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Sustainable Water Resources Management, Volume 3: Case Studies on New Water Paradigm

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REPORT SUMMARY

This report identifies and evaluates the foundation and requirements for a sustainable water infrastructure at the community and watershed scales. The report will be of value not only to the public water supply, stormwater management, and wastewater treatment sectors, but also the electric power sector, given the strong interdependencies among the four sectors. In addition, the report will of value to government agencies involved in water regulations and policy.

Background

In 2006, money was appropriated to USEPA to fund a National Decentralized Water Resources Capacity Development Project (NDWRCDP). The web site for the program is located at www.ndwrcdp.org. NDWRCDP is a cooperative program that supports research and development to improve understanding, training, and practice in the field of onsite/decentralized wastewater and stormwater treatment. The Water Environment Research Foundation (WERF) administers the program. One of the principal cooperators in the Program, as designated in the appropriation, is the Electric Power Research Institute (EPRI). EPRI's involvement in NDWRCDP is based on the water sector's use of electric power and the strong interdependencies between electric power and water sustainability with respect to community social and economic vitality. This report is the result of a research project initiated and managed by EPRI with NDWRCDP funds.

Objectives

Communities face many challenges with respect to meeting their water needs. These challenges include increased water scarcity and/or flooding associated with climate variability, economic uncertainty, a complex web of regulations and bureaucracy, aging and degrading infrastructure, pollution and impaired water resources, and a broad range of stakeholders with poor understanding of water issues. The objective of this study is to create a platform for communities to overcome these challenges through organizing around and operating under key sustainability principles and practices. The report uses examples and perspectives from two case study communities to offer real world context.

Approach

The project team recruited two communities (Tucson/Pima County, Arizona and Northern Kentucky) and an expert advisory panel to participate in a retreat to flesh out ideas for a new water infrastructure paradigm. The retreat took place in Hebron, Kentucky from June 1 – June 3, 2009. Thirty-five people comprised of research team members, case study community representatives, and expert advisory panelists attended. The real-life circumstances for each of

the two case study communities provided a basis for discussion to define a new water management paradigm. The group first discussed conceptual model components in the context of each community and then worked together to generate ideas for a broadly applicable model for the new paradigm.

Results

Based on input received at the retreat and follow-up research, the research team defined the new paradigm as a composite of five integrated components: 1) sustainability goals, 2) sustainability operating principles, 3) integrated technological architecture, 4) institutional capacity, and 5) adaptive management. Many of the core principles defined for the new paradigm contrast with past and current practices, for example, valuing all water as a resource, moving toward a performance-based regulatory framework, aspiring toward better outcomes, and recognizing true costs while maximizing the value of action. The report constructs a framework for supporting a new sustainable water infrastructure paradigm. The framework includes an integrated planning structure that connects current institutional silos, a technical toolbox to use in the context of performance-based requirements at the watershed and community scale, regulatory flexibility to encourage innovation and affect better outcomes, research and demonstration to build knowledge and capacity, new partnerships and funding mechanisms, and a variety of means for engaging the community stakeholders to broaden support and affect better outcomes.

EPRI Perspective

As more communities and the nation as a whole drive to become sustainable and measure progress through triple-bottom line indicators, environmental, economic, and social; they are seeking guidance in developing their approaches to particular problems. This report provides a foundation for others to build upon and refine in developing a new approach to water management. Knowledge on sustainable practices and technological architectures increases on a daily basis, but to achieve success it is equally important to address institutional barriers and operate in an integrated manner. Future efforts should continue to focus on practical means for replacing old practices and institutional approaches with new ones in line with an ever-changing environment.

The electric sector needs to understand the perspectives of the water sector and work to create and test new collaborative water resource management approaches to achieve energy/water sustainability on the community and regional levels.

Keywords

Water sustainability
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New water management paradigm
Low impact growth

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY

Anaerobic digestion – process in which microorganisms break down biodegradable material in the absence of oxygen which is widely used to treat wastewater solids and organic waste and recover biogas which can be used as a fuel.

Biomimicry – scientific field that examines nature, its models, systems, processes, and elements – and emulates or takes inspiration from them to solve human problems (e.g., water management) sustainably.

Bioretention – areas designed to retain stormwater through the use of vegetated or landscaped depressions engineered to collect, store, infiltrate, and treat runoff. Where soils are highly impermeable, conditioned soil and underdrains are used to help infiltrate and slowly release the stormwater. Sometimes also called a "raingarden."

Built environment – the manmade surroundings and supporting infrastructure that provide the setting for human activity, ranging in scale from personal shelter to neighborhoods to large-scale civic surroundings.

Centralized system – water treatment system serving a relatively large area of many users or customers with an interconnected network of pipes and a centralized treatment system.

Clean Water Act – the primary federal law in the United States governing water pollution.

Cleantech – industry around knowledge-based products or services that improve operational performance, productivity, or efficiency, while reducing costs, inputs, energy consumption, waste, or pollution.

Closed loop development – development which occurs in a manner that generates zero waste (i.e., through resource recovery and recycling)

Cluster system – treatment system located close to a wastewater source serving two or more buildings.

Combined sewer overflow – overflow associated with wet weather events affecting combined sanitary sewer and stormwater conveyance piping.

Composting – process whereby solid organic waste is purposefully decomposed to generate a value-added soil amendment.

Decentralized systems – treatment system located close to its feed wastewater source(s).

Distributed management – management of water systems utilizing combinations of decentralized and centralized infrastructure as appropriate.

Ecosystem services – human benefits associated with the resources and benefits provided by natural ecosystems. They can be assigned monetary value for inclusion in costing exercises.

External costs (externalities) – non-monetary costs associated with infrastructure decisions. They can be assigned monetary value for inclusion in costing exercises.

Fit-for-purpose treatment – water system which utilizes only as much treatment as necessary to meet the quality requirements of the end use.

Full cost accounting – methodology where monetary and non-monetary costs as well as advantages for each proposed alternative are considered in the decision-making process.

Gray infrastructure – water infrastructure relying on large piping networks and highly mechanized treatment systems.

Graywater – wastewater from sinks, showers and (sometimes) kitchens and laundries, which may be treated and reused in systems separate from the sanitary sewage (blackwater) system.

Green building – building and development designed based on principles of sustainability.

Green infrastructure – water infrastructure relying on localized treatment systems typically based on natural processes that infiltrate, evapotranspirate, or reuse water. Green infrastructure facilities mimic natural processes that also recharge groundwater, preserve baseflows, moderate temperature impacts, and protect hydrologic and hydraulic stability.

Hydrologic cycle – the combination of natural processes representing movement of water from the atmosphere to the earth and back to the atmosphere, including precipitation, infiltration, percolation, storage, evaporation, transpiration and condensation.

Hydromodification – alteration of the hydrologic characteristics of coastal and non-coastal waters, which in turn could cause degradation of water resources.

Infrastructure – the basic physical and organizational structures needed for the operation of a community or the services and facilities needed for the community to function. (See also green infrastructure and gray infrastructure definitions.)

Integrated resource management – coordinated development and management of water, land, nutrients, energy and related resources to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

Land application – wastewater and stormwater management approach where treated effluent is applied to or below the land surface for additional treatment and dispersal into the receiving environment.

LEED – Leadership in Energy and Environmental Design, a popular green building rating system developed by the U.S. Green Building Council.

Life cycle analysis (or assessment) – the investigation and valuation of the environmental impacts of a given product or service caused or necessitated by its existence.

Low-impact development (LID) – a land planning and engineering design approach to managing stormwater runoff emphasizing conservation and use of onsite natural features in combination with small-scale engineering to protect water quality and replicate to the extent practicable the pre-development hydrologic regime of watersheds through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source.

Multi-criteria decision analysis – discipline aimed at supporting decision makers who are faced with making numerous and conflicting evaluations; it aims to highlight the conflicts and derive a way to come to a compromise in a transparent process.

Natural capital – the extension of the economic notion of capital (manufactured means of production) to environmental goods and services; the stock of natural ecosystems that yields a flow of valuable ecosystem goods or services into the future.

Onsite/onlot treatment system – treatment system located on the property of the facility whose wastewater is being treated.

Paradigm – a pattern or model reflecting a philosophical framework.

Performance-based – an approach that focuses on achieving a specific outcome rather than on prescribing a specific method.

Resource recovery – treatment approach focused on the efficient recovery and beneficial reuse of water, carbon, energy and nutrients from wastes.

Responsible Management Entity – legal entity that has the managerial, financial, and technical capacity to ensure the long-term, cost-effective operation of onsite and/or cluster wastewater treatment systems in accordance with applicable regulations and performance requirements (e.g., a wastewater utility or wastewater management district).

Reuse – the beneficial use of resources recovered from wastes (e.g., nutrients, energy, water).

Safe Drinking Water Act – the principal federal law in the United States that ensures safe drinking water for the public.

Sanitary sewer overflow – sewer overflow typically associated with inflow and infiltration into the sanitary sewer associated with wet weather events.

Sewer mining – wastewater management approach where a sewer line is essentially tapped to provide raw sewage to be treated for localized reclamation and reuse; interconnection to the centralized collection system may be used for backup and residuals management.

Source separation – wastewater management approach where different waste streams are separated at the source for the efficient recovery of resources (e.g., urine/feces separation).

Sustainability – broadly, the capacity to endure. Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The resiliency or robustness of systems to adapt to and thrive in the face of change.

Sustainable urban drainage systems – surface water drainage systems designed to reduce the potential impact of new and existing developments by replicating natural systems using cost effective solutions with low environmental impact to drain away dirty and surface water runoff through collection, storage, and cleaning before allowing it to be released slowly back into the environment.

Triple bottom line – the three key attributes associated with sustainable systems – environmental performance, economic benefit and social equity/acceptance.

Water reclamation – wastewater treatment to quality standards that allow for beneficial reuse of the effluent.

Watershed – an area of land that drains to a common waterbody such as a stream, large river, lake, wetland, or estuary.

Watershed planning – the process of creating and implementing management plans to sustain and enhance watershed functions that affect plant, animal and human communities within the boundaries of a watershed.

Xeriscaping – methods for landscaping and gardening that reduce or eliminate the need for supplemental irrigation.

1
INTRODUCTION

Background

Growing demands on resources and increasing management challenges are driving communities throughout the nation to become more sustainable. For example, greenhouse gas (climate change) concerns are driving desire for carbon (CO_2) reduction, energy conservation, and reduction in urban heat island effects. Changes in flooding and drought patterns (for example, the 2009 flooding in Minnesota and the 2007 drought in Atlanta, Georgia) are pushing communities to assess vulnerabilities and take action to become more resilient. Water scarcity and water quality concerns caused by changing population and land use pressures are forcing communities to think beyond traditional water management approaches. The high cost of aging infrastructure maintenance and replacement has many communities seeking alternatives. Increasing concern over energy cost and energy security (e.g., vulnerability from excessive reliance on foreign energy sources) and reliability has increased the public pressure for sustainability. Additionally, the increase in public preference for sustainable agriculture is leading to revised field practices and local food markets and entrepreneurial partnerships. Overall, the increase in concern for public health, the environment, economy, and social fabric of society is pushing communities to seek balance to provide for a higher quality of life and sustainability.

Water and water management are integral to this overall trend. New models for more efficient and holistic water management and infrastructure development that integrate sustainable site-scale to watershed-scale strategies are beginning to evolve. An international group of forward-thinking professionals in 2007 adopted the Baltimore Charter for Sustainable Water Systems (Nelson et al. 2007), which affirms "a commitment to design new water systems that mimic and work with nature. These systems will both protect public health and safety and will restore natural and human landscapes." In the European Union, the Sustainable Water Management Improves Tomorrow's Cities' Health (SWITCH 2009) program aims to bring about a paradigm shift in urban water management away from existing ad hoc solutions to urban water management and toward a more coherent and integrated approach. The U.S. National Academy of Engineering (2009) recently adopted clean water as a grand challenge, acknowledging that the rethinking of our water infrastructure management paradigm is critical and that addressing water sustainability will recognize the interrelationships between water management and energy, agriculture/food production, land use and associated ecologies.

Despite the good work that is emerging, most communities and technical professionals have difficulty in moving from traditional water management concepts toward tangible sustainable water management policy and practice. The green building sector, by contrast, has been relatively quick to embrace innovative onsite water reclamation, rainwater harvesting, and water reuse. However, most green building projects (and the programs that support them, such as

LEED) focus exclusively on site-scale water management, sometimes at the expense of community-wide and watershed-scale concerns.

There is a great need to bring together the site-scale innovation being driven by the green building movement with the watershed management and integrated infrastructure planning being increasingly promoted and implemented by communities. Without this connection, it is unlikely that green building will be successful in helping our communities address common water quality problems. For example, despite our intense connection to water and our detailed scientific understanding of the hydrologic cycle, USEPA indicates that 45 percent of assessed rivers and streams, 47 percent of assessed lake acres, and 32 percent of assessed bay and estuarine square miles are listed as pollutant impaired, with the chief causes being nutrients, pathogens, and sediment from nonpoint sources including that from onsite wastewater systems and polluted stormwater runoff (USEPA 2007). These impairments impact our water supplies, public health, fishing and shellfishing, recreation, aesthetics, and ecological resources. To truly be successful, green building decisions must be linked to the specific human and ecological needs of a community. Rather than having green building rating systems based on prescriptive menus, designs need to be performance-based (i.e., rated in the context of how well they address the specific environmental issues in watersheds in which they reside), and adaptable to the changes that occur within the community.

Water infrastructure management in particular needs a performance-based context. The quality of water needed for different uses varies, so efficient management must take context into account. For example, irrigation of land typically does not require the same quality of water needed for potable water supply, so use of highly treated wastewater (e.g., “reclaimed water ”) for irrigation reduces potable water treatment costs, and lowers energy requirements. Similarly, communities typically have unique water resources with varying water quality protection needs. Some waters are more sensitive to nutrient loading, others are more threatened by sediment or habitat degradation, others have greater concerns with the presence of pathogens or toxics, and many waters have multiple concerns. Knowing what the environmental concerns are in a given community and its watersheds helps to determine needed performance standards for that community. This in turn informs sustainable water infrastructure management decisions, such as what potential contaminants need to be prioritized for material recovery in wastewater and stormwater to help meet watershed-based pollutant loading performance standards.

Water infrastructure also needs to be connected to other aspects of the community, including transportation, energy and other public services and amenities. The water-energy connection provides a good example. The existing water infrastructure management paradigm is not addressing the interdependency of energy and water, and the threats to national energy production resulting from limited water supplies. In a report to Congress, the U.S. Department of Energy (2006) identifies concerns regarding water demands of energy production and discusses science and technologies to address water use and management in the context of energy production and use. For example, in calendar year 2000, thermoelectric power generation accounted for 39 percent of all freshwater withdrawals in the U.S., roughly equivalent to water withdrawals for irrigated agriculture. The River Network (Griffiths-Sattenspiel et al. 2009) estimates that U.S. water-related energy use is at least 521 million MWh per year (including embedded energy and end uses)—equivalent to 13 percent of the nation’s electricity consumption. They also report that the carbon footprint associated with moving, treating and heating water in the U.S. is at least 290 metric tons per year, representing 5 percent of all U.S. carbon emissions (equivalent to the emissions of over 62 coal-fired power plants). Thus, sustainable practices that accomplish water conservation, efficiency and reuse and that support maintenance of the hydrologic cycle, in turn reduce energy demand and greenhouse gas emissions. The main point is that energy and water are essential, interdependent resources and that through science- and systems-based natural resource management; energy-water infrastructure synergies will likely constitute a critical portion of our communities' sustainable solutions.

So why aren't all communities simply opting for sustainable approaches? The reality is that it takes time for a paradigm shift. Mindsets have to shift. The way we make decisions has to shift to include more criteria than is typically considered. There is considerable momentum nationwide for simply repeating past practices and following current water infrastructure management based on policies and regulations set forth under the Clean Water Act and Safe Drinking Water Act. Existing institutions established under the current water management paradigm have inadvertently created obstacles to innovative new infrastructure approaches that have the potential to help address many of today's complex challenges. As a society, we need to adapt and apply new ways of thinking.

While the existing paradigm has gotten us to where we are today in addressing many past issues such as widespread waterborne disease outbreaks and gross surface water pollution problems, it does not appear that it can adequately address many of today's emerging problems. In addition to the existing water quality impairments mentioned above, we are reminded almost every day that the nation's water infrastructure is aging, with some piping networks being more than 100-years-old. As indicated by USEPA (2003), collection system failures have been reported to increase at a rate of approximately 3 percent per year, while another study indicated that approximately 50 major main breaks and 500 stoppages occur per 1,000 miles of pipe per year, amounting to an estimated 50,000 breaks and 500,000 stoppages annually in the U.S. Based on the USEPA's Clean Water Needs Survey (2003), replacement costs for the nation's sanitary collection systems alone are estimated to be from $1 trillion to $2 trillion. The national cost to mitigate Sanitary Sewer Overflows (SSOs) over the next 20 years has been estimated at $155 billion. Despite tens of billions of dollars currently being spent each year, the U.S. Government Accountability Office (GAO) reported the gap in water infrastructure funding needed over the next decade to be in the $150-$400 billion range (GAO 2009).

Part of the reason for this gap can be attributed to the current paradigm, whereby water provision and waste management are generally viewed as extractive, linear processes where:

- Water is extracted, treated to potable standards, conveyed to numerous consumers, used once and disposed as wastewater.
- Wastewater is collected, conveyed to a central out-of-the-way location, and treated to remove pollutants, with relatively clean water and residuals disposed.
- Stormwater is managed primarily for flood control through rapid conveyance and discharge.

Such thinking adds to societal cost (e.g., for infrastructure, pumping, treatment, and environmental impacts) rather than using more integrated approaches that incorporate concepts of efficiency, recovery and reuse, potentially reducing full life-cycle costs.

Given the magnitude of existing problems and challenges, extensive discussion has taken place over the past decade or so about the need for a change in direction—or a new paradigm—for water infrastructure planning and resource management. In February 2002, a workshop was convened in Arlington, Virginia on "Soft Path Integrated Water Resource Management" (Nelson 2003). Participants helped outline training, research and development needs for integrated and sustainable practices, many of which have begun to be met over the past few years. Elements of soft path water infrastructure include demand management opportunities, waterless sanitation, green infrastructure, daylighting culverted waterways, rainwater/stormwater harvesting, and distributed resource management (Pinkham 1999).

Workshops in 2005 and 2006 were convened to explore institutional issues and new strategies for catalyzing and facilitating a transition from largely centralized to more decentralized or distributed water infrastructure, and to develop an agenda of priority short-term research and development and outreach projects (Nelson 2008). Six priorities were grouped into four basic strategies: create spaces for local paradigm models to emerge, support conversations, research and collaborative design, and build support for major governmental policy and funding shifts.

Watershed Management

Over the past 15 years there has been a growing foundation for watershed management. More and more agencies, institutions, local governments, and associations are using the boundaries of watersheds to organize and implement water resource programs. In 1996, the Water Environment Research Foundation (WERF) published the "Framework for a Watershed Management Program," (Clements et al. 1996) which illustrates how stakeholders can organize within watershed management units to address technical, policy, economic, and administrative management planning and implementation. In 2008, USEPA published the "Handbook for Developing Watershed Plans to Restore and Protect Our Waters," (USEPA 2008) providing detailed guidance for developing and implementing a sustainable watershed approach. These examples help bridge the gap between water infrastructure decisions made at the site scale and those at the community and watershed scale. Assessment information for the watershed defines environmental sustainability goals, while comprehensive planning provides for evaluation of economic efficiency and social acceptability.

More recently, The Aspen Institute reported on a dialogue regarding *Sustainable Water Infrastructure in the U.S.* (Bolger et al. 2009). Three principles emerged regarding a new way of thinking, including:

- Definition of water infrastructure must evolve to embrace a broader, more holistic definition that includes both traditional manmade water and wastewater infrastructure, and natural watershed systems.
- This definition should be embraced by all public and private entities involved in water management; decisions should consider and integrate a set of criteria that include environmental, economic and social considerations.
- A watershed-based management approach is required for drinking water, wastewater and stormwater services to ensure integrated, sustainable management of water resources (see side bar on Watershed Management).

It is widely accepted that the technology to efficiently use and reuse water and other resources exists or will be developed as demand increases; in other words, technology is not expected to be a barrier to a new water infrastructure management paradigm. While the tools to implement these technologies effectively and reliably need to be refined, integrated and more cohesively presented to practitioners and decision-makers, the most significant barriers to enabling this new paradigm are institutional. Our communities need to integrate water into their economic and social fabric, demonstrating a valuing of the water cycle, integrating water management with the natural environment, and placing local water issues in the context of regional and national water management issues. Accordingly, this research focuses on further defining the new paradigm for water infrastructure management, and further exploring how communities can achieve this integration.

Research Approach

Under EPRI Project Number 068143-01, a research team led by Tetra Tech was contracted to organize and hold a retreat where diverse teams of experts work through two or more case studies to help elicit ideas for effectively describing and advancing the new paradigm for water infrastructure management. The Tetra Tech team recruited two communities endeavoring toward sustainable water management to use as retreat case studies: Tuscon-Pima County Arizona and Northern Kentucky. Tucson-Pima County is located in the arid southwest where water supply is scarce, precipitation is low and typically comes in a few large events, perennial streams are rare, wastewater reclamation is prevalent, and large swaths of land are under federal government and native American tribal ownership. The Northern Kentucky community, on the other hand, is located east of the Mississippi River where precipitation is considerably higher, precipitation events are spread throughout the year, perennial stream flow is abundant, and most of the land is under local jurisdiction. The two communities offer a broad spectrum of physical and cultural differences for consideration of concepts to be applied to a new paradigm (see the highlighted text boxes below for more background information on each community).

Experts in a variety of disciplines and organizations related to water infrastructure were recruited to form an advisory panel (Appendix A contains biographical sketches for the panelists). The panel consisted of engineers, planners, scientists, sustainability consultants, governmental agency representatives and non-governmental agency representatives.

Community representatives and advisory panelists were oriented to the project purpose and engaged in a dialog regarding a conceptual approach for the new paradigm via a teleconference held on April 30, 2009. Based on the teleconference discussion, the Tetra Tech team established the following definitions for “Sustainability” and “Water Infrastructure” that will be used for this research:

Sustainability (General Definition)

Sustainability refers to community development that meets the needs of the present without compromising the ability of future generations to meet their own needs. As a part of this characteristic, communities must demonstrate their resiliency or robustness to adapt to and thrive in the face of change. The degree to which community needs are met sustainably is evaluated using a “triple bottom line” of environmental, societal, and economic considerations.

