Sustainable Water Innovation Initiative for Southwestern Pennsylvania

A report of the Water Innovation Consortia Planning Committee
March 2012

An expanded version of this report, including additional historical context, case examples of Southwestern Pennsylvania's rich history of water innovation, background on water issues and opportunities, study participants, listing of leading organizations in the region and their demonstration projects, role model water collaborations elsewhere, as well as detailed references and appendices, is found on-line at:
www. http://www.pittsburghwed.com

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Abstract

A Water Innovation Consortia Planning Committee was formed as a follow-up to the "*Water Matters!* Global Water Conference" held in conjunction with the *United Nations World Environment Day 2010 Pittsburgh*. The goal of the committee was to identify the water-infrastructure related assets and capabilities of the Southwestern Pennsylvania region that can be brought together to develop innovative solutions in the water sector.

Development of innovative water technologies, systems, and services that target regional water issues will improve the regional standard of living and act as an economic driver by stimulating investment and creation of new business activity and opportunities. Novel technologies and approaches developed for water management here can be exported to regions with similar needs. Further, clusters of organizations with complementary interests and capabilities in the region enable collaboration to develop solutions to water challenges around the globe.

To identify promising opportunities for such collaboration and the characteristics necessary for their success, the committee invited regional organizations involved with water infrastructure and water resources to participate in a series of meetings and workshops to propose opportunities for innovative water projects in the Pittsburgh region and to explore how these projects could be successfully demonstrated.

The committee, in collaboration with representatives from local universities, non-governmental organizations, government agencies and local industries explored successful past innovative projects and developed screening criteria for use in selecting future innovative demonstration projects. From analysis of previous innovative water projects in the region, it was concluded that a successful project should use innovative technology, have an advocate, be region-centric and marketable and exportable to other regions, focus on implementation actions, and emphasize collaboration, including a university partner, public engagement and commercial partners.

Applying these criteria, eight projects from four broad areas were identified as potential projects for regional water innovation consortia, including:

(1) energy development and water management;
(2) navigation infrastructure, monitoring, and water security;
(3) stormwater and green infrastructure; and
(4) regional watershed and drinking water interactions.

Of the eight projects selected, three were related to navigation, two were energy related, two stormwater related, and one was related to drinking water.

Executive Summary

As a follow-up to the "*Water Matters!* Global Water Conference" held in June 2010 in conjunction with the *United Nations World Environment Day 2010 Pittsburgh,* the Water Innovation Consortia Planning Committee was formed to identify the water-infrastructure related assets and capabilities of the Southwestern Pennsylvania region that can be brought together to develop innovative solutions in the water sector.

Development of innovative water technologies, systems, and services that target regional water issues will improve the regional standard of living and act as an economic driver by stimulating investment and creation of new business activity and opportunities. Novel technologies and approaches developed for water management here can be exported to regions with similar needs. Further, clusters of organizations with complementary interests and capabilities in the region enable collaboration to develop solutions to water challenges around the globe.

This report presents the results of the study by the Water Innovation Consortia Planning Committee.

Report composition:

- Section 1 of the report gives a brief overview of the goals and activities of the Committee.
- Section 2 describes the process of engagement with water related organizations from across the region, and presents key findings regarding innovative water projects that have been performed in the region and their characteristics. These findings were used to establish a list of screening criteria for future projects.
- Section 3 describes 19 candidate projects that emerged from the workshops with regional water organizations. Using the screening criteria identified in Section 2, the list of potential projects was narrowed to eight.
- Section 4 describes the next steps in moving the top eight potential projects to implementation.

(A section providing a detailed historical overview of water innovation in the region and background of the region's water assets and challenges can be found in the full expanded on-line version of this report.)

The committee hosted a series of workshops with water professionals from many water-related private- and public sector organizations in the Southwestern Pennsylvania region. The purpose of the meetings was to identify innovative water projects that have been implemented in the region, and key components of successful projects. The innovative projects that were identified span a range of water infrastructure and water resource topics, such as the innovative treatment of acid mine drainage for material recovery, ecological rehabilitation of a flood plain, urban stream restoration using a combination of innovative tools and techniques, and management of stormwater quantity and quality in an urban watershed.

From evaluation of successful water innovation projects that have been conducted in the region, the Committee identified six key attributes for use in screening potential water innovation projects. It was determined that to have the best chance of success, a potential project should:

- use innovative technology;
- have an identifiable project champion or advocate;
- be region-centric with marketable and exportable characteristics;
- have funding potential and be implementable and action oriented;
- emphasize collaborative solutions involving education, tech transfer and public engagement
- involve a regional university and potential users.

These project attributes were used to evaluate 19 candidate projects, which led to the identification of eight projects from four broad areas as potential demonstration projects for the water innovation consortia.

The four areas were:
(1) energy development and water management;
(2) navigation infrastructure, monitoring, and water security;
(3) stormwater and green infrastructure; and
(4) regional watershed and drinking water interactions.

Of the eight projects selected, three were related to navigation, two were energy related, two stormwater related, and one was related to drinking water. These eight candidate projects are listed below.

The two *energy related* projects that scored in the top eight were:

- Project No. 2: Treatability center to evaluate field-scale treatment systems for flowback and produced waters from Marcellus gas production sites; and

- Project No. 4: Develop a "Marcellus Shale Consortium" to focus on harmonizing regional gas development and multimedia environmental protection.

The three *navigation related* projects that scored in the top eight were:

- Project No. 5: Demonstrate value of infrastructure-sensing of bridges – Conduct field test to correlate sensor outputs with results of manual field inspections;
- Project No. 6: Development of broadband network to collect, compile and manage real-time monitoring data collected on and near the rivers of Pittsburgh; and
- Project No. 7: Develop non-destructive sampling techniques and/or sensors for river structures that will provide a cost-effective means for predicting failure.

The two *stormwater related* projects that scored in the top eight were:

- Project No. 9: Develop an information system for a targeted subarea of the region to develop an understanding of the green infrastructure for the proper management of assets; and
- Project No. 11: Target a watershed and conduct a demonstration to evaluate the effectiveness of alternative stormwater management options (i.e., rain barrels, permeable pavements, green roofs) on quantity and quality of stormwater runoff.

The *drinking water related* project that scored in the top eight was:

- Project No. 19: Conduct infrastructure assessment of a public drinking water distribution system to permit improved asset management and to minimize losses of product water.

The top two ranked projects are both navigation projects (Project Nos. 5 and 6). These projects are already moving forward, in part due to activities of the Water Innovation Consortia Planning Committee.

Business and economic development opportunity will be derived from the capacity to mobilize as a region and advance new, sustainable innovations for water management and protection. These innovations will have the potential to spark new business growth, attract research and infrastructure investments, and create a platform for the region to be a true global center---exporting solutions to a world that will increasingly need advances in water related technologies to ensure survival as we increase both population and urbanization under uncertain climate conditions.

The critical next steps for the Pittsburgh region must begin with an effort to create a capacity to mobilize and undertake projects that can demonstrate innovative and sustainable solutions to major water challenges. In moving forward, the region should focus on the development of a flagship or anchor center that can be a unifying focus for the overall effort to create a regional water technology initiative. Such a center could help integrate the targeted projects into a broader overall regional effort, as well as provide much-needed coordination among government, non-governmental organization, universities and business interests. As a region, Pittsburgh is globally recognized for its legacy of environmental action and its capacity to make effective economic transitions. Seizing the potential to be a leader in next generation water technologies affords a unique opportunity to build on these legacies.

