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Midwest Technology Assistance Center for Small Public Water Systems Final Report USEPA Grant# X832591-01

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Midwest Technology Assistance Center for Small Public Water Systems Final Report

USEPA Grant# X832591-01

The Midwest Technology Assistance Center (MTAC) was established October 1, 1998 to provide assistance to small public water systems throughout the Midwest via funding from the United States Environmental Protection Agency (USEPA) under section 1420(f) of the 1996 amendments to the Safe Drinking Water Act. This report summarizes progress made under USEPA Grant# 832591-01 for funds received in Federal Years (FY) 05 and 06.

MTAC is a cooperative effort of the 10 states of the Midwest (congruent with USEPA regions 5 and 7), led by the Illinois State Water Survey and the University of Illinois. The director of their Water Resources Institute (WRI) coordinates the participation of each state in MTAC. Dr. Richard Warner (WRI director) and Kent Smothers were the principal investigators for this project. Kent Smothers serves as the managing director of the center, and is responsible for conducting routine activities with the advice and counsel of Dr. Richard Warner.

FY05 Projects

Internal Applied Research Projects

Applied Research: MTAC funded six projects selected by the project principal investigators from proposals solicited from campus researchers and professors. Proposals were funded for work in the following subject areas:

1. Projects that address small system needs in meeting health-based standards, especially in regard to arsenic, microbial rules, and the Bioterrorism Act.
2. Projects that will increase the technical, managerial, or financial capacity of small systems.

Final selection of funded proposals was based on how well they addressed USEPA priorities, how well they addressed the needs of small systems in the Midwest, and the reputation and past performance of the project principal investigators.

Topic 1: Fate of Arsenic in the Mahomet Aquifer: The Influence of Added Sulfate and Nitrate

Walt Kelly, Tom Holm, Steve Wilson, George Roadcap, ISWS
Robert A. Sanford, Craig M. Bethke, Dept. of Geology, University of Illinois

Project Description

Material from the Mahomet aquifer, known to have pockets of high arsenic concentration, was evaluated for different microbiological activities that could influence the mobility of arsenic in groundwater. Project activities included a thorough assessment of core material collected in a region of the aquifer known for high arsenic concentration and flow-through column experiments evaluating the potential nature of arsenic mobilization in the subsurface.

Fresh core material was collected from a total of 25 intervals of Glasford aquifer sand, Mahomet aquifer sand, and till layers overlying the two aquifers. In order to determine the chemical form of arsenic in the sediments, samples from eight intervals of the Glasford aquifer were chemically extracted using increasingly aggressive reagents. Arsenic was detected in at least one fraction for all extraction samples. The highest concentrations were found in the crystalline iron and manganese oxides fraction.

Project Results/Outputs

The experiments showed vertical spatial variability in microbial activity and bacterial community composition in aquifer sediments from both aquifers. Despite the very low natural sulfate concentrations, sulfate-reducing bacteria were uniformly distributed throughout both anoxic aquifers. This is consistent with a coexistence model for iron-reducing bacteria and sulfate reducers occurring in groundwater observed in other studies.

Column experiment results were surprising in the sense that although little or no iron-reduction activity was apparent by traditional ferrous iron analysis, arsenic release was dramatic once an inoculum was added. The column experiment appears to have changed the dynamic association between iron-reducing bacteria and the detection of ferrous iron; however, there appears to be little impact on the extent of arsenic release. Thus there appears to be a bacterial-mediated arsenic release that precludes its readsorption to the abundant iron-oxides remaining in the column.

The final report for this project is available on the MTAC Web site at: http://mtac.isws.illinois.edu/mtacdocs/pubs/MTACTR08-06.pdf. There is also a companion Fact Sheet available: http://mtac.isws.illinois.edu/mtacdocs/qf/MTACFS08-06.pdf.

Project Outcomes

1. The project increased the knowledge of the relationship of iron-reducing and sulfate-reducing bacteria in aquifers containing both iron and arsenic material. In particular, there was some light shed on how these bacteria impact the release and readsorption of arsenic. This is

important information geochemists need to evaluate the effect of various aquifer conditions on arsenic release into groundwater supplies.

Topic 2: Developing Guidelines for Evaluating Drought Impacts to Small Surface Water Supply Systems

H. Vernon Knapp, Illinois State Water Survey

Project Description

This report presents approaches and data availability for evaluating the drought vulnerability of small community water supply systems in the Midwest that obtain water from surface water bodies, such as rivers, streams, natural lakes, and man-made reservoirs. A description is provided of the various types of surface water sources from which 320 small community systems in the Midwest, each serving 10,000 or fewer people, obtain their water. The small community surface water system most commonly obtains its supply from one or two small impounding reservoirs. However, a substantial number of communities instead obtain their water from either direct river withdrawals or off-channel storage of water withdrawn from streams and rivers. Sixty of these 320 small community surface water systems were interviewed to gather information on the availability of data to determine the drought vulnerability of these systems. Although hydrologic and physical data exist for evaluating many of these systems, relatively few of the interviewed system managers could provide such pertinent information.

Project Results/Outputs

For most states, there is no predefined drought threshold that communities are required to surpass in developing their water supply sources. For very small communities, it may not be economically feasible to develop alternative water supplies capable of meeting water use during a drought of record if supplies are adequate during moderate droughts. For communities where there are no existing alternative supply options, especially for larger communities, it would seem essential that existing resources are capable of meeting water needs during a very severe drought. The past half century has shown that climate is variable, so even if it has been many decades since the occurrence of some of the worst droughts on record, the likelihood exists that such droughts can occur again. Attention should be given toward planning for that eventuality.