City of Tucson – Pima County Case Study Community Overview

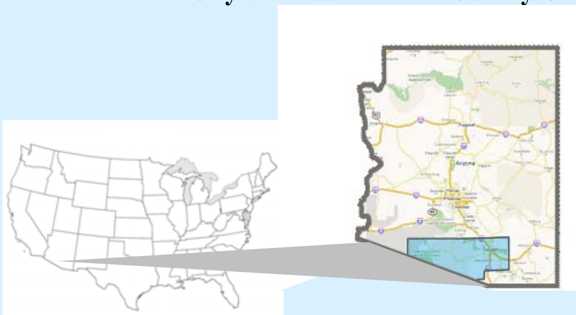

Photo courtesy of Pima County Regional Wastewater Reclamation Department

Pima County covers 9,200 square miles (an area roughly the size of the State of Massachusetts) of arid western land in Arizona. Approximately 42 percent of the county is Native American land, 44 percent is public land, and only 14 percent of the land is in private ownership.

The population in the county is roughly one million, with 742,000 living in the City of Tucson. There is rapid growth around Tucson, including satellite areas that pose special problems for utilities.

The arid west is defined by rainfall. Annual rainfall recorded in the metropolitan area averages about 12 inches. There are three distinct rainfall seasons: June to September is characterized by intense thunderstorms; October to November has occasional storms from Pacific hurricanes; and December to March can have large slow-moving storm fronts. Pima County's drainages all flow northward. Despite the intensity of storms, they are infrequent and drought conditions frequently pose challenges to the region.

Tucson's potable water system serves approximately 800,000 customers and is comprised of 212 production wells and 65 water storage facilities. The City also has a reclaimed water system comprised of 160 miles of pipeline, 5 reservoirs, a 10 million gallon/day (MGD) filtration plant, and recharge and recovery facilities. Reclaimed water is used at approximately 820 sites including 18 golf courses, 47 parks, 61 schools and 704 single family residences. Pima County adds 11 wastewater reclamation facilities (3 metropolitan and 8 sub-regional), including over 3,400 miles of sewer pipe, 64.8 million gallons per day of treated wastewater, and about 30 dry tons per day of biosolids to be applied to agricultural lands. In addition to using reclaimed water for park and golf course irrigation, effluent discharges are utilized for riparian restoration and aquifer recharge.

Currently the large majority of the total water volume used in Tucson-Pima County comes from the Central Arizona Project where Colorado River water is diverted to groundwater storage facilities for future use, with the remainder coming from local groundwater, reclaimed effluent, a replenishment district and incidental recharge.

There are significant water regulatory challenges associated with arid Arizona land. All of the water is allocated or owned through water rights. This includes groundwater rights and effluent entitlements.

Water quality issues in the region include high levels of salinity (from the Colorado River water), impacts of nutrients, pesticides, perchlorate and endocrine disrupter compounds (EDCs). Additionally, rainfall can be so intense that stormwater runoff overwhelms internal storm drains causing flooding, and erosion and sedimentation in stream channels. Wildfires also alter watershed conditions and subsequent runoff quality.

Other challenges that Tucson-Pima County face include regulatory requirements (the Clean Water Act was generally created for non-arid lands). The community believes that improved science and policy are needed for effluent-dependent and ephemeral streams.

Northern Kentucky Case Study Community Overview

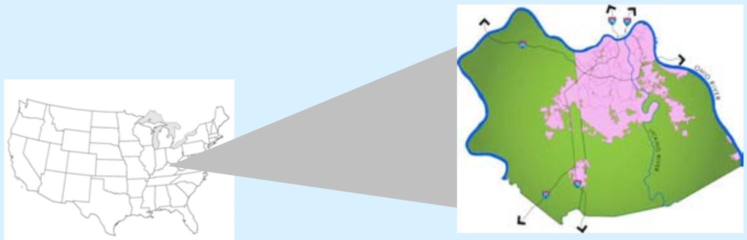

Photo courtesy of SD1

The area referred to as Northern Kentucky in this case study is approximately 229 square miles and is comprised of three counties—Boone, Kenton, and Campbell. The current population of these counties is approximately 350,000 with the City of Covington being the largest municipality at 40,000 people. The region is part of the growing Cincinnati metropolitan area—overall growth rate for the area was 27 percent between 1990 and 2008, with Boone County experiencing 100 percent growth during that period. A portion of the area is known as the "golden triangle" for its economic activity; it is home to the Cincinnati Airport (Delta/Comair hub) and Northern Kentucky University, as well as significant businesses including Fidelity Investments, Toyota, and Citigroup.

Sanitation District No. 1 of Northern Kentucky (SD1) was established as a special district in Kentucky and has been in existence for over 60 years. It is responsible for providing sewer services to most of the Northern Kentucky region, and it also oversees stormwater management for the region. SD1 oversees more than 1,600 miles of sewer pipeline, and two regional water reclamation facilities with a third under construction. It currently has 50.5 MGD of treatment capacity which discharges to the Ohio River and Twelve-mile Creek (which eventually flows into the Ohio River).

Many of the areas near the City of Cincinnati have older sewers that are in deteriorating condition. The system is prone to inflow and infiltration, and it has limited capacity to handle wet weather flows. Combined sewer overflows (CSOs) from 97 locations have totaled an estimated 1.8 billion gallons annually. Another 240 million gallons annually is attributed to sanitary sewer overflows (SSOs) at 126 locations. This has contributed to a number of streams being placed on the State's 303(d) list of impaired waters for bacteria and dissolved oxygen. Other causes of impairment include stormwater runoff, septic systems, agricultural land runoff, and severe stream bed erosion.

SD1 is under a Consent Degree with USEPA and the Kentucky Department of Water, with a compliance deadline of December 2025. They are required to develop "Watershed Plans" every five years that describe how the District is to address CSOs and SSOs. These plans have led to the development of sustainability initiatives including gray, green and watershed controls.

Water infrastructure is managed by the Northern Kentucky Water District (NKWD), which operates three water treatment plants and oversees 20 storage tanks, 15 pump stations and 1,192 miles of water main pipes. The plants draw their water out of the Ohio and Licking rivers, and water is provided for about 300,000 people. Service includes the Cincinnati metropolitan airport. NKWD's challenges include aging infrastructure (water mains are over 100 years old in some areas).

NKWD is governed by a Board of Commissioners comprised of representatives from both counties and is regulated by the Kentucky Public Service Commission. Planning is reviewed and updated about every 5 years, resulting in a 20-year list of improvement projects and initiatives to meet needs categorized as regulatory compliance driven; capacity from growth; repair and replacement of aging infrastructure; enhancements to level of service for customers; and improvements to communication technology. NKWD is migrating toward a performance driven asset management program that will assist in prioritizing projects.

Water Infrastructure (General Definition)

Water Infrastructure refers to the basic physical and organizational water-related structures needed for the functional operation of society. These include both built (e.g., reservoirs and retention systems, piped collection and distribution systems, treatment systems) and natural infrastructure (e.g., forested land, stream buffers, flood plains and hydrologic networks, wetlands).

Following the teleconference and in preparation for the retreat, the research team offered five components to organize conceptual thinking for the new paradigm:

1. Technological Approaches: System Architecture
2. Integrated Planning
3. Regulatory and Programmatic Change
4. Community Engagement
5. Management and Financing

It was generally agreed that discussion of system architectures and technologies for each of the two communities would help establish a vision of what the future might look like in the context of sustainable water infrastructure. The other four components would essentially describe the supporting structure for how each community could achieve its vision for sustainable infrastructure. Appendix B contains the research team's initial (pre-retreat) ideas for key concepts for consideration under each component.

In preparation for the retreat, the two case study communities were asked to prepare background papers that described their sustainability goals and objectives, existing efforts and building blocks, challenges to achieving their objectives, and opportunities and potential solutions for moving forward for each of the five organizational components. The background papers (Appendix C) were distributed to invitees approximately 10 days prior to the start of the retreat. Additionally, the two communities were asked to prepare presentations to use at the beginning of the retreat to orient the participants to their local environment and water infrastructure.

The retreat was conducted in Hebron, Kentucky from June 1 – June 3, 2009. Proceedings from the retreat are summarized in Appendix D of this final report. Thirty-five people comprised of research team members, case study community representatives and advisory panelists attended. The real-life circumstances for each of the two case study communities provided a basis for dialogue to define the new paradigm from the perspective of the retreat participants. Retreat participants first discussed the five conceptual model components listed above in the context of each community, and then the entire group worked together to generate ideas for a refined model for the new paradigm in light of the community dialogues. Based on input received at the retreat and from follow-up discussion, the research team then defined the new paradigm as a composite of five integrated components (Figure 1-1).

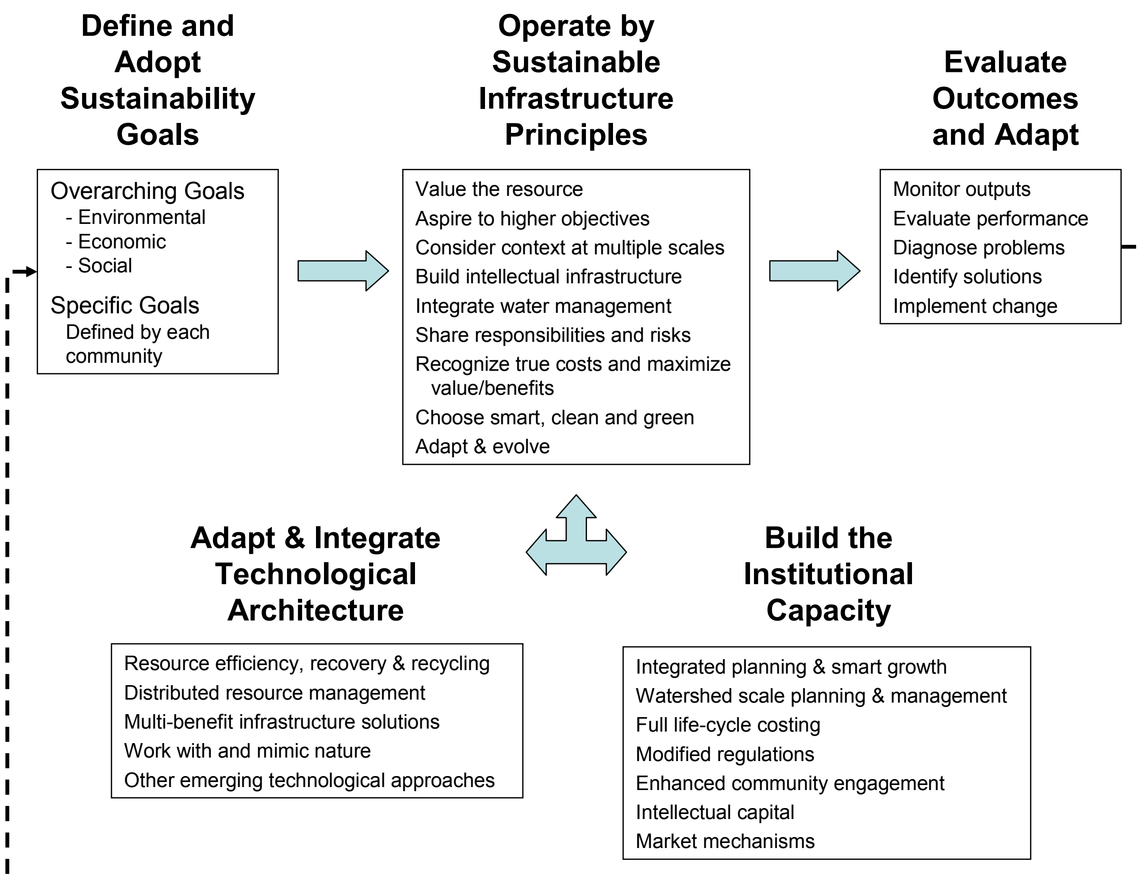

Figure 1-1
Overview of new paradigm

The remainder of this document explores and further defines these components to collectively constitute a more thorough definition of the new paradigm from the perspective of the research team as advised by the retreat participants. Examples are provided both in the context of the community case studies, and for efforts from other communities where existing application of recommended approaches provides real-life illustration. The reader is reminded that there is a glossary at the beginning of this document to help with terms used that may be unfamiliar.

2
DEFINING GOALS AND PRINCIPLES FOR THE NEW PARADIGM

The first component listed for the new paradigm involves communities adopting and defining sustainability goals. If there is to be a new way of thinking, then communities need to establish goals that will guide them toward more sustainable solutions and outcomes. Formally establishing collective sustainability goals among core community government institutions and agencies (including those involved with water infrastructure) as well as the broader populace engages the community by raising awareness and obtaining up front consensus for making decisions down the road that will lead to more sustainable practices and outcomes.

One of the case study communities, Tucson-Pima County, is currently working on a joint Water and Wastewater Infrastructure, Supply and Planning Study. Core goals of the study are to:

1. Assure a sustainable community water source given continuing pressure on water supply caused by population growth
2. Identify and agree on basic facts related to the condition and capacity of water, wastewater and reclaimed water infrastructure, and the ability of the infrastructure to accommodate existing and future population within the city and county service areas

The study has multiple phases that will collectively produce the foundation for community sustainable infrastructure.

Our other community case study, Northern Kentucky, has not explicitly initiated a process to establish broad community-scale sustainability goals. However, aspects of sustainability concepts are being explored and actions are already being taken to support further use of "green infrastructure" within the community.

While potential goals for consideration by each case study community were touched upon during the June retreat, it was acknowledged that a much broader set of stakeholders will need to be involved in formal goal adoption for each community. Input from retreat participants and follow-up by the research team, however, did produce some recommendations for overarching goals that communities should consider and refine for their specific circumstances. These ideas and recommendations are provided below.

Overarching Environmental, Social and Economic Goals

What are the overarching goals that communities should consider for sustainable management of water resources? We do not claim to have the only answers for this question, but the following ideas reflect a combination of what has been learned from this research to date. These are far-reaching community sustainability goals, providing something for communities to aim toward.

They reflect the concept of the “triple bottom line” and integrate the collective thinking of many of the professional disciplines working to define sustainability in practical terms for communities. The term is used to refer to three key attributes associated with sustainable systems —environmental performance, economic benefit and social equity/acceptance.

The following overarching goals are offered for communities to consider from a sustainable water infrastructure perspective (organized by the triple bottom line factors—environmental, social, and economic—to be pursued simultaneously).

Environmental Goals

The community makes decisions that are

1. Carbon neutral or positive (i.e., having a net zero carbon footprint from water infrastructure by balancing the amount of carbon released with the amount sequestered)
2. Hydrologically neutral or restorative
3. Ecologically neutral or restorative
4. Nutrient (and other reusable/recyclable waste resource materials) neutral or restorative
5. Air quality neutral or restorative

Each of these broad goals uses the term “neutral,” by which we mean not upsetting the natural balance. For example, as a community increases development (and thus increases its built upon area), it must manage stormwater to support the local hydrologic cycle. This can mean adopting policies and implementing practices that support local (close to the source) capture of runoff from impervious surfaces (e.g., rooftops, driveways, streets, and parking lots), natural rates of infiltration to groundwater, evapotranspiration to the atmosphere, and runoff to the down-slope hydrologic network of wetlands, streams, rivers, etc. Where impacts and imbalances already exist, communities can set goals to restore elements to functioning levels associated with a healthy environment (i.e., the “be restorative” or “have positive benefits” portion of some of the overarching environmental goals).

A quick review of these environmental goals reveals that they are all context-based. In other words, what it takes to be hydrologically or ecologically neutral or restorative in one community may be very different from that for another. For example, the infrequent but relatively extreme rainfall events in the Tucson-Pima County region require greater consideration of “flashy” (from no volume to large volume) runoff conditions, intermittent stream conditions, and groundwater recharge processes. Thus, what it takes to be hydrologically or ecologically neutral in that part of the country is very different from the context for Northern Kentucky, where rainfall events are more evenly distributed, and a significant portion of the streams flow perennially. Consequently, even with the broad overarching goals, communities need to develop knowledge of what this means for them so they can act sustainably.

Social Goals

The community makes decisions that achieve

1. Clean and abundant water supply
2. Safe and secure food supply
3. Clean and stable energy supply
4. Healthy and enjoyable living, working, and recreational space
5. Social connectedness
6. Environmental justice (equitable sharing of costs and benefits)

Many communities likely would say that they traditionally support goals such as providing clean and abundant water supply, and a safe and secure food supply. What is different, however, is considering them simultaneously with the other goals to try to accomplish the environmental, social and economic goals collectively. Additionally, water infrastructure management decision-making has not always prioritized goals involving enjoyable living, social connectedness and environmental justice. These are part of the new way of thinking to support sustainable communities.

Economic Goals

1. Water systems are effectively managed and self-supporting (customers pay full cost)
2. The value of water infrastructure services exceeds the monetary cost
3. The community and its infrastructure are robust in the face of economic and/or social disruption (caused by extreme events such as floods, hurricanes, etc.)
4. Economic opportunity is provided across socioeconomic class
5. Local “cleantech” (technologies that improve productivity while reducing resource consumption/pollution) industry growth is facilitated

From an economic standpoint, the existing paradigm typically looks for low cost alternatives without considering the value of the services offered and other community objectives. The goals recommended under the new paradigm include some other economic considerations. For example, building in resilience helps to avoid potential future high cost of infrastructure repair/replacement following extreme events and the cost to the community when services are disrupted due to damage. Facilitating economic growth through the promotion of clean and green industry both helps provide local solutions to environmental challenges while providing economic benefits across the workforce.

Setting Local Goals, and Expected Benefits

Communities can use the overarching goals listed above as a starting point in setting local water sustainability goals. Ideally, this would be done in conjunction with local comprehensive planning efforts and accompanying land use planning as these can provide excellent vehicles for communities to define and coordinate policy on a range of long-term issues affecting water such as land use, transportation, environment, housing, water and sewer infrastructure, parks, waste disposal, etc.

Alternatively, a local sustainability task force might be appointed to establish sustainability goals (including but not limited to water), which can later be incorporated into comprehensive planning efforts and other more specific infrastructure and land use plans. Many communities across the U.S. have implemented ambitious sustainability plans that cover a range of objectives and indicators across environmental, societal and economic considerations. The key is to set the goals within the context of other local long-term or "vision" plans, rather than in a silo, so that the sustainable water goals and principles are applied along with other local policies in small area or district plans, watershed plans, development standards, utility capital improvement plans, facility master plans, and others. By addressing such issues across disciplines in a coordinated, integrated way, institutional barriers can be avoided or minimized. While a broad range of overarching goals should be considered in this process, operating within the local context will help the community identify which specific goals are most relevant and important to its future vision. The community will most likely identify other goals that should be added.

Typically, comprehensive plans and other local vision plans have indicators, measureable objectives and concrete actions associated with each goal. Within the formal planning processes of many communities in the U.S., comprehensive planning provides an ideal opportunity to lay the groundwork for new technological architectures for water and the new institutional protocols needed to facilitate a new water infrastructure management paradigm. But such planning and implementation processes should be driven by the community setting local goals and it should reflect current initiatives occurring outside of formal planning processes.

To be achievable, the overarching goals need to be articulated as community goals and the community goals need to need to be linked to things people care about—that benefit their everyday lives or the lives of their grandchildren. According to SD1, in Northern Kentucky, this often includes:

- Health—as it relates to water quality, both drinking water and recreation
- Money and cost—how this increases or decreases current and future water/sewer or energy bills
- Maintenance burden (both to homeowners and the utility)
- Reliability
- Beauty of open space, parks, or other "green" infrastructure
- Conservation for the next generations

"Community," in the context of this discussion includes a broad range of stakeholders who are integrally engaged throughout infrastructure planning and management processes, not just at the end of a planning phase. Engaging stakeholders in setting goals up front typically yields more meaningful involvement all through the process and stronger strides toward the goals. Such an approach also can yield surprising and effective synergies and partnerships as the technical and organizational capacity of the entire community (not just its government) are tapped.

Principles for Moving to the New Paradigm

In our attempt to better define the new paradigm for water infrastructure, a considerable amount of time was spent by the research team and retreat participants to identify the core principles that constitute this new way of thinking. Many of the project's advisory panelists said that these thoughts are among the most important outcomes of the retreat to communicate because they reflect the type of thinking and action that communities need to follow to successfully achieve a strong triple bottom line (i.e., the environmental, social and economic goals listed above). For example, valuing the resource (the first principle that will be discussed below), should lead to decisions and actions that are environmentally neutral or restorative. Actions that have this outcome are also likely to help in supporting clean and abundant water supply, healthy living, and economic value (e.g., associated with recreational amenities in areas with healthy ecosystems).

While the principles were derived from discussion involving the two case study communities, they are recommended for any community striving for sustainability and as such they constitute the second component of the research team's definition of the new paradigm. Like the example provided in the previous paragraph, each of these principles can be linked to multiple goals. There are too many connections to list them all, so just a few will be discussed to provide illustration.

1. Value the Resource

   A core principal for the new paradigm is to recognize all water as a valuable resource including stormwater and wastewater. Water is vital for life, and water in its various forms contains valuable resources such as nutrients, energy and carbon. From an environmental perspective we need to value the entire water cycle, recognizing the importance of precipitation, interception, storage, infiltration, runoff and evapotranspiration processes to sustaining a strong triple bottom line. There is also social and economic value to the beauty and community that water can create (e.g., parks, beaches, hiking and boating areas).

   How is this different from the current paradigm? The linear way that water is frequently managed now provides a good example. As mentioned in the Introduction, under the current paradigm, communities typically extract, treat and distribute water for one-pass use, treat the resulting "waste" water, and return it to the environment. Under the recommended new paradigm, cyclical or systemic ("closed loop") water management is emphasized; i.e., resources in "wastewater" (reclaimed water, nutrients, carbon, metals, biosolids) are recovered for beneficial uses including potable water offsets (e.g., irrigation), fertilizers, and generating power. Additionally under the new paradigm, stormwater is harvested for water supply, irrigation, and infiltration benefits as opposed to the current tendency to convey stormwater offsite as quickly as possible with little or no regard for maintaining the hydrological integrity of the ecosystem.

2. Aspire to higher objectives that spawn better outcomes

   The core of this principle with regard to water infrastructure is that designs should add value and provide multiple benefits (for example, natural treatment systems that double as recreational spaces or bioretention areas that serve as public art for the community). A key part of this higher objective is integrating the built environment with the natural environment (for example, using native soils and vegetation as green infrastructure to capture and treat stormwater runoff from the built environment). Under this principle, communities should consider life cycle impacts of actions beyond their local boundaries (for example, looking at impacts of local water infrastructure decisions on global climate change, or controlling water quality in the Ohio River to minimize the hypoxic zone in the Gulf of Mexico).