I. Introduction

Water has been critical to economic development in Southwestern Pennsylvania, starting with transportation for trading and materials supply, followed by ship-building, glass manufacturing, and iron and steel production. The steel industry, launched in the last decades of the 1800s, was enabled by access to coal, iron ore, and limestone via water transportation, and by abundant water for cooling and metal manufacturing.

The industrial revolution and associated activities quickly expanded the population and economic power of the region, but with severe impacts on air and water quality. Over the past 50 years, with the growing interest in environmental quality and stewardship throughout the United States and in Southwestern Pennsylvania, the region has made great progress in restoring and improving its environmental quality, though difficult problems remain. Various reports have been generated regarding the changes in water quality in the region (see on-line presentation of this report for a timeline and short description of each of these prior reports).

The transition in the regional economy, coupled with the widespread awareness of the linkage of environmental quality and community well-being, has led to more emphasis on the importance of a healthy, natural water system and high functioning water infrastructure. Various communities, non-profit organizations, and companies across Southwestern Pennsylvania have developed missions and goals related to next-generation water infrastructure and water resource management. Many regions have similar interests and goals and have begun planning activities related to water (these are briefly described in the on-line full presentation of this report).

The Southwestern Pennsylvania region is uniquely positioned, through its assets, culture, and experience, to be a leader in various aspects of water infrastructure innovation. For example, the region has over 2,800 firms providing water components, services, and products that contribute over $4.4 billion in economic activity (Fourth Economy, 2010). Additionally, Southwestern Pennsylvania water supplies sustain an agricultural and food processing sector of over $3 billion, and a multitude of water-dependent ("wet") industries such as the $13.7 billion energy sector (Fourth Economy, 2010). The Port of Pittsburgh ships and receives approximately 41 million tons of cargo each year (USACE, 2011a), making it the second busiest inland port in the nation. In other sections of this report, we provide an overview of water infrastructure in Southwestern Pennsylvania and its development, with a look at historical examples of water infrastructure innovation.

The Southwestern Pennsylvania region has an abundance of water resources that provide economic and social benefits through their use for industrial, domestic, and recreational activities. The headwaters of the Ohio River basin are among the most reliable watersheds in the world. This water resource, *and its reliability*, has played a critical role in the development history of the region just as it sets the stage for the next regional transformation.

SWPA region encompassing the Allegheny and Monongahela watersheds

This study, led by the Water Innovation Consortia Planning Committee, was intended to focus on sustainable water-infrastructure-related, successfull projects in the Southwestern Pennsylvania region that can be leveraged to develop innovative solutions in the water sector. The focus was specifically on the capabilities, role and involvement of the non-profit sector, including universities, governmental agencies and non-governmental organizations. This work was conducted in parallel with the assessment of Southwestern Pennsylvania's Water Sector from a business perspective, which was released in January 2011 as Pittsburgh's H_2Opportunity: An Assessment of Southwestern Pennsylvania's Water Sector. (Fourth Economy, 2010)

This report compliments Pittsburgh's H_2Opportunity and proposes close coordination among the non-profit and for-profit sectors in development of the next steps to build water partnerships in the region.

Development of innovative water technologies, systems, and services that target regional water issues will improve the regional standard of living and act as an economic driver by stimulating investment and creation of new business activity and opportunities. Novel technologies and approaches developed for water management here can be exported to regions with similar needs. Further, clusters of organizations with complementary interests and capabilities in the region enable collaboration to develop solutions to water challenges around the globe.

Specific objectives in this planning study for a water innovative consortia were:

(1) to identify opportunities for innovative water projects in the Southwestern Pennsylvania region by considering regional needs and regional capacity to address these needs in novel ways;

(2) to identify potential collaborative partners in business, academia, non-governmental organizations (NGOs), and government who could come together to pursue the opportunities identified. The role of the consortia is envisioned as identification of opportunities and facilitation of their development through demonstration projects.

The consortia strategy is based on the assumption that a key to success lies in collaborating with regional water stakeholders to identify and prioritize opportunities with regards to regional assets, issues, capabilities, funding options, and best practices for implementing successful demonstration projects.

The committee began by identifying key personnel from federal and state agencies, non-governmental organizations, and academic institutions who have been associated with successful regional projects in the past, and who will be valuable assets in the design and deployment of future demonstration projects. Following a series of listening meetings (held in summer 2010) to gather past success stories and evaluate commonalities, the Committee held a round of topically focused workshops, targeted to areas that surfaced repeatedly in the listening meetings. Again, key members of the academic, non-profit, and government organizations were invited; members of the industrial and corporate sectors were also invited. These workshops (held in January 2011), focused on uncovering opportunities within the following four topical areas:

1. Energy development and water management;
2. Navigation infrastructure, monitoring and water security;
3. Stormwater and green infrastructure; and
4. Regional watershed and drinking water interactions.

The objective of these meetings was to identify the best opportunities for demonstration projects to develop and implement sustainable technologies in water systems. A further goal was to assess and form linkages among different sectors through the identification of future demonstration projects, thus creating a model that will be accessible for participants from every sector and at all levels (region, watershed, county, etc.). This goal was further validated during the first round of stakeholder meetings when collaboration was identified as a key to the success of past demonstration projects. Summaries of all meetings that were conducted by the committee can be found at: www.pittsburghwed.com

In addition to engagement with regional water organizations and leaders, the committee also examined water innovation initiatives in other regions of the United States and prepared a summary of these initiatives. This summary provides ideas for the region to consider in consortia development, as well as facilitates assessment of the uniqueness of the potential opportunities identified for the region (summary can be found at the expanded on-line version of this report.)

The following sections of this report describe the process of engagement with water related organizations from across the region, describe potential projects that emerged from the workshops with regional water organizations; and describe the next steps in moving the top eight candidate projects to implementation. (The on-line version of this report also includes key findings regarding innovative water projects that have been performed in the region and their characteristics).

The findings of this study provide the basis for establishment of consortia of water-related organizations in the Southwestern Pennsylvania region to pursue opportunities for critical and innovative water solutions. Demonstration projects conducted within the collaborative consortia will help expand water innovation as a key contributor to utilizing our water resources for economic growth and community well-being.

II. Southwestern Pennsylvania Success Stories in Water Innovation

Information Collection

A series of individual and group meetings with different regional stakeholders were held with the goal of identifying successful innovative/sustainable projects in Southwestern Pennsylvania and gathering information about each of them to answer the following questions:

- What were the primary technical characteristics of each project that made them successful?
- How were the projects organized and funded?
- How was success measured?
- What lessons learned are transferable and potentially useful as screening criteria for including future projects in a Southwestern Pennsylvania water consortia initiatives?

Three stakeholder groups were targeted as part of this exercise: (1) universities, (2) nongovernmental organizations, and (3) industry and government agencies.

The expanded on-line presentation of this report includes:

- detailed summaries of these meetings
- detailed descriptions of some of the specific projects that were identified and discussed as part of those meetings
- additional perspectives on these regional projects
- an overview of some of the more prominent sustainable water demonstration projects in other regions of the United States

In addition, a number of related reports were reviewed as well as information gleaned from participation in regional forums and conferences on related water issues. Also, one-on-one discussions were conducted with representatives of leaders amongst the regions water industry.

Characteristics of a Successful Project

Several successful projects were identified during the stakeholder meetings and/or discussions. These projects, a few of which are described in detail in the expanded on-line version of this report, covered a range of technical topics, including the treatment of acid mine drainage using innovative treatment and material recovery technologies, ecological rehabilitation of a flood plain, stream restoration using a combination of innovative tools and techniques, and management of stormwater quantity and quality in an urban watershed.

AMD remediation ponds

An overview of these projects in relation to the previously identified questions is provided below.