To evaluate their vulnerability to severe drought, communities that depend on reservoir supplies need to obtain accurate measurements of the capacities of their reservoirs, if they have not recently been conducted. State agencies in Kansas, Missouri, and Illinois have conducted measurements for a number of water supply reservoirs. A first step for communities with impounding and off-channel reservoirs can be to identify the agencies or consultants that are capable of conducting a bathymetric survey of their reservoir. Capacity estimates not developed from a detailed survey of this type may be substantially inaccurate and particularly may be biased towards overestimating the capacity for small reservoirs. Capacity estimates also should account for the loss of capacity over time as the result of sedimentation.

The critical drought duration is a measure of the length of time during which low streamflows are incapable of providing a community's water needs, requiring that the community rely upon stored water from either a reservoir or low channel dam. For impounding reservoirs, flow data provided in Illinois State Water Survey (ISWS) Contract Report 2009-10, combined with an approximate value of reservoir capacity, can be used to estimate the critical duration associated with the most severe drought periods.

If hydrologic data and basic physical data such as storage capacity are lacking, it will be difficult for either system managers or experienced professionals to estimate a community system's yield and potential drought impacts, particularly for off-channel reservoir and low channel dam systems that are more likely to be vulnerable to drought. There are several types of data, in addition to the measurement of storage in reservoirs and behind low channel dams, that a community could begin collecting that may be useful for future assessments. Daily records can be kept of (1) stream withdrawals, including a description of the pumping amount and the number of days when water was not withdrawn because water quality was poor or stream levels were too low; (2) drawdown levels for reservoirs and low channel dams in the pools; and (3) precipitation. The first two sets of data could provide information on the relative availability of water, which could then be compared to more complete hydrologic data from regional streams for predicting local conditions during severe drought. Without proactive efforts to keep records of these types, the only alternative for many communities is to wait and see what the next drought brings.

The final report for this project is available on the MTAC Web site at: http://www.isws.illinois.edu/pubdoc/CR/ISWSCR2009-10.pdf. There is also a companion Fact Sheet available: http://mtac.isws.illinois.edu/mtacdocs/qf/MTACFS09-02.pdf.

Project Outcomes

1. This study revealed that many small systems in the Midwest do not have an adequate plan for dealing with an extended drought, and often do not have the necessary data to address the issue.
2. The authors also identified several types of data that are easy for a system to collect that would be invaluable to water resources professionals in developing a comprehensive and effective drought response plan. Small-system managers can begin collecting this data immediately and should seek out local resources for assistance in putting that information to use.

Topic 3: Building Technical, Financial, and Managerial Capacity for Small Water Systems: The Role of Consolidation, Partnership, and other Organizational Innovations - Phase 2

John Braden and Martin Jaffe, University of Illinois

Project Description

The purpose of this study was to assess the role of consolidation as a strategy for small community water systems to achieve technical, managerial, and financial competency under the

Safe Drinking Water Act. The research involved: (1) The development of a model of choice of regulatory compliance strategy in which water systems choose to continue independent operation or be acquired by another system. The model generates hypotheses about organizational responses to regulation. (2) Collection and analysis of federal and state data on trends in the consolidation and performance of water systems serving communities of less than 10,000 people and to test theoretical predictions about organizational response to regulation.

Project Results/Outputs

The study results support the theory that merger and acquisition is a method of improving corporate governance. Anecdotally, operators of many small water systems lack the technical, financial, and managerial resources to provide reliable, safe drinking water. Some of those operators are either unwilling or unable to acquire the requisite skills. Future and current profits/losses as well as transactions costs play a role in determining if water systems will remain independent or choose to be acquired. Findings confirm that a merger may be a means to exit the industry, increase the skill level of operators, and avoid future expenses associated with investment in (human and physical) capital.

Poorly performing systems, those with drinking water quality or monitoring violations, are more likely to be acquired than highly performing systems. Furthermore, patterns of merger and acquisition activity in the drinking water systems indicate that transactions costs are likely to play a large role in affecting mergers in the industry. The study indicates that inducing organizational changes may be an alternative means to raise the management skill of drinking water system operators. Encouraging small systems to form rural cooperatives or purchase water from a neighboring system might also be effective policies.

There is some evidence that smaller systems have a higher probability of acquisition. This is consistent with the hypothesis that acquired water systems may be merging to achieve economies of scale. However, this is by no means conclusive evidence. It may also suggest that systems that are non-core components of a larger business (such as systems serving residential or commercial property developments) are essentially being spun-off or sold to a company or agency for which water supply is a core enterprise.

The final report for this project is available on the MTAC Web site at: http://mtac.isws.illinois.edu/mtacdocs/pubs/MTACTR07-01.pdf. There is also a companion Fact Sheet available: http://mtac.isws.illinois.edu/mtacdocs/qf/MTACFS07-01.pdf.

Project Outcomes

1. The results of this study have been presented in at least four published papers, including the *Journal of the University Council on Water Resources* (UCOWR) and a feature article in the National Drinking Water Resources Center publication *On Tap*.
2. Technical assistance providers and capacity development professionals working with small systems are presented with a detailed analysis of the factors that contribute whether or not acquisitions and mergers occur in small systems.

Topic 4: Continuing Education to Support Smaller Water Systems

Dick Warner, University of Illinois

Project Description

The Office of Continuing Education at the University of Illinois and county governments in the state have recently formed partnerships with industries and local governments to develop continuing education programs via a Web portal. The emerging partnership afforded the opportunity for MTAC to take advantage of the Web portal design and other resources related to the partnerships, initially for Illinois. Hence, MTAC developed continuing education programs for the needs of managers of Midwestern smaller water supply systems. The key partners in this initiative were initially the Illinois Water Resources Center, the Illinois State Water Survey, MTAC, the Office of Continuing Education, University of Illinois at Urbana-Champaign, and University of Illinois Extension. As the programs continue to be developed and tested, they will be made available to the Technical Assistance Center (TAC) network and via other organizations such as the American Water Works Association (AWWA) and National Institutes for Water Research (NIWR). This project was funded over two fiscal years. The course was designed to help managers of small water systems think holistically about security, including the protection and monitoring of critical assets (e.g., physical infrastructure, finished drinking water, etc.).

