AC 2009-1939: WATER-RESOURCE MANAGEMENT CAPACITY DEVELOPMENT: A SMALL-SYSTEMS TECHNOLOGY-TRANSFER MODEL

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Karla Andrew is currently employed by the Center for Water Resource Studies at Western Kentucky University (CWRS WKU) as the Information Technology Manager. Her primary responsibilities include but are not limited to: managing student workers in the area of Information Technology tool development and research; coordinating Geographic Information Systems development; coordinated web and applications development; assisting drinking water and wastewater utilities with information technology issues that arise; providing technical assistance to water districts; and supporting the information technology needs within CWRS. Ms. Andrew has over 20 years of computer experience with the most recent 8 years being in the hydrology area. Previously Ms. Andrew worked at the Illinois State Water Survey and focused on database programming for Hydrological Models. Work included management strategies for flood protection in the Lower Illinois River (developing an interface to use the UNET Model for Real-time Simulation of Flooding), work on water quality issues within the Fox River, hydrologic modeling of climate scenarios for two Illinois watersheds, and served as Co-PI on a project involving flow forecasting for the Stratton Dam in northern Illinois. She also coordinated programming for the evaluation of the Illinois stream flow gauging network, effective discharges of Illinois streams, the Illinois Stream Flow Assessment Model (ILSAM), and data management tools for water sampling data (IDAPP).

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Mr. Jeff Ballweber is currently employed in the Department of Agricultural and Resource Economics at Colorado State University as a Community Development Specialist. Jeff received B.S. degrees in Philosophy and Political Science from Oregon State University in 1987 and a J.D. from the University of Oregon School of Law in December 1990. From March 1993 through

August 2007 Jeff directed the Mississippi Water Resources Research Institute. Since 1997, as a Principal Investigator Jeff has received and managed more than $4,500,000 in external funding from federal, state and local agencies in Mississippi. In particular, Jeff has been active with the Environmental Protection Agency's (EPA) university-based TACnet program and the Principal Investigator for the Southeastern Regional Small Drinking Water Systems Technical Assistance Center (SE-TAC) at Mississippi State University since its creation in 2000 until 2007. In that capacity, Mr. Ballweber has worked closely with various state Rural Water Associations, State Primacy Agencies and Rural Community Assistance Programs on many water system compliance issues relating to Source Water Protection and Capacity Development for Small Public Water Systems in the Southeastern U.S. Jeff's other projects address: water resources development and management, source water protection, Low Impact Development, Smart Growth, mechanisms for statutory integration and interjurisdictional institutions, and remote sensing and geospatial technology applications for water related Decision Support Systems. Jeff is on the Mississippi Water Resources Association's Board of Directors and was President from 2004-2006 and Chairman of the Board from August 2006- August 2008.

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Dr. Ni-Bin Chang received his Master's and Ph.D. degree from Cornell University in 1989 and 1991, respectively. Both are in the field of Environmental Systems Engineering. He is a professor with Civil and Environmental Engineering Department, University of Central Florida (UCF). He has been directing academic research in the field of environmental and water resources engineering systems over 20 years. Since 1992, as a Principal Investigator Chang has received and managed more than $5,000,000 in external funding from federal, state and local agencies. His area of expertise is water resources management, sustainable systems engineering, environmental systems modeling, remote sensing, environmental informatics, and industrial ecology. He owns those distinctions which are the selectively awarded titles, such as the Board Certified Environmental Engineer (BCEE), Diplomat of Water Resources Engineer (DWRE), Certificate of Leadership in Energy and Environment Design (LEED), an elected Fellow of American Society of Civil Engineers (ASCE) and an elected member of the European Academy of Sciences (M.EAS). He has authored and co-authored over 132 peer-reviewed journal articles, 7 books and chapters, and additional 122 conference papers. Dr. Chang has considerable experience in managing international journals. He was one of the founders of International Society of Environmental Information Management and the former editor-in-chief of Journal of Environmental Informatics. He is currently editorial board member or associate editor of 21 journals.

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He received a B.S. in Chemistry and Biology (double major) from WKU and a M.S. in Biomedical Science from the University of Tennessee, and later pursued doctoral studies in Environmental Biotechnology at the University of Tennessee Center for Environmental Biotechnology. Further education includes cave and karst geology, geohydrology, and microbial biogeochemistry at the Center for Cave and Karst Studies at WKU.

