Related to 104 Research Projects:

Fryar (C-03)

Similar sorption of trichloroethene to alluvial soils and Cretaceous sediments from the lower Ohio valley: talk by Alan Fryar, presented at the Geological Society of America Annual Meeting, Reno, Nevada, November 16, 2000.

Brion (C-05)

Using Neural Network Analysis to Classify Runoff Sources, Soil Science Society of America 2000: Agronomy, Crop, and Soil Sciences: Stars of the 20th Century - Beacons for the 21st. Minneapolis, MN, November 2000.

Westrick (B-01)

Algal Monitoring on the Ohio River: An Increase in Cyanobacteria Concentration, International Conference on Toxic Cyanobacterial Blooms, Morocco.

Water Quality Differences between the Ohio River and the Storage Reservoir of the City of Newport Drinking Water Plant, Northern Kentucky University Center for Integrated Science and Mathematics Poster Presentation, Highland Heights, Kentucky.

Water Quality Differences between the Ohio River and the Storage Reservoir of the City of Newport Drinking Water Plant, American Water Works Association 2000 Water Quality Technology Conference.

Whiteman (B-07)

Developmental stability as an indicator of amphibian population health. Invited speaker, Partners in Amphibian and Reptile Conservation Symposium, 2000, American Society of Ichthyologists and Herpetologists Annual Meeting, UABCS, La Paz, MX.

Developmental stability as an indicator of amphibian population health. Guild of Rocky Mountain Population Biologists Meeting, 2000, Rocky Mountain Biological Laboratory, Colorado.

Other Information Transfer Activities:

The Ohio River Basin Commission seeks to improve the water resources programs and related land resources programs of its member states, and as an interstate body, the Ohio River Basin Commission endeavors to contribute to the formulation of a comprehensive, coherent, and coordinated national water policy that recognizes interstate water issues and the primary role of the states in water resources planning and management. June 30, 2000 marked the Commission’s twelfth year on the campus of the University of Kentucky and its association with the Water Resources Research Institute. ORBC cosponsors the Institute’s annual symposium.

An interactive video teleconference was held on Saturday August 26 to help citizens understand how water management agencies hope to restore water quality in Kentucky streams by setting Total Maximum Daily Loads (TMDL). The conference, hosted by the KWRRI, originated from the UK campus and was broadcast to remote sites at the Pikeville campus of Prestonsburg Community College, Madisonville Community College, and Somerset Community College. There were over 40

participants at the 4 sites. Presentations provided information on how the TMDL process is being implemented in Kentucky and how citizens can play a role in applying this tool to their local watersheds. Speakers included Lindell Ormsbee and Greg Epp of the Kentucky Water Resources Research Institute.

The Kentucky Water Resources Research Institute co-hosted an interactive teleconference on the Kentucky Agriculture Water Quality Act on Friday October 13, 2000 (1:30-4:00 p.m.). The law requires farmers to develop a plan by October 2001 that addresses how their specific operations will be managed to ensure that the state's water resources are protected. Goals of the workshop included informing participants of the components of the law, providing an update on progress toward implementation across the state, and demonstrating how the law can support local and statewide watershed protection efforts. The teleconference originated from Elizabethtown Community College and transmitted to remote sites at Murray State University, Somerset Community College, and room B110 in the W.T. Young Library at the University of Kentucky. Speakers included Curtis Kirk, Kentucky Division of Conservation; Henry Duncan, UK Cooperative Extension Service; Hank Grady, Sierra Club; and Rebeckah Freeman, Kentucky Farm Bureau. Panel discussions included personnel from local Conservation Districts, the Natural Resources Conservation Service, and UK Cooperative Extension.

http://www.uky.edu/WaterResources/Watershed is the web address for the Kentucky River Watershed Page. This site includes general information about the Kentucky River Watershed Management Framework. The Kentucky River Basin Assessment Report (completed summer 2000) is also available at this site. The assessment report was utilized in regional meetings during fall 2000 to make decisions about watershed priorities and to work toward development of watershed task forces. The intent of the management framework is for local groups, government agencies, andindividuals to collaborate in forming teams to solve problems in the priority watersheds that were identified through this process. The KWRRI is serving as the basin coordinator for the Kentucky River, which is the first basin where the watershed management framework is being implemented in the Commonwealth.

Each August, over 650,000 people visit the Kentucky State Fair. One of the most popular features of the Fair is a major educational exhibit. The theme selected for the Special Educational Exhibition at the 2001 Fair (August 16-26, 2001) is "2001: A Water Odyssey." An ambitous planning effort began during summer 2000. The exhibit will be created in a 22,000 square foot area in the South Wing at the Kentucky Fair and Exposition Center. The centerpiece will be a large-scale, physical model of a watershed. Visitors will navigate a giant living stream to discover how waterways impact our history, culture, ecology, economy, recreation, and health. Interactive exhibitions and Learning Lab programs will enable participants to explore aquatic biology, water quality, and the many ways that we use water. Main objectives of the exhibit will be: 1) to foster an understanding of watersheds, 2) to increase public awareness of nonpoint source pollution, and 3) to develop a variety of positive actions that citizens can take to preserve or improve water quality in their own communities. Historically, the educational exhibitions have received extensive media coverage and have drawn large crowds (an estimated 400,000 people experience some aspect of the exhibition at the fair each year). A growing component of the education program is student participation. Hundreds of thematic artworks, essays, and class projects will be featured throughout the exhibition, and thousands of students will tour the exhibit on prearranged school field trips (the aggressive goal is to double field trip attendance to around 15,000 students in 2001). Additional students will be reached after the Fair through related curriculum and educational products created in conjunction with the exhibition (teachers around the state are being encouraged to submit lesson plans for thematic projects to be included in a Water Odyssey curriculum). In addition, 2001: A Water Odyssey will complement the theme for the 2001 annual Conservation Writing and Art Contest, sponsored by the Kentucky Farm Bureau Companies, the Louisville Courier-Journal newspaper, and the Kentucky Soil Conservation Districts. In total, it is