Technical Characteristics

Some form of innovative technology was utilized in each of the identified projects. The term "innovative" is used here to indicate that the technology, system, or approach is emergent and is not yet widely deployed. An example of a common technical theme was the application of passive treatment technologies, which take advantage of natural systems for flow and/or contaminant management. These passive treatment strategies often included innovative components such as material recovery or the reuse of existing wastes as part of the treatment process. Specific examples of these passive technology applications include:

- Oxidation ponds for precipitation and recovery of iron oxide from AMD followed by constructed wetlands for removal of residual iron oxide and final polishing of the water prior to surface water discharge (Lowber and Wingfield Pines Projects);

- Passive wetlands for municipal wastewater treatment followed by the use of highly alkaline bauxite waste from aluminum production facilities for final disinfection (Alcoa Corporation);
- Vacant lot redevelopment using urban gardening techniques for the reduction of stormwater runoff (Wilkinsburg); and
- The use of green roofs, rain barrels, permeable pavement, and rain gardens with the intent of reducing the quantity, or improving the quality, of stormwater runoff to the sewers (Multiple locations).

These passive strategies were selected for a number of reasons including their generally low capital and operating cost and the ability to incorporate them into the existing landscape. The innovative add-ons to these approaches originated from small niche companies (e.g., Iron Oxide Recovery, Inc.) or larger companies (e.g., Alcoa Corporation) which had developed them for internal use and were now looking for external applications as a means to recoup a portion of their investment costs.

Project Organization and Funding

Not surprisingly, no single organizational structure or funding mechanism was associated with the successful projects. However, generic organizational elements could be identified that were both necessary and sufficient for a successful project. For example, most of the projects were organized at the watershed level and championed by a watershed association, or other organization, that had the interest, capability, and resources to take a broad, integrated view of the problem, engage multidisciplinary stakeholders, and design and implement innovative solutions that served all of the major stakeholders.

Each project also had a technical leader that brought unique expertise to the problem. This leader took several different forms, ranging from academics with relevant research expertise to commercial or government entities with specific technical knowledge related to a problem of interest and a commercial interest in seeing it applied. The latter factor also played an important role in securing the funding for the project, as there was an economic incentive or financial return that could be envisioned and, in some cases, quantified. On the other hand, the participation of a university, while not as directly linked to sources of funding, did provide project stakeholders with a level of confidence that "good science" was being applied to the project. This university involvement frequently was identified as a factor in securing the funding for the project.

Lastly, each project typically had interested third party participants that most often included local and state regulators such as the City of Pittsburgh (Departments of Planning or Public Works) or the Pennsylvania Department of Environmental Protection as well as non-governmental organizations such as the Green Infrastructure Network. Potential funding sources also accompanied these project participants.

Measures of Success

The successful projects had quantifiable metrics that were established as a basis for measuring their performance. These metrics ranged from very specific targets, such as the achievement of a NPDES permit discharge limit or an improvement in water quality, to broader improvements of ecosystem characteristics such as diversification of a habitat or restoration of a stream to a self-sustaining condition (i.e., requiring no human intervention). More specific metrics for success lead to more specific monitoring programs, which in turn generated the data that were necessary to properly evaluate the success of the program. To that end, it was noted during several of the meetings that the lack of ability to secure funding for green infrastructure projects, such as rain barrels or green roofs, was due to the inability to measure the success of the effort and hence, quantitatively determine a rate of return (ROR) on the investment. Without an ROR, most investors are not willing to commit the funds for investigating a new, innovative technology.

Critical Project Attributes

Several critical project attributes were identified upon examination of successful projects in Southwestern Pennsylvania. These attributes are transferable to other projects and can be used as initial screening criteria for identifying potential projects as part of regional water innovation consortia. The most salient attributes that were identified are:

- **Innovative Technology -** Successful projects involved the development or deployment of innovative approaches or technical solutions. The innovation often provides the impetus for funding or is necessitated by the challenge of completion of the project using more routine methods.

- **Identifiable Project Champion -** Every proposed project needs a champion who will serve as its advocate and push it to completion. The champion must be vested in the outcome of the project but not to the extent that it interferes with the interpretation of the project results. Ideally, the best champions

for a project will represent a broad spectrum of the stakeholders and have the ability to effectively communicate the project results.

- **Region-Centric with Exportable Characteristics** - The proposed projects should be both region-centric, i.e., produce results that will be of value to the regional stakeholders of the water consortia, as well as exportable to other regions of the United States or around the globe. For example, managing high salinity brines from shale gas production may yield innovative technologies for desalinization initiatives. This exportable characteristic will enhance the economic development of the region by expanding the market for technologies and services beyond the local or regional markets.

- **Action Oriented** - The goal of the proposed project should be "implementation" and not "recommendations". In too many instances, the results of a study generate little new data; rather, the study results in a list of recommendations for future work. This is not very satisfying to most investors or third-party project participants. Consortia projects should be action oriented, generating data that can be evaluated and interpreted to yield a meaningful assessment of the value of the work.

- **Collaborative Solutions** - The proposed projects should not be focused only on technologies; rather, they should embrace the concepts of collaborative solutions that go beyond technology developments and include elements of education, technology transfer, and public engagement. Technical successes lacking support of the local, state and federal regulators and the public-at-large will not be implemented nor flourish within the region and will not be a major factor in achieving the goals of the water consortia.

- **University and Vendor Participation** - Participation of universities in the proposed project is an important feature. It ensures the application of good science to the project and an objective technical evaluation of the project results. At the same time, it is also important to have substantial technical input from the vendors of a technology or technique and/or potential users of the study results. This ensures that real problems are being addressed, recognizing the challenges associated with the scale-up and field-scale implementation of any innovative, sustainable water project.

The above project attributes provide a baseline of project characteristics that will be considered during the development of water consortia for Southwestern Pennsylvania. This baseline will be modified and expanded, as necessary, to accommodate site-specific factors that reflect the unique characteristics of the region and its stakeholders.

III. Southwestern Pennsylvania Future Directions in Innovation and Water Sustainability

Topical workshops were convened in January 2011 that focused on specific regional, water related problems. A cross section of representatives from all of the primary stakeholder groups (i.e., universities, non-governmental organizations, government agencies and local industry) participated in these workshops with the intent of coalescing ideas around identified problem areas and defining candidate projects for consideration by water consortia. The broad topics addressed by these workshops were:

- Energy Development and Water Management;
- Navigation Infrastructure, Monitoring, and Water Security
- Stormwater and Green Infrastructure; and
- Regional Watershed and Drinking Water Interactions.

A list of the stakeholder meeting/topical workshop invitees, the meeting/workshop participants, and a summary of the workshop discussions is provided in the expanded on-line version of this report. The remainder of this section highlights the candidate projects that were identified during the workshops and then evaluates them against the project attributes that were identified in this report based on a review of the past successful projects in the region. Those projects that best demonstrated these attributes are highlighted for further development as one of the initial "hub" projects of a Southwestern Pennsylvania water innovation consortia.

Identification of Candidate Projects for Water Consortia

Energy Development and Water Management

Energy development has always been a primary economic driver in Pennsylvania, including extraction

of oil, natural gas and coal. The most recent of these developments has been the extraction of gas from the Marcellus Shale Formation, which underlies a large portion of Pennsylvania. The nexus of energy development and water management in the region continues to present challenges and represents an area where innovation is required.

The topical workshop reflected this regional need and resulted in the identification of a total of four overarching energy-water projects for consideration as part of regional water innovation consortia:

- The development of alternative water supplies for energy technologies with a focus on the reuse of acid mine drainage (AMD) as fracturing makeup water for Marcellus Shale gas development. One of the critical requirements to implement this reuse strategy, which would address two major water issues within the region, is providing water to the shale gas developers that has sulfate concentrations of less than100 parts-per-million (ppm).