Broad experience has been acquired by employment as a research associate at Oak Ridge National Laboratory, The Procter & Gamble Co., Baylor College of Medicine, Genosys Biotechnologies, and St. Jude Children's Research Hospital. While laboratory manager of the WKU Biotechnology Center from 2000-2004, Fowler began the first molecular biology study of bacteria in Mammoth Cave in collaboration with Dr. Chris Groves. His research was incorporated into the Center for Water Resource Studies at WKU in conjunction with the merger of environmental laboratories at Mammoth Cave National Park and WKU. Fowler's research career has produced over 15 articles in peer-reviewed journals including Science and Nature and he was co-winner of the National Caves Association Science Award in 2001. He is a member of the

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Water Resource Management Capacity Development: A Small Systems Technology Transfer Model

Abstract

The Center for Water Resource Studies at Western Kentucky University promotes and facilitates a public/private sector partnership focused on the development and transfer of water resource management technologies that specifically target the small to medium sized industry market. This market includes municipalities, water and wastewater utilities and districts serving populations less than 25,000, local and state government agencies, commercial and non-profit organizations providing engineering, scientific, technical, financial, managerial and analytical services, and the industry relevant trade associations. The size and scope of services needed/offered in this market sector tend to limit the rate of return of product development investment, and, as a result, only a few companies tend to invest in this sector. The partnership integrates small technology startup entrepreneurial firms with the end-user/target market sector and the water resource technology development capacity of the partnering universities to facilitate the translation of market need into technological concept, development, transfer and commercialization. The needs and capacity of the target market dictate a high-volume, low-margin approach to be commercially feasible, and so is typically under-served. By relying on small startup firms for commercialization, and minimizing licensing burden, the partnership promotes a technology development and transfer model process that is sustainable. The partnership focuses on developing processes for rapid identification, development, transfer and commercialization of incremental advances in technology that have an immediate benefit on the target market. The key to success of the partnership is the adoption of the successful "Red Hat Business Model," that relies on integrating the end-user into an open product development process. Key principles incorporated into such a business model include a "first-to-market" philosophy, a highly responsive consumer feedback process, and a balanced reliance on product service and intellectual property protection for commercialization.

Technology Transfer at Comprehensive Universities

The common definition of a comprehensive university is one that grants bachelors and masters but not doctoral degrees, consistent with the 2000 Carnegie Classification[1] definition of institutions that "offer a wide range of baccalaureate programs and are committed to graduate education through the master's degree." As a result of the relatively limited emphasis on post-graduate work, universities falling within the comprehensive university classification have historically focused on traditional curricula approaches for fulfilling an explicit educational mission. An outcome of this has been that the missions of many comprehensive institutions have become synonymous with a regional service focus and, in many cases, a liberal arts education.

A symbiotic relationship can be drawn between institutional classification and local socio-economic structure. That greater probability of technologically driven economic evolution occurring in the vicinity of Doctoral/Research institutions is indisputable[2]. The converse is also true – institutional growth is linked closely to the health of the local economy. Regional technological creative capacity enhancement is crucial for maintaining a competitive advantage in an increasingly global technologically driven economy[3]. An outcome of globalization, or a "flattening" of the world economy[4], is the increased competitiveness of emerging nations in the upper blue-collar/lower white-collar technological job market. International outsourcing of the manufacturing sector, followed by technical support/call center, applications development, and, most recently, the research and development arms of traditionally nationally located enterprises, are symptoms of the evolution of global commerce that cannot be ignored by academia.

These factors, in conjunction with a national trend of decreasing state support for public institutions of higher education, have forced many comprehensive institutions to reassess their traditional roles[5]. Themes common to most institutions in this situation are increased offerings of professional programs (business, engineering, medicine, law, pharmacy, etc) and increased offerings of graduate (doctoral) programs. Both these approaches, while driven by real market needs, require a distinct evolution in institutional student, faculty and administrative culture that often limit successful institutional transformation. Moreover, transformational failures often result from misguided attempts to re-mold institutions from comprehensive to doctoral without a clear assessment of supporting market drivers, faculty interest, or administrative capacity.