Project Results/Outputs

The continuing education course, *Thinking Critically about Security Needs for Small Water Supply Systems*, was outlined, the module writing was completed, and the Internet portal for the course was designed. The early course development planning also verified that this effort does not duplicate efforts underway by other TACs, AWWA, or other entities.

Project Outcomes

1. The course developed will prove valuable for small systems should an appropriate delivery vehicle be developed. This project made clear that there is a need in the small drinking water community for something more robust and interactive than a traditional Web site. MTAC has begun development of a cybercollabratory (http://smallwatersupply.org/) that will eventually fulfill this need.

Topic 5: Improved Monitoring for Safe and Secure Water Supplies: An Integrated Approach to Emerging Information Technologies

Dick Warner, University of Illinois

Project Description

The federal government is moving rapidly toward developing sensors to protect national security. At the same time, nearly all major federal agencies are beginning to discuss and design region-to-continent approaches to science and earth systems monitoring that will deploy sensors and cyber infrastructure that will enable information sharing in real time among scientists,

agencies, and society in general. Such technology has great potential for developing more effective and efficient approaches to testing, monitoring, and reporting of the health of water systems.

The tasks of this project were to (1) convene a workshop of 12 experts from academia, including The National Center for Supercomputing Applications (NCSA), industry, and public agencies to describe the status of work underway in this regard; (2) invite representatives of the other TACs to attend and otherwise participate; (3) establish an ongoing work group to identify promising, priority areas of sensor development as they relate to the management of water supply systems; and (4) develop recommendations for how the emerging vast cyber infrastructure for national security and science can be used to help ensure a safe and secure water supply.

Project Results/Outputs

The workshop was convened at the University of Illinois, and the group discussed recommendations for improvements that more effectively employ the cyber infrastructure for the benefit of the small drinking water community.

Project Outcomes

1. This project made clear that there is a need in the small drinking water community for something more robust and interactive than a traditional Web site. MTAC has begun development of a Cybercollabratory (http://smallwatersupply.org/) that will eventually fulfill this need.

Topic 6: Emerging Health Concerns Related to Water Treatment

Michael Plewa, University of Illinois

Project Description

Drinking water utilities provide an exceedingly important public health service through their generation of high quality, safe, and palatable tap water. The disinfection of drinking water in public facilities primarily employs chemical disinfectants such as chlorine, chloramines, ozone, and chlorine dioxide. These disinfectants are oxidants that convert naturally occurring and synthetic organic material, bromide, and iodide in the raw water into chemical disinfection byproducts (DBPs). DBPs are an unintended consequence and were first discovered over 30 years ago. Each disinfection method generates a different spectrum and distribution of DBPs; to date over 600 DBPs have been identified. While reducing the public health risk of acute infection by waterborne pathogens, the unintended generation of DBPs poses a chronic health risk. DBPs represent an important class of environmentally hazardous chemicals that are regulated by the U.S. Environmental Protection Agency (USEPA) and carry long-term human health implications. Epidemiological studies demonstrated that individuals who consume chlorinated drinking water have an elevated risk of cancer. DBPs have been linked to reproductive and developmental effects, including the induction of spontaneous abortions in humans.

Although chlorine has been used for over 100 years in the United States as a water disinfectant, the majority of DBPs present in drinking water have yet to be chemically characterized. With only approximately 30 percent of the total organic halide identified to specific DBP chemical classes, and a small fraction of these evaluated for their biological and toxicological effects, it is clear that a great deal of work remains in the characterization of DBPs.

Project Results/Outputs

This project applied *in vitro* mammalian cell chronic cytotoxicity, genomic DNA damage, and acute cytotoxicity assays to investigate two important emerging classes of nitrogen-containing DBPs (N-DBPs): the haloacetonitriles and the haloacetamides, as well as an emerging class of poorly studied C-DBPs, the haloaldehydes. With changing disinfection practices, the formation of these emerging DBPs deserves attention by managers of drinking water utilities in Illinois and the nation.

A comparative, *in vitro* analysis that measured chronic cytotoxicity and acute genomic DNA damage in CHO cells of three chemical classes of emerging DBPs was conducted. The N-DBPs (haloacetonitriles and haloacetamides) and a C-DBP class (haloacetaldehydes) were evaluated such that a rank order of their chronic cytotoxicity to CHO cells was generated, and is included in the final report. The selection of these three DBP classes was based on information from the USEPA DBP priority study and the USEPA Nationwide Occurrence Study. Mammalian cell cytotoxicity and genotoxicity data provided a rank ordering of the relational toxicities of regulated and emerging DBPs and related agents both within an individual chemical class and among classes. The use of alternative disinfectants generates new DBP compounds and alters the distribution of DBP chemical classes.

The final report for this project is available on the MTAC Web site at: http://mtac.isws.illinois.edu/mtacdocs/pubs/MTACTR08-05.pdf. There is also a companion Fact Sheet available: http://mtac.isws.illinois.edu/mtacdocs/qf/MTACFS08-05.pdf.

Project Outcomes

1. The water supply community will be able to consider these factors when employing alternatives to chlorine disinfection. In addition, these data will be available to prioritize DBPs for future *in vivo* toxicological studies and risk assessment.

Outreach Activities

Groundwater Resource Assessment for Small Communities

Kenneth J. Hlinka, Illinois State Water Survey

Funding for this project was split between FY05 and FY06 budgets.