Water Impoundment for hydraulic fracturing operation. Photo Courtesy Range Resources.

- The development of a regional database for energy-related water discharges (quantity and quality) and water requirements (quantity and quality) tied to a GIS mapping system to improve regional water decision-making by facilitating water recycling and reuse on a regional basis. Water reuse and recycling at this scale is patterned after the water recycling demonstration projects that are currently employed in the water-scarce regions of the United States. A sustainable, water recycling project of this magnitude is being demonstrated in California as described in the expanded on-line version of this report.
- Development of a shale gas-water technical center to conduct technical evaluations and certify field-scale treatment systems for flow-back and produced waters from Marcellus Shale gas production sites to improve options for disposal and/or recycle/reuse of treated water. This technical center would use a common set of assessment protocols and provide data to evaluate the ability of a given technology to meet discharge limits or recycle requirements. This common approach to analysis would permit a comparison of various treatment alternatives. This technical center would focus on problem contaminants such as total dissolved solids (TDS), strontium, barium, and naturally occurring radionuclides as well as treatment of new pollutants that are identified as critical to comply with either regulatory or process constraints.
- Development of a "Marcellus Shale Consortium" similar to the regional "Stripper Well Consortium" to focus on harmonizing regional gas development and multi-media environmental protection. The shale gas-water technical center identified above could be an integral part of this consortium. The concentration of the projects on shale gas is appropriate at this time but should not overshadow the fact that there are still substantial challenges associated with the management of legacy mine drainage, as well as other ongoing and potential water impacts from energy exploration and development, and fossil fuel utilization for electricity production in the region. For this reason, it may be more appropriate to bundle these projects under a more generic energy-water technical center that focuses on the energy-water nexus, as a whole, rather than only those water management issues directly associated with shale gas development.

Navigation Infrastructure, Monitoring and Water Security

This workshop highlighted ongoing efforts by the Port of Pittsburgh Commission and the US Army Corps of Engineers (USACE) to establish a risk framework and real-time monitoring network for the regional waterways. The risk framework will provide the basis for allocating limited resources to the aging river infrastructure (e.g., bridges, dams, locks, water intakes and discharges), while the broadband monitoring network will provide a capability to compile and analyze data that are required to evaluate the risk elements associated with aging

Innovative Inland Navigation Systems

The Port of Pittsburgh Commission, the U.S. Coast Guard, the U.S. Army Corps of Engineers, and their customers, partners and contractors together represent unique regional capability for inland navigation. The Port of Pittsburgh is the second busiest inland port in the U.S., with approximately 41 million tons of cargo shipped and received each year. Coal is the primary commodity transported on the rivers, but large amounts of sand, gravel, and iron ore are also moved on the rivers.

The U.S. Army Corps of Engineers, Pittsburgh District is responsible for the system of 23 navigational locks and dams on the Allegheny, Monongahela and Ohio Rivers. The system is old and in need of upgrade and replacement. There has been some upgrading and replacement of components of the system over the years, and a lot of maintenance and repair. As a result, there is regional expertise and experience with inland navigation infrastructure renovation. The regional experience in this regard has included some very innovative, large-scale projects, including the in-the-wet navigation dam replacement at Braddock by the U.S. Army Corps of Engineers.

The Port of Pittsburgh Commission is undertaking a project to improve communication and the efficiency of navigation on the major rivers of the region. The planned River Net system will involve a broadband-based, wireless communication network along the rivers. This project is in its initial stages. The project concept was developed in part through collaboration with Carnegie Mellon University. The Port of Pittsburgh Commission is interested in partnering with other groups for wider use of the wireless communication network that they are installing, and to help share the costs of implementing it and maintaining it. The planned wireless broadband network along the rivers offers the opportunity for innovative use of technology for monitoring, management, and operation of water infrastructure. For example, water quality monitoring devices could be installed along the river with the data transmitted through the wireless network, potentially reducing the costs of water quality monitoring.

Another project being considered by the Port of Pittsburgh Commission is the development of a Smart Lock system, a sensor-based interface designed to provide lock-approach information to tow-boat pilots in close-to-real time. This will allow pilots to approach locks in a safe and consistent manner. This project concept was also be developed in part through collaboration with Carnegie Mellon University .

Allegheny Lock 6. US Army Corps of Engineers

infrastructure, environmental impacts, and variable water supply and quality.

A particularly unique, sustainable feature associated with this effort was also introduced at the workshop. This feature involved the development of a "River Information Services" by the USACE to harmonize the data that are collected from the monitoring networks. In doing so, this service could be offered to users along the river who desire real-time data but who can not afford to develop the broadband support network that is necessary to compile, process, and interpret them. Fees for this service would be used to maintain and expand the network over time.

A total of four candidate projects for the water consortia were identified during this workshop, beginning with a high level project focused on the development of an end-state vision for the river system. This vision statement would describe the continued development and use of

the river system, ensuring that all of the stakeholders are properly aligned and providing a common basis for guiding the development and management of the maintenance decisions that are made on the rivers. The other three projects were focused on the implementation aspects of the broadband monitoring network and the real-time collection of infrastructure and environmental data using advanced sensors and robots. Finally, it was envisioned that the broadband network could be the basis for a Live Net public awareness tool, which could provide general public access to river-related information.

In addition to this overarching end-state vision statement for the river system, three other projects were identified for consideration as part of this topical area:

- Conduct a demonstration project to establish the value and accuracy of the infrastructure sensing of bridges.

  Barge collisions with bridges represent a significant cost to the region. When a barge collides with a bridge structure, the bridge has to be shut down until an inspection can be completed; shut downs can last hours to days. This is a significant problem for the local public and commercial businesses in the region, resulting in poor public relations and an interruption of services and increased costs. However, history tells us that rarely, if at all, do these collisions result in actionable structural damage to the bridge. With sensors, it is possible that this post-impact "inspection" could be conducted in 30 minutes or less following the incident. This project would install sensors on a subset of bridges and then compare the sensor results to inspection results following a specific incident. A dataset of this nature could be used to examine whether a correlation exists between the sensor data and actual data and observations from the standard inspections. A good correlation would suggest that the sensors are capable of cost-effectively assessing injury to the bridge structure while still being protective of public safety.

- Develop non-destructive sampling techniques or sensors for river structures that will provide a means to improve predictions of steel and concrete failure.

  The USACE would like to improve its ability to manage its assets along the river systems. To do this, it would be advantageous in they had rapid, cost-effective methods for testing the structures without having to resort to standardized tests that require extraction of a sample followed by destructive testing in a laboratory. The sensor data, which would be available on a real-time basis, would provide the USACE with a cost-effective, technical basis for making replacement/repair and maintenance decisions; and

- Expand the broadband "Test-bed Demonstration" that is being planned by the Port of Pittsburgh Commission and the USACE.

  The "Test-bed Demonstration" is focused on the development of a broadband network capable of cost-effectively managing the USACE river data, such as barge/location and traffic and water flow. This project could be expanded by extending the basic computer network to other users, who could collect data of interest to them and use the network, on a for-fee basis, to compile and process the data. Several workshop participants shared the concern that the analysis and interpretation of the real-time data was the major problem facing the use of advanced sensors. Stated differently, the data could be collected at rate faster than it could be analyzed and interpreted. The broadband network discussed here would address that major concern.It is envisioned that the other data of interest would include environmental data (air and water quality) and river security data that are needed by various public and private sector entities. This project has the added feature of sustainability as the broadband developer could charge a fee for the use of the network.