A clear case for increased emphasis on research and commercialization can be made for comprehensive institutions. This is critical for institutions serving regions experiencing economic downturns as a result of globalization and outsourcing, as a means of developing the local workforce to attract the more technologically advanced enterprises required for global competitiveness, and equally important for institutions in regions where the economy has maintained a competitive edge through adaptation and evolution. It is indeed apt for the role of comprehensive institutions to be likened, to that of the original role of land grant institutions[6] in the mid 1800's to expedite "a practical higher education" to fuel, in this time, the "new economy." It is critical that any comprehensive institution shouldering this role differentiate between the drivers and outcomes applicable to technology development and commercialization and those typically affecting fundamental research executed at doctoral universities.

In order to support the evolution of a comprehensive institution into its role in the twenty first century, a cultural evolution must take place within the organizational structures. Key is the refinement of necessary bureaucratic processes to support the redefined institutional role. Paramount in this is an understanding of the different impact technology licensing that a twenty first century comprehensive institution has with the commercial sector as opposed to research intensive/extensive universities. The type of research typically executed at comprehensive institutions, even those embracing a re-defined role, results more often in lower national or global impact than that of fundamental/theoretical research outcomes from doctoral institutions, although high impact research is by no means uncommon. There is significant regional economic value in attracting technology-based start-up/entrepreneurial firms that are most likely to find utility in, and maximize the benefit of, comprehensive institution research outcomes. This provides the basis for tuning intellectual property management policies[7] to stimulate intellectual property development and effective transfer of technology that rewards the inventor, benefits the institution, and arguably most importantly, maximizes the potential for market success by the commercial entity. Without market success, no institution or inventor benefit can be realized.

It is evident, therefore, that for a traditionally comprehensive institution to be competitive in the research arena, and yet be faithful to its regional service mission, applied research in readily transferable technologies must be highlighted. Traditional comprehensive university processes cannot sustain an increased focus on applied research, technology transfer, and commercialization. Such a focus requires a symbiotic relationship between the university and the commercial sector. Unfortunately, the traditional university bureaucratic processes (contracting, purchasing, personnel, accounting, etc) are woefully inadequate when juxtaposed with the near-instantaneous responsiveness required of entrepreneurial firms[8]. Institutions succeeding in this transformation develop more responsive processes while maintaining the strict accountability structures required of tax-payer subsidized entities[9].

Linkages with regional economic development groups are essential for an institution to be responsive to changing community needs and corporate investment recruitment potential. Faculty involvement in local and regional technology incubators, and both research and industrial parks will maximize the stimulation of new marketable technologies supportive of the regions economic growth potential, and therefore maximize their potential for market success.

In order to maintain true to their primarily baccalaureate educational mission, comprehensive institutions must embrace the challenges of applied research and commercialization, while at the same time maximizing the engagement of undergraduate students in the process. This serves two, among many, key purposes. First, undergraduate students engaged in research activities develop greater problem solving, critical thinking and creative skills that are essential both for advanced studies and entrepreneurship. For student bodies that possess a high percentage of individuals who are first generation college educated, engagement in applied research that demonstrates a short term return potential in the commercial sector and provides interaction avenues with entrepreneurial firms, further serves to validate the benefits of a college education. Second, an engaged student body, whether through civics, creative research, or entrepreneurship, is a fertile ground for recruitment by the entire array of job sectors, in addition to being an attractor for the location of commercial enterprises within the university's service region.

While undergraduate students will typically form the largest student body at comprehensive institutions, and therefore, based on sheer numbers, will produce the greater number of entrepreneurs, a much greater rate of return can be secured from appropriately optimized graduate programs. Properly stimulated, professor-graduate student interactions can closely resemble creative discussions, or brain-storming sessions, at entrepreneurial firms, resulting in increased productivity. Undergraduate research programs will stimulate creativity, but often require a greater investment by faculty on a per-student basis than appropriately recruited graduate students. Faculty creativity, and the stimulation of entrepreneurship in students can be maximized by the use of post-doctoral researchers and technical professional staff to shoulder the day-to-day time-critical functions that could interfere with faculty teaching and student learning primary functions. The combination of faculty, technical professionals, graduate and undergraduate students can be a highly effective mix of capabilities and potential.