Project Description

For over 50 years, the Center for Groundwater Science at the Illinois State Water Survey (ISWS) has provided groundwater information to any requesting individual, commercial facility, or public water facility. Groundwater resource assessments have been an integral part of this public service and have been undertaken for thousands of individuals and facilities throughout our history. Using existing staff and focusing on the smaller communities (less than 2,000 population), current groundwater system adequacy (adequate, marginal, or deficient) and resource potential (within a 5- and 10-mile radius) will be developed for those small communities determined to have "deficient" groundwater supplies based on certain criterion. The 60 facilities identified as being the most at risk will be investigated further.

Project Results/Outputs

The project developed letter-type reports for the 60 facilities that use shallow groundwater resources for their water supplies. The reports target the 60 facilities that have been determined to be most at risk in producing groundwater for their towns, under certain criterion. A summary of available resources within 5 and 10 miles of the facility is included as part of each report. The summaries typically include unexplored groundwater resources that would require further investigative study by the facility. The reports are posted on the MTAC Web site: http://mtac.isws.illinois.edu/gwassmnts.asp.

Project Outcomes

1. The 60 small drinking water systems in Illinois most at risk of having inadequate supply in the future have been provided with an assessment of their existing and potential groundwater resources to enable them to plan for the future. Many of these supplies would have had difficulty financing such a study on their own.

FY06 Projects

Internal Applied Research Projects

Applied Research: MTAC funded six projects selected by the project principal investigators from proposals solicited from campus researchers. Proposals were funded for work in the following subject areas.

Topic 1: Workshop for Non-Community Water System Compliance Managers: Status, Progress, and Information Sharing for Assisting Non-Community Systems with the New Arsenic Rule

Steve Wilson, Illinois State Water Survey

Project Description

The USEPA Region 5 non-community compliance managers meet once a year to discuss programmatic issues, share strategies and information, and keep up on progress of rules and implementation. Region 5 includes Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin. The meetings have typically rotated among the states, and in October 2008, the meeting was held at the Ohio EPA offices in Columbus, where half a day was devoted to this workshop.

MTAC had approached the Region 5 NTNC managers in October 2006 about planning a workshop to discuss arsenic compliance and other NTNC issues. Though they were interested in such a program, they had several reasons for wanting to limit the scope of the event: (1) They didn't want a meeting to affect their existing format and schedule; (2) They didn't want to have a separate event that would require more time away from the office and cost additional resources; and (3) They believed the success of the meetings to date was directly due to the informal, supportive nature of the program.

Project Results/Outputs

MTAC made plans to work with the Illinois Department of Public Health (IDPH) to co-host the 2007 meeting, but IDPH had a specific agenda in mind and were not supportive of adding even a half-day workshop, unless it was added at the end. MTAC felt that having an additional half day just for the workshop would limit participation because of the delay it would cause in travel back to their home states. In the end, IDPH planned the meeting without MTAC's input.

The Ohio Environmental Protection Agency (EPA) agreed to provide half a day for the workshop at their 2008 meeting. This event was held October 7 and 8, 2008 at the Ohio EPA offices in Columbus, Ohio. MTAC organized the second morning's program, and provided a fresh perspective on a number of topics.

To facilitate the event, MTAC offered to pay travel expenses for state staff members that were interested in attending. Unfortunately, no one accepted this offer. This seemed particularly

timely because two states, Illinois and Wisconsin, had travel restrictions in place for their state staff. However, even though MTAC was willing to pay their travel, neither state was able to send someone to the meeting. In the end though, MTAC had the budget to provide a full two-day workshop completely free of charge, including participant travel. MTAC ended up providing only lunch on the first day.

MTAC asked the NTNC managers for topics of interest to could bring in speakers that would be the most beneficial. One topic that was brought forward by several states was lead and copper. In organizing the morning program, MTAC also considered topics that NTNC managers might not know a lot about and that might be beneficial for their NTNC systems.

The morning workshop dealt with several relevant topics for small and NTNC systems. Ohio EPA gave a presentation on their efforts with non-conventional arsenic treatment. They described the pilot projects they had in place, and how their systems were faring in regards to compliance.

Darren Lytle, from the USEPA Office of Research and Development (ORD) in Cincinnati, gave a presentation about his research and the information ORD has learned in regards to lead and copper in water systems, as well as other areas of their research. Tom Sorg, also from USEPA ORD, came with Darren. They were able to lend expertise to the group throughout the day on a variety of topics that arose, so they were a great addition to the meeting.

There were two other presentations that morning. Steve Wilson, the project PI, gave a presentation about MTAC's new efforts to create a dynamic Web site for small water supply operators. He outlined the plans for building a "cybercollaboratory" Web site to assist operators who need a place on the Internet to get assistance, share information, and find resources in an easy and simple way.

Lastly, the Ohio Rural Community Assistance Program (RCAP), which has been very active in the Check Up Program for Small Systems (CUPSS) training, spoke about their CUPSS training program. The CUPSS is a USEPA developed software for public water supplies that allows them to track assets and manage resources. As part of an asset management program, CUPSS is a tool in Excel that simplifies record keeping, asset tracking, and maintenance schedules, as well as many other tasks. Representatives from the Ohio RCAP ran through some examples of how CUPSS can benefit managers of small systems and provided a nice overview of the software.

Project Outcomes

1. The workshop was only a fraction of the envisioned two-day event that was originally proposed; but in the end, MTAC was able to provide a great event at almost no cost, so it was definitely worth the effort. It was a successful meeting overall, and the feedback from the NTNC managers was all positive. It has also provided us with an opportunity to work more closely with some of the states since the meeting, and building those relationships is an important step in future efforts to support small supply systems.