In general, this topical area is driven by the fact that the "loss of the river pool" represents a significant economic risk to the region. This loss would result in economic losses associated with the loss of navigation, public issues associated with the loss of drinking water intakes, and environmental issues associated with the inability to properly discharge industrial and municipal wastewaters and stormwater. The USACE expressed its concern that this risk was not fully understood by the region and would need to be emphasized as part of the pursuit of any of the above projects. Furthermore, the candidate projects, while focused less on water innovation, do emphasize harnessing the information technology prowess of the region for the benefit of improving the use and management of the water resources of the region. In this regard, these projects reflect some of the characteristics of the sustainable CSOnet project in South Bend, Indiana, as described in the expanded on-line version of this report.

Stormwater and Green Infrastructure

A wide variety of projects were discussed as part of the stormwater and green infrastructure workshop. Generally speaking, they contain many of the elements of the green infrastructure initiative implemented by the City of Philadelphia, as described in the expanded on-line version of this report.

Green Roof installed at Carnegie Mellon University.
(Photo Credit: Dave Dzombak)

The candidate projects focus on documenting the effectiveness of the current suite of green infrastructure approaches for stormwater management, using innovative passive treatment technologies for management of failing septic systems or stormwater polishing, daylighting of urban streams, and development of an improved understanding of stormwater assets, as a basis for better asset management. The specific projects that were highlighted for consideration as part of the water consortia include the following:

- Apply software/sensing instrumentation to evaluate CSOs/SSOs: Municipalities are faced with an aging infrastructure that is making it difficult for them to properly manage their sewer systems to control overflows during wet weather. Shrinking budgets make it even more difficult for the effective management of these critical assets. This project would use advanced robotic systems to map a CSO/SSO infrastructure in a targeted subarea of a municipal system. The data from this mapping effort would be evaluated for use as an asset management tool;

- Demonstrate use of passive wetlands technology as a means to control stormwater and other non-point sources of water discharge (e.g., failing septic systems): Alcoa, Inc. has developed passive treatment technologies that can be tailored for use on different nonpoint source discharges of water, including stormwater runoff. A project to demonstrate the use of this technology in a municipal setting for the control of stormwater runoff was proposed.

- Assess effectiveness of green infrastructure strategies for stormwater management: This project would target a single watershed and demonstrate the effect of a multi-pronged effort to manage stormwater using rain barrels, permeable paving, green roofs, etc. Baseline stormwater runoff conditions would be documented to establish a baseline and innovative monitoring techniques would be used to demonstrate the improvements on stormwater flow and quality that accompanied the application of these evolving green infrastructure approaches to stormwater management.

- Development of regional green infrastructure database: A green infrastructure database would be developed to: (1) facilitate identification of green infrastructure vendors for residential and commercial applications; (2) map installation of green infrastructure systems in the region; and (3) provide assistance in evaluating the impacts of green infrastructure on both stormwater flow and quality.

Combined sewer discharge structure located in Pine Creek, Pa.

- Low-head hydro demonstration project: This project would demonstrate the ability to use water resources to generate power for a local community using low-head hydro technology.

- Urban stream day-lighting project: Projects similar to Nine-Mile Run were suggested to further demonstrate the environmental, economic, and social benefits associated with bringing subsurface urban streams to the surface and integrating them into the urban landscape.

Several of the above projects were driven by an underlying contention that the inability to calculate a return on investment for a green infrastructure projects was inhibiting their use, especially at the municipal level. Hence, there was a desire to generate data that could be used to calculate the cost-benefit of applying the various green infrastructure technologies. To implement these projects will require creative project designs as well as innovative monitoring and data interpretation techniques, which in and of itself represents a valuable, as well as exportable, contribution to moving the application of these technologies forward.

Regional Watershed and Drinking Water Interactions

This topical workshop identified several candidate projects that emphasized asset management and life cycle analyses, development of a source water database, real-time monitoring of baseline water quality and the expansion of the existing regional water quality monitoring program to include additional organic contaminants. A brief description of each of these projects is provided below.

- Development of the next level of real-time (in-plant or in-distribution) drinking water monitoring techniques: Improved real-time monitoring techniques such as innovative bioassays, including in-line sentinel fish systems, are needed to provide the more sensitive measurements of water quality that are needed for increased water security as well as improved process control for drinking water treatment.

- Development of a regional source water characterization database (pH, conductivity, dissolved oxygen, and dissolved gases): This project would construct a regional source water database by integrating existing databases and installing sensor networks in surface waters or distribution lines to address current data gaps. Close interaction with the United States Geological Survey (USGS) is required for the proper placement of all surface water monitors.

Experimental pipe loop system for evaluation of real times chlorine sensors. Dr. Damian Helbling is adjusting the sensor calibration. *(Photo Courtesy Carnegie Mellon University)*

- Expand collection and analysis of organic contaminants in the source water of the region: This project would expand the current efforts of the Ohio River Valley Water Sanitation Commission (ORSANCO) by adding gas chromatography-mass spectroscopy (GC/MS) analyses of organic contaminants to their existing four monitoring stations in Southwestern Pennsylvania. These organic contaminant data would be mined to determine the existence of key correlations such as the presence of organic contaminants and the presence of disinfection by-products in drinking water.

- Conduct life cycle analysis of water usage at large regional industrial facilities: This project would focus on local industrial facilities or sites where there is a potential for significant water discharges to source waters of the region, one example being the Pittsburgh Airport. The project would complete a water balance and identify potential recycle and reuse options to minimize impacts to local source waters.

- Conduct infrastructure assessment of public drinking water distribution systems: Asset management is also important to drinking water processing plants and distribution systems. However, as with other systems in the overall water cycle, there is currently insufficient data to permit a methodical, quantitative assessment of these assets. This project would use advanced robotic and sensing techniques such as ultrasonic and acoustic dopplers, to document and measure flows and losses of water (currently estimated to be near 25%) at a primary drinking water plant and throughout its distribution system. The data would then be used to develop an optimal asset management plan for the drinking water system.

Initial Screening of Candidate Water Consortium Projects

Table 1 presents a summary of the 19 candidate projects that were identified during the topical workshops for consideration as part of an initial hub of projects for the water consortia. These projects were identified and briefly reviewed in the previous section. To determine which of these projects provided the best foundation

Table 1. Assessment of Candidate Projects for Inclusion in SW PA Water Innovation Consortia