A focus on applied research, technology transfer, and commercialization is a potentially rewarding track in the re-defined role of comprehensive universities in the twenty first century. In order to be successful, an institution navigating this transformation must be prepared to undergo an organizational evolution to support and stimulate the process of innovation and commercialization. Successful transformation will occur at institutions that facilitate and stimulate innovation and commercialization at the smallest scale. As commercialization becomes more routine within the university culture, the probability of a high return innovation will increase dramatically, as will the willingness of entrepreneurs to partner and commercialize. Comprehensive institutions that initially aim to produce the next "Gatorade®" will be doomed to constrict innovation and limit commercialization by establishing processes that will discourage the small start-up entrepreneurial partnerships and place a high burden of productivity on creative faculty not yet fully engaged in the technology transfer process.

The Center for Water Resource Studies at Western Kentucky University

Western Kentucky University (WKU) established the Office of Research and Economic Development in 2005, along with a new Associate Vice President for Research and Economic Development reporting to the University Provost. In addition to consolidating most research and graduate program units under one roof, including the Office of Sponsored Programs, and College of Graduate Studies, the new Office established an office for technology licensing and the WKU Center for Research and Development (The Center). The Center is co-located with the Central Region Innovation and Commercialization Center (ICC), a regional technology accelerator funded by the Commonwealth of Kentucky and local governments. The Applied Research and Technology Program (ARTP) is a Program of Distinction within the Ogden College of Science and Engineering at WKU, emphasizing the integration of undergraduate research, technology development and transfer, and stimulation of entrepreneurship as a mechanism for technology-base regional economic development. The ARTP seeds and facilitates the establishment and growth of multi-disciplinary centers supporting its integrative mission. Several ARTP centers that epitomize the public-private sector vision are located adjacent to the ICC and The Center, providing a catalyst and attractor for technology startups.

The Center for Water Resource Studies (CWRS) is an ARTP center specializing in the transfer of cutting-edge research into practical water resource management tools. The CWRS maintains a full staff of qualified technical professionals providing a broad range of services, including: Water and Wastewater Laboratory Analysis; DNA Cloning and Sequencing; Operational Troubleshooting; Specialized Training; Mapping and Modeling; Sampling and Monitoring; Applications Development; Proof-of-Concept and Technology Verification. Center staff act at the interface between university research faculty and graduate and undergraduate students to provide effective translation of ideas into action. The CWRS is organized into three divisions – The Water Analysis, Training, Education and Research Services laboratory consortium; the Environmental Informatics and Information Technology division; and the Field Operations and Outreach division. The Water Analysis, Training, Education and Research Services (WATERS) Laboratory is a State certified laboratory specializing in the analysis of drinking water, wastewater and source water for compliance with State and Federal regulations. WATERS provides cost-effective analytical services to water and wastewater treatment facilities, industries, and the general public by using state-of-the-art instruments and experienced staff. The Field Operations and Outreach Division (FOO) is staffed by trained and certified professionals specializing in the collection of field data and on-site training and technical support. This unit provides sub-foot GPS mapping, sample collection, monitoring program development and implementation services under rigorous quality control standards. The division provides mapping and data collection services to municipalities and utilities, in-stream water quality monitoring campaigns for watershed planning and Total Maximum Daily Load development, and water, wastewater and stormwater system evaluations. The Environmental Informatics and Information Technology Division (EIIT) employs state-of-the-art Geographic Information System (GIS) technologies and software development environments in the design and development of analysis and visualization applications. The integrated Information Technology (IT) and environmental expertise allows the division to develop real-world applications that meet both the IT demands and the requirements of the water districts within our region. The Division specializes in the integration of web and GIS applications and mapping tools, rules based logic, expert systems and semantic web applications.

CWRS was re-defined in 2003 into its current form, to be more consistent with its primary funding sources and service role within the Commonwealth of Kentucky. With a newly adopted mission of capacity development focused on small to mid- sized water and wastewater infrastructure systems, the CWRS established an external advisory board comprised of as broad a spectrum of relevant organizations, including representatives from state agencies, non-governmental organizations, universities, and private sector commercial entities. A review of its inventory of products and services revealed a significant potential for technology licensing, in addition to an untapped potential for collaborative product development with private sector partners. An informal partnership was developed with Spatial Data Integrations, Inc., (SDI) a small business Geographic Information Systems service firm headquartered in Louisville, Kentucky, to further explore this concept. This resulted in SDI establishing an office presence at the ICC with shared space with the CWRS EIIT and FOO divisions.