Topic 2: Development of a Cybercollaboratory for Small Water Systems Operators: The Next Step in Developing an Integrated Approach to Emerging Information Technologies

Richard E. Warner, University of Illinois

Project Description

The majority of small systems operators are now making at least limited use of electronic (Web-based) resources. Further, the emerging generation of water systems operators will have access to, and make effective use of, such electronic media. Although the USEPA and professional water organizations have invested heavily in making printed and Web-based resources available to small systems operators, professionals in these organizations are of the opinion that most operators (and managers) of small water systems make limited use of these resources. Hence, the long-term goal of this project was to develop a Web-based forum that will become the "go-to" Web site for operators of small water systems. The near-term goal of this project was to carefully involve representative small water systems operators throughout the Technical Assistance Center (TAC) network, state and federal agencies, and professional organizations, to identify how to design and promote what is intended to become to premier forum for small water systems operators.

Project Results/Outputs

In partnership with the Illinois Water Resource Center, Illinois State Water Survey, MTAC, the University of Illinois, and University of Illinois Extension, the Knowledge & Learning Systems Group (KLSG) at the National Center for Supercomputing Applications helped to develop the framework for a cyberenvironment to support collaboration among managers and operators of small water systems that will also eventually include tools to deliver instructional modules. Nine small water system operators attended the MTAC Operator Workshop that was convened October 16, 2007. This workshop gave the operators hands-on training with the Small Water System Cybercollaboratory. The meeting was an especially meaningful experience for many of the operators because they had limited on-the-job computer experiences and opportunities. The operators quickly learned how to maneuver within the site to access information. The participants also were engaged in security-related case studies during which they were required to respond via the cybercollaboratory. Information gathered from this project helped formulate the framework and identified needs to be addressed by the MTAC Cybercollaboratory, which was launched in the fall of 2009 (http://smallwatersupply.org/).

Project Outcomes

1. Important information was accumulated that was needed for the development of an effective cybercollaboratory for small drinking water system operators, and the basic prototype of the Web architecture was produced.

Topic 3: Development of an Anionic Exchange Glass Fiber Substrate POU Device to Remove Arsenic

James Economy and Zhongren Yue, University of Illinois
Walt Kelly and Tom Holm, Illinois State Water Survey

Project Description

In this project, an iron oxide (Fe_2O_3) system supported on a glass fiber substrate developed at the Department of Materials Science at the University of Illinois at Urbana-Champaign was evaluated for removal of arsenic from water. Laboratory tests were performed to evaluate the effectiveness of these filters in removing arsenic to concentrations below the maximum contaminant level (MCL) and to determine how long the filters remained effective. Both deionized (DI) water and natural groundwater spiked with arsenic were used in the laboratory tests to evaluate the rate of fouling and determine the significance of solute (i.e., anions such as bicarbonate, silicate, and phosphate) interference. Finally, a prototype of a point-of-use (POU) device was developed and tested in the homes of volunteers who had elevated arsenic concentrations in their well water.

Project Results/Outputs

The iron oxide coating on the glass fiber (IOCGF) system worked well in laboratory tests with both DI and natural groundwater spiked with arsenic. The number of bed volumes before IOCGF failure were large enough that the development of POU devices seemed promising. However, the POU devices failed to perform adequately in field tests. It seems likely that the interference of other ions, especially bicarbonate, may have compromised the ability of the filter to absorb arsenic. It is also possible that the POU design did not allow sufficient contact time with the water to efficiently remove arsenic.

Further research is being conducted at the Department of Materials Science, and a new filter system has been developed. This system depends on a chelating fiber that removes arsenic but is less vulnerable to competing ions and other contaminants than is the IOCGF. Early laboratory results are promising, but further testing using natural groundwater needs to be done. Because of the simplicity and low cost of these systems, they still remain promising technologies for the removal of arsenic from drinking water.

The final report for this project is available on the MTAC Web site at: http://mtac.isws.illinois.edu/mtacdocs/pubs/MTACTR08-07.pdf. There is also a companion Fact Sheet available: http://mtac.isws.illinois.edu/mtacdocs/qf/MTACFS08-07.pdf.

Project Outcomes

1. Important information was obtained in the goal of creating an effective, inexpensive tap-water filter for the removal of arsenic from drinking water. This project has spurred further research towards this goal.

Topic 4: Smart Pipe – Nano-sensors for Monitoring Water Quantity and Quality in Public Water Systems

Yu-Feng Lin, Center for Groundwater Science, Illinois State Water Survey
Chang Liu, Department of Electrical & Computer Engineering, University of Illinois at Urbana-Champaign

Project Description

A 2009 study by the American Society of Civil Engineers (ASCE) showed that 7 billion gallons of clean, treated drinking water disappears every day, mostly due to old, leaky pipes and mains. The amount is enough to serve the population of California in daily water usage. The approximate dollar cost, given varied water rates in different U.S. regions, is $20 to $100 million daily. Unfortunately, America's drinking water systems face an annual shortfall of at least $11 billion to replace aging facilities that are near the end of their useful lives and to comply with existing and future federal water regulations. Moreover, leaking systems have wasted not only dollars but also priceless natural and energy resources for future generations. This research project was initiated to develop the concept of a sensor unit to improve water supply infrastructure via a highly advanced, cost-efficient monitoring system. A research group led by the Illinois State Water Survey, in collaboration with the Department of Mechanical Engineering at Northwestern University, was formed to develop a "Smart Pipe" prototype: a multi-sensor unit to monitor water flow and quality using state-of-the-art nanotechnology.