estimated that the message of 2001: A Water Odyssey will directly reach at least 10% of the population of the state. The lead agency for the project is the Kentucky State Fair Board (in the Kentucky Tourism Development Cabinet). Other partners participating in the current planning process are:

Center for Environmental Education, Jefferson County Public Schools Jefferson County Conservation District Kentucky Department of Agriculture Kentucky Department of Fish and Wildlife Resources Kentucky Division of Conservation Kentucky Environmental Education Council Kentucky Institute for the Environment and Sustainable Development, Univ. of Louisville Kentucky State University Aquaculture Resource Center Kentucky State University Research Farm Kentucky Water Resources Research Institute, University of Kentucky Kentucky Waterways Alliance The Louisville Courier-Journal U.S. Army Corps of Engineers U.S. Geological Survey, Kentucky District University of Kentucky Cooperative Extension Service Kentucky Natural Resources and Environmental Protection Cabinet

In 1986, Congress authorized the National Institute of Environmental Health Sciences (NIEHS) to implement a university-based program of basic research. In addition to scientific bench research, the Superfund Basic Research Program at the University of Kentucky is collaborating with educators and outreach personnel to develop community-based programs to help answer the many questions that citizens have associated with Superfund sites. Educational materials and programs will be developed based on the nutritional implications of site chemicals gathered from the basic research. During 2000, the KWRRI Director served as a member of the Superfund Basic Research Program Faculty and several additional personnel from the unit (including a Program Coordinator hired by the Institute specifically for this activity) assisted with the development of the first products of the outreach program, an informational brochure and drinking water tabloid insert for state newspapers.

The Association of State Dam Safety Officials (ASDSO) is a national, non-profit association dedicated to the improvement of dam safety through research, education, and communications. Since its formation in 1984, ASDSO has served as one of the premier professional organizations for individuals committed to ensuring the safety of dams in the U.S. The national ASDSO office is located in Lexington, Kentucky and the unit is affiliated administratively with the Water Resources Research Institute. Regional Technical Seminars conducted during 2000 included: May 18-19, 2000-ASDSO West Region Technical Seminar on Construction Inspections by USBR Technical Service Center, Portland, Oregon May 25-26, 2000-ASDSO Southeast Region Technical Seminar on Stability Analysis of Embankment Dams, GEI Consultants, Knoxville, Tennessee July 2000-ASDSO Northeast Regional Technical Seminar on Evaluation of Concrete Dam Stability, Mead & Hunt, Atlantic City, NJ September 25-26, 2000-ASDSO Northeast Regional Technical Seminar on Stability Analysis of Embankment Dams, GEI Consultants, Providence, Rhode Island

ASDSO also maintains "Information Central" a clearinghouse of books, videos, articles, and CD-ROMs on subjects related to dam safety. Individuals who are searching for information on specific topics, or who would like the advice of subject matter experts who are members of ASDSO, may contact Information Central for assistance. Two searchable bibliographic databases, utilizing a common set of keywords, are available. Over 3700 citations are currently listed; updates are made monthly.

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	11	1	0	0	12
Masters	4	1	0	0	5
Ph.D.	1	0	0	0	1
Post-Doc.	1	0	0	0	1
Total	17	2	0	0	19

Notable Awards and Achievements

Notable Achievements:

Tracy Farmer Center for the Environment - It was announced on August 15, 2000 that Mr. Tracy Farmer provided a $2 million gift to the University of Kentucky to establish a research and educational center that will assist public and private organizations in addressing environmental issues. The Commonwealth of Kentucky is contributing an additional $2 million from the Research Challenge Trust Fund, for a total of $4 million to create the initital endowment for the new center. The Kentucky Water Resources Research Institute prepared the original concept paper describing how such a center could utilize the university's existing resources, including experts from a variety of disciplines, to provide a broad perspective on environmental research and education to help address complex environmental issues facing the Commonwealth. On the basis of this framework, Mr. Farmer elected to donate his gift to the university. Dr. Lindell Ormsbee, Associate Director of the KWRRI, is serving as the initial Interim Director of the Tracy Farmer Center for the Environment and existing support staff of the Water Institute are assisting with establishing operations of the Center during the start-up period.

Awards:

Westrick Judy, Stuart Oehrle, and Miriam Steinitz-Kannan, 2000, Water Quality Differences between the Ohio River and the Storage Reservoir of the City of Newport Drinking Water Plant, Northern Kentucky University Center for Integrated Science and Mathematics Poster Presentation, Highland Heights, Kentucky - Placed Second in the Poster Competition.

Publications from Prior Projects