   One way that this is different from the current paradigm is how this new way of thinking affects the complexity of design. Under the current paradigm, there is a tendency for administrative agencies and decision-makers to favor more well-known, less complex, standard infrastructure designs and technologies. Under the new paradigm, new technologies and strategies (tested at the demonstration scale as appropriate) that may integrate several disciplines or institutional silos are encouraged where better outcomes are needed which cannot be provided using standard approaches.

   Another example of this change in thinking involves the design of water collection and distribution systems. Most current pipeline systems are designed for one-way transport from supply side to a single use, or to treatment and disposal. Under the new paradigm, a higher objective is placed on reuse and reclamation. Communities use water multiple times reclaiming treated water for the supply side of the infrastructure (for example using household graywater for irrigation).

3. Consider context at multiple scales

   Local actions can have implications at every scale; some impacts occur on site, some at the watershed scale, some regionally and some globally. For example, excess runoff from a developed site can erode soil on site, the excess runoff in turn destabilizes downstream channels adding further sediment to the water column at the small watershed scale, and the pollutants associated with the sediment combine with other runoff to impact water quality at the regional scale (for example, nutrients in the Mississippi Basin feed algae in the Gulf of Mexico leading to large segments of the Gulf that are devoid of aquatic life). Similarly, we are often reminded that energy consumption at our water and wastewater treatment facilities may lead to additional CO_2 emissions.

   This principle brings us back to the green building issue raised in the Introduction. Building design decisions (including water infrastructure) need to be made in the context of critical concerns for a given community. Watershed-based assessments are needed to identify thresholds for variables such as pollutant loads so that performance standards can be established locally, and building decisions are made to support neutral or restorative measures. Decision-makers need to avoid “one size fits all” solutions, instead staying attuned to ecological, social and economic opportunities, issues and constraints associated with their community.

4. Build intellectual infrastructure

   To support new paradigm approaches, communities need to foster and support research, development and new ideas for water infrastructure management. Finding good triple bottom line solutions will often be challenging, and use of research and demonstration projects, and the compiling of a knowledge base of new technological approaches will facilitate success.

   Additionally, communities need to build knowledge about their specific water resource issues. This means investing in maintenance of watershed characterization decision support tools. Monitoring and modeling systems (that can predict future conditions, support performance standard development, and help evaluate alternative water infrastructure management options) are both important in this regard.

5. Integrate water management decisions with all aspects of community planning and development

   Under the new paradigm, all community decision-making must consider water. This is different from most community projects that currently do not consider water directly or treat it as an afterthought when issues arise. Valuing water and understanding that most infrastructure projects will affect the natural hydrologic cycle means addressing these issues up front in the planning and design phases. In particular, land use planning and water resource management must be coordinated.

6. Share responsibility and risk throughout the community

   Under the new paradigm, the process of informing and engaging stakeholders regarding water infrastructure management should be transparent and inclusive. Too often under the existing paradigm, stakeholders are only informed when approval of pre-chosen solutions is required. Under the new paradigm, stakeholders are engaged in the decision-making process from the beginning. The open process is more likely to result in shared responsibility and risk, which helps the community move more as a whole toward sustainability goals. A part of sharing responsibility and risk involves building and relying on local capital for creative and science-based decision making. This also creates a greater “stake” in the outcome, which helps to focus efforts. Additionally, the inclusive and transparent approach is more likely to serve the overarching economic justice goal, deriving solutions that share cost across the community.

7. Recognize true costs and maximize value/benefits

   Under the new paradigm, communities use triple bottom line principles to plan, design and manage water systems. Current infrastructure management decision-making often relies heavily on capital and recurring (e.g., operation & maintenance) cost as the primary quantitative factor for cost-benefit analysis. The new way of thinking incorporates use of full life cycle costs over a long-range (e.g., 100-year) life cycle to evaluate water resource management decisions. This information takes into consideration the external social and environmental impacts. Through this approach communities are more likely to be able to adequately assess whether they are meeting their overarching goal of having the value of services exceed the monetary cost of alternatives.

8. Choose Smart, Clean and Green

   "Smart" infrastructure uses information and signaling (e.g., real-time meters) to modify water use behavior and treatment supporting efficient use of resources. "Clean" infrastructure uses resources and methods that are resource efficient and avoid use of harmful substances. "Green" infrastructure learns from and works with nature and uses soil and vegetation to manage water and restore natural ecosystems. Again, these new paradigm approaches differ from the existing paradigm approaches that tend to favor gray infrastructure approaches (linear, single-pass, centralized systems). Smart, clean, and green approaches are directly linked to the overarching environmental, social and economic goals because they emphasize efficiency, conservation, low environmental impact, healthy living, and an economy with more emphasis on clean industry.

9. Adapt and evolve

   Change is inevitable. Even though the perceived risk of change is often high, continuing under the current water management paradigm may be riskier as waterbodies become more polluted, the cost of infrastructure management increases, and resources are depleted. The new paradigm recognizes this by emphasizing flexible systems that can adapt and evolve over time. Communities need to implement management approaches that monitor performance so that progress toward goals can be assessed and corrections to plans, designs and operations can be made as needed.

Table 2-1 summarizes a number of the key differences between operating under the new and old paradigm principles.

Table 2-1
Summary of what's different under the new paradigm (adapted from the Rocky Mountain Institute, 1999)

Topic	Current Practice	New Paradigm
Water Use	Single use—water is used only once before treatment and disposal.	Greater emphasis is placed on water reuse and reclamation, use water multiple times (e.g., household graywater for irrigation), and reclaim treated water for the supply side of the infrastructure.
Water Quality (supplied)	Treat all supply-side water to potable standards.	Apply "right water for right use"—level of water quality supplied is based on the intended use.
Wastewater	After one-pass use, treat the resulting "waste" water, and return it to the environment.	Cyclical/"Close the Loop" —recognize the value in "wastes"; recover resources (reclaimed water, nutrients, carbon, metals and biosolids) for beneficial uses including potable water offsets, fertilizers, and generating power.
Stormwater	Convey stormwater offsite as quickly as possible with no regard for maintaining hydrological integrity of ecosystem.	Harvest stormwater for water supply, irrigation, and/or infiltration benefits.
Increase System Capacity	Add capacity to water and wastewater facilities and collection/distribution systems as water demand increases.	Implement cost-effective demand side and green infrastructure before increasing gray infrastructure.
Type of Water Infrastructure	Primarily use gray infrastructure—engineered and constructed materials (pipes and treatment facilities and pumps).	Integrate the natural capacities of soil and vegetation to capture, infiltrate and treat water (green infrastructure) with gray infrastructure.
Centralized Infrastructure	Preference for large, centralized treatment and distribution systems that focus on economies of scale at the treatment facility without considering the whole system, which includes collections and distribution systems as well.	Favor distributed approach evaluating the spectrum from small decentralized systems to larger centralized systems, including combinations, based on local needs and the triple bottom line.
Complex Design	Administrative programs tend to favor more well-known (established), less complex, standard infrastructure designs and technologies.	Since today's problems cannot always be solved with today's standard solutions; new technologies and strategies are encouraged (tested at demonstration scale as appropriate).
Infrastructure Integration	Water, stormwater and wastewater are typically managed as separate systems (creating management "silos").	Water is water—integrate infrastructure and management of all types of water regionally, as appropriate.
Public Involvement	Stakeholders are informed when approval of pre-chosen solutions is required.	Stakeholders are engaged in the decision-making system from the beginning.
Monitoring and Maintenance	Water and wastewater facilities use computerized Supervisory Control and Data Acquisition (SCADA) to monitor and control processes.	Moves smart systems out to end users to provide real-time feedback regarding energy use and water use rates to build understanding, modify behavior for higher efficiencies, and notify for maintenance.
Cost-benefit Analyses	Use estimates of capital and recurring costs as the primary quantitative factor for cost-benefit analyses.	Develop an understanding of the full cost and benefits of infrastructure, including externalities.

3

ADAPTING AND INTEGRATING TECHNOLOGICAL ARCHITECTURE

The third component of the new paradigm defined by the research team (i.e., after setting goals and implementing sustainable principles of operation) involves adapting and integrating technological architecture. The new paradigm goals and the operating principles both represent a new way of thinking and thus change. Most communities know from experience that change is difficult. Based on discussion at the retreat and follow-up research, the team identified two key components for facilitating such change in communities (refer back to Figure 1-1). The first of these two supporting components—adapting and integrating technological architecture—is described in this chapter of the report.

To set up the discussion of technological systems and architectures under the new paradigm at the retreat, both case study communities provided background papers to the research team and panel advisory members (Appendix C). The initial breakout session at the retreat then focused on examining opportunities for using new technologies or architectural systems in each community to advance their degree of sustainability. More detailed notes from the breakout discussions can be found in Appendix D, but highlights are summarized below for each community.

Highlights of Retreat Discussion on Technological Approaches/System Architectures in Northern Kentucky

Northern Kentucky is challenged by extreme wet weather flows in both its combined and separated sewer systems that impact water quality in the region. Suburban growth presents another challenge with respect to sewer service and nonpoint source water quality. Community objectives expressed at the retreat revolve around improving water quality in the region, keeping water and sewer rates reasonable, and improving energy performance. Engaging the local community is a key goal that will help build support and capacity for more ambitious sustainability initiatives in the area.

Given these challenges and objectives, community representatives and advisory panelists identified potential promising technologies/architectures for Northern Kentucky. These included green infrastructure, water conservation, high efficiency pumps, increased use of decentralized water and wastewater systems outside of the core urban areas served by centralized systems, and resource recovery for such current wastes as biosolids, fats, oil and grease.

Highlights of Retreat Discussion on Technological Approaches/System Architectures in Tucson-Pima County

Currently, the large majority of the total water used in the Tucson-Pima County service area comes from the Central Arizona Project (CAP), where Colorado River water is diverted to groundwater storage facilities for future use. Supply is augmented by groundwater withdrawals and regional water reclamation systems The community is quite concerned about reliability of water supplies due to the uncertainties of drought and climate change. Additional objectives include greater integration between the built and natural environment, and greater integration of water management with energy management and other resource management initiatives.

The community representatives and advisory panelists discussed numerous technological architecture opportunities. The region is fortunate to have a relatively engaged and active community which appreciates and supports the unique and sensitive indigenous environment. This support can be used to link land use planning with system architecture to be more water-centric (i.e., mixing natural and physical infrastructure, and bringing demand closer to local supply of water, and accomplishing closed loop greenfield development). Energy-water connections can be increased integrating solar and co-generation options with water and wastewater facilities. Additionally, the community can integrate smart systems in homes and business to take advantage of the conservation ethic in the region. Community representatives also see an opportunity to develop greater understanding of arid hydrology and ecology to support increased use of effluent, reclaimed water, stormwater

Toward the end of the project retreat, participants discussed how technology needs to be considered in the context of the broader new paradigm that could apply to all communities. A fundamental theme coming out of the retreat associated with new paradigm technologies revolves around integration—integration of resource management approaches as well as integration of technological architectures. Integrated resource management describes the coordinated development and management of water, land, and related resources to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. Water (and other resources—nutrients, carbon, energy, etc.) can be more sustainably managed by considering the system holistically, rather than separately as specialized elements (e.g., water supply versus stormwater versus wastewater versus aquatic ecosystems) with limited interrelationship.

Under a new technological framework rooted in integrated management, a number of movements or fields of study and practice continue to develop. These movements are not mutually exclusive—applied collectively, they support new and exciting infrastructure system architectures that combine closed loop resource recovery at localized scales with centralized management and oversight informed by smart and responsive monitoring and control systems. Existing infrastructure may be repurposed for new functions, such as the case with a wastewater collection and treatment system managing residuals and providing backup for satellite water reuse. Likewise, institutional structures may change; traditional municipal utilities may be adapted to take on roles with higher purposes and improved community outcomes as goals.

For the purposes of this report, the research team has organized the new technological approaches into the following four categories:

1. *Resource efficiency, recovery and recycling*—in addition to water, other waste-related resources should be used as efficiently as possible, while resources in waste should be recovered and recycled.
2. *Distributed resource management*—a combination of infrastructure scales, from decentralized to centralized, should be used as appropriate; managing resources closer to the source of generation and reuse opportunity is often more efficient.
3. *Multi-benefit infrastructure solutions*—infrastructure solutions can and should provide a multitude of benefits spanning the triple bottom line of environmental, societal and economic attributes.
4. *Design new water systems that mimic and work with nature*—these systems will both protect public health and safety and will restore natural and human landscapes. Nature and man can cooperate to rebuild healthy communities and restore natural ecologies through incorporation over time of sustainable infrastructure designs and principles, with water at the center of these designs.

Each of these four approaches is described below in more detail along with some examples for illustration. While each approach has merit on its own, the new paradigm emphasizes integrating across the spectrum of approaches as appropriate for the context within each community. Additionally, since technological approaches are applied with the objective of attaining certain levels of performance to achieve triple bottom line goals, the new paradigm emphasizes monitoring outcomes and adapting these technological approaches to enhance performance over time. Many of the examples provided below demonstrate integration of multiple approaches.

Technological Approach #1: Resource Efficiency, Recovery and Recycling

The earth's fossil-based resources are limited. The way we design and manage water infrastructure systems is integral to sustainable resource management. Resource efficiency, recovery and recycling concepts directly relate to consensus environmental sustainability goals of neutrality with respect to carbon and energy, by using smart, clean and green technologies to recover value from waste-related resources.

It was noted in the Introduction that energy generation as a whole is very water intensive. Even "green" sources of energy, such as biofuels, can require enormous amounts of water to be viable future sources. Likewise, sourcing, treating and moving water requires energy. The goal for water infrastructure practitioners is to design and manage water systems in the most resource-efficient way possible. Much like in the energy sector per se, the initial focus is on efficiency. On the supply side, reducing the amount of water used and the leakage from distribution system pipes and fixtures has direct energy efficiency implications—less water to pump, less water to treat, and less wastewater to process. Implemented properly, water reuse can also maximize efficiency by using water that required energy to extract, treat and transport multiple times.

Advanced water reclamation systems are being sited strategically, in order to be closer to the reuse area thus minimizing energy demands associated with conveyance. Additionally, where regulations allow, reclamation systems can be more efficiently designed to treat water only to the quality needed for the specific reuse application.

Energy recovery from water and waste can be optimized in a variety of ways, including the following (also see Sonoma County example below):

- Biofuel production using waste related resources, such as grease and oil, as feedstocks
- Anaerobic digestion is commonly applied at wastewater treatment plants for recovering biogas from biological wastewater treatment residuals (biosolids or sludge)
- Co-generation or combined heat and power (CHP), for simultaneous production of electrical energy and recovery of byproduct thermal energy
- Co-digestion of wastewater biosolid residuals with other carbon-based wastes such as agricultural waste or municipal solid waste to generate methane
- Wastewater effluent heat pumps where the thermal energy in wastewater and treated effluent is harnessed and used to help heat and/or cool buildings
- Micro hydropower where small turbines convert gravitational energy to electricity
- Microbial fuel cells are an emerging technology where biological reaction energy (e.g., as generated by treatment on attached growth media) is harvested directly and converted to usable electrical energy

Sonoma County Water Agency (SCWA) Energy Initiatives

Sonoma County Water Agency (SCWA) has set an aggressive community-specific sustainability goal to be carbon neutral by 2015—to have a zero carbon footprint for the county's water system in an effort to insulate their operational costs against volatile energy prices, as well as secure an independent energy supply for the health and safety of their customers. SCWA uses enormous amounts of energy to pump, deliver, and treat the water they deliver to the 600,000+ residents they serve, so their approach to becoming carbon neutral combines a mixture of standard approaches such as solar and small-scale hydropower and newer, emerging technologies. Currently, SCWA has 2 MW of solar power installed in three locations while obtaining 0.4 MW of power from a low-impact hydroelectric facility.

Aside from these more traditional approaches to transition operations to renewable energy, SCWA is pursuing a range of non-traditional energy sources. Some examples include wave energy off the Sonoma Coast, biodigesters to utilize dairy waste to produce electricity while cleaning up waterways, a fuel cell at one of their treatment plants, geoexchange technology to use their wastewater as a community heating and cooling system, and developing a countywide fleet of electric vehicles.

Being a water and power utility puts SCWA in a unique position to develop some of these newer technologies as they have the technical expertise as well as a financially vested interest in finding long-term solutions to a renewable energy supply. All their projects are evaluated for financial feasibility and grants are aggressively being pursued to fund this work.

Concepts: ***integrated resource management, resource recovery, integrated utilities, multi-functionality***

In addition to the water-energy nexus, wastewater contains a variety of finite and valuable resources that can be recovered and reused as appropriate. Water, of course, is the obvious recovery target and has been the focus of many utilities and wastewater treatment systems. Aside from the water fraction, nutrients are both serious water pollutants and valuable agricultural resources; their recovery and reuse is a necessary element of a future sustainable infrastructure paradigm. For example, phosphorus is finite (expected to be fully exploited in 60-150 years), agriculturally- and nutritionally-required, and largely disposed via wastewater discharges and landfilled sewage sludge, both of which are difficult, if not impossible, to recover after-the-fact (Ashbolt and Goodrich 2009). Closing the loop on water- and waste-related resource cycles through efficient systems for recovering and reusing these resources is a critical element of the new paradigm (see Hillsboro, OR example below).

Hillsboro, Oregon: Ostara nutrient recovery system

The Clean Water Services water utility in Hillsboro, Oregon, teamed with commercial enterprise Ostara to implement a process for recovering phosphorous and to a lesser extent, nitrogen, in treatment plants that utilize biological phosphorous removal (BPR). The process creates an environment for the controlled formation of struvite, a phosphate mineral. The Hillsboro BPR treatment plant's digester centrate is rich with ammonia and phosphorous, two of the three required nutrients for struvite formation. The third nutrient, magnesium, is present at much lower concentrations, so additional magnesium is added to the centrate stream prior to entering an Ostara reactor for enhanced nutrient recovery through maximum struvite formation. The finished product is packaged as fertilizer under Ostara's trademarked name Crystal Green.

In addition to recovering and reusing nutrients, the Hillsboro project provides a good illustration of a multi-benefit infrastructure solution, because uncontrolled struvite formation will clog digester piping and nozzles. Additionally, the first 11 tons of Crystal Green produced at the water reclamation facility were sold to a river rescue agency in British Columbia to revive a nutrient depleted waterway. Owing to the revenues associated with this value-added recovered resource stream, the payback period for the technology is expected to be 5 years or less.

Additional Information:

http://www.cleanwaterservices.org/AboutUs/News/Ostara.aspx

http://www.oregonlive.com/business/index.ssf/2009/06/kennedy_lauds_sewage_plants_gr.html

http://www.ostara.com/

Concepts: ***integrated resource management, resource recovery, multi-functionality***

Other examples of resource recovery technologies include:

- Composting, whereby solid wastes (potentially including wastewater residuals) are mixed with bulking agents and degraded over time to produce a value-added soil amendment
- Urine separation for use as liquid fertilizer
- Bioretention for storing, treating, evapotranspiring and potentially reusing stormwater
- Rainwater harvesting using rain barrels and cisterns to augment water supply
- Land application to recharge local aquifers and help maintain groundwater levels and baseflows in groundwater influenced streams

The key points associated with this subtopic follow:

- Existing and emerging technologies can be applied in ways that efficiently conserve and reclaim resources by focusing on source control (e.g., water conservation, pollution prevention) and efficient reclamation and resource recovery systems that are informed by performing mass balances across appropriate system boundaries to optimize design for resource recovery rather than environmental dispersal.
- A systemic approach to water and waste management can help close the loop on resource cycles including water, nutrients, carbon, energy, and metals, recovering value and creating revenue streams that are net positive. For water management, consider the system in an integrated and holistic fashion, rather than separately (e.g., as stormwater vs. wastewater vs. aquatic ecosystems).

Where Can I Learn More?

The government of British Columbia commissioned an independent report on integrated resource management that examines approaches for local governments across British Columbia to use solid and liquid waste to create energy, reduce greenhouse gas emissions, conserve water, and recover nutrients: http://www.cd.gov.bc.ca/ministry/whatsnew/irm.htm

Technological Approach #2: Distributed Infrastructure Management

Distributed infrastructure management describes integrated planning, design, and management using system infrastructure at various scales, based on an equitable approach that considers suitability and sustainability. Distributed stormwater systems also known as “low impact development” (LID) are management practices designed to infiltrate, intercept, and/or treat stormwater near where it originates. Likewise, distributed wastewater management is an approach to wastewater collection, treatment, and disposition (discharge, reuse, dispersal) that uses appropriately scaled systems—which can vary from onsite to cluster to centralized—across a service area, watershed, or other political or natural boundary.

Effectively planned, implemented, and managed distributed wastewater systems are critical elements of sustainable “green to gray” infrastructure in the United States, featuring several potential advantages over alternative approaches, which relate directly back to core principles associated with the new paradigm:

- Sustainable infrastructure funding. “Pay as you go/grow” promotes equitability and allows for alternate project delivery. Investments are smaller and more incremental, with failure far less catastrophic. This approach may also allow enhanced opportunities for private financing.
- Energy efficiency. Treatment close to the source requires less energy for conveyance. Urban reuse retrofits are non-disruptive. Relatively passive, bio-utilization system designs (using soil and vegetation for treatment) can be used effectively.

- Water cycle integration. Distributed approaches facilitate integrated stormwater and wastewater reuse. Land application of water and biosolids promotes hydrologic and ecological restoration. Multiple watershed benefits are achievable.
- Sustainable design/green building. Multiple Leadership in Energy and Environmental Design (LEED; U.S. Green Building Council rating system) points related to water conservation are available. Diverse benefits result from integration into building and site designs. These may include, for example, microclimate and energy efficiency benefits offered by green roofs for stormwater control or vegetated filter used to treat wastewater at building scales, as well as multi-functionality associated with natural treatment systems that double as recreational spaces or educational amenities.
- Resiliency. Distributed systems are often more resilient to natural and manmade disasters. By being spread out, there is less risk that entire systems for a community are impacted, and there is usually less risk of environmental impairment (or the scale of damage is typically less).

Historically, decentralized wastewater systems were synonymous with septic tanks and other low-tech onsite treatment approaches that unfortunately were afforded inadequate management. While traditional septic systems are still appropriate and sustainable technologies in many circumstances (it should be noted that septic tanks are remarkably efficient reactors, performing several key treatment functions while requiring low or no energy input), a key point of the new paradigm is that such systems need to be properly managed to be sustainable components of the nation's water infrastructure (see Thurston County, WA and Loudoun County, VA distributed management examples below). Additionally, advanced treatment processes and innovative effluent dispersal are becoming more popular where receiving environments require higher levels of treatment and where the effluent products will be reused.