Cooperative Development Model

In 2005, the co-location of CWRS/EIIT with SDI's Business Development office, incubated a concept for establishing a cooperative venture tentatively named the Center for Outreach and Application Development in Environmental Informatics (COADEI). Its purpose would be to create an environment for furthering research and development, training and outreach in an overlapping area to provide technological services and applications to rural Kentucky and surrounding areas. COADEI was to consolidate research and development efforts as well as provide faculty and students an outlet to commercialize ideas while utilizing economies of scale and synergy to provide the broadest regional impact. The two founding partners, CWRS and SDI, espoused very specific common goals:

- **Research & Development**: Maximize the ability of each partner’s ability to further the research and development missions through the formalization of resource sharing.

- **Shared Intellectual Property**: Predefined intellectual property agreements enabling each partner to benefit from the commercialization of jointly created applications giving an immediate avenue for professional development to students and staff.

- **Provide GIS tools to rural utilities**: Provisions allowing each utility in the Commonwealth serving fewer than 3,300 populations, to obtain Geographic Information

System (GIS) software.

- **MoTER**: Based on the Mississippi State University Global Education Mobile (the "Brain Bus"[10]), a Mobile Training and Emergency Response vehicle. This vehicle was to be outfitted with a mobile GIS lab to provide outreach and training opportunities to rural communities of the Commonwealth. In the event of malicious, manmade or natural disasters, the mobile lab would be used to assist incident command centers in the analysis and output of data for the real-time assessment of response strategies.

Although the COADEI concept was never formalized, it did set the stage upon which the broader Water Resource Management Technologies evolved.

Needs Assessment

As a preliminary market assessment, A PEST analysis may be used to assess the Political, Economic, Social and Technological factors impacting the target market sector.

Political - Rural communities and small public water systems are increasingly being impacted by the expanding regulatory scope under the Safe Drinking Water Act (SDWA) and the Clean Water Act (CWA). In many cases, these rural communities and small, mostly rural water systems are faced with significant regulatory pressures for the first time. Furthermore, they frequently lack the technical, administrative and economic capacity to proactively plan for and respond to these new regulatory burdens. In addition, these communities and systems do not have an objective, reliable source of information to understand and evaluate alternative methods to comply with these new regulatory hurdles. Usually, universities are a trusted resource for training and technology transfer for these communities and systems. As such, universities, in cooperation with the private industry, have an opportunity to design new and modify existing technologies to help this under served community comply with regulations. In addition, by working in conjunction with universities, industry can explore alternative technology delivery mechanisms (the Internet) and price structures to both serve this new market and ensure that their products are affordable to them. The prime need is to develop and deliver a proactive response to federal and state regulations. This is a national problem but very apparent in the Southeastern United States.

Economic -Traditional governmental funding sources for water resources development and infrastructure have undergone a rapid transition in the past ten years. Grants programs are declining or being reprogrammed into loan or loan guarantee programs. Many federal loan programs are under capitalized and the federal government is reluctant to increase funding for capitalization (e.g., SDWA and CWA Revolving Loan Funds). At the same time traditional funding sources are shrinking, a larger share of consumer fees and other local revenue is being shifted to maintain the status quo rather than invested into capitol or technology improvements. Corresponding to this transition, failure to meet new regulatory standards can result in penalties that directly compete with proactive compliance efforts. The primary source of funds in a robust economy is from the private sector and in rural areas mainly from residential and commercial/industrial land development. The potential use of technologies that support land development (and preservation), both from the regulatory perspective (i.e. local government planning and zoning, and compliance and enforcement) and from the speculators' perspective (i.e. land developers and contractors) is limited only by the rate of local economic growth. Local economic growth is maximized by minimizing the overhead and maximizing the capacity of local utility providers, and stimulating an economic engine that increases capacity of the supporting local service providers and governmental authorities and the associated infrastructure. All private economic development requires access to drinking water and wastewater. Provision of technologies and tools tuned specifically to the local utility providers and service companies, increase their capacity to scale up rapidly in response to investment interest, and, as a result, increase the potential for attracting industry investment.