Project Results/Outputs

System development included hardware, software, and experiments. Each component was designed considering the feasibility of the manufacturing process, practical usage, and cost efficiency. Detailed specifications of the hardware and software are available upon request, or visit the project Web site at: http://www.isws.illinois.edu/gws/sensor/smartpipe/.

The results from the experiments have demonstrated the efficiency of detecting pipe leakage using flow and pressure sensors as well as the feasibility of using a wireless infrastructure. Test results for multiple sensors with an advanced packaging process have shown the feasibility of using durable field material (PVC pipe) for the outdoor environment. Further study is recommended to improve this prototype via real-life application that includes the study of the frequency of required maintenance, fouling investigation, measurement calibration, real-time data communication software, manufacturing cost efficiency, long-term stability, and precision and accuracy assessment for commercial-grade products. The temperature sensor has been tested and is ready for future application in water quality detection. Since the Smart Pipe was designed as a module unit, it has an expandable capability for future available sensor units such as those for arsenic or radium. The nanosensor set has greater potential in addition to pipe leakage detection.

The final report for this project is available on the MTAC Web site at: http://www.isws.illinois.edu/pubdoc/CR/ISWSCR2009-11.pdf. There is also a companion Fact Sheet available: http://mtac.isws.illinois.edu/mtacdocs/qf/MTACFS09-03.pdf.

Project Outcomes

1. This project has developed a conceptual prototype of the Smart Pipe unit and has demonstrated its potential for benefiting water supply systems in small communities. The broader application of this new generation of nanosensor sets is dependent on future research funding.

Topic 5: Spatial Variability of Arsenic in Groundwater

Tom Holm and Steve Wilson, Illinois State Water Survey

Project Description

Approximately 50 Illinois public water systems have source water with arsenic (As) concentrations that exceed the maximum contaminant level of 10 micrograms per liter. Some of these systems may consider drilling one or more new wells in an attempt to locate low-arsenic water. Recent research by the Illinois State Water Survey and other agencies has found that As concentrations can vary dramatically among wells that are separated by distances of 1 to 10 kilometers (km). The objective of this research was to characterize the variability of As concentrations over distances of tens to hundreds of meters and determine the feasibility of a process that a small water system could use to site a new well with low-As water. Two clusters of 10 to 20 private wells of 1 to 2 km in diameter in Tazewell County and 10 private wells in Wonder Lake in McHenry County were sampled for As and supporting geochemical data.

Project Results/Outputs

Arsenic in Illinois groundwater can be highly variable over distances as short as tens of meters. The arsenic concentration at any point in these areas would be difficult to impossible to predict from a regional model, based on these results. For all three study areas, total organic carbon (TOC) values were 2 milligrams per liter (mg/L) or greater and most As concentrations were above the MCL. This is in agreement with earlier work in Tazewell County and is consistent with the hypothesis that hydrous ferric oxide (HFO) reduction is the source of As in these aquifers. Sulfate was generally undetectable for TOC values greater than 2 mg/L and detectable in most samples with lower TOC values. For all Hopedale and Tremot wells and six Wonder Lake wells, either As or sulfate was detectable, but not both. These data are consistent with complete sulfate reduction in areas with abundant organic matter and incomplete sulfate reduction in other areas. The data are also consistent with the limitation of dissolved As by sorption to ferrous sulfide (FeS) in areas with active sulfate reduction. As(III) was the main As species in all three study areas, in agreement with earlier results for Tazewell County. Values of pH and oxidation reduction potential (ORP) were qualitatively consistent with As speciation for the Hopedale wells as indicated by an As Eh-pH diagram. For the other two areas, the ORP measurements were consistent with much lower proportions of As(III) (i.e., they were higher than expected). Fifteen out of 17 wells showed no significant differences between filtered and unfiltered As concentrations. Clearly, particulate As concentrations were generally too low to be calculated by difference. ORP measurements for the two softened Wonder Lake wells were much higher than for the eight untreated wells, as would be expected if the redox electrode

responded largely to dissolved iron. (Softening reduces the Fe^{2+} concentration.) ORP measurements combined with general knowledge of the system may be useful in future field studies to indicate treated water when untreated water is expected.

The final report for this project is available on the MTAC Web site at: http://mtac.isws.illinois.edu/mtacdocs/pubs/MTACTR09-01.pdf. There is also a companion Fact Sheet available: http://mtac.isws.illinois.edu/mtacdocs/qf/MTACFS09-01.pdf.

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Project Outcomes

1. Important information was gained on the relationship between arsenic concentration and speciation and HFO and sulfate in central Illinois groundwater aquifers.
2. Siting a new well in these areas would likely require that every nearby well of interest be sampled. Conversely, sampling existing private wells, when those wells exist, may be an economical way for a community to assess the possibility of siting a new well near their municipal well.

Topic 6: Assessing the Environmental and Capacity Development Outcomes of Small Water System Board and Management Training Phase I

Stephen Gasteyer, Department of Human and Community Development, University of Illinois. Co-PIs: Richard Warner, Director of Extension, University of Illinois and Jeri Marxman, University of Illinois Extension

Project Description

This project assessed the outcomes of community water system board and management training (BMT) in enhancing community technical, financial, and managerial capacity and in achieving or protecting environmental quality and public health. The assessment recognized and compared the diversity of types of board training, and the context in which these trainings were conducted. The research involved a comparative case study framework (Ragin and Becker, 2002) to assess the likeness and differences between board and management training programs and to make a preliminary assessment of impacts. This involved, first, a compilation of the literature on community capacity development in the area of water. Using this framework, this assessment investigated five state programs to understand how small community water system board and management training was implemented and what the impacts of these trainings were.

Project Results/Outputs

Through surveying different state programs, it is possible to piece together the similarities and differences in the context and implementation of BMT. These strategies produce particular outcomes, in terms of who is trained, the depth of their training, the kinds of skills gained, and ultimately the impacts that result from training.