Thurston County, Washington: LOTT Alliance highly managed, just-in-time water infrastructure

The cities of Lacey, Olympia, and Tumwater in Thurston County, Washington form the LOTT Alliance which delivers wastewater service and reclaimed water to the area. LOTT has pursued an innovative approach to plan and manage wastewater infrastructure in their service area. The approach taken by LOTT to expand their wastewater treatment system was the result of a long-range planning process that led to establishment of an environmentally-based system for adding small units of capacity, responding just-in-time to actual measured conditions. New units of capacity are gained through production, distribution, and use of reclaimed water, including groundwater recharge methods. Using this just-in-time capacity development strategy, LOTT will save an estimated $87 million over the course of its 20-year capital improvements planning period, while minimizing risk, wisely managing community resources and taking advantage of the latest advances in technology (Klein and Zuchowski 2008).

Water reclaimed from the Budd Inlet plant meets Washington State's Class A Reclaimed Water standards and is used to irrigate a number of parks, for equipment washdown, boat washing, dust suppression, pond construction, pumpseals, and pump station cleaning. At the Hawks Prairie Satellite Reclaimed Water Plant, reclaimed water is used to create constructed wetlands and ponds that provide opportunities for public education, recognition, and acceptance of reclaimed water, while four large kiosks provide interpretive displays about reclaimed water, groundwater recharge, and natural features. The ponds also serve as an amenity for the surrounding area by offering visitors the opportunity to view and enjoy a wide variety of animals, birds, and aquatic life.

Web site: www.lottonline.org

Loudoun County, Virginia Distributed Infrastructure Management

A different approach to distributed infrastructure management is being done by *Loudoun Water*, the municipal utility providing water and wastewater service for Loudoun County, VA, a D.C. suburb/exurb. In addition to a central system serving more than 56,000 connections through wholesale water purchase and wastewater treatment agreements as well as a satellite reuse facility, Loudoun Water owns and/or operates several small (community) water and/or wastewater facilities that serve over 1,000 county customers. Key sustainability elements of Loudoun Water's approach include:

- Growth pays for growth through a public-private delivery model and sunk infrastructure costs are minimized. Developers design and construct facilities to Loudoun Water standards and turn the systems over at no cost to Loudoun Water.
- Preventing sprawl development by limiting the boundaries of the centralized sewer system and requiring the use of decentralized systems and land use zoning outside of those boundaries to preserve the character of the countryside.
- Loudoun Water manages all water—drinking, storm, waste and reclaimed, uses full cost assessment of alternatives, and conducts needs and service assessment to support planning; and master planning of service areas (Danielson 2009).

Concepts: ***distributed management, multi-functionality***

Even more innovative distributed infrastructure approaches are emerging, where decentralized wastewater treatment systems are being used in urban and suburban areas (see New York City example for distributed reuse implemented within a highly urbanized city). Some projects have been driven by connections to green building and sustainable design where the reclamation of water close to the source and reuse location is desired for efficiency. Other projects have been driven by a desire for independence by communities not willing to sink large sums of money (and associated financing, debt service, and customer implications) into centralized sewer connections to maintain their economic and societal sustainability. Still other distributed system approaches are being driven by mainstream water utilities seeking to optimize their infrastructure and efficient delivery of water services to their customers. Examples of this final category include utilities managing cluster treatment systems, as well as those implementing sewer mining and satellite reuse systems. Satellite systems are regional or neighborhood scale systems with a primary purpose of reclaiming and reusing treated effluent closer to the source and reuse area while sewer mining refers to a sewerline tapped to provide raw sewage to be treated for localized reclamation and reuse. Both satellite and sewer mining systems are typically integrated with existing infrastructure, being interconnected to a centralized collection system as a backup and/or to discharge residuals.

New York City: Battery Park, Manhattan Urban Water Reuse

The Battery Park City Authority (BPCA) is a state authority that was created in 1970 to develop 92 acres of land that was created along the Hudson River on the southern end of Manhattan in New York City for the highest and best use for New York City by establishing a mixed-use community that performs with less environmental effect than traditional urban communities. Its Environmental Residential and Environmental Commercial Guidelines established goals and objectives for a sustainable urban development which include energy, water, and air quality and conservation attributes.

All of the projects have followed the United States Green Building Council's Leadership in Energy and Environmental Design (LEED) program for new construction and have earned LEED Gold or Platinum certification. Specific requirements for water management include treating all wastewater and reuse to maximum extent possible with an onsite Reclaimed Water Treatment System, using ecology-based treatment processes (i.e., ultrafiltration), as opposed to a chemical treatment system, for reclaimed water treatment, and using reclaimed water for toilet flushing, cooling tower makeup, irrigation, laundry (to the extent allowed), building and sidewalk maintenance. The stated goal is to: "Minimize the impact on New York City's sewer system and reduce the use of potable water by treating and reclaiming water from lavatories, toilets, showers, sinks, laundry, and dishwashing facilities."

Although the various water reuse systems are similar in nature and function, each have individual designs with slightly varying operational characteristics. The individual systems are owned by the building owners and are operated by a single private utility company, Applied Water Management, under operating agreements with the owners.

Website: www.batteryparkcity.org

Concepts: ***distributed management, integrated resource management, resource recovery, public-private partnership, multi-functionality***

Activities ongoing for our case study community of Northern Kentucky provide a good example of the distributed infrastructure management from the stormwater management perspective. SD1 is using green infrastructure to achieve some wet weather runoff reduction that contributes to CSOs. As a part of leading by example, SD1 has incorporated green infrastructure into their main administrative campus including a green roof for initial water capture and enhancement of building energy efficiency, a large cistern for storage of rooftop runoff, and a constructed wetland for capture, treatment, infiltration and evaporation of runoff from campus impervious surface (see photos below).

Sanitation District #1 of Northern Kentucky: Distributed Stormwater Management

SD1 is leading by example. While working with the local communities in Northern Kentucky to adopt and implement low impact development (LID) approaches, SD1 has incorporated green infrastructure into its own campus. Demonstrations include a greenroof, cistern and constructed wetland (see photos below).

Green Roof

Wetland

Cistern

Photos courtesy of SD1

Website: http://www.sd1.org

Concepts: ***distributed management, resource recovery, multi-functionality***

The key points associated with this subtopic follow.

- Water service delivery should utilize a distributed infrastructure approach whereby a range of infrastructure scales (decentralized to centralized) and technologies are deployed under a centralized management and oversight framework. These infrastructure scale decisions should be made within an integrated planning framework optimizing across triple bottom line indicators, using equitable and robust cost/benefit tools.

- For wastewater, distributed system technologies range in scale from onsite or on-lot to cluster or neighborhood to optimized centralized systems; for stormwater, dispersed systems are associated with low-impact design and related best management practices (BMPs) as part of a green and gray infrastructure approach.

Where Can I Learn More?

The National Decentralized Water Resources Capacity Development Project (NDWRCDP) is a cooperative effort funded by the U.S. Environmental Protection Agency (USEPA) and administered by the Water Environment Research Foundation (WERF) which supports research and development to improve our understanding and strengthen the foundations of training and practice in the field of onsite/decentralized wastewater and stormwater treatment. A variety of publications and other useful information can be found at their website: http://www.ndwrcdp.org/.

WERF seeks to improve the capacity of public and private agencies to respond to the increasing complexities of, and expanding need for, decentralized wastewater and stormwater systems, as part of an integrated water management approach. WERF will achieve this primarily through support of research and development projects that help communities, engineers, regulators, and others address critical knowledge and information gaps in decentralized systems. Information about WERF's decentralized water management research as well as the latest products and tools arising from past projects can be found at their website: http://www.werf.org/decentralized.

The Using Rainwater to Grow Livable Communities website is designed to encourage and facilitate the integration of stormwater BMPs into development projects in your area by providing tools and resources for effective communication and implementation as well as in-depth case studies that examine BMP integration in several cities across the United States. http://www.werf.org/livablecommunities/

EPA concluded in its 1997 Report to Congress that "adequately managed decentralized wastewater systems are a cost-effective and long-term option for meeting public health and water quality goals, particularly in less densely populated areas." EPA's decentralized wastewater website offers valuable information and resources to manage onsite wastewater systems in a manner that is protective of public health and the environment and allows communities to grow and prosper: http://cfpub.epa.gov/owm/septic/index.cfm.

The Low Impact Development Center was established to develop and provide information to individuals and organizations dedicated to protecting the environment and our water resources through proper site design techniques that replicate pre-existing hydrologic site conditions. The Center focuses on furthering the advancement of Low Impact Development technology. Low Impact Development is a new, comprehensive land planning and engineering design approach with a goal of maintaining and enhancing the pre-development hydrologic regime of urban and developing watersheds. http://www.lowimpactdevelopment.org/

Technological Approach #3: Multi-benefit Infrastructure Solutions

While water infrastructure systems are typically designed to meet the specific objectives of treatment and management of potable, waste and storm waters, other functions may be considered in the planning and design process. The water management systems themselves can be considered an amenity provided that appropriate planning and technical expertise are brought into the design process at its outset.

Natural treatment systems can double as recreational spaces for the public while potentially restoring ecosystems and their functions (see Tucson-Pima County example below). Likewise, treatment or effluent dispersal systems can become a functional and attractive part of the landscape. Preserving forested areas in drinking water supply watersheds not only enhances the safety of the water supply, but can also protect ecosystems, create recreational opportunities, and provide carbon credits.

Tucson-Pima County: Multi-Purpose Environmental Restoration

Pima County has integrated stormwater capture, wastewater reclamation, wetland restoration and natural resource amenities as a part of its water infrastructure management approach. Below are photos of the recently completed Kina Restoration Project and the proposed Avra Black Wash Reclamation and Riparian Restoration Project. (*Photos courtesy of the Pima County Regional Wastewater Reclamation Department*).

Kino Environmental Restoration Project

Proposed Avra/Black Wash Reclamation and Riparian Restoration Project

Website: http://www.tucsonpimawaterstudy.com/

Concepts: ***multi-benefit infrastructure solutions, resource recovery, ecomimicry***

Advantages from multifunctional water infrastructure design may not be immediately recognized. For example, creating an educational element to a wastewater treatment system can increase public awareness and build more support for the system than it might otherwise receive. Users may become more aware of their environmental footprint, creating additional benefits that transcend the system itself.

Engaging a diverse team of open-minded professionals is critical for facilitating multifunctional design processes. In addition to design engineers, architects, landscape architects, ecologists, and other professionals as needed for the specific project should be integrally involved in the design process. It is just as important to facilitate the creative input of non-technical stakeholders, including community leaders, economic development officers, educators and others as appropriate.

Key points to take away from this subtopic are:

- Built water infrastructure should serve multiple benefits by supporting and enhancing/ restoring natural water ecosystems while providing societal benefits such as recreational amenities, educational features, and synergies with other infrastructure systems (e.g., energy).
- Infrastructure systems that serve multiple uses tend to have cascading benefits which synergistically maximize the environmental, social and economic impacts of individual benefits and add increasing value.

Where Can I Learn More?

The green building movement is driving building- or site-scale wastewater reclamation and reuse systems. In their widely accepted green building rating systems, the U.S. Green Building Council offers up to 10 Leadership in Energy and Environmental Design (LEED) credits related directly to water and wastewater management (USGBC 2009). The LEED rating system has helped drive water conservation and localized (but perhaps not watershed-scale) water quality improvements.

The building-scale or site-scale systems that LEED and other green building rating systems promote can be designed to mimic natural systems and be integrated into the facilities they serve as architectural elements or site amenities, providing multiple cascading benefits including those related to aesthetics, comfort, and microclimate improvements.

The Living Building Challenge (Cascadia Region Green Building Council 2006) provides an alternative to the LEED rating system, by using a benchmark of what is currently possible given the best current knowledge available. It includes a prerequisite for chemical-free, net zero water buildings as well as a requirement to manage all stormwater and wastewater onsite in an integrated system to meet project demands.

Following is a list of Green Building Rating Systems, sponsor(s), and associated websites:

- Leadership in Energy and Environmental Design (LEED), U.S. Green Building Council (USGBC), http://www.usgbc.org/DisplayPage.aspx?CategoryID=19
- The Living Building Challenge, Cascadia Region Green Building Council, http://ilbi.org/
- The Sustainable Sites Initiative, American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center, and others, http://www.sustainablesites.org/
- BREEAM: the Environmental Assessment Method for Buildings Around the World, http://www.breeam.org
- Green Globes, The Green Building Initiative (in the U.S.), and others, http://www.greenglobes.com/
- Model Green Home Building Guidelines, National Association of Homebuilders (NAHB), http://www.nahb.org/generic.aspx?genericContentID=56077
- Green Matrix, Ratcliff Architects, http://www.greenmatrix.net/

Additional discussion is provided in *Pilot Projects on Sustainable Water Management and Green Building Approaches* (EPRI, Palo Alto, CA and The Cadmus Group, 2009).

Technological Approach #4: Work with and Mimic Nature

The Baltimore Charter, signed on March 15, 2007 by participants in a long-range planning workshop convened by the Water Environment Research Foundation (WERF), was drafted as a commitment by a diverse group of professionals to design new water systems that mimic and work with nature. These systems will both protect public health and safety and will restore natural and human landscapes, thus meeting multiple sustainability objectives across environmental, societal and economic areas.

Nature operates with patterns and principles that can be adapted to how we treat and manage water. For example:

- Nature creates order and builds from the bottom up with modular units
- Nature is multi-functional in its forms
- Nature adapts and adjusts to changing conditions
- Nature is cyclic and recycles, uses and reuses
- Nature creates beauty and abundance and no waste

Nature and man can cooperate to rebuild healthy communities and restore natural ecologies through incorporation over time of sustainable infrastructure designs and principles, with water at the center of these designs. This approach is sometimes called “water-centric” design and it is critical to core new paradigm principles that focus on valuing the entire water cycle, aspiring to higher objectives and integrating water management with other infrastructure decisions (see Victoria, BC design example below).

Victoria, British Columbia: Dockside Green Water-Centric Brownfield Redevelopment

Dockside Green is a brownfield redevelopment project in the city of Victoria, British Columbia that provides an excellent example of water-centric design in practice. The site is a former heavy industrial, contaminated site, designated by the City for development. The development concept was based upon an integrated resource management (IRM) construct, with a wastewater collection, treatment, and disposal system that will enhance environmental quality. The core design concept of the onsite treatment train process is a closed-loop cycle minimizing operating costs, while providing a fit-for-purpose, reclaimed water supply used for toilet flushing, landscape irrigation, green roof watering, and an onsite natural stream/pond complex.

A natural stream channel and pond complex has been constructed through the central longitudinal axis of the site, providing direct residential access to a natural landscape feature, maintained in proper functioning condition. This feature has significantly enhanced the valuation appraisal of those residential units fronting the stream/pond system, while significantly increasing the biological diversity of the site. The increased economic return from enhanced real estate value exceeds the cost of the construction of an ecologically viable stream/pond complex. Rainwater capture further augments the closed-loop design process, as rainwater routes are aligned to the stream/pond complex, providing for the design with nature concept of "capture, store, beneficial use." Water within the stream/pond complex can be recycled to provide a range of flow rates to optimize seasonal water quality, as the stream facility provides a natural polishing process.

Finally, the implementation of a closed-loop water management and treatment train process permits the green roofs to be managed such that soil moisture is optimal for plant growth and high rates of evapotranspiration, resulting in significant cooling of buildings and the potential for an urban agriculture-based production of high value crops, as further revenue generation. The natural, terrestrial landscape (contiguous horizontal and vertical connection via the soils) is replaced with an "Island Archipelago" ecology (buildings with ecologically functional green roofs), with the roads and other ground-level structures forming the media within which the "islands" are situated: thus, the essential sustainable design concept that an ecosystem's proper functioning condition must not be lost but may be changed from one functional condition to another."

Website: www.docksidegreen.com

Concepts: ***integrated resource management, resource recovery, multi-functionality, distributed management***

Where Can I Learn More?

The Biomimicry Institute (TBI) promotes learning from and then emulating natural forms, processes, and ecosystems to create more sustainable and healthier human technologies and designs, http://www.biomimicryinstitute.org/.

The Sustainable Water Forum (http://www.sustainablewaterforum.org/), hosted by the Coalition for Alternative Wastewater Treatment (CAWT), supports sustainable water designs and technologies that work with and mimic nature, that restore natural hydrologies and ecosystems, and that provide multiple energy, green space, and other benefits to communities. CAWT is a national alliance of advocates for and experts in decentralized water and wastewater treatment and management. Formed in 1994, the Coalition has focused on analysis of federal, state, and local policies and funding, and on developing innovative approaches in regulations, markets, planning, and community participation.

Ask Nature—a free online database of nature's solutions, organized and searchable by design function, http://www.asknature.org

Mimicry describes a design approach whereby the patterns and responses of nature and communities are used to inform design. Biomimicry is the science of mimicking other organisms or natural systems to solve human design problems. Including a biomimic in the planning or design charrette may offer surprising alternatives from the rich library of biology research. Ecomimicry—learning from "life's design principles" (i.e., nature uses solar energy; there is no waste in nature, etc.)—is a type of biomimicry and can be used to set sustainable planning and design parameters (see Spanaway, Washington example below). Anthromimicry describes design that synthesizes lessons learned by studying the practices of indigenous peoples and communities.

Spanaway, Washington: Efficient water storage mixing using natural fluid flow as a guide

Standpipes (high vertical pipes used to secure a uniform pressure in a water supply system) present a particular challenge for most mixing systems because of unfavorable depth-to-width ratios. The Spanaway Water Company (Spanaway, Washington) discovered the problem of low turnover standpipes first-hand when an operator noticed a layer of condensation on the outside of one of their standpipes and discovered that the content of the tank was substantially thermally stratified creating insufficient residual chlorination and stagnant water with associated taste and odor problems in some areas.

Spanaway decided to install a PAX mixer in an attempt to solve their challenging mixing problem. PAX Scientific is an industrial design firm that has developed fans and mixers based on the spiral geometries found in natural fluid flow. Because PAX's approach translates nature's flow efficiencies into streamlined mixer geometries, the resulting designs reduce energy usage and noise compared to conventional rotors used for mixing. PAX employs these nature-based geometries to significantly improve the performance, output, and energy usage of a wide range of technologies.

The installation of the PAX mixer took less than a day and required no crane or heavy equipment; the only preparation was that the reservoir water level was lowered to 100 feet and isolated until divers could complete the installation, which solved Spanaway's water quality problem in an energy-efficient, cost-effective manner.

Concepts: ***learning from nature, ecomimicry***

Summary for Technological Innovation and Emerging Approaches

The four approaches described above represent ways in which technological approaches and system architectures can support communities operating under the new water paradigm principles in efforts to achieve overarching and specific sustainability goals as established through local efforts. Emerging technologies and approaches for sustainable water infrastructure and resource management typically include the integration of decentralized water management and closed-loop resource recovery systems into existing infrastructure portfolios across a variety of scales from building to neighborhood to region and a sphere of applications from rural to suburban to urban. These emerging technological applications will yield reconfigured system architectures where new and old, and centralized and decentralized infrastructure are integrated synergistically, maximizing the value of the complete system.

A variety of technologies and systems can and should be considered and used based on *context-specific* applications and resource management and infrastructure objectives. Appropriate systems may range from simple, low-tech systems to more mechanical, higher tech systems depending, for example, on the disposition of the product or the area being served. For example, both low-energy or passive, natural wastewater treatment systems and more energy-intensive mechanical systems are capable of reliably producing re-use quality water, although mechanical systems may be more appropriate in highly urbanized areas requiring small system footprints. Alternately, natural systems can be integrated into building spaces and public spaces to serve multiple functions.

Smart, clean and green water collection and treatment technologies should be informed by emerging technical disciplines of nanotechnology, materials science, responsive “smart” controllers, mimicry, and other technologies and approaches under the new paradigm.

Demand side approaches are those that target end uses and have implications throughout the system. Two broad categories of relevant demand-side approaches include water efficiency and smart monitoring and control systems. Water efficiency can be optimized with the end user, by facilitating modifications in behavior with respect to water. Good examples include installing water-saving appliances (including low-flow toilets, showers, waterless urinals) and designing landscapes based on xeriscaping principles (including site design, soil conditioning, native/adapted plant selection, and high efficiency irrigation systems). Smart metering of resource (e.g., water) use can help educate end users while enabling more responsive process controls that optimize system performance and save energy. Demand side rate-setting tools include peak pricing, separate irrigation meters, and credit for reclaimed water, among others.

In addition to the variety of treatment techniques and tools for resource recovery and management which have been discussed in some detail in previous subsections, supply side approaches may also include optimized reservoir management to extend existing water supplies along with innovative and sustainable water source development to both augment and offset potable water demand.

In summary, system architectures need to be context sensitive and should include consideration of the following system elements:

- Integrated water, energy, materials design and architecture at the building/site scale—for the purpose of reducing energy and water use and life-cycle costs
- Neighborhood scale—location/design of buildings, open space, infrastructure, etc. — “eco-blocks” and multifunctional regional facilities
- Municipal scale—networks of embedded and natural systems infrastructure (energy, water, etc.) and urban design in conjunction with centralized systems
- Watershed scale—systematic location of activities in watershed where they maximize ecosystem preservation and quality of life, etc.
- Decentralized (onsite and cluster) wastewater treatment for pretreatment and/or resource recovery prior to dispersal or reuse
- Distributed systems that integrate decentralized and centralized facilities
- Repurposing of existing infrastructure and integration with new infrastructure serving new development and retrofits
- Use of treatment technologies based on natural systems for ecosystem and quality of life enhancements, and associated cascading benefits

4
BUILDING THE INSTITUTIONAL CAPACITY

The second supporting component defined by the research team for the new paradigm (and fourth overall component described) involves building the institutional capacity to facilitate operating under the new paradigm principles and integrating new paradigm technologies and architectures (refer back to Figure 1-1). Although there are innovative and effective technologies available that recover and reuse water, mimic and preserve ecological functions and services, and holistically integrate water, stormwater, and wastewater management, most utilities still rely on conventional technologies. To shift to the new water infrastructure management paradigm, we need to bring together the site-scale innovation being driven by the green building movement with integrated infrastructure and watershed management planning. This water paradigm shift will depend, in great part, on institutional change and building the capacity to support sustainable operations.