Social - Rural communities have a unique and prized ethos and sense of community that built this nation. The growth of agurbs (suburbs located geographically further from urban areas) is threatening the social fabric of rural communities. Traditionally, rural communities and small rural public water systems had certain independent spirit linked to close ties to the land with individuals depending on agricultural or natural resource based employment. Conversely, the agurbs are a reflection of a very mobile society increasingly comfortable with telecommuting and internet based technologies. Local and county governments are caught in the middle of this transition as new residents likely expect a higher level of public services at the same time they are under increasing pressure, by both state and federal regulators, and their local population, to constrain development in a socially acceptable manner. This often translates to consolidation of water and wastewater management entities that is often viewed as a social negative. Social impact directly on the target end-user is limited to its technological value and corresponding ease of use. The key social value for the targeted market is retaining local utility providers through an increase in technological capacity.

Technological - Currently, most rural communities and small public water systems lack the resources necessary to gain access to many cost-saving technologies. In addition, many existing technologies have only been proven and are only cost effective when used by medium and large water/wastewater utilities. Accordingly, there is both a technology gap and an economic gap to be overcome to validate and demonstrate the utility of new technologies to rural communities and small water systems. From a technology perspective, either new, easy to use technologies need to be developed or existing technologies, scaled down to apply at a smaller scale. From an economic perspective, new marketing and cost structures need to be developed to make those technologies affordable to rural communities and small water utilities. A phased in technology/pricing structure may be necessary to allow rural communities to make an initial foray into new technologies. After getting the communities to adapt “basic” technologies often for the first time, a series of “add on” technologies or upgrades could be developed and made available as the communities become more familiar with technology in general and recognize the cost-savings of integrating technologies into their operations. The application of technologies appropriate in scope and scale to small and medium sized utilities has, by definition, a positive impact on the local economy.

Scope of Services

The technologies focused on under this model are those that support the management and operation of small to medium-sized water resource management entities. The target sector for these technologies include water and wastewater utilities, municipalities, and authorities as well as watershed management and conservation districts. These entities are typically supported by engineering, science and technology service organizations such as consulting firms and analytical laboratories. Both the target sector and the service sector rely on technology manufacturers and vendors to provide: software for management and operations support, as well as planning, design and assessment services; instrumentation hardware; and process methodologies, among others. Local, state and federal agencies with regulatory authority over the target sector also rely on similar technologies for oversight, while water and wastewater trade associations are also end-users of these technologies, supporting their membership. Consistent with the needs of the target sectors, the following thematic areas are addressed:

- Low total cost of ownership measured relative to target market budgets
- Multi-purpose, as opposed to specialized tools (i.e. "Swiss Army Knife" approach)
- Modular, extensible software for management, operations, planning, design and assessment
- Instrumentation and hardware to minimize operator error
- Method development for laboratory analyses and operations

In general, the technologies developed fall under the following broad categories:

- Software Applications
- Analytical Methods and Instrumentation
- Field Operations Techniques and Tools
- Workforce Training Tools

Business Model

Open Business Model - The traditional business models rely on the valuation of intellectual property to discriminate the product or service being marketed[11]. As a result, an inordinate amount of emphasis is placed on the protection and restriction of the intellectual property in order to maintain a competitive edge. This model makes knowledge a commodity, effectively restricting incremental technological advances. The open business model[12], on the other hand, relies on the discrimination of products and services based on branding and quality. This approach promotes the sharing of knowledge and makes the *application* of knowledge the valued commodity. With the principle business discriminator being knowledge application, rather than protection, a greater emphasis is placed on the provision of quality products and services. This results in the adoption of rapid product development cycles, and reliance on "first-to-market" principles to maintain market share[13].

Innovation in Engineering Service – The provision of engineering services in the current competitive environment has led to a new breed of engineer[14] who emphasizes more holistic and integrative approaches. Large, multi-national engineering service firms maintain market share by exerting political influence and systematic market governance[15]. By coupling the provision of services with the use of provider-specific proprietary tools and technologies, large firms set *de facto* standards, effectively controlling the direction of innovation[16], and limiting incentives for entrepreneurial development.