Mandating that all elected or appointed community water board members receive training, as is done in Mississippi, is the best way to ensure that all board members receive some

training. This state initiative may be an artifact of political action at the end of the 1990s, when state resources were better. The Mississippi program involves a multiorganizational partnership, and is backed by an activist capacity development evaluation initiative, administered through the Mississippi Department of Health (MsDH). Every small community water system board member in the state at least has exposure to the critical issues facing a community water system and this may account for Mississippi's consistently high compliance rate with Safe Drinking Water Act (SDWA) rules and regulations. Yet, this program is not well replicated in other states. The appetite for new mandates on communities and new allocations of state resources to improve water system capacity is probably weak right now. Further, the data on compliance probably only tells one small part of the community water system story. There are many reasons that community water systems may or may not be in compliance with rules and regulations.

Other strategies seem to have strengths and weaknesses as well. A critical issue is whether training is reaching a critical mass of board members. Ohio and Kentucky, using very different methods, have developed ongoing BMT programs that reach good numbers of community water system officials. But in both cases, many attendees are not board members, but operators seeking continuing education credits to maintain their operators' license. What is not known in any of these cases is the extent to which board operators internalize training in their planning and decision-making about the water systems. Four, six, or even 12 hours of lectures and PowerPoint slides could result in the internalization of significant knowledge about water system issues. It could also result in overload. It is possible that the on-site trainings, as conducted by the Kentucky Rural Community Assistance Program (RCAP) and Illinois RCAP, could do a better job of delivering the needed information and practices to decision-makers. Further, the theories of governance training (Robbins, 2008) emphasize the importance of building networks and relationships among multiple decision makers, allowing them to share experiences across geographic contexts and jointly solve problems. Currently, such networking and sharing of experiences is informal among those who attend BMT. Additionally, the forums for such interaction are being eliminated to save costs. More research is needed to really understand the impacts of BMT.

The outputs of this initiative include: (1) a manual on outcome measurement of local government BMT (http://mtac.isws.illinois.edu/mtacdocs/pubs/MTACTP09-04.pdf); and (2) a final report (http://mtac.isws.illinois.edu/mtacdocs/pubs/MTACTR09-04.pdf) that provides an assessment of BMT as implemented in Illinois, Kansas, Kentucky, Mississippi, and Ohio.

Project Outcomes

1. The outcome of this initiative is a greater knowledge by the EPA, technical assistance providers, and partners about how to measure the environmental and capacity development impacts of BMT.

Reallocation Projects

Several projects were funded with money remaining from other completed projects that were completed under budget for a variety of reasons.

Activities in Support of the Cybercollaboratory Project and MTAC Outreach and Education Programs

Steve Wilson, Illinois State Water Survey

Task 1: Work with the Central Region Groundwater Protection Committee and the Tazewell County Health Department on the Clean Water Celebration to highlight operator career issues and the value of community tap water.

All of the work associated with Task 1 was completed prior to this quarter, except for the "value of tap water" video contest. The video contest was retooled in wake of the disappointing response to the idea portion of the contest. Based on the advice from several high school teachers at the Clean Water Celebration, MTAC visited every high school Web site in the state, both public and private, and created a list of 3,500 science and journalism teachers' e-mail addresses.

Our staff and committee solicited ideas from water professionals, college students, and even their own children for the contest. From a group of about 25 acceptable ideas, 10 were chosen to be formally included in the contest. The rules, information, and release forms were all redone to fit the new direction of the contest.

Also, based on feedback from high school teachers, the dates of the contest were changed to coincide with the 2009 fall semester. This would allow teachers to use the contest as a semester or class project for their students. The new solicitation was sent out on September 17, 2009 to all 3,500+ teachers. The rules allowed students to submit their own ideas by October 15. We had about 10 requests for using their own ideas, and all were approved. The videos were due on December 11, 2009.

The committee of seven water professionals who developed the solicitation for the video contest served as judges and represent Association of State Drinking Water Administrators, MTAC, IL-American Water Works Association (AWWA), IL American Water Company, IL Science Teachers Assoc., and the Tazewell County Health Dept.

The rules are available at: http://mtac.isws.illinois.edu/cyber/videocontest.asp. Commitments for funding of prizes have been received from the Illinois American Water Company ($1000) and Illinois Section of AWWA ($500). The remaining $500 for the prizes will likely come from the four priority planning region groundwater protection committees that were established by the Illinois EPA. Two have already agreed to support the project.

Task 2: Fund participation in stakeholder conferences and meetings to support MTAC and the collaborative Web site.

We attended the following events:
Illinois Rural Water Association Conference - February 2009
NWETC water quality conference – May 2009
AWWA National Conference – June 2009
USEPA small systems workshop – August 2009
IL Potable Water Supply Operators Conference – September 2009

Task 3: Develop a module for the collaborative Web site to promote the advantages of a career as a water operator.

The careers page development is still in progress. The launch date of the Web site was delayed so that when launched, the available information would be substantial enough to keep users coming back. It's proven to be an even larger undertaking than the staff imagined, but they are making significant progress and have received many positive comments about the Web site.

The Delaware intern fell through due to contracting issues with the UI and their vendor requirements, but we were able to work with the second intern in an Illinois community. The young man worked for four weeks with the community of Rock Falls, IL, where he participated in all aspects of their water and wastewater operations, including spending some time working with billing customers. His experience will be part of the careers page, when launched, and we have video interviews with both the intern and the water operator at Rock Falls to include on the Web page.