During the project retreat, a significant portion of time was spent on discussing various aspects of institutional factors that play an important role in water infrastructure management decision-making including: integrated planning, community engagement, regulatory and programmatic change, and management and financing. For each of these factors, breakout groups for Northern Kentucky and Tucson-Pima County identified opportunities and challenges for each case study community building off of their existing management foundations to help them achieve triple bottom line goals. The results of these discussions and follow up by the research team led to defining several key areas where communities in general can focus on building their institutional capacity, including:

- *Integrated Planning and Smart Growth*
- *Watershed Scale Planning and Management*
- *Full Life-Cycle Costing*
- *Improved Regulations*
- *Enhanced Community Engagement*
- *Investment in Intellectual Capital*
- *Market Mechanisms*

Each of these capacity types is discussed below in more detail. Where applicable, case study information is provided to illustrate the results of preliminary research that helped direct further definition of this component of the paradigm.

Capacity Type #1: Integrated Planning and Smart Growth

Integrated planning links local land use and community infrastructure planning (including water, transportation, energy, parks and recreation, etc.) to reflect local conditions and community values. Smart growth is an urban planning theory that values long-range, regional considerations of sustainability over a short-term focus. Its goals are to achieve a unique sense of community and place; expand the range of transportation, employment, and housing choices; equitably distribute the costs and benefits of development; preserve and enhance natural and cultural resources; and promote public health.

Integrated planning and smart growth connect local land use and community infrastructure planning. This connection and valuing of long-range, regional considerations provides the context needed for sustainable water resources planning and improved sustainability outcomes.

Building this type of institutional capacity is not without its challenges. Across most stakeholder groups—local governments, engineers and designers, and others—the existing paradigm generally relies on specialization (or "siloing") in planning, design and execution with limited coordination to help avoid conflicts in infrastructure development, and, importantly, without recognizing, considering, and celebrating connections between water management and other natural and built infrastructure. Furthermore, the number of entities and number of local planning efforts in a given region can be quite daunting with regard to integration. Under the current paradigm, utilities are often the primary decision-makers; however, they may be subject to numerous conflicting drivers and can be placed in uncomfortable positions by political pressures. To make matters worse, planning areas may not be congruent and the entities may compete for tax dollars and revenue. The incentives and existing structure for integrated planning efforts between different utility service providers may also be problematic as there are few legally established areas that require coordination between these groups with respect to water, sewer or stormwater issues.

Participants in the project retreat discussed some of these challenges regarding integrated planning in the context of each case study community. General consensus held that integrated planning and smart growth are essential tools for supporting sustainable community operations. Opportunities for enhanced integrated planning were identified for each community with consideration given to existing building blocks (see discussion highlights below).

Highlights of Retreat Discussion on Integrated Planningin Northern Kentucky

Northern Kentucky's community objective is to achieve a more regional approach to sustainability, with better recognition of the interaction between different types of infrastructure (water, sewer, stormwater, power, transportation, etc.). SD1 and NKWD have good working relationships with local jurisdictions, planning and zoning agencies, community groups, and other utility service providers in the region providing a reasonable foundation upon which to build a more integrated planning framework. Nonetheless, community representatives see several challenges to accomplishing this integration. Leadership (a local champion) is needed, along with stronger coordination between SD1 and NKWD regarding sustainability policy and infrastructure planning/ investment. Community representatives are also concerned that corresponding state and federal oversight agencies for water, wastewater and stormwater are not currently positioned to coordinate well among themselves and with local institutions.

Given these challenges and objectives, community representatives and advisory panelists identified potential opportunities for Northern Kentucky. In addition to SD1 providing sewer and stormwater services and NKWD providing water services, the region has the Northern Kentucky Area Planning Commission (NKAPC) which coordinates planning with individual local governments and among governments of the region, including developing model ordinances and land use policies. NKAPC is leading the forthcoming update of the Kenton County Comprehensive Plan that will include sustainability planning. NKWD and SD1 will be participating in the Plan development as well as the State Department of Water representatives. The regional agencies can offer the Kenton County sustainability planning as a model for other local governments in the region. Additionally, upcoming rate increases anticipated if conventional practices are used in the future for compliance with SD1's consent decree may provide an impetus for seeking greater efficiency through integrated system architectures organized regionally.

Highlights of Retreat Discussion on Integrated Planning in Tucson-Pima County

Regional planning and management of water resources are essential in the rapidly growing arid southwest since balancing economic growth and preservation and protection of environmental and cultural resources is dependent on a sustainable water future. City and County representatives would like to improve overall community ability to work collaboratively within the dynamic, complex circumstances, and sometimes conflicting interests among diverse stakeholders, to achieve comprehensive integrated planning. The community wants to find tools and incentives that achieve the performance-based planning outcomes of sustainable urban forms, stronger links between land use planning, water resources and infrastructure planning, and growth that is directed to suitable areas and is financially sustainable.

The community faces several challenges in trying to achieve these outcomes. In the past, water and wastewater services were extended throughout the region based on demand. This approach has led to continual expansion of the service areas without regard to sustainability criteria. There are also regulatory and institutional barriers to comprehensive integrated planning such as multiple jurisdictions with distinct land use plans, and multiple water providers, both public and private, with numerous service area boundaries that are not aligned with jurisdictional land use boundaries. Additionally, a lack of defined performance standards for the arid southwest, and the lack of technically-based tools can stymie regional planning due to insufficient backup. The cost of comprehensive planning is extensive, and local capacity may not always be sufficient with regard to infrastructure management.

Given these challenges and objectives, community representatives and advisory panelists identified potential opportunities for Tucson-Pima County. The community can build on existing regional planning efforts such as the *Sonoran Desert Conservation Plan* and joint *Water and Wastewater Infrastructure, Supply and Planning Study.* Key City and County opportunities include directing growth to suitable areas through joint land use and capital investment planning efforts, acquisition of open space, new policies for integrated planning embedded in updated long range planning documents, conducting advance planning of water resources for the future growth areas, and identifying mechanisms for providing renewable water resources to these areas. The existing reclaimed water system can be further developed along with graywater and rainwater harvesting, and linked to land use planning. This will require a new platform for planning across different departments and community programs. Using this platform, the City and County could develop shared water efficiency goals and strategies at the sub-regional and neighborhood scales.

When the case study community breakout groups were brought back together for joint discussion at the retreat, several benefits of integrated planning were identified that provide incentives for working through the challenges, including:

- An integrated community governance structure provides simultaneous oversight of all elements of the community's infrastructure responsive to multiple local objectives. Local plans are implementable and implemented such that all community decision-making considers water.
- Integrated planning connects and coordinates land use and water resource management through the local comprehensive plan, smart growth plan, infrastructure master planning, the development and zoning ordinances, and other local plans, policies, and regulations.
- The plans generated by integrated planning can help to emphasize both collective and personal responsibility in solving local problems and seizing opportunities with greater buy-in due to joint development.
- The adaptive decision-making process within integrated planning is linked to and supportive of sustainable development's triple bottom line.

A number of retreat participants and the research team believe that integrated planning includes technical analysis and performance based standards. As such, there is a need for a planning process that supports these components and that is driven by the local sustainable water resource goals and operating principles. There are multiple methods for organizing the planning process, but one example was generated at the retreat (Figure 4-1). A key first step is finding champions within a community as well as within key agencies to lead the process, and then engaging a broad range of stakeholders—integrated planning integrates multiple perspectives and disciplines (Figure 4-2).

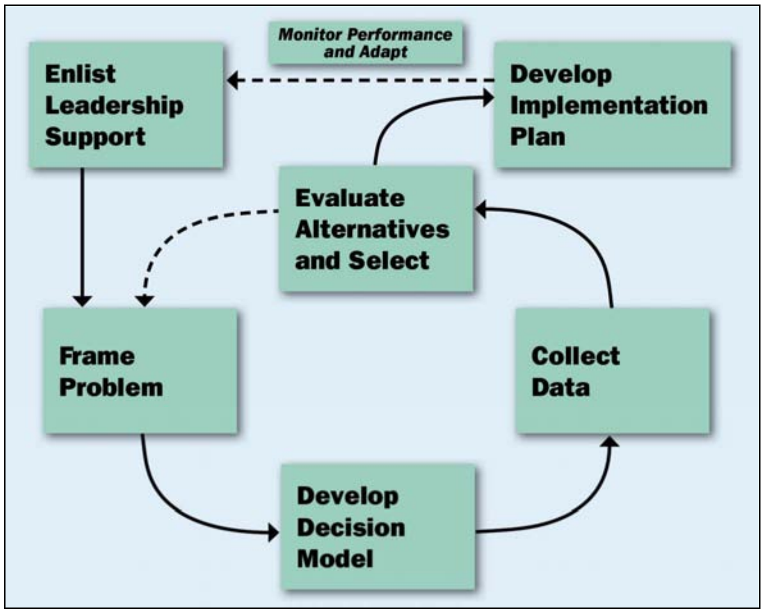

Figure 4-1
Integrated planning process to support sustainable water resources management

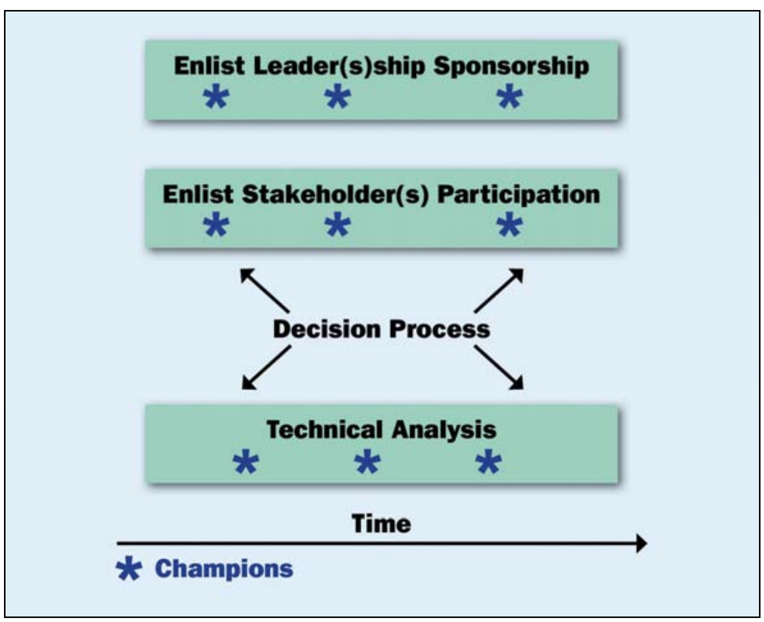

Figure 4-2
A stakeholder driven process led by champions

Another point emphasized by numerous retreat participants is the importance of addressing different levels of integration. In addition to integrating across institutional programs (e.g., water, wastewater, stormwater, energy, transportation, parks and recreation), success is expected to require integration of partnerships (e.g., public-private) and connection of community groups, businesses, and government institutions. Thus, while the planning process outlined in Figure 4-1 is nothing new, the way in which it is carried out is different—reflecting the new paradigm principles.

Capacity Type #2: Watershed Scale Planning and Management

Watershed scale planning and management uses watershed boundaries to organize planning efforts and conduct technical assessments, allowing for a holistic, systems-type approach to water management. This provides the context for understanding local natural constraints and opportunities, as well as the key local drivers for sustainability. It also provides the context for establishing specific environmental performance needs for the community. For example, knowing the long-term watershed performance needed or quality targets for a stream or lake allows developing site-based performance standards for new development that fit the local context and should link to local green building standards.

Developing watershed assessment capacity supports technically-based integrated planning, while also helping to address key challenges under many existing planning approaches. One key challenge is the historical emphasis on human and economic needs, where the general community does not understand environmental issues around the allocation of water. Traditionally, infrastructure decisions have been based on demand for services without evaluating what areas are most suitable and sustainable for future growth. In other words, built water infrastructure tends to have to follow or serve development, rather than focusing development in places that facilitate efficient water service delivery, not to mention preserve and protect existing water resources. Using a watershed-based approach places water infrastructure management within the environmental context where social and economic needs can be considered via triple bottom line evaluation. Per the model shown in Figure 4-2, champions can frame the problem within the watershed context, using assessment models that include indicators for primary goals.

Watershed scale planning and management was not addressed as a separate discussion topic at the project retreat (note that it was a subtopic under the topic of integrated planning), but because of its importance it has been elevated to a separate capacity development recommendation. The case study communities recognize this importance as evidenced by their initial watershed planning applications. Northern Kentucky has developed a watershed approach to help put its CSOs and SSOs into context with other pollutant sources, and to be able to integrate evaluation of gray and green infrastructure and watershed controls. Community representatives stated that this approach is helping them establish priorities and maximize benefits.

Similarly, Tucson-Pima County conducted the Santa Cruz River Watershed Management study to identify major water and environmental resources, and establish appropriate floodplain and stormwater management policies and practices. Objectives include preserving riparian habitat, balancing sediment transport, and minimizing flood and erosion hazards. As part of their future vision, the community sees regional watershed management based on dynamic watershed models that support evaluation of changing environmental conditions. In their urban locations, they see these watershed-based tools helping to optimize decisions for stormwater retrofits needed to achieve their goals and objectives.

Several communities throughout the nation have taken watershed-scale planning to the next level, using it as the basis for integrated water infrastructure planning. One recent example that is worth examining further involves the 17 communities that comprise the Beaver Lake watershed in northwest Arkansas. This regional effort describes how local champions engaged the community stakeholders in establishing some triple bottom line goals and objectives, developed watershed-based assessment tools to evaluate the connection between land use planning and water, established environmental targets to guide performance standards, and developed a Watershed Protection Strategy in light of local social, economic and environmental considerations. The community is continuing to build its institutional capacity to maintain watershed management on an ongoing basis, incorporating performance monitoring and strategy adaptation principles (see Beaver Lake Watershed approach description highlighted below).

Beaver Lake Watershed, Arkansas – Building Watershed-Scale Integrated Planning Capacity

Beaver Lake is the primary drinking water source for more than 350,000 Arkansans, and a major recreational destination. As the principal water supply for the Northwest Arkansas region, the lake is recognized as a lifeline for current citizens and businesses, and for the projected growth of the region. People in Northwest Arkansas also enjoy the beauty of the lake – the large open water and surrounding hills.

The majority of the year, the lake meets the State's water quality standards. However, the upper end of the lake is impacted by sediment and algae. This in turn affects drinking water quality, recreation, and aquatic habitat in the upper lake. In an effort to proactively address the potential for problems and protect water quality, the Northwest Arkansas Council initiated the development of a Beaver Lake Watershed Protection Strategy.

The lake protection planning process involved working closely with a 23-member Policy Advisory Group (PAG) representing diverse interests and a Technical Advisory Group (TAG). Early on, the PAG established guiding principles, goals and objectives for the Beaver Lake Watershed Protection Strategy. The Overarching Goals are:

1. Maintain a long-term, high-quality drinking water supply to meet present needs and continuing growth of the region.
2. Restore water quality of impaired stream and lake areas (as listed on ADEQ's list of impaired waters).
3. Minimize additional costs and regulations for people living and working in the watershed.

A watershed modeling tool and lake response modeling tool was developed that could help to evaluate existing conditions and predict future conditions (year 2055) under current policies, or Baseline Conditions. The models were subsequently used to predict future conditions under different water quality protection alternatives. Results were evaluated and reported in light of the lake protection goals and targets. Costs for different management techniques were reviewed and evaluated to screen for the most cost-effective solutions.

The Beaver Lake Watershed Protection Strategy has five complementary components:

Beaver Lake Watershed Council: A diverse group representing different interests that would provide sustained leadership for lake protection, including implementing and adapting the Beaver Lake Watershed Protection Strategy.

Core Best Management Practices (BMPs): The Core Voluntary BMPs hinge on a voluntary and targeted land conservation program involving conservation easements or conservation agreements. Easements can be achieved through donation or purchase, a voluntary carbon credit program, and a voluntary Transfer of Development Rights program. They also include improved construction site management, riparian buffer and bank restoration, pasture BMPs, buffer preservation, unpaved road improvements, and stormwater BMP retrofits in developed areas. A number of these voluntary BMPs do "double duty" in reducing sediment and phosphorus loads to the lake and helping to mitigate current sediment loading in the existing impaired streams.

Protection Certification Program: For local governments, site design engineers, developers, and contractors willing to implement protective stormwater controls for new development in the Municipal Planning Area and sign a Lake Protection Pledge.

Education and Stewardship Program: Community outreach to teach property owners about lake protection efforts and how they can help.

Monitoring and Adaptive Management: To address uncertainty and changing conditions and provide early warning signs—or water quality trigger points—for needed changes.

Open space preservation in the watershed can provide multiple benefits: enhanced drinking water safety, reduced or avoided treatment costs, ecosystem preservation or restoration, recreational opportunities, carbon offsets, more focused development in planned urban areas, and watershed aesthetics—all of which contribute to the region's sustainability and quality of life. The region is also considering other sustainability approaches such as biomass to energy facilities.

Concepts: ***watershed scale planning, integrated planning, building intellectual capital***

Key summary points with regard to watershed scale planning and management are:

- Conduct assessment and planning at multiple watershed scales—from building lot and large development along a stream corridor to the small neighborhood watershed to the large regional watershed or river basin. This nesting of watershed scales allows for a holistic, systems-type approach to water management, and is critical to integrating water supply, stormwater, and wastewater management.
- Watershed tools should be used to assess multiple management objectives with indicators that cross multiple environmental, financial, and social sustainability decision criteria. Tool selection, including computer models, requires thoughtful consideration. Recommended methods and criteria are available in the USEPA's *Handbook* and *Compendium* resources highlighted below.

Where Can I Learn More?

Handbook for Developing Watershed Plans to Restore and Protect our Waters, USEPA, http://www.epa.gov/nps/watershed_handbook/

Compendium of Watershed Modeling Tools, USEPA (EPA841-B-97-006)

Framework for Watershed Management Programs, WERF (PROJECT 93-IRM-4)

Center for Watershed Protection, www.cwp.org

Capacity Type #3: Full Life-Cycle Costing

Infrastructure choices historically have been made using a limited amount of information to inform decision-making. Capital-improvement planning typically only considers study, design, permitting, and capital and recurring costs in quantitative comparisons of alternatives over a relatively short period of time (e.g., 20 – 30 yrs), without considering the full costs of infrastructure including externalities in decision-making. Under the current paradigm, risks are borne by the community, as passed on to the utility by the engineer. This drives decision-makers toward projects perceived to have low risks, hindering innovation while ignoring very real risks related to impending or emerging concerns, such as energy shortages and climate change impacts. Decision-support evaluations can be made far more robust and equitable by assigning costs to what are currently considered "externalities" in infrastructure planning in what is known as "full-cost accounting."

Full cost accounting factors the true costs and benefits of water and other resources into infrastructure development and asset management. Several key elements need to be considered in a full-cost accounting evaluation for water management and infrastructure:

1. Accounting for costs rather than financial outlays
2. Accounting for life-cycle costs of decisions or options, where the goal is to compare the full range of environmental and social benefits and damages assignable to products and services
3. Accounting for hidden (e.g., overhead and indirect) costs
4. Accounting for secondary effects of decisions

5. Accounting for past and future outlays associated with the decision or option
6. Accounting for avoided costs associated with decisions or options
7. Accounting for the value of natural resources and ecosystems (i.e., natural capital and services)
8. Using 30-, 60-, 90-year useful life assumptions for net present value (NPV), with sensitivity analysis

When the full and true costs of infrastructure decisions are considered over the full life cycle of water infrastructure, more sustainable solutions will be favored, fueling a transition to the new paradigm.

Full life-cycle costing was not a separate topic discussed at the project retreat. However, it was a recommendation brought up by numerous retreat participants during general discussion of management and financing under the new paradigm. The case study communities are aware of the approach, but have not found practical means for implementing it at this time. One of the retreat participants who is a native of Australia indicated that the concept was gaining traction in his country as communities are developing the capacity to perform life-cycle costing analyses. A brief description of some of these efforts is provided below (see Australian Experience highlight).

Australian Experience

In 1999, Sydney Water performed its first ISO-compliant life cycle assessment (LCA, defined as evaluation of the environmental impacts of a given product or service caused or necessitated by its existence) on biosolids management options (Peters and Lundie 2002) and has since done similar work on disinfection techniques, sludge digestion alternatives (Beavis and Lundie 2003), water sustainable urban design (WSUD) concepts (Dean et al. 2003) and the world's first megalopolitan water cycle LCA (Lundie et al. 2004). Combined with a simple life cycle costing, it examined a number of future scenarios, from variations in future population statistics, to desalination and WSUD concepts (Lundie et al. 2006).

Elsewhere in Australia, Yarra Valley Water published an LCA and life cycle costing (LCC) study of the sustainability of rainwater tanks (Hallman et al. 2003) as well as studies on WSUD (Grant et al. 2006) and the relationship between pressure and gravity sewage conveyance (Narangala and Trotter 2006). The South Australian Water Corporation performed its first LCA in 2002—a retrospective comparison of treatment alternatives at the Bolivar Sewage Treatment Plant. Subsequent work has examined water supply alternatives (including desalination) for the Eyre Peninsula (Peters and Rouse 2005) and alternative reticulation options in its Adelaide water supply (Peters et al. 2006).

Concept: ***life-cycle costing***

Communities wishing to learn more about practical methods for application can go to the sources referenced below.

Where Can I Learn More?

Costing for Sustainable Outcomes in Urban Water Systems: A Guidebook was written by The Institute for Sustainable Futures at the University of Technology, Sydney for The Cooperative Research Centre for Water Quality and Treatment in Australia. It can be accessed here: http://www.waterquality.crc.org.au/publications/report35_costing_sustainable_outcomes.pdf

USEPA includes full cost pricing as one of the four fundamental pillars of its Sustainable Infrastructure for Water & Wastewater program. Additional information about the program can be found here: http://www.epa.gov/waterinfrastructure/index.html

Capacity Type #4: Modifying the Regulatory Approach

Breakout discussions on regulatory and programmatic change were conducted at the project retreat. This topic generated considerable debate among participants, as some believe that current regulatory practices are among the biggest barriers to the new paradigm while others believe that the current regulatory framework brings much more attention to the environmental considerations of water infrastructure than would otherwise be given by many communities. However, if communities commit to operating under the new paradigm principles (i.e., value the resource, aspire to higher objectives that spawn better outcomes, consider context at multiple scales), then this opens up the door for regulatory modifications to remove barriers and create incentives for sustainable water infrastructure management.