Product/Service Examples

Several technologies have been developed so far under this model. Some are discussed below:

Long Term Control Plan Expert System – The CWRS, in partnership with the Kentucky Rural Water Association and SDI, established the Kentucky Collaborative for Combined Sewer Overflow Management (KCCSOM) to support small communities in Kentucky under state and federal mandate to meet the requirements of the 1994 Combined Sewer Overflow Control Policy[17]. The CWRS/EIIT developed an on-line expert system[18] to guide the elected officials and public works managers through the process of developing the required Long Term Control Plan (LTCP). This product included the ability for users to collaboratively develop control measures for incorporation, as well as integrating aspects of sub-project cost/benefit assessment, prioritization and sequencing. This has enabled the KCCSOM to provide clients the option of utilizing the on-line system themselves, or in conjunction with technical assistance from KCCSOM partners.

Cryptosporidium Monitoring Source Water Filtration – Under the Interim Enhanced Surface Water Treatment Rule[19], certain public water systems are required to monitor for the specific waterborne pathogens (e.g. Cryptosporidium and Giardia Lambdia). With the analytical methods requiring the filtration of 10L of source water under precise pressure and flow conditions prior to staining and microscopic enumeration, the WATERS laboratory devised a product allowing the utility or municipality to filter the source water on-site and ship only the filter. Over a 2-year monitoring period, the estimated savings for the utility could approach $5,000. Two models were developed, one requiring manual adjustment to meet pressure and flow requirements, and an electronically controlled version that automated the entire process. Units were provided to existing WATERS clients and used as a means to develop new clientèle.

GeoExpert – Core functions of the CWRS have increasingly relied on Geographic Information Systems (GIS) and related geo-spatial tools for effective product development and delivery of services. Marrying the rule-based decision support knowledge base first deployed with the LTCP Expert System, an internal need for data quality assessment or large geo-spatial datasets was addressed through the development of GeoExpert[20]. GeoExpert integrates spatial data visualization and analysis capabilities of GIS with the reasoning and inference capability of an expert system. While GeoExpert itself was not deployed in a commercial venue, it has set the trajectory for subsequent product ventures.

GIS Integrated Expert System for Stormwater Management – A collaborative product development project between SDI, CWRS and Ernest & Sons Environmental Engineers, this product builds on the core functionality of GeoExpert, to develop a GIS/visualization based toolbox for urban stormwater managers. Initially funded by the Kentucky Science and Technology Corporation, this product evolved into a tool that utilizes concepts of reverse trajectory modeling to support the Illicit Discharge, Detection and Elimination minimum control measure.

TMDL Data Management – The Total Maximum Daily Load (TMDL) Data Management System is designed to track data chain of custody, store field data linked to the chain of custody event ID, link to LIMS lab data systems. The system additionally includes user authentication and quality control measures. This system was originally designed to support a specific contracted watershed TMDL development project, but has been expanded for application to any water quality monitoring project with a minimum of programmatic changes. The product is under development for commercialization, with added marketable features such as integration with GIS and groupware/project management applications.

Drinking Water Distribution System Sensor Optimization - Having a well-thought-out expert system (ES) in place before an emergency situation occurs, allows responders to rapidly stabilize potentially chaotic situations. A prototype cost-effective spatial rule-based expert system is currently being developed to support both emergency response and operational management. Currently in progress, this project, sponsored is by the Kentucky Science and Technology Corporation and is being executed in partnership with Hardin County Water District #1 and Caveland Environmental Authority. Understanding the contributing factors within the watershed is essential to assess the potential health risk. Factors include knowledge of the different sources of contamination in the watershed, identification of associated health risk, and assessment of the level of baseline. The technology uses a combination of facts and rules, along with user input, to determine the status of a water supply plant/company during a potential emergency situation. Primary applications of the technology will include determination of sensors/sensor networks deployment strategies that combine all early warning information from source water monitoring systems to process monitoring of water treatment plants, and the operational monitoring of water quality in distribution systems.

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The newest stoker furnace technology is low air incineration that aims for high-efficiency power generation, which is already under construction in Japan. The figure below shows one example of the latest technology: a facility exhibiting high pollution prevention and high-efficiency power generation capacity. Advanced Waste Incineration Facility.Â A water shielding sheet covers the floor and sloped surfaces of the controlled landfill site to prevent the pollution of underground water. Sheets with outstanding durability are being developed and used. When the site is constructed over an impervious layer, a liner sheet need not be required if the layer has a thickness of 5m or more and the coefficient of permeability is 1x10-5cm/second or less.