Energy Development and Water Management	
Project No. 1	Alternative water supplies for energy technologies, i.e., Reuse of AMD as hydrofracturing water for Marcellus Shale gas exploration.
Project No. 2	Treatability center to evaluate field-scale treatment systems for flow-back and produced waters from Marcellus gas production sites.
Project No. 3	Development of regional database of energy-related sources and sinks (quantity and quality) tied to GIS mapping system to facilitate water recycling and reuse on a watershed/regional basis.
Project No. 4	Develop "Marcellus Shale Consortium" to focus on harmonizing regional gas development and multimedia environmental protection.
Navigation Infrastructure, Monitoring and Water Security	
Project No. 5	Demonstrate value of infrastructure-sensing of bridges – Conduct field test to correlate sensor outputs with results of manual field inspections.
Project No. 6	Development of broadband network to collect, compile and manage real-time monitoring data collected on and near the rivers of Pittsburgh.
Project No. 7	Develop non-destructive sampling techniques and/or sensors for river structures that will provide a cost-effective means for predicting failure (e.g., concrete or steel failure).
Project No. 8	Develop end state vision for river system to guide development, management and maintenance decisions. Tie to risk analysis for purposes of prioritizing allocation of limited capital and maintenance budgets.
Stormwater and Green Infrastructure	
Project No. 9	Develop information system for targeted subarea of a region to develop an understanding of the green infrastructure for the proper management of assets.
Project No. 10	Demonstrate use of Alcoa passive treatment wetlands technology as a means for controlling failing septic systems in rural communities.
Project No. 11	Target a watershed and conduct demonstration to evaluate the effectiveness of alternative stormwater management options, i.e., rain barrels, permeable pavings, green roofs, etc., on impacts (volume and quality) to stormwater runoff.
Project No. 12	Develop green infrastructure database to facilitate identification of vendors for residential and commercial applications, map green infrastructure installations, and assist in evaluating effectiveness of green infrastructure strategies.
Project No. 13	Demonstrate value and effectiveness of low head hydro with local community.
Project No. 14	Perform project similar to Nine-Mile run for daylighting of other urban streams in Pittsburgh [Panther Hollow, Sheridan Run, and Burn Hollow].
Regional Watershed and Drinking Water Interactions	
Project No. 15	Demonstrate use of next level of real-time monitoring (in-plant or in-distribution) using innovative bioassays/ techniques.
Project No. 16	Develop source water database by integrating existing databases and installing sensor networks in surface water or distribution lines to gather the missing data.
Project No. 17	Expand collection of organic data by ORSANCO in SW PA and mine these data to define/predict presence of disinfection by-products and provide additional data regarding breakdown of organic carbon.
Project No. 18	Conduct life cycle analysis of water usage at Pittsburgh airport recognizing these facilities represent significant impacts to local source waters.
Project No. 19	Conduct infrastructure assessment of public drinking water distribution systems to permit improved asset management and minimize losses of product water.

upon which to build the water consortia, they were evaluated against the project attributes identified below:

- Use of innovative technologies;
- Identifiable project champion;
- Region-centric with marketable and exportable characteristics;
- Action-oriented;
- Collaborative approaches that transcend technology developments by including a project component involving education, technology transfer and/or public engagement; and
- Involvement of a regional university in addition to commercial vendors.

The evaluation of the 19 candidate projects in Table 1 was performed using a simple linear scale ranging from 0 to 5, where a 0 indicated the lack of a specific characteristic and a 5 indicated the strong presence of the characteristic. The general ranking of the projects was then based on the summation of these numerical scores across the six project attributes, yielding a maximum score of 30 and a minimum score of 0. The evaluation was performed by three individuals of the Water Consortia Planning Committee who had participated in all of the technical workshops, Drs. Dzombak, VanBriesen and Nakles. Their individual scores were summed to yield a total score for each project, which could range from 0 to 90. The total scores for each of the projects, listed in order from the highest to the lowest score, are presented in **Table 2**.

Based on this evaluation rubric, the candidate projects from **Table 1** that had scores of 60 or greater were identified as the primary candidates for further consideration as potential hub projects for the water consortia. As shown in **Table 2**, this list of priority projects includes a total of eight individual projects, including three navigation projects, two energy projects, two stormwater projects and one drinking water project. These eight projects are listed below, by category:

- Project No. 4: Develop "Marcellus Shale Consortium" to focus on harmonizing regional gas development and multimedia environmental protection.

Candidate Navigation Projects

The three navigation projects that were assigned a high priority are:

- Project No. 5: Demonstrate value of infrastructure-sensing of bridges – Conduct field test to correlate sensor outputs with results of manual field inspections;
- Project No. 6: Development of broadband network to collect, compile and manage real-time monitoring data collected on and near the rivers of Pittsburgh; and
- Project No. 7: Develop non-destructive sampling techniques and/or sensors for river structures that will provide a cost-effective means for predicting failure (e.g., concrete or steel failure).

Candidate Stormwater Projects

The two stormwater related projects that were assigned a high priority are:

- Project No. 9: Develop information system for targeted subarea of a region to develop an understanding of the green infrastructure for the proper management of assets; and

Water Quality Sensor Panel at two River Alert Information (RAIN) Sites. On left, Jess Wilson, graduate student at Carnegie Mellon University, reads the sensor values. *(Photo Credit: Sandra Karcher.) (www.3rain.org)*

Candidate Energy Projects

The two energy projects that were assigned a high priority are:

- Project No. 2: Treatability center to evaluate field-scale treatment systems for flowback and produced waters from Marcellus gas production sites; and
- Project No. 11: Target a watershed and conduct demonstration to evaluate the effectiveness of alternative stormwater management options, i.e., rain barrels, permeable pavings, green roofs, etc., on impacts (volume and quality) to stormwater runoff.

Candidate Drinking Water Project

Within the past few decades, drinking water innovation has focused on more complex challenges including:

- Improved removal of trace organics, including personal care products and pharmaceutical residuals;
- Improved removal of pathogens and chemical contaminants, while reducing the formation of organic by-products of disinfection;
- Improved removal of pesticide and herbicide residuals;
- Increased attention to changes in water quality as it moves from the plant through the distribution system;
- Increased attention to water security; and
- Increased attention to managing source water to reduce cost of treatment.

In each of these areas, traditional treatment methods were insufficient and innovative methods and equipment were, by necessity, developed.

Pittsburgh Water and Sewer Authority Pilot Plant Test Unit. *(Photo Credit: Sandra Karcher.)*

Pittsburgh has been an innovator in several of these areas, including helping to develop and participating in river water quality alert networks for source water protection; adding one of the largest microfiltration treatment plants in the nation within its distribution system to provide additional safety after the open reservoir in Highland Park and development of rapid analytical techniques for improved water safety and security. Pittsburgh Water and Sewer Authority operates one of the largest on-site permanent pilot treatment facility to test new treatment methods and protocols prior to implementation at full scale.

The drinking water related project that was assigned a high priority is:

- Project No. 19: Conduct infrastructure assessment of public drinking water distribution systems to permit improved asset management and minimize losses of product water.

The top two ranked projects are both navigation projects (Project Nos. 5 and 6). These projects are already moving forward, in part due to the topical workshops and other activities of the Water Consortia Planning Committee. The USACE has already awarded a project for the sensing of levees and dams and the Port of Pittsburgh Commission is very near releasing a Request for Qualifications (RFQ) for the development of a wireless waterways interoperability test bed. The former project will investigate the changes that need to be made to the instrumentation infrastructure that the USACE has in place on their dams and levees with the goal of making the current monitoring operations more efficient and to facilitate the management of these liabilities and integration of future, advanced technologies. The key questions that will be answered are: (1) What types of failure modes are expected on critical dams and levees?; (2) What monitoring and data capturing technologies are well suited for each of these infrastructures?; and (3) How can the USACE automatically and remotely integrate different automated data capturing technologies?

The wireless waterways interoperability test bed project includes three locks and dams and a USACE operational facility, Pittsburgh Engineer Warehouse and Repair Station (PEWARS) on Neville Island, all of which will be linked back to the Port Commission's Offices located in the Regional Enterprise Tower (RET) in the City of Pittsburgh. Funding to initiate the development of the wireless waterway test bed is coming from a Port Security Grant and the RFQ is reaching out to the private sector for moving beyond this initial phase of development. Ultimately, it is envisioned that the broadband network could be made available on a fee-for-service basis to other organizations who wish to use it for managing other types of water-related data. This would yield a sustainable broadband network that could service all users of the Pittsburgh waterways, increasing the economic productivity of the rivers, improving river safety, increasing public awareness, and improving the monitoring of the river flow and quality as well as the river infrastructure.