The research team and retreat participants have identified some important barriers to address:

1. *Regulatory Program Silos*: There is a perception that many federal and even state regulations do not adequately consider local scientific context in their application. The federal Clean Water Act (CWA) and Safe Drinking Water Act (SDWA) regulations continue to drive specialized, linear water management systems that are well-suited to address some relatively well-defined issues (public health, hygiene, flooding) but that are less suited for addressing more complex emerging problems (climate change impacts, ecosystem impairment, hydrologic cycle disruption) which require more systemic responses. The fact that there are separate EPA programs for water, stormwater and wastewater (with the first falling under the SDWA and latter two falling under the CWA) illustrates this issue. It has been suggested that an overarching U.S. Sustainability Act could help reconcile issues associated with the CWA and SDWA.
2. *Prescriptive Compliance*: A risk-averse approach is institutionalized within most water-related regulatory agencies at all levels of government. This approach often manifests in regulations which prescribe specific solutions rather than specifying performance standards which leave methods of compliance to communities and designers. The prescriptive approach under most circumstances stymies or at least disincentivizes innovation. While interested in promoting improved processes, regulatory entities as well as the environmental community are often afraid of losing enforcement capability associated with prescriptive requirements. Regulators and some environmental non-governmental organizations (NGOs) may also be wary of "signing off" on an innovative project given a perception of greater risk—

particularly when lacking staff resources to review such designs—and perhaps opening a precedent for other unfamiliar designs. Practitioners, regulators, and other interested stakeholders will need to know how to determine a "functioning system" when performance rather than prescriptive standards is used.

3. *Conflicting Regulations:* Many instances of regulations that create disincentives or even outlaw more sustainable water practices have been documented. Some examples include:
   - Zoning/subdivision regulations banning permeable pavement, or prescribing street widths, setbacks, open space, parking and other requirements in such a way as to limit or prohibit effective use of green infrastructure
   - Plumbing codes which ban the treatment and reuse of graywater or impose strict requirements on interior use of reclaimed water
   - Weed ordinances (essentially requiring mowing down to the stream's edge) which often prevent use of natural areas while increasing lawn size and subsequent irrigation requirements
   - Western water rights which sometimes prevent stormwater capture, use and recharge
   - For decentralized wastewater infrastructure, a backup system is often required (i.e., 100 percent repair area) which poses a significant barrier especially to retrofitting existing development

   Regulatory impediments to sustainable design and development and service delivery should be identified and eliminated. This requires close evaluation of state and local codes, ordinances, policies, and administrative procedures.

4. *Uncontrolled Land and Water Use:* In some cases, a lack of control or regulatory coverage makes effective water management difficult. For example, the City of Tucson and Pima County have no regulatory authority for groundwater withdrawal even though extractive industries are depleting aquifers in the region affecting the community's water supplies. Additionally, it is difficult to effectively design and implement reuse or green infrastructure without the integration of land use regulation and water use.

To move to the new water paradigm, codes need to be modified to include performance-based standards to allow more flexibility and to encourage solutions that are both more creative and responsive to the needs of a development site and a community (i.e., context sensitive). Risk assessment that incorporates watershed scale planning and full life-cycle costing tools provide the means for establishing that context and performance standards. Additionally, incentives should be incorporated into regulations and programs to encourage the use of sustainable approaches (e.g., expedited permitting or development review; certification/awards programs; tax credits).

Modifying the regulatory approach will involve some relatively straightforward decisions to address some barriers (e.g., local conflicting ordinances, integration of land use control and water use) and much greater effort for the more complex issues (e.g., program silos, prescriptive compliance). Opportunities for the two case study communities were discussed at the project retreat and are highlighted below.

Highlights of Retreat Discussion on Regulatory and Programmatic Change in Northern Kentucky

Planning in Northern Kentucky is managed through a relatively large number of planning and zoning entities. Ideally, local regulations that affect water quality would be developed with the input of all necessary parties, with everyone operating from a basis of clear understanding of the issues.

From SD1's and NKWD's perspective, the federal and state regulations related to water and sanitary sewer service are sometimes overly restrictive and lead to the allocation of funds towards projects that yield minimal results. For example, all sanitary sewer overflows are deemed "illegal" by the USEPA with little recognition of the complexity of those problems. Many of SD1's SSOs are small volume overflows that occur during relatively large rainfall events and represent a minimal source of pollution into streams that are impacted by many other sources of water quality impairment (failing septic systems, urban runoff, loss of riparian corridor, etc.). The elimination of such SSOs often requires the use of funds that could provide more benefits if they were directed toward other water quality improvement projects. An ideal regulatory/programmatic paradigm would be based on reasonable, flexible, and scientifically-based federal regulations affecting water, sewer and stormwater utilities.

One opportunity that the community can act on in the near term involves using the forthcoming Kenton County comprehensive plan update to identify and address barriers in local ordinances to better support sustainable approaches such as green infrastructure. Longer term, the Northern Kentucky representatives would like to work with state and federal agencies to establish context-based regulations. This could include looking at all sources of pollution in the watershed and determining where proper management will result in the best bang for the buck.

Highlights of Retreat Discussion on Regulatory and Programmatic Change in Tucson-Pima County

The City and County assume the trend of more stringent regulation will continue. Their objectives as the regulatory framework evolves include:

- Improve understanding of arid western ecology, research arid west water quality criteria, and establish appropriate regulatory standards for arid conditions.
- Move from a prescriptive-based approach to a performance-based approach; accomplish this in a more holistic manner than current separated programs (silos) approach.
- Move away from risk averse regulation toward support for innovation and adaptive approach.

A big challenge to the community is that western water rights do not necessarily support water conservation (e.g., sometimes preventing stormwater capture, use and recharge) and performance-based approach. Additionally, Arizona regulations have prescriptive processes that are not flexible which is an impediment to innovation (e.g., method for classifying reuse water).

Some near-term opportunities identified included mandating performance standards for new development, and reviewing current codes for impediments and developing model codes that support the sustainable water infrastructure approach. Training of regulatory staff is necessary to increase understanding of sustainable water infrastructure technologies and architectures and how to implement a performance-based process. The community will need to incorporate faster verification measures for new technologies into the more flexible regulatory process. Additionally, the City and County can jointly advocate for policy and rule changes to overcome barriers to maximizing use of reclaimed water and to dissuade the use of groundwater when other renewable sources are available.

Capacity Type #5: Enhancing Community Engagement

Considerable time at the project retreat was focused on the topic of enhancing community engagement. Many of the attendees believe that, in some areas, there is a lack of support for more sustainable methods of wastewater and stormwater management because stakeholders may perceive their community as having a plentiful water source, there is a lack of appropriate incentives, or other reasons. The complexity of issues surrounding sustainability and mixed messages delivered by the media can make it difficult to establish strong understanding among the public. Regional public consensus is lacking on public values regarding issues related to sustainable water resource planning and management such as quality of life tradeoffs associated with conserving water, the priorities and appropriate balance of human, environmental and economic needs for water, and the acquisition of future supplies. A recent case in San Diego where the general public overwhelmingly rejected water reuse illustrates the challenge for raising public awareness.

At the individual level, people in theory want "green" solutions, but need to see how it makes their living experience better; how the beauty of Low Impact Development enhances neighborhood aesthetics; how new sustainable water practices make water at their tap more reliable; how water conservation saves money; how community space and civic art can be created using green infrastructure; how this natural infrastructure makes for more healthy living in their neighborhood, and that it adds to long-term profit and property values. It is essential to communicate the social and economic benefits first, then the stewardship benefits behind sustainable design and water management. People need to see how it can work in their community or region. Create spaces that encourage innovative approaches. This could include charrettes, incubation or demonstration projects, and design competitions.

Transparent, effective planning processes that engage stakeholders require strong leaders as well as a supporting structure; therefore if leaders leave a community, someone else can step up and take their place. Leaders of the new paradigm will know how to identify and communicate a real suite of benefits for sustainable infrastructure projects and system architectures. Leading communities will figure out how to promote innovation and collectively take the risk of implementing new solutions. Communities need to focus on developing their leadership capacity by fostering the creative, entrepreneurial power in the community for innovation and infusing it within the planning process. One option is to train young leaders throughout all levels of the local school system.

During the retreat, Northern Kentucky provided a presentation on how they have begun to engage the community in stormwater management. Highlights of the program are summarized below.

Northern Kentucky: Engaging the Community in Stormwater Management

SD1 manages the stormwater program on behalf of 31 cities and 3 counties. It developed interlocal agreements with all of these jurisdictions and worked with them to come up with the stormwater requirements. Through its stormwater permit compliance program, SD1 has an award winning public education program. Public Education and Outreach weaves throughout everything that they do. The program includes:

An interactive outdoor learning center called Public Service Park that features environmental best management practices. The park was built with contractors and developers in mind but turned into an extensive education and outreach project. SD1 hosts tours for engineers, schools kids, community groups, etc.

An educational program taught in over 60 elementary schools (4th and 5th graders). The program has been successful at the elementary level. Therefore, programming for middle and high school students is currently being developed. A 200 level college course titled "Protecting Water Resources" began at NKU in fall 2009.

Waterific, a hands on science fair all about water tailored for sixth graders. Students are given the opportunity to interact with many local environmental agencies and learn how these organizations work to better the water resources and quality of life in Northern Kentucky. Typically about 300 kids attend.

A protecting the environment award program in which schools apply for funds to help complete a stormwater related project. Applications are reviewed by outside agencies and the money awarded to the winners is supplied through a Wal-Mart grant.

Adult Education: workshops, seminars, educational resources and media outreach. All programs and resources are developed with the intent to encourage a change in behavior.

Contractor and Developer Awards Program recognizes one contractor and developer for bettering the community through employment of erosion and sediment control BMPs.

Concepts: ***enhanced community engagement, building intellectual capital***

During the breakout session for Tucson-Pima County, several opportunities for enhanced community engagement were proposed. Highlights of the discussion are shared below.

Highlights of Retreat Discussion on Enhanced Community Engagement in Tucson-Pima County

The City and County want to assure effective community participation in determining and realizing a sustainable water future in the region. Diverse participation, two-way dialogue and response to public input are key facets of effective public participation. Diverse participation means inclusion of non-expert community members in water and wastewater management allocations, policy, and planning decisions. Non-expert participation requires that they acquire a basic understanding of issues, options, and decision tools. In addition, they need to understand the science, the areas of uncertainty, the areas of disagreement, and needs for additional information without delaying decisions that must occur in the absence of perfect information.

Opportunities to expand public participation in water resource management decision making include the upcoming regional visioning process and the updates of the Pima County Comprehensive Plan and the City of Tucson General Plan. Successful methods that have been used in the past that are being considered include training of community leaders to conduct round table dialogues within existing forums and organizations to obtain broad and substantive input across a diverse cross section of the community.

Capacity Type #6: Building Intellectual Capital

Although it was not the topic of a specific breakout discussion at the retreat, the importance of building intellectual capital came up during the course of several other discussions. It was noted that most of the practicing engineering community lacks an adequate level of expertise in sustainable infrastructure approaches and thus promotes more familiar traditional infrastructure concepts. This is exacerbated by the lack of understanding and support of water quality issues by the community at large and its decision-makers. Additionally, some believe that the quantity of water-related research is declining to the extent that the United States is falling behind less developed countries in terms of technological innovation in the water and resource management field. Thus, building intellectual capital (i.e., using research and information management technologies to advance knowledge and spur innovation) throughout the nation will be important to supporting operations under the new paradigm. Through investments in intellectual capital, efficiencies will be realized, producing more integrated, sustainable water management goods and services.

The new water infrastructure management paradigm introduces more complexity than the more linear and segregated systems of today. Therefore, systems thinking needs to be cultivated in all participants in water resources management—regulators, agency personnel, existing practitioners, and the community at large. Additionally, recent and future experiences with integrated water management systems need to be effectively captured and assessed, with the resulting knowledge transferred to others. It is essential that spaces, such as research and demonstration projects, be provided for innovative and creative ideas to be explored with lessons learned used to build the intellectual capacity needed to successfully adapt the new paradigm. The role of demonstration projects—and their associated monitoring and documentation—are particularly important in advancing improved designs and architectures.

Other recommendations made for building intellectual capacity include:

- Use latest information management technologies to provide the feedback needed for adaptation
  - Smart controls that maximize system efficiency, allow for remote monitoring, and educate users
  - Remote monitoring devices that can be used to continually update knowledge about system performance
- International, national and locally-sensitive clearinghouses of technology transfer are needed
- Continually develop and update guidance documentation

Where Can I Learn More?

The Water Environment Research Foundation (WERF), formed in 1989, is America's leading independent scientific research organization dedicated to wastewater and stormwater issues. Over the past 20 years WERF has produced 300 research reports, valued at over $62 million. www.werf.org

WateReuse represents an international group of organizations and individuals working together to improve and increase local water supplies. WateReuse consists of two independently governed organizations with a unified mission and combined staff – the WateReuse Association and the WateReuse Foundation. www.watereuse.org/.

The Water Research Foundation, formerly the American Water Works Research Foundation, is a member-supported, international, nonprofit organization that sponsors research to enable water utilities, public health agencies, and other professionals to provide safe and affordable drinking water to consumers. The Foundation was established in 1966 to provide a centralized, practical research program for the drinking water community, www.waterresearchfoundation.org/. The Water Research Foundation is the independent research arm of the American Water Works Association www.awwa.org./.

Society for Organizational Learning, www.solonline.org

Sustainability Institute, www.sustainer.org

Capacity Type #7: Market Mechanisms

Market mechanisms were discussed at the project retreat under the breakout group topic of Management and Financing. Limited funding for local communities to implement sustainable water management efforts remains a challenge so finding alternative means to financing water infrastructure was highlighted by a number of retreat participants. The lack of adequate tools can stymie planning processes because there is insufficient backup for ideas that are presented. The cost of full and comprehensive planning processes to accommodate growth can be high. Additionally, the current economic climate limits capacity for conducting outreach to the degree warranted—the bottom-up approach is highly effective in implementing community-wide sustainable water management but it is also very time and resource intensive.

Primary revenue sources for water service providers typically come from customer billing, which is based on usage—water rates often go down for larger users. This structure provides little incentive to encourage water conservation. In fact, utility regulators in some jurisdictions may set rate structures that prohibit conservation pricing. In the case of Tucson-Pima County, unregulated groundwater withdrawals mean that some significant water resource users have no incentive to reduce consumption or use reclaimed or alternate sources—the cost of reclaimed water resources is perceived as high relative to groundwater.

Market mechanisms for natural resources and services need to be developed at a programmatic level to provide incentives for multiple parties to support (i.e., leverage) new paradigm implementation. The key is to develop diversified and consistent funding mechanisms that incentivize sustainable practices while funding integrated planning. Examples of such market mechanisms are carbon credits and nutrient trading. Another example would be to tie economic development to green jobs, and provide incubator funds for startups. See the example below on the "Conservation Marketplace" being developed by the Idaho National Laboratory in partnership with SAS.

Conservation Marketplace

The Idaho National Laboratory in partnership with SAS is setting out to fundamentally change renewable energy and environmental stewardship by building a science- and economics-based marketplace to manage, buy and sell conservation and stewardship information and services. The "Conservation Marketplace" is intended to create new ways for businesses to create value, consider risk mitigation, differentiate among competitors, realize new revenue streams through ecosystem services protection, access capital and new markets, and save on costs. The project will promote new mindsets on the part of regulators and key stakeholders that prioritize holistic ecosystem approaches over siloed management of air, freshwater, biodiversity, etc.; new market valuation techniques as trendsetters incorporate ecosystem services into their research; and new criteria for project finance and credit, as financiers signal that some environmental assets are priceless.

Concept: ***market mechanisms***

Opportunities for alternative financing were discussed at the retreat for each of the case study communities (see highlights listed below).

Highlights of Retreat Discussion on Financing in Northern Kentucky and Tucson-Pima County

Northern Kentucky indicated that they could aim long-term toward making sustainable practices the community standard and requiring private development and ownership. In the short-term, SD1 and NKWD believe that they could jumpstart the design and construction of the sustainable practices through incentives and public funding. They would anticipate requiring covenants or contracts to ensure that such facilities are maintained over the long-term.

Tucson-Pima County is interested in creating consortiums for funding projects, leveraging funding to a much greater extent than under current approaches. They will likely continue to ~~push the~~ allocate the full cost of growth for future customers onto the development industry, and fund rehabilitation and replacement of existing infrastructure through charges to current customers. The City and County are already studying how to take advantage of integrated funding opportunities with joint effluent and reclaimed water projects. They also believe that they will need to provide financial incentives to achieve higher rates of application of new paradigm principles. One idea is to use water conservation savings to fund environmental projects ("Conserve to enhance," e.g., customers earmark savings to go to environmental restoration).

5
EVALUATE OUTCOMES AND ADAPT

The fifth and final component defined by the research team for the new paradigm involves evaluating the outcomes of a community's water infrastructure management approach and adapting goals, policies, tools, methods and/or operations as needed where performance assessments indicate an unacceptable shortfall from established goals and objectives. This component was not a separate discussion item at the project retreat, rather it grew out of the participants' dialog regarding the core principles of the new paradigm—that innovation and aspiring to better outcomes involves learning from earlier results (and information from new research) and incorporating change to try to improve future results. Outcomes are often uncertain when charting new waters, so monitoring results iteratively allows decisions to be optimized over time to reduce uncertainty and improve the outcome. Since this topic was not discussed in depth by retreat participants, the research team conducted a limited amount of follow-up to provide the following overview. There is certainly more than one method that is applicable here, but the general concepts are expected to be similar.

Per the defined new paradigm (refer back to Figure 1-1 as needed), triple-bottom line goals and objectives are defined, and communities operate under the sustainable infrastructure principles to generate water infrastructure outcomes in line with the goals and objectives. Integration of sustainable technology approaches or system architectures is applied within those operations to help generate the outcomes. Similarly, institutional tools (e.g., integrated planning, watershed models, full life-cycle costing, etc.) support management operations (including the setting of performance standards at multiple scales) and applications of technologies and systems. When decisions on water infrastructure are made or infrastructure projects are completed, this evaluation and adaptation component comes into play. Those decisions/projects are evaluated against the triple-bottom line objectives, which requires selecting indicators for each or representative objectives.

Targets or performance standards that have been set for the indicators provide the basis for evaluation. If targets or performance standards are not met, evaluators move into a diagnostic phase (where does the problem lie?—goals? technologies? application? policies? operations?). Based on the lessons learned from this diagnostic review, and any new information (e.g., related new research), stakeholders identify solutions or new approaches to take for the next iteration. Selecting the refined or new approaches will likely involve using the support tools (e.g., watershed models, full life-cycle costing) for infrastructure projects to provide triple bottom line justification. The community then moves forward to implement those changes, and the evaluation process cycles through another iteration.

These steps are summarized below in outline form for quick review:

1. Monitor outputs (decisions, infrastructure)
2. Evaluate performance (using indicators and performance standards for triple bottom line objectives)

   Are objectives/performance standards being met? If yes, continue with approach but consider any new information (research, other project results) for potential improvements/innovations that will perform even better (see step 4). If no, proceed to step 3.

   1. Diagnose problems
      a. What are the reasons for the objectives/performance standards not being met?
      b. What needs to be changed (goals, technologies, policies, operations, other)?
   2. Identify solutions/new approaches
   3. Evaluate alternatives as necessary to select new approach
   4. Implement changes

   (repeat cycle)

Where Can I Learn More?

Williams, Byron K.; Robert C. Szaro; Carl D. Shapiro (2007). *Adaptive Management: The U.S. Department of the Interior Technical Guide*. U.S. Department of the Interior. ISBN 1-411-31760-2.

Handbook for Developing Watershed Plans to Restore and Protect our Waters, USEPA, http://www.epa.gov/nps/watershed_handbook/

6
OPPORTUNITIES FOR MOVING FORWARD

Despite the challenges that have been identified by the research team and retreat participants, there are important actions that can be taken in every community to start building the foundation and architecture for new paradigm sustainable water infrastructure management. Implementing near-term opportunities can have immediate results. However, a number of challenges and actions will take longer to address, and require leadership, capacity-building, and persistence. Based on the retreat outcomes, recommended steps for moving forward are summarized below.

Near-Term Opportunities

Coordinate Water Master Planning to Realize Synergistic Benefits

Most communities currently conduct master planning for water and wastewater separately in different departments or utilities such as water, wastewater, and stormwater. At a minimum, these plans, which look 20 to 30 years into the future (sometimes even 50 years), should be coordinated with each other and with local comprehensive plan updates, which usually occur every 10 to 15 years. This is important because the Comprehensive Plan is where the local land use plan is developed and resides, and where transportation, open space, recreation, and other long-range planning efforts can come together. The Plan is what legally drives local zoning and rezoning of land uses. This opportunity—either formally or informally linking infrastructure master plans and local land use plans—exists in all local governments. One idea to promote coordination is to have the different departments coordinate annually on Capital Improvements Plans. Regional agencies can either help pull together the pieces to provide a larger perspective, or could—with the concurrence of local governments—lead a regional master planning effort.

Revise Building and Zoning Codes to Remove Barriers to Sustainable Practices

Generally, there is no secret about the barriers to sustainable water practices that exist in most state and local building codes and local zoning and subdivision ordinances. It is a matter of each state and local government finding provisions in their regulations that contain those barriers, and making revisions to allow or encourage sustainable water practices. This will likely involve the local planning and zoning, public works, engineering, and health departments, as well as state departments of health and environment, insurance and plumbing commissions, etc. Ultimately, we recommend that local codes have green building requirements tailored to meet the local context and needs (see longer-term actions subsection below). Communities do not have to wait for the grand plan; we know enough about green building technologies to start incorporating them now.

Build Local Demonstration Projects to Lead by Example

Individual demonstration projects can be the foundation and the early bricks for the sustainable water system architecture. Government entities can require that all new public buildings incorporate multiple sustainable water features, and support private, incubator demonstration projects. Local examples are essential— communities need to demonstrate success to increase public awareness and support and to help develop the local context for sustainable water management practices.

Use Social Marketing Techniques to Increase Awareness and Support for Sustainable Water Practice

Non-governmental organizations should develop social marketing tools to advance sustainable water practices. Following are some important marketing tips from *Robin Hood Marketing, Stealing Corporate Savvy to Sell Just Causes* by Katya Andresen, 2006:

- Focus on getting people to do something specific. Define an action for each audience that will help us meet our goals, and test those actions to ensure they are sufficiently specific, feasible, and free of barriers.
- Appeal to our audiences' values, not our own. Gather the information that will enable us to tap into our audiences' values and motivate them to take action.
- React to the forces at work in the marketplace. Consider which market forces affect our audiences' likelihood of taking action. Partner around mutual benefits.
- Put the case first and the cause second. Shape rewards that taps the audiences' values. For example, for the general public, we need to first show how sustainable water practices improve peoples' lives and pocketbooks, and then stress the environmental benefits.
- Four things our message must do: Establish a Connection, Promise a Reward, Inspire Action, and Stick in Memory (or CRAM for short).