We also have video footage of several operators discussing their reasons for being a water operator, which will be used on the careers page as real-life examples of what being an operator is all about. The page will contain a list of Junior/Community College programs around the country that offer programs for water and/or wastewater operator training. We will be offering to develop a custom version of the New York Dept of Health's career brochure for any technical assistance (TA) provider for their state or region, as long as they are willing to include ALL partners from that state on the brochure.

Because it has taken longer than envisioned to get the Web site ready to launch, the careers page will be launched sometime before the end of the calendar year.

Task 4: Provide print materials for operators as part of the cybercollaboratory Web site and links to TA resources.

The goal of this task is to support those operators that would like to have manuals and paper materials that can be downloaded from the Web, but either can't print them in color or can't effectively download those materials because of connection speeds and technology issues. SmallWaterSupply.org, will provide a service to print and mail those materials to individual operators who request them. To date, this task is built into the Web site framework and plans, but has not been implemented. The Web site will also link to most, if not all, TA providers and include summaries of the information on those Web sites, so the operator can quickly determine which materials might be useful. We have talked to a number of TA providers about this already and have received a positive response.

This task was well intentioned but because we did not launch the site until October 5th, it may have been premature. We are offering this service, and will always do so at SmallWaterSupply.org, but unfortunately the word is still not out yet about our site to a large enough degree that we have had any requests for printing information. However, requests have been received for about 15 different CD's that are available from the TAC's and NESC from the events staff attended, and have provided hundreds of these CD's, in total, to operators and TA providers from a number of states.

Task 5: Develop an onsite recertification program for Illinois NTNC systems.

A recertification workshop for NTNC managers in Illinois was held August 5, 2009 at the Illinois Institute of Technology. The Illinois Rural Water Association provided the training at the workshop and MTAC provided support and handled the logistics of the event.

Workshop information was sent to almost 300 NTNC operators who either already have expired certifications, or their certifications will expire this year. Thirty-two NTNC operators attended the event and are now recertified in Illinois. The ILRWA passed out an evaluation form at the event, and all in attendance were positive about the experience. Brad Larson, MTAC, attended and gave a short presentation about SmallWaterSupply.org.

Task 6: Provide Support for NTNC system recertification by providing "operator basics" to NTNC operators.

MTAC purchased 2,000 copies of Operator Basics from NESC. Staff has handed out over 200 copies of the CD so far. It's also led to more cooperation with NESC, which will be more evident in the upcoming year.

Outreach Activities

Groundwater Resource Assessment for Small Communities

Kenneth J. Hlinka, Illinois State Water Survey

Funding for this project was split between FY05 and FY06 Budgets

Project Description

For over 50 years, the Center for Groundwater Science at the Illinois State Water Survey (ISWS) has provided groundwater information to any requesting individual, commercial facility, or public water facility. Groundwater resource assessments have been an integral part of this public service and have been undertaken for thousands of individuals and facilities throughout our history. Using existing staff and focusing on the smaller communities (less than 2,000 population), current groundwater system adequacy (adequate, marginal, or deficient) and resource potential (within a 5- and 10- mile radius) will be developed for those small communities determined to have "deficient" groundwater supplies based on certain criterion.

Project Results/Outputs

The project developed letter-type reports for the 60 facilities that use shallow groundwater resources for their water supplies. The reports target the 60 facilities that have been determined to be most at risk in producing groundwater for their towns, under certain criterion. A summary of available resources within 5 and 10 miles of the facility is included as part of each report. The summaries typically include unexplored groundwater resources that would require further investigative study by the facility. The reports are posted on the MTAC Web site: http://mtac.isws.illinois.edu/gwassmnts.asp.

Project Outcomes

1. The 60 small drinking water systems in Illinois most at risk of having inadequate supply in the future have been provided with an assessment of their existing and potential groundwater resources to enable them to plan for the future. Many of these supplies would have had difficulty financing such a study on their own.

Information Dissemination
(FY05 and FY06)

The MTAC Web site has continued to see a steady flow of traffic and downloads. We have tabulated dates from Web traffic for the years in which this work was performed. During the period of January 1, 2005 to December 31, 2009, the Web site had nearly 850,000 hits from more than 238,000 user sessions. There was an average of 130 user sessions per day. The MTAC Web site experienced approximately 235,000 downloads during this period. The software somewhat loosely defines a download as an adobe acrobat (pdf) file being opened, so we can't tell for sure how many of these downloads were saved to the individual's computer. However, we can say for certain that there is a great deal of traffic on the site and interest in our final reports. There were roughly 57,000 unique visitors to the site during this period and of those, more than 14,500 visited multiple times. This indicates a substantial number of people have identified our Web site as a valuable resource and refer back to it for information.

We have given an account in various quarterly reports during the duration of this project regarding presentations at regional and national meetings and papers in refereed journals that are based upon work funded by MTAC and detailed in this report. The exact number is difficult to track, but there have been dozens of presentations and many published articles, including several in peer-reviewed journals. We also cooperated with the Drinking Water Clearinghouse to produce Tech Briefs based upon MTAC projects. MTAC has also produced and/or distributed thousands of training aides and reports.

The dissemination and distribution plan for all completed final reports was as follows: Pending completion of the review of the report, hard copies were produced of each document. Hard copies were mailed and/or electronic copies were e-mailed to each of the following locations: USEPA Project Officer, USEPA Regions 5 and 7 Capacity Development

Coordinators, IEPA Division of Public Drinking Water, and the other seven Technology Assistance Centers. Electronic versions of the report and a one-two page summary document suitable for use by small public water systems operator/administrators were posted on the MTAC Web site. Additionally, project teams were all encouraged to publish their work in appropriate scientific journals, and make presentations at professional meetings to increase dissemination of their results.

Financial Accounting

Official financial accounting for the project was conducted by the University of Illinois Office of Grants and Contracts, and they will be forwarding any required information regarding budgetary expenditures.

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