The third high priority navigation project (Project No. 7), as well as the high priority stormwater (Project No. 9 and Project No. 11) and drinking water (Project No. 19) projects are all focused on asset management of one form or another. The navigation project is focused on

using innovative sampling techniques and sensors for predicting structural failures as a means of prioritizing the allocation of a limited capital budget and the stormwater and drinking water projects emphasize infrastructure assessments (e.g., sewer and drinking water distribution systems) and/or systematic assessments of green infrastructure performance (e.g., green roofs, rain gardens, etc.) for the purposes of quantifying a return on investment and maximizing the impact of these investments for stormwater management.

Finally, the highest priority energy projects (Project No. 2 and Project No. 4) are both focused on Marcellus Shale gas production. These projects emphasize harmonizing regional gas development and multimedia environmental protection, with an emphasis on the treatment of the flowback and produced waters.

These priority projects will be further vetted with representatives of all of the key stakeholder groups to finalize their selection as a hub project for regional water consortia. At that time, the alignment of the candidate projects with the regional expertise, resources, and assets will be evaluated along with the potential for both economic and environmental benefits. This evaluation will serve as a basis for down-selecting individual projects for detailed development, which will include finalizing project participants, scopes of work and budgets, and pursuing project funding from interested parties.

IV. Next Step for the Sustainable Water Innovation Initiative in Southwestern Pennsylvania

This analysis has confirmed that the Greater Pittsburgh region is home to a broad range of water related capabilities—including a strong university research base and vibrant companies across a range of product and service areas. The work has also reaffirmed that the capacity to generate innovative water solutions will be central to our future economic competitiveness and the ability to maintain a high quality of life that includes safe drinking water, the effective flow of commerce, and enjoyment of the waters for recreational purposes.

Several other regions across the US and the world are undertaking analyses similar to this work as they seek to explore the potential to become a major business hub for a water technology industry that is expected to grow significantly over the next decade. From Cincinnati to Milwaukee to cities in Europe, Asia and the Middle East, initiatives to seize the opportunity to become water innovation centers have been launched. The opportunities for the Greater Pittsburgh region to become a water innovation hub are defined by the water challenges it must overcome in the next decade. These challenges include addressing major stormwater overflow and capacity issues in cost effective ways, maintaining water accessibility and quality in an aging infrastructure system, creating the capacity to make water systems "smart" so as to address maintenance, operation, and investment challenges more effectively, and ensuring safe drinking and watershed protection while meeting the critical need to tap new sources of energy.

It is this mix of critical challenges that creates the opportunity for leadership in water technologies and industry for the region. Business and economic development opportunity will be derived from the capacity to mobilize as a region and advance new, sustainable innovations for water management and protection. These innovations will have the potential to spark new business growth, attract research and infrastructure investments, and create a platform for the region to be a true global center---exporting solutions to a world that will increasingly need advances in water related technologies to ensure survival as we increase both population and urbanization under uncertain climate conditions.

Building Consortia with a Demonstration Project Focus

The critical next steps for the Greater Pittsburgh region must begin with an effort to create a capacity to mobilize and undertake projects that can demonstrate innovative and sustainable solutions to major water challenges. The careful development of a targeted set of demonstration projects can provide a basis for attracting investment to address critical regional water challenges while effectively incubating growth in the research and industry base that will be key to making the region a global water center.

The development of an organizational structure that brings together industry, universities, the public sector, and environmental organizations should incorporate the following characteristics:

- The consortia effort should draw upon a coalition of organizations focused on bringing their core competencies to bear in a regional effort—much as

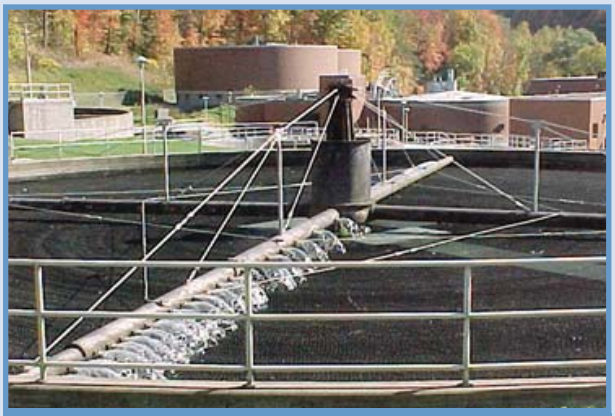
the Energy Alliance has sought to create a network focused on advancing the region's potential as an energy industry center. As with the Energy Alliance, an existing or set of organizations could provide an organizational home for the consortia effort— acting as a facilitator and engaging partners to advance targeted projects and strategies.

- The design of an organizational approach for the consortia must also advance stronger linkages and interaction among industry and university researchers. The capacity to more dynamically link research funding with new product and service developments within the region's water industry will be vital to enabling the projects to be a catalyst for significant industry growth. The capacity to blend participation by existing industry with new business creation will be vital to generating a more vibrant regional base.

- The demonstration projects selected must reflect the core water challenges the region faces. These include new approaches to improve the efficiency of the water transportation infrastructure, projects to address the critical water challenges associated with energy production and projects to advance next generation safe drinking water and wastewater infrastructure.

Recent innovations in wastewater treatment include:

- Use of membrane-based systems for general removal of dissolved substances or specific contaminant removal;
- Development of technologies for nutrient removal (nitrification, denitrification, phosphorus removal);
- Advanced oxidation techniques to remove trace organic pollutants, and as an alternative to chlorine for wastewater disinfection; and
- Anaerobic treatment systems with energy recovery. A number of wastewater treatment facilities in Southwestern Pennsylvania have been leaders in adopting innovative technologies and treatment approaches. For example, the Franklin Township Municipal Sanitary Authority in Murrysville, PA, implemented nitrification treatment to remove ammonia, ultraviolet light for disinfection, and generation of heat and electricity onsite using methane recovered from anaerobic treatment as part of its plant expansion in the 1990s. More recently, they have deployed a new odor control technology, as their plant is surrounded by a residential neighborhood. Other plants have implemented innovative trickling filter operations to achieve nitrification even in winter temperatures, have transitioned from activated sludge to other processes to enable better control when flows are highly variable due to infiltration of stormwater, and have incorporated acceptance of industrial wastewaters and septage (from pumped out septic tanks) into their treatment processes.



Franklin Township (Murrysville, PA) Wastewater Treatment Plant. Foreground is media trickling filter, background is nitrification towers (left) and sludge digesters (right).
(Photo Courtesy Dick Luthy.)

- The selection of projects to address critical regional problems should be accompanied by an effort from the earliest stage of the project to extrapolate to export-based opportunities. For example, a project focused on treatment of post-fracturing produced water should include design criteria to explore pathways between those breakthroughs and global desalinization issues. The mix of regional problem solving and global export development is vital to incorporate into the consortia focus.

- Each project must engage participation across a full continuum of the partners to yield an effective regional water industry. These actors include community leaders, environmental and stewardship organizations, industry and technology development participants, workforce participants including organized labor, the university research base, and state and federal partners.

- The approach must be adaptable to mobilize support for specific near-term potential demonstration projects, while creating the capacity to generate ideas and consensus to identify and mobilize around emerging challenges and opportunities.

- Water technologies are highly integrated with regional strengths in the information technology, robotics, energy, and life sciences sectors. The strategy to build a regional consortium should therefore leverage research and industry capabilities and efforts to develop these sectors. Some of the earliest opportunities for new business, supply chain and market growth may come from companies within other regional technology clusters identifying water market opportunities. The action by the Allegheny Conference on Community Development to include the water industry in its regional supply chain development efforts is a vital first step in this effort. Opportunities to engage cluster and business development initiatives in each demonstration project will be vital.