Use Stimulus Dollars and Federal Infrastructure Grants and Loans to Jumpstart Efforts

Through 2010—and perhaps beyond—there are federal dollars allocated specifically for sustainable, green water management practices. This includes money for states to set up rebates for water efficiency and water reuse systems, green stormwater infrastructure, decentralized wastewater systems, and others. Local utilities, affordable housing agencies, and local and state economic development agencies can take advantage of federal stimulus grants and loans to create local green industries and jobs, retrofit existing homes and treatment facilities, and build demonstration projects.

Enhance Training and Certification to Build Intellectual Capital

Some state universities and extension agencies, such as North Carolina State University (NCSU), have LID training and certification programs that address stormwater management. The opportunity is there to begin redefining "low impact development" beyond stormwater to include water and wastewater management in a more holistic way. This will require integration of training from various disciplines. A recent NCSU decentralized water reuse workshop provides an excellent example of this integration: http://www.werf.org/AM/Template.cfm?Section=Home&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=11451. While the focus was on decentralized wastewater treatment and reuse, stormwater, rainwater harvest and other resource recovery approaches were integrated into the curriculum. There should be a conference/exchange to advance the setup of LID training and certification in other states, as well as enhanced web-assisted training to deliver important technical transfer and knowledge to all parts of the U.S. and world.

Longer-Term Opportunities

Develop Water Performance Standards to Provide Context

Critical to spending public and private water dollars most effectively is reorienting the siloed-, prescriptive-based standards to performance standards linked to preserving watershed functions and services, and protecting human and ecological health. And to stress again, the standards must be based on context, relative risks, and outcomes. They must provide flexibility. Importantly, they must be able to target public and private water dollars to those sustainable practices that are most effective across water, wastewater, and stormwater management. The context based performance standards would include large river basin standards, watershed standards, and local green building standards—all linked—to meet multiple sustainability goals. This will require watershed, risk management and economic tools—which are available. More importantly, it will require a shift in thinking from federal, state, and local governments. It will require changes in federal, state, and local laws—from the Clean Water Act and Safe Drinking Water Act to local land development codes. It may require an overarching Sustainability Act. And it will require dedicated funding. One relevant example would be performance-based standards for fit-for-purpose water quality. In other words, the water quality required to irrigate plants or flush toilets could be lower than that required for potable consumption. Moving toward these types of flexible standards has the potential to drastically improve water service delivery efficiencies, while sparking water sector cleantech innovation.

Establish New Ownership and Maintenance Models to Address Past Shortfalls

As we move to a combination of distributed and centralized water infrastructure, we are faced with the thorny issue of who is responsible for the distributed systems. Who builds, owns, operates, and maintains them? For distributed wastewater systems, the USEPA has developed guidelines on responsible management (http://www.epa.gov/owm/septic/pubs/septic_guidelines.pdf) and WERF recently released guidance for successfully establishing and running Responsible Management Entities (www.werf.org/rme). However, for some distributed systems—from community wastewater systems and septic systems, to stormwater detention ponds and bioretention areas, to community wells—homeowners and homeowner associations have been put in charge after development is completed. This model has not worked well. We have to come up with new models of ownership and maintenance that work. This could range from local government/utility ownership and maintenance, cooperatives, or water districts. In any case, the entity will need to be a multi-purpose RME, so building on the EPA guidance for distributed wastewater systems is a good starting point. In some states, this may require revisions in state enabling legislation.

Develop Funding and Market Mechanisms to Leverage and Expand Capacity

We need to change local rate structures and state regulations that govern how infrastructure is funded or financed. As previously discussed, the new rate structures should encourage conservation and account for the true costs of providing sanitary sewer and stormwater utility services, including externalities and ecosystem services. Again, models need to be developed and tested that can provide a reliable stream of revenues which cover these full costs—and which are affordable to all customers. While we can glean ideas from the energy sector regarding setting rates and the use of smart monitoring and control technology, affordability must be addressed. Clearly, affordability is an issue now with the silo approach to regulatory requirements. As we look for cost-effective, cross cutting water solutions, customer affordability is part of the bottom line.

Based on the discussion at the retreat, it is clear that the case study communities have already moved forward on some of these actions, but believe progress still needs to be made in these and other areas in order to advance their sustainable water goals. Table 6-1 highlights the case study communities' status related to the identified opportunities for moving forward.

Table 6-1
Case study communities: opportunities for moving forward (It's not a check-mark contest, but there is much more ongoing for each of us! I have suggested some additional checks.)

Description	Currently Ongoing		Identified as Needed	
	Northern Kentucky	Tucson/ Pima County	Northern Kentucky	Tucson/ Pima County
Coordinate water master planning		✓	✓	✓
Revise building & zoning codes	✓	✓	✓	✓
Build local demonstration projects	✓	✓	✓	✓
Use social marketing techniques	✓	✓	✓	✓
Use stimulus dollars			✓	✓
Enhance training & certification	✓	✓	✓	✓
Develop water performance standards			✓	✓
Establish new ownership/maintenance models			✓	✓
Develop funding & market mechanisms	✓	✓	✓	✓

Recommended Actions for Specific Stakeholder Groups

Per the narrative above, the following is an example checklist of recommended actions for different types of stakeholders to take action over the short-term (i.e., within next 3 years) and the long term (within next 10 years).

Non-Governmental Organizations

Short-Term Actions

- Develop social marketing techniques to advance sustainable practices.
- New message: water is water. Formally link water-wastewater-stormwater. From the Low Impact Development Center, Center for Watershed Protection, Coalition for Alternative Wastewater Treatment, etc., all need to support education on this new paradigm.
- Continue working with water industry leaders and stakeholders to bridge the gap between allowing regulatory flexibility to encourage innovation while ensuring that performance standards can be met and enforced.

Local Champions

Short-Term Actions

- Use social marketing tools to educate stakeholders and increase demand for water sustainability.
- Push for adoption of local sustainability goals that can be used to guide planning efforts and demonstration projects.
- Get involved in local utility master planning and local government comprehensive planning efforts.

Longer Term Actions

- Champion efforts to begin building institutional capacity.

Local Elected Officials

Short-Term Actions

- Establish a citizens' Sustainability Advisory Committee or an equivalent organization.
- Adopt local sustainability goals that can be used to guide planning efforts and demonstration projects.
- Use sustainability social marketing tools to get the message out to developers and potential homebuyers.

- Pledge that all local public buildings will employ sustainable water technologies as appropriate.
- Update Comprehensive Plan and Local Land Use Plan using sustainability principles.

Longer Term Actions

- Adopt performance standards into local codes.
- Change rate structures to better capture the full costs of water service delivery and encourage sustainable usage and practices (for example, stormwater utility fees based on percent impervious cover).
- Work with local champions to support other institutional capacity building efforts.

Local and Regional Planning Departments

Short-Term Actions

- Use sustainability principles and locally adopted goals to update local comprehensive plans and associated land use plans.
- Revise subdivision, zoning, and other land development codes to allow or encourage green building practices.
- Link land use planning to water, wastewater, and stormwater master planning, again using sustainability principles and locally adopted goals.
- Use sustainability social marketing tools to get the message out to developers and potential homebuyers.

Longer Term Actions

- Develop performance standards. Move to local adoption.
- Work with local champions to support other institutional capacity building efforts.

Local Water, Wastewater, Stormwater, Engineering, and Public Works Departments

Short-Term Actions

- Link water, wastewater, and stormwater master planning to land use planning, using sustainability principles and locally adopted goals.
- Revise stormwater codes, street codes, and design manuals to allow or encourage green building practices.

- Provide leadership and technical support for sustainable water planning. This includes requesting or applying for needed funding to incorporate into annual budgets.
- Implement equitable options analyses that consider full costs of projects based on triple bottom line considerations.

Longer Term Actions

- Revise local rate structures to better capture the full costs of water service delivery and encourage sustainable usage and practices.
- Work within state and federal efforts to develop performance standards with sensitivity to the local context. Move to local adoption.
- Work with local champions to support other institutional capacity building efforts.

Local Health Department

Short-Term Actions

- Work with the appropriate State department or commission to change regulations governing graywater systems and plumbing codes to allow or encourage sustainable water practices. The agencies will vary by state, but will likely include the State Department of Health, Department of Environment, Department of Insurance, and/or the Plumbing Commission.
- Work with State to develop local context-specific policies and requirements to facilitate the development and use of decentralized water reuse and resource recycling systems.

Local and State Economic Development Agencies

Short-Term Actions

- Identify green job opportunities in your state or community.
- Create micro-business or incubator funds for sustainable water technologies.

Private Sector Businesses and Associations

Short-Term Actions

- Participate in Low Impact Development training and certification programs.
- Pledge to use sustainable water technologies in sensitive watershed areas.
- Get involved in local sustainability advisory committee.
- Actively support revisions to local codes and ordinances.
- Publicize results and successes.

State Government

Short-Term Actions

- Departments or Commissions governing plumbing and graywater systems: Work with state and local health departments to revise regulations and plumbing codes governing graywater systems to allow or encourage sustainable water practices.

Longer Term Actions

- Environmental Regulatory Departments: Revise state drinking water and Clean Water Act standards using performance-based approaches to water management and public health protection.
- Utility Regulatory Commissions: Revise rate approval criteria and procedures to allow for rate structures that provide adequate revenue streams while recognizing the benefits of water/wastewater reuse and other demand management approaches.

State Universities

Short-Term Actions

- Develop and provide training and certification on sustainable water practices. Expand definition of "Low Impact Development" to include distributed wastewater management and other sustainable practices.
- Design, build and monitor demonstration projects. Publicize results.
- Conduct research to continually refine and improve social marketing techniques for water sustainability practices.
- Train engineering students about all relevant wastewater treatment and resource recovery approaches including distributed and decentralized systems.

While these recommendations stemmed from discussion regarding the two case study communities, they have broad-scale applicability to other communities. The five components used by the research team to define the new paradigm for water infrastructure management provide a foundation upon which communities can build as they move toward a new way of thinking and a more sustainable approach.

7
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A
RETREAT PARTICIPANT BIOGRAPHICAL SKETCHES

Tetra Tech Project Team

Trevor Clements, MEM – Principal Investigator, Facilitator from Tetra Tech. Mr. Clements has 26 years of experience in the assessment and management of surface water quality and is the Watershed Program Director for Tetra Tech. He is an expert in comprehensive watershed management working with numerous local, state, and federal agencies and organizations to develop integrated management frameworks. He was the Principal Investigator for the WERF project, Framework for a Watershed Management Program (1996) and a principal co-author of the EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (2008). His consultation has helped to change the business paradigm for numerous state and local agencies from program silos to integrated watershed management approaches. He has achieved national recognition for his skills in facilitating intensive work group sessions and partner meetings, troubleshooting framework development and implementation barriers, facilitating stakeholder involvement, and refining watershed management program roles and procedures.

Victor D'Amato, PE – Co-Investigator, Distributed Water Systems Engineer from Tetra Tech. Mr. D'Amato currently leads sustainable infrastructure and resource management and design out of Tetra Tech's Research Triangle Park, NC office. He is a nationally-recognized expert on distributed approaches to water management, and is the Principal Investigator of a WERF funded project focused on when and how to utilize distributed wastewater management approaches in urban and suburban settings. He is a member of the Water Environment Federation's (WEF) Small Communities and Distributed Wastewater Systems Committee and is that committee's Technical Practices Committee Chair. Mr. D'Amato has worked as an environmental engineer for the NCDNR Onsite Wastewater Section and as a process engineer for a major wastewater process developer and vendor where he designed, started-up, troubleshot, and trained operators on several nutrient removal wastewater treatment processes for plants with design flows up to 420 million gallons per day (mgd). Mr. D'Amato also spent eight years leading the water resources research effort for the U.S. arm of a 12,000-employee international environmental consulting firm. He has developed, designed, and supervised the installation of integrated water management systems, with a focus on sustainably designed onsite and cluster wastewater reclamation and stormwater recovery systems.

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Edward A. Clerico, PE, LEED AP, Co-Investigator, Management Systems Specialist from Alliance Environmental. Mr. Clerico is a nationally recognized expert in the area of distributed water resource management systems with a reputation for providing hands-on experience. In 1984, Mr. Clerico founded Applied Water Management, Inc. (AWM) which was one of the first firms in the U.S. to offer integrated, full-scope of water and wastewater utility development services wherein design, construction, operation, finance and resource acquisition were combined into one privatization package. Under Mr. Clerico's leadership, AWM performed extensive contract operations on more than 60 systems in five states, introducing the concept of wastewater recycling to the New York and Boston metropolitan areas and designing/operating 23 water reuse systems. Mr. Clerico served as Vice President of Strategy for American Water, the largest private water/wastewater utility in the U.S. and Technical Development Director for Thames Water America. With Alliance Environmental, he now serves as a sustainability consultant for some of America's leading green developers and is helping municipalities implement progressive sustainability plans. Mr. Clerico's experience includes a background in management and strategy, both private and municipal.

Elizabeth Dietzmann, Esq., Co-Investigator, Legal Specialist, is a partner with Inman and Strickler, PLC, Virginia Beach, Virginia, and will help the team focus on legal and regulatory components and community stakeholder participation. She has worked with numerous clients nationwide on decentralized wastewater implementation, wetlands preservation, public funding, Chesapeake Bay Act compliance and stormwater management issues. Her clients include municipalities, state and local regulators, privately-owned utilities, county and state governments and developers. She writes a regular column on decentralized wastewater and stormwater topics for *Onsite Water Magazine* and *Stormwater Magazine* (Forester Publications) and is a member of the National Sanitation Foundation Joint Committee on Wastewater Issues. Currently, she is working on a number of projects involving sustainable low impact development and coordination of both decentralized wastewater and onsite stormwater treatment as part of a comprehensive water management program.

Kimberly Brewer, AICP – Urban and Watershed Planner, Facilitator from Tetra Tech. Throughout her 25 years of water resources planning and management experience, Ms. Brewer has coupled technical and policy analysis with stakeholder facilitation to develop innovative, cost-effective watershed protection and green design strategies. As a planning consultant, she has assisted in conducting numerous local watershed protection studies and helped pioneer approaches for low-impact design. Prior to consulting, Ms. Brewer worked 11 years in local, state, and regional agencies, gaining extensive experience in program development and management in the areas of water resource protection. Ms. Brewer's experience working with government agencies and diverse stakeholder groups, along with her practical experience studying and implementing cost-effective innovations, allows her to understand different perspectives and to design strategies that meet multiple objectives. Ms. Brewer has been the facilitator, principal planner and cost analyst on watershed management projects, providing comprehensive watershed management planning services, including watershed management plans, ordinance review and development to encourage LID and green infrastructure, site design evaluation tools for BMPs, training, LID pilot projects and case studies, and public education/outreach.

EPRI/WERF Sponsor Representatives

Tina Taylor is Director of Business Development in the Environment Sector at the Electric Power Research Institute (EPRI). She holds a Bachelor of Science degree in chemical engineering from Tufts University. Ms. Taylor is responsible for partnerships, initiatives and services that add value to and extend the reach of EPRI's research. She is currently leading work in the areas of climate change, fish protection, water availability and sustainability. She has worked in the electric power industry for 20 years and joined EPRI in 1997. She led the Engineering and Environment Services group at EPRI Solutions since its inception in 2001. Prior to joining EPRI Solutions she was a project manager in the Nuclear Sector of EPRI where she was responsible for the development and delivery of a real-time plant monitoring and diagnostic system. Previously, Taylor specialized in chemistry and corrosion work for nuclear plants, working as a senior engineer at B&W Nuclear Technologies and before that as an engineer at Northeast Utilities.

Robert Goldstein, PhD is Senior Technical Executive for Water and Ecosystems in the Environment Sector at the Electric Power Research Institute (EPRI). His current activities include strategic planning for the Water and Ecosystems Area, and managing research in the Strategic Water Issues and Fish Protection Programs. Prior to joining EPRI in 1975, Dr. Goldstein was a Systems Ecologist with the Oak Ridge National Laboratory. Dr. Goldstein holds a Doctor of Engineering Science degree from Columbia University, is the author of numerous papers on environmental subjects, and has served as an advisor to numerous government, professional and research organizations.

Jeff Moeller, PE, is a Senior Program Director at the Water Environment Research Foundation (WERF), located near Washington, DC, where he has worked since 1997. Mr. Moeller directs two of WERF's research programs: stormwater and decentralized systems. These programs focus on advancing the science and knowledge of LID and BMPs; onsite and small-community wastewater systems; stormwater and wastewater monitoring and management; source controls;

receiving water impacts; integrated water management; green infrastructure; graywater; and other issues. Mr. Moeller has over 15 years of experience in water resource engineering, and previously worked as a consulting engineer for Hazen and Sawyer designing water, stormwater, and wastewater systems. He has worked on water projects in the mid-Atlantic and Southeastern U.S., as well as internationally funded projects in Central America. Jeff has a master's degree in Civil and Environmental Engineering from M.I.T., and is a registered Professional Engineer.

Project Advisory Panelists (alphabetical order by last name)

Blake Anderson, PE is an independent consultant specializing in strategic planning, public policy, organizational development and regulatory matters related to water quality, public infrastructure, water supply and environmental issues. He works independently and in association with other firms for public sector and private sector clients. Mr. Anderson was the General Manager of the Orange County Sanitation District for five years and 25 years overall in number of leadership capacities. He proposed the concept and helped to influence the joint decision of the Sanitation District and the Orange County Water District to plan, finance and build the world's largest reclamation plant using advanced treatment technology. The plant began producing 70 million gallons per day of highly treated water in 2007. In 2009 the ASCE named it the Outstanding Engineering Achievement of the Year. Under his leadership, the agency changed the way it planned, designed and maintained its facilities, embracing asset management methods and other business principles to effectively address the environmental, social, and fiscal needs of a large metropolitan area. Mr. Anderson has been active in watershed management policy issues. He has testified before Congress and written on the concept of watershed protection and served on two National Research Council Committees on watershed and wastewater management.

Nick Ashbolt, PhD is Title 42 Senior Research Microbiologist with the National Exposure Research Laboratory, U.S. EPA Cincinnati (since January 2007). Previously he was Professor and Head of the School of Civil and Environmental Engineering, the University of New South Wales (UNSW) Sydney. He has 25 years' experience in environmental microbiology, with a focus on the fate and transport of environmental pathogens. Over the last 10 years Dr. Ashbolt has worked in joint Australian-Sweden and European programs developing methods to interpret pathogen data with the aid of quantitative microbial risk assessment within an urban water sustainability framework. This work has contributed to the risk-based approach adopted in the recently published WHO recreational, drinking and reuse water guidelines and the Australia national urban water sustainability framework used by the water industry. He has published 27 book chapters, 110 journal papers and over 100 conference proceedings since he joined UNSW in 1994. His research at EPA is focused on distribution system pathogen risks and application of QMRA to drinking, reuse and recreational waters.

Paul R. Brown, AICP is the Executive Vice President, directing strategy, brand, marketing, and sales management for CDM worldwide. Most recently, he served as President of CDM's Public Services Group, serving state, regional, and local governments across the United States. He has nearly 30 years' experience in project development, project finance, and the planning and management of public utilities and environmental facilities for clients that include the states of California and Colorado; the Metropolitan Water District of Southern California (MWD); the

Santa Clara Valley Water District; the Orange County (CA) Sanitation District; and the cities of Los Angeles, San Diego, San Francisco, San Jose, and Seattle. A member of the American Institute of Certified Planners (AICP), Mr. Brown's educational background includes an MBA from The Wharton School, University of Pennsylvania (1982); an MA from the University of Rochester (1973); and a BA from Tufts University (1971). He serves a member of the Stockholm Industry Water Award Committee. He is co-editor (with Dr. Vladimir Novotny) of the book *Cities of the Future: Towards Integrated Sustainable Water and Landscape Management,* published by IWA; and a contributor to *Growing Greener Cities: Urban Sustainability in the Twenty-First Century,* published by the University of Pennsylvania Press.

Glen T. Daigger, Ph.D., P.E., BCEE, NAE, is a recognized expert in wastewater treatment, especially the use of biological processes. Dr. Daigger is currently a Senior Vice President and Chief Technology Officer for CH2M HILL where he has been employed for 29 years. He also served as Professor and Chair of the Environmental Systems Engineering Department at Clemson University. As the author or co-author of more than 100 technical papers, four books, and several technical manuals, he has contributed to advancing practice within our profession. He is Senior Vice President of the International Water Association (IWA). For the Water Environment Federation (WEF) he has served as Chair of several committees, including the task force that developed the most recent edition of the WEF MOP No. 8, *Design of Municipal Wastewater Treatment Plants*, Board of Editorial Review of *Water Environment Research*, the Technical Practice Committee, and the Committee Leadership Council (CLC). He has also served in the House of Delegates and on the Board of Trustees. For the Water Environment Research Foundation (WERF) he served on the Board of Directors and Research Council where he served as its chair. He is the recipient of numerous awards, including the Kappe and Freese lectures and the Harrison Prescott Eddy, Morgan, and the Gascoigne Awards from WEF. A member of a number of professional societies, Dr. Daigger is also a member of the National Academy of Engineers.

Scott Drake, P.E., is a Senior Engineer for East Kentucky Power Cooperative (EKPC), where he has worked for 18 years. He has planned, designed, and managed the construction of numerous electric transmission and distribution facilities. For the last 2 years, Scott is EKPC's Transmission System Maintenance Engineer. Previously, Scott worked in the Research and Development area of EKPC for 9 years focusing on consumer and community services and Power Plants. Scott is an advisor to several research programs about rural wastewater issues and rural wastewater services development. He assisted or advised several small community wastewater projects in Kentucky. Scott is a Registered Professional Engineer in Kentucky.

Robert Goo currently works for the Office of Wetlands, Oceans and Watersheds in the Office of Water at EPA HQ in Washington, D.C. His area of concentration is sustainable decentralized stormwater and wastewater treatment systems. He has worked at EPA since 1988 on a variety of issues including biosolids, centralized waste treaters, multi-media transfer of waste, low impact development approaches and practices, onsite wastewater treatment systems and management programs, rangeland and grazing issues, best management practices for forestry and low volume roads and a range issues related to stormwater runoff, smart growth and green infrastructure. He helped develop voluntary environmental standards for the skiing and golfing industries and is currently working with the USGBC to help develop the LEED Neighborhood Development stormwater credit system and the hydrology credits for the Sustainable Sites Initiative. Robert works closely with the NDPES program to promote the development of more effective municipal stormwater programs through the use of green infrastructure/low impact development approaches and practices. To achieve these goals he is working with big box retailers, federal, state and local agencies, the transportation industry, and nongovernmental organizations to develop policies, tools, life-cycle analyses, demonstration projects, guidance, monitoring protocols, etc. to promote the adoption of decentralized and integrated approaches to water management (stormwater, wastewater and drinking water).