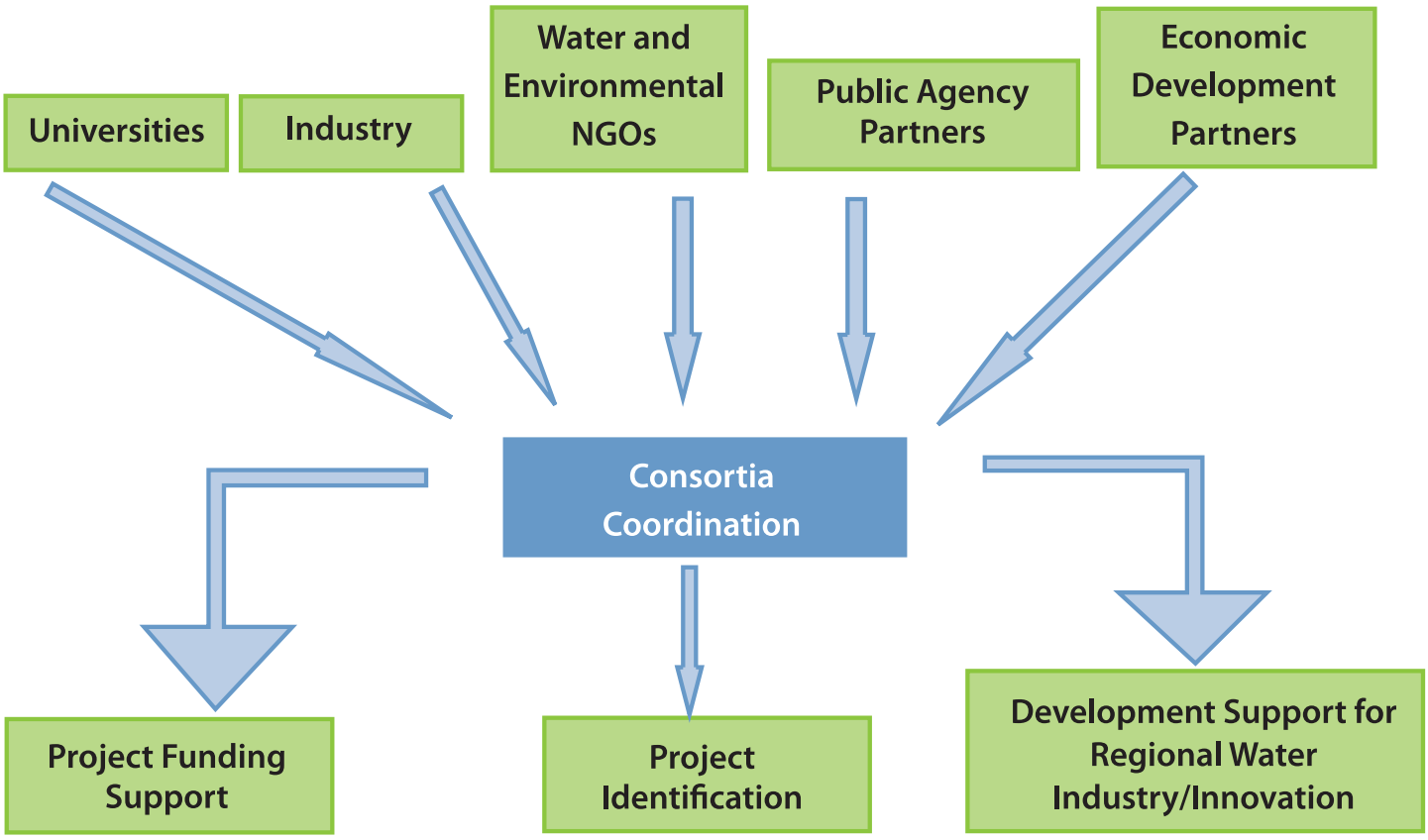
- To some extent the Greater Pittsburgh region is in a race with other US regions to establish a leading role in an industry that is expected to grow at a global rate of 10% per year over the next decade. But in the more fundamental sense we are linked with these regions in a commitment to advance sustainable water technologies and ensure that the US invests appropriately in water related research and funding for sustainable water system deployment. In advancing a demonstration project-led approach Pittsburgh should therefore step forward to act as a convener of regions engaging in water strategies. Before we can be competitors we must work to ensure that the building blocks for advancing sustainable water innovations are in place.

- Finally, the World Environment Day activities demonstrated the degree to which an engagement with water resources is an integral part of this region's pulse. This initiative builds upon an existing legacy to reclaim the rivers and riverfronts. It will be important in the execution of the consortia to create and maintain opportunities for citizen engagement and the ongoing celebration of the waters of the region.

The diagram below seeks to reflect the basic architecture of an organizational approach for structuring a regional water consortia. The design envisions building on existing organizational capacities of existing organizations while drawing on the strengths of collaborators in key operational areas. It envisions extending the consensus on emerging projects reported earlier in this work—while creating a mechanism that also fosters greater interaction across various components of the water development spectrum. Most critically, it is designed with the goal of being *action oriented*.

To support this demonstration project focus, the region should also focus on the attraction or development of a flagship or anchor center that can be a unifying focus for the overall effort to create a regional water technology initiative. Such an anchor initiative would be intended to help integrate the targeted projects into a broader overall regional effort. The identification of a potential anchor initiative should reflect deep regional consensus and several candidates exist for consideration. For example, the nation is in desperate need for a national water/energy research and technology center that can serve as a hub for the large scale effort that will be needed in the next two decades to address these critical challenges. A National Science Foundation (NSF)- funded Science and Technology Center or Engineering Research Center could fulfill this objective; however, the planning and proposing of such a large scale initiative will require significant engagement and seed funding.

Similarly, the future of effective water management will depend upon the capacity to bring intelligence to all water operations and a greater understanding of regional water resources. It would be a strategic opportunity to site a national water data observatory in Pittsburgh that utilized the region as a test bed for creating the kind of data-based water management capabilities that will be vital to addressing water challenges within the region and across the globe. Other candidates for such an anchor initiative can certainly be identified; however, the regional strengths in data management and the nation-wide call for water data integration to support water management suggests this represents a regional capacity and a national need. Again, the key role of this anchor initiative is to provide a focal point for creating synergy among the distinct demonstration projects, help advance day to day collaboration among industry, university researchers and regional water organizations and establish an overall identity for the region among the world's leading water technology centers.



Basic Architecture of a Collaborative Structure for Regional Water Innovation Consortia.

Conclusion

The capacity to confront environmental challenges and harness the energy from that effort to transform and reposition the region is not new for the people of Pittsburgh. Today we face critical water challenges that are likely to affect the cost of infrastructure investments, water quality for multiple uses, job and economic development prospects, and the ability to continue to enjoy the water environment. Finding innovative and sustainable approaches to addressing those challenges can also place the region among the global leaders in innovative water technology.

Building upon an earlier companion study highlighting the region's existing base of water business and research capabilities this analysis has sought to identify a set of core demonstration projects that can set a path towards distinguishing Southwestern Pennsylvania as a leader in water technology and a general structure for organizing those efforts. Building upon recent regional initiatives in energy, a design has been outlined that would create a flexible, action-oriented structure for integrating industry, university, technology, and environmental interests.

The goal of this design is to advance the consensus building and greater collaboration needed to successfully mobilize around cutting edge water innovation demonstration projects.

As a region Pittsburgh is globally recognized for a legacy of past environmental action and a capacity to make effective economic transitions. Seizing the potential to be a leader in next generation water technologies affords a unique opportunity to build on these legacies.