Mary Hansel has an extensive and varied background in sustainability principles and strategies, and financial and information management. She was a licensed Certified Public Accountant (CPA) for 20 years, and graduated with a Bachelor of Science in Business Administration from the University of Arizona. Ms. Hansel currently works as Sustainability Director for Carollo Engineers, leading a strategic initiative to integrate more sustainable practices into their daily operations and professional practices. Carollo specializes in water supply and wastewater treatment, providing master planning, design, and construction management services for municipal clients. The firm employs over 750 employees in 25+ offices in the United States. Ms. Hansel also serves as Treasurer of The Biomimicry Institute and is enrolled in the Two-Year Certificate Program in Biomimicry.

Jim Kreissl retired in January, 2001, after 37 years of service with the USEPA as principal expert for small community wastewater collection, treatment, and reuse systems, including onsite systems and community-based environmental processes. Since that time, he has performed several domestic and international consulting assignments, primarily with Tetra Tech, Inc., but also for the Canaan Valley Institute, West Virginia University, and others. He has been a member of the Steering Committee for the National Decentralized Water Resources Capacity Development Project since 2001 when it was directed by Washington University of St Louis, and a member of the Decentralized Research Advisory Council for that project since its move to WERF. He has also been an Affiliate of the NESC of WVU since 2001, which has primarily involved assisting NESC in planning and implementing annual State Onsite Regulator Conferences and writing and reviewing materials. Since 2001 he has served as Vice-Chair and Chair of the Small Communities Committee of the Water Environment Federation, and chaired a task force that completed the update of the 2008 WEF Manual on Alternative Collection Systems (MOP FD-12). He served as the primary technical author of three USEPA reports on responsible management programs, delivered several presentations to numerous USEPA, national and tribal forums, and created large sets of materials that will be available through EPA’s website. He presently also serves as a Supervisor of the Kenton County (KY) Soil and Water Conservation District.

Stephen R. Lane, PWS, CPESC is an Environmental Scientist with Duke Energy. He has a B.Sc. in Biology (1992), B.A. in Geography, Environment and Resources Management (1996), and M.Sc. in Physical Geography (1999) all from The University of Western Ontario, London, Ontario, Canada. His expertise includes Power plant and infrastructure siting studies and permitting, wetland delineation, stormwater permitting, environmental site assessments, environmental regulatory analysis, 401/404 permitting, stream assessments, ecological mitigation, public communication, electromagnetic field studies, and geographic information systems. Prior to joining Duke Energy in 2006, Mr. Lane worked for URS Corporation and Cinergy, both in the Cincinnati region.

Steve Moddemeyer is Associate Principal and a sustainability advisor for CollinsWoerman NEXT – Sustainable Solutions and Design Innovation, with over 19 years of experience leading governments, planners, architects, land owners, and project teams towards increased sustainability. Mr. Moddemeyer specializes in creating tools and strategies for more resilient infrastructure systems for cities and large developments. He has extensive experience with complex public/private development issues, including representing Tribal interests, leading local government habitat preservation responses to the Endangered Species Act, and negotiating multi-million dollar settlements and contracts for utility-based organizations. As a City Planner, Mr. Moddemeyer was responsible for creating a new award-winning landscaping ordinance for commercial development that improves environmental functions in dense urban business districts of Seattle. Mr. Moddemeyer integrates his systems knowledge about water and energy, landscape architecture and urban infrastructure, economic development and sustainable design to help clients make smart urban investments. He writes and speaks internationally on "Cities of the Future" and sustainable infrastructure topics.

Daniel J. Murray, Jr., P.E., M.ASCE is a Senior Environmental Engineer with EPA's Office of Research and Development in Cincinnati, Ohio and has been with U.S. EPA for over 28 years. Mr. Murray is currently leading EPA's Aging Water Infrastructure Research Program. Mr. Murray received his BS in Civil Engineering from Merrimack College in North Andover, Massachusetts and his MS in Civil Engineering from Northeastern University in Boston, Massachusetts. Prior to joining the Office of Research and Development, Mr. Murray worked in EPA Region 1 in Boston, and EPA Region 5 in Cleveland. Mr. Murray also worked for the Massachusetts Water Resources Authority, leading the CSO control program. In 1995, Mr. Murray received the Gold Medal for Exceptional Service, EPA's highest honor, for his work in supporting the development of the Agency's CSO Policy. Mr. Murray is a registered Professional Engineer in Massachusetts and Ohio and an active member of the Water Environment Federation and the American Society of Civil Engineers. Mr. Murray also serves on the Fairfield City School District and Butler Technology and Career Development School District boards of education.

Valerie Nelson, PhD is the Director of the Coalition for Alternative Wastewater Treatment, which is a national alliance of advocates for and experts in decentralized water, wastewater, and stormwater treatment and management. Dr. Nelson served two terms on the Gloucester City Council and was the Executive Director of the national Lighthouse Preservation Society. She was a Lecturer and Visiting Assistant Professor at the Kennedy School of Government and M.I.T.

Bob Pitt, PhD is the Cudworth Professor of Urban Water Systems in the Department of Civil, Construction, and Environmental Engineering at the University of Alabama. He is also Director of the UA interdisciplinary Environmental Institute. He received a BS in Engineering Science from Humboldt State University, an MS in Civil Engineering from San Jose State University, and was awarded a PhD in Civil and Environmental Engineering by the University of Wisconsin-

Madison. His teaching and research interests include the fates and effects of hazardous materials lost during transportation accidents and associated contingency planning, analytical methods to detect sources of contaminants in urban drainage systems, development of new analytical methods for the rapid and sensitive detection of toxicants, sources of pathogens in urban areas, modeling of urban infrastructure systems, development of stormwater control technologies, modifications of soil structure due to urbanization, and the integration of hydrology and water quality objectives in drainage design. He has published more than 100 publications, including journal articles, research reports, and several books. Dr. Pitt received a Distinguished Service Citation from the University of Wisconsin, was a member of the project team that received a first place national award for a combined sewer project from the Water Environment Federation, and has received several outstanding teacher and volunteer service awards. He is a registered Engineer and a Diplomate of the American Academy of Environmental Engineers and a Diplomate, American Academy of Water Resources Engineers. Dr. Pitt has also served on numerous professional committees in the U.S. and abroad.

Linda Reekie, a Project Manager at the Water Research Foundation (previously Awwa Research Foundation) for ten years, has managed scores of research projects and facilitated annual research planning efforts with water stakeholders in the topical areas of water utility environmental sustainability, organizational management, and stakeholder communications. She has a BS Degree in Environmental Resource Management from the Pennsylvania State University. Linda previously worked as an environmental planner for the Lancaster County Planning Commission and an environmental health specialist for the Boulder County Health Department. She dabbles in sustainable living at the Harmony Village Co-Housing Community in Golden Colorado.

Paul Schwartz is Clean Water Fund Water Policy Coordinator. Paul's current work focuses on integrated water policy, water infrastructure finance, green infrastructure, and Clean Water Act and Safe Drinking Water Act programs. Mr. Schwartz works with Clean Water Fund and Clean Water Action staff and leaders to integrate local, state and federal water policy approaches and solve community problems in over 20 states. Mr. Schwartz is on the Board of the Clean Water Network where he is the Co-Chair of the Wet Weather and Water Infrastructure Work Group and the Global Climate Change and Water Work Group. He also sits on the steering committee of the Campaign for Safe and Affordable Drinking Water. At the local level, he was appointed by DC Mayor Adrian Fenty to the DC Green Building Advisory Council. Mr. Schwartz has testified in front of Congress multiple times on both aspects of clean water and drinking water policy and is a frequent panelist and facilitator at government, water utility association and civil society meetings. He started work with Clean Water Fund 30 years ago.

Julie Smoak is an Environmental Scientist with the KY Division of Water. In her 6 years with the Division she has become quite familiar with the challenges of wastewater service in Kentucky.

Northern Kentucky Representatives (alphabetical order by last name)

James P. Gibson, Jr – Director of Water Resources, Sanitation District No. 1 of Northern Kentucky. Mr. Gibson joined SD1 in May of 2000 and was appointed the Director of the newly formed Water Resources Department in 2007. The Water Resources team coordinates and implements:

- The Northern Kentucky regional Phase II storm water permit, which includes 30 cities, 3 counties and the Kentucky Transportation Cabinet as co-permittees;
- A comprehensive watershed monitoring program that includes in-stream water quality sampling, habitat and biological assessments and stream flow gauging for the development and maintenance of various stream/watershed models, as well as a stream condition index; and
- The watershed related control elements of SD1's Consent Decree, such as the implementation of the pollution source identification program and the evaluation of constructed wetlands and regional retention facilities as cost-effective non-sewer overflow alternatives that achieve greater overall improvements in water quality.

Prior to joining SD1, Mr. Gibson was employed for six years with the Ohio River Valley Water Sanitation Commission (ORSANCO). Located in Cincinnati, Ohio, ORSANCO is an interstate regulatory agency representing eight states and the federal government concerning water pollution control, primarily for the Ohio River. Mr. Gibson earned his Bachelor of Science degree in Natural Resources and Environmental Science in 1993 from Purdue University in West Lafayette, Indiana. In 2003, he was recognized as the "Young Scientist of the Year" by Engineers and Scientists of Cincinnati (ESC).

Larry Klein is the Assistant City Manager for the City of Covington, Kentucky since May of 2008. Previously he was the City Administrator for the City of Fort Wright, Kentucky from 1998-2008, and prior to that he worked for Kenton County Fiscal Court from 1988-1998 where he worked in the Treasurer's Office administering the County and Cities' occupational license fees and business licenses. He is a founding member and past President of the Kentucky Occupational License Association, a professional association of 250 city and county tax administrators from across the Commonwealth of Kentucky and remains active in that organization. He has also served in the 1980's and 1990's as Zoning Administrator for the cities of Elsmere and Lakeside Park in Kenton County. He is a former Member of Erlanger City Council and the Erlanger Board of Adjustments. Larry has a Bachelor's degree in Public Administration and minor in Business Administration from NKU as well as a Master of Public Administration degree from NKU.

Jim Turner, P.E., is a Program Manager working in the Capital Improvements Program of Sanitation District No. 1 (SD1) of Northern Kentucky. His current work is focused on the application of green infrastructure to meet SD1's Consent Decree goals for CSO/SSO control.

Mr. Turner earned a Bachelor of Science in Civil Engineering from Purdue University and a Master of Science in Oceanography from the University of Washington. He is a registered Professional Engineer in Kentucky, Ohio, and Indiana and has nearly 15 years of work experience in public and private sector employment.

Tucson – Pima County Representatives (alphabetical order by last name)

Edward F. Curley – Strategic Planning Manager, Pima County Regional Wastewater Reclamation Department. Mr. Curley has been employed by the Department for 30 years and is a graduate of the University of Arizona. He currently oversees the strategic planning activities and public policy activities of the Department and has most recently been involved with the American Recovery and Reinvestment Act funding of a $10 million WIFA loan/grant for the $41 million Santa Cruz Interceptor, Phase IV (Plant Interconnect) – a major sewer interceptor project. Mr. Curley is also involved in analysis of state and national legislative activity and coordination with regional water quality planning. His previous assignments have included the development of the 2006 Metropolitan Facility Plan Update and of the current 20-year $1.4 billion Capital Improvement Plan for the Department. From 1995-2007, Mr. Curley served as Project Director of the Arid West Water Quality Research Project (AWWQRP), an EPA-sponsored assistance grant administered by the Department which produced a series of major technical and policy papers on the science and policy aspects of water quality standards for arid environments. Mr. Curley is a co-editor of *Relevance of Ambient Water Quality Criteria for Ephemeral and Effluent-Dependent Watercourses of the Arid Western United States* (SETAC, 2008). He is on the Board of Directors of the Western Coalition of Arid States (WESTCAS) and is involved with the Arizona Water Pollution and Control Association (now AZ WATER) and the Water Environment Research Foundation. Mr. Curley received a National Environmental Achievement Award from the Association of Metropolitan Sewage Agencies in 2002, a Metropolitan Pima Alliance “Common Ground” Award in 2005 and the WESTCAS President’s Award in 2007.

Melodee R. Loyer, PE – Managing Engineer, Tucson Water. Ms. Loyer has over 25 years of experience preparing master plans, permits, water studies, design reports, and facility designs, as well as managing the construction of water related facilities. This extensive experience has encompassed potable water, reclaimed water, and wastewater facilities, as well as on-site stormwater permitting/designs. Her design work for a wastewater treatment plant in Phoenix won an Engineering Excellence Award. Ms. Loyer is currently responsible for the operation and future planning of the Tucson Metropolitan area’s reclaimed water system. The existing reclaimed system treats Class B effluent to Class A and then distributes the reclaimed water to over 900 customers through 300+ miles of distribution system. The system is capable of delivering over 32 million gallons per day of reclaimed water to its customers. She is also responsible for ensuring that the reclaimed facility meets its permitting requirements, including State water reuse and aquifer protection permits. In addition, Ms. Loyer plans for the Capital Improvement Program needs of the reclaimed system, and coordinates with Pima County regarding the impacts of wastewater treatment on the reclaimed system. Ms. Loyer is also responsible for managing a Customer Support Unit and engineering water quality evaluations for the potable water system. The potable water system includes over 200 active groundwater wells, treatment systems, and a water supply (via the Central Arizona Project) that provides for over 50% of the community’s water needs. Ms. Loyer has been active in AWWA, and WEF committees, and she has prepared and delivered a number of presentations at conferences pertaining to reuse facilities, wastewater treatment, and distributed treatment. Her breadth of experience across water issues is ideally suited to providing 'grounded' input to the research for the Conceptual Model for Water Infrastructure Management Paradigm.

Melaney Seacat – Pima County Coordinator: City/County Water and Wastewater Study. Ms. Seacat has 20 years of public sector work experience in water resources and land use planning, with skills in collaborative problem solving, regional public participation practices, team building, and facilitated approaches to public policy dialogue. She holds undergraduate and masters degrees in Environmental Science/Biology and Regional Development. Ms. Seacat is the Pima County representative to the joint City/County Water and Wastewater Study. She provides support leadership to a joint City/County Oversight Committee and coordinates the efforts of City/County staff to work collaboratively towards completing this multiple-phased Study. These efforts are focused on compiling and presenting a range of information on water and wastewater infrastructure, supply and planning variables. Key outcomes of the study include a report providing a common set of baseline facts and information on the condition and capacity of City/County water, wastewater and reclaimed water infrastructure and supplies. The report also documents a range of critical factors associated with planning for a sustainable water future such as balancing human, environmental and economic needs for water, developing adaptive management strategies to address uncertainties related to climate change, increased water conservation and the use and reuse of locally generated water resources, and use of more rigorous planning processes. Additionally, several technical papers were completed which provide joint City/County recommendations on goals and strategies related to reclaimed water, drought management, water conservation, protection of groundwater dependent ecosystems, and supplemental use of stormwater.

Suzanne J. Shields, PE – Director and Chief Engineer, Pima County (Arizona) Regional Flood Control District. Ms. Shields has over 30 years of professional experience in the areas of civil engineering, stormwater management, flood control, and environmental management for surface and groundwater hydrology. She is responsible for the administration of the District's $14 million annual operating budget for floodplain and stormwater management, infrastructure maintenance, water resources and flood control planning, water resources, and riparian habitat protection in Pima County. Pima County contains more than 130 miles of major watercourses, and a vast network of tributary watercourses traverse the county. Regulated activities, including local floodplain and stormwater regulations, involve 230,000 acres of FEMA floodplains and 87,300 acres of riparian habitat. The District's annual Capital Improvement Program has a budget of approximately $25 million which includes various flood control projects along major rivers, regional and neighborhood detention basins, riparian restoration projects, drainage improvements and storm drains. The Regional Flood Control District earned an Award of Excellence from the U.S. Army Corps of Engineers for the Kino Environmental Restoration Project. Under its unique and well established Floodprone Land Acquisition Program, the District manages upstream watershed areas and has preserved over 10,000 acres of natural floodplains, consistent with the county's Sonoran Desert Conservation Plan which is a science based land use plan designed to protect natural resources. In addition to her duties as Director of the Regional Flood Control District, Ms. Shields serves as the Chief Engineer of Pima County.

B
CONCEPTUAL IDEA FOR SUSTAINABLE WATER INFRASTRUCTURE MANAGEMENT MODEL: PRE-RETREAT

Water Infrastructure Sustainability

Draft 5/6/09

Sustainability (general definition)

- Development that meets the needs of the present without compromising the ability of future generations to meet their own needs
- Describes resiliency or robustness of systems to adapt to and thrive in the face of change
- Incorporates "triple bottom line" of environmental, societal, and economic considerations

Water Infrastructure (general definition)

- The basic physical and organizational water-related structures needed for the functional operation of society
- Includes both *built* and *natural* infrastructure

Sustainable Water Infrastructure Principles

Environmental

- Carbon neutral or positive
- Hydrologically neutral or restorative
- Ecologically neutral or restorative
- Nutrient (and other reusable/recyclable waste resource materials) neutral
- Neutral or positive air quality benefits

Social

- Provides clean and abundant water supply
- Supports safe and secure food supply
- Supports clean and stable energy supply

- Supports healthy and enjoyable living, working, recreational space
- Supports and enhances social connectedness

Economic

- Promotes economic opportunity across socioeconomic class
- Promotes local "cleantech" industry growth
- Minimal debt and associated servicing – low life cycle costs
- Robust in the face of economic and/or social disruption

Technological Approaches: System Architecture

1. Apply existing and emerging approaches within the context of ***integrated resource management***, whereby efforts to efficiently conserve and reclaim resources (water, nutrients, carbon/energy, etc.) are prioritized
2. Service delivery uses ***distributed infrastructure*** approach covering a range of infrastructure scales (decentralized to centralized) and technologies
3. Decisions are made within integrated planning framework optimizing across triple bottom line indicators, using equitable and robust cost/benefit tools
4. Designs focus on ***source control*** for water conservation and efficient reclamation
5. Water collection and treatment technologies informed by ***emerging technical disciplines*** of nanotechnology, materials science, smart controllers, and mimicry
6. Built water infrastructure serves ***multiple benefits*** by supporting and enhancing/restoring natural water infrastructure and societal benefits of built infrastructure as recreational amenities and the like

Four Supporting Components

1. Integrated Planning

   A. ***Administrative support structure*** providing comprehensive planning and simultaneous oversight of infrastructure (water supply, waste water, stormwater, transportation, parks and recreation) responsive to multiple community objectives

      1) Planning uses ***adaptive decision-making*** linked to triple bottom line evaluation across community objectives (e.g., Comprehensive Planning; Capital Improvement Planning)

   B. Use of ***watershed management*** tools for linking multiple objectives

      1) ***Indicators*** that cross multiple objectives

         1. Environmental
         2. Financial (life cycle costing; full-cost accounting)
         3. Social/Programmatic

      2) ***Assessment tools*** for evaluation of indicator measurements

      3) ***Guidance manuals*** on sustainable practices

      4) ***Stakeholder participation***

2. Regulatory and Programmatic Change

   A. Regulatory and programmatic structures and composition are re-established to facilitate sustainable approaches

      1) ***Minimum standards*** addressing integrated planning needs provide for clear direction and social/economic equity

      2) Impediments to sustainable design and service delivery are recognized and corrected in local ***ordinances, codes, policies and administrative procedures***

      3) ***Incentives*** incorporated with regulations and programs enhance likelihood of use of sustainable approaches (e.g., expedited permitting or development review; certification/awards programs; tax credits)

3. Community Engagement

   A. Community offers ***multiple scales and levels for public involvement*** from passive learning to advising, to voluntary action, to supporting implementation of sustainability programs and practices.

   B. Via triple-bottom line planning and operations, ***socioeconomic opportunities*** are provided including green jobs and programs/projects that stimulate the economy and provide local amenities.

4. Management and Financing

   A. Management structure reflects multi-objective, ***integrated decision-making*** approach that recognizes ***interconnections across scales*** (site, watershed, region, country, global).

   B. ***Financial links or market mechanisms*** (including rate setting for associated service levels) used to connect and incentivize sustainability efforts for both supply and demand side resource management and more systemic and integrated technological approaches

   C. ***Utilities and service providers*** (public and private sector) are structured to be adaptable and versatile, while maximizing efficiency and innovation

   D. Communities develop diversified and consistent ***funding mechanisms*** that incentivize sustainable practices while funding integrated planning

   E. Infrastructure development programs allow for ***alternate, more efficient project delivery***

   F. ***True costs*** of water and other resources are factored into infrastructure/asset management.

C
CASE STUDY COMMUNITY BACKGROUND INFORMATION PAPERS

Northern Kentucky Community Background Information for EPRI-Sponsored Retreat on Water Infrastructure Sustainability

5/22/2009

Northern Kentucky is a part of the growing Cincinnati metropolitan area. Water infrastructure is managed by two primary entities: Sanitation District No. 1 (SD1) of Northern Kentucky which oversees wastewater and storm water components, and Northern Kentucky Water District (NKWD) which oversees water supply services.

SD1 Overview:

Sanitary sewer and storm water utility service provider to over 300,000 residents of Northern Kentucky. Service area encompasses three counties and includes 30+ local jurisdictions. Planning and design is performed by SD1 staff with the support of engineering consultants. Majority of construction dollars are currently directed toward large-scale capital projects through bid contracts. Majority of operation and maintenance activities are performed by SD1 staff. SD1 is currently operating under a watershed-based consent decree with Kentucky Division of Water and U.S. EPA that is focused on CSO and SSO control.

SD1's vision for more sustainable water infrastructure management would involve more coordination/collaboration with and the support of all involved stakeholders of Northern Kentucky (other utility providers, local jurisdictions, Planning and Zoning agencies, transportation agencies, general public). Modifications to the infrastructure management process would involve a greater emphasis on water conservation, distributed infrastructure, and development/planning practices that support development projects that incorporate sustainable infrastructure principles.

NKWD Overview:

Drinking water is provided by the NKWD to 81,000 customer accounts located within its service area covering two counties plus wholesale supply agreements with three customers serving areas in adjacent counties. The NKWD is governed by a Board of Commissioners comprised of representatives from both counties and is regulated by the Kentucky Public Service Commission.

Planning is reviewed and updated about every 5 years, resulting in a 20-year list of improvement projects and initiatives to meet needs categorized as regulatory compliance driven; capacity from growth; repair and replacement of aging infrastructure; enhancements to level of service for customers; and improvements to communication technology. Planning is conducted with the assistance of consultants and includes discussion with multiple local planning agencies to forecast capacity requirements. It appears that the per capita water consumption is declining modestly as environmental awareness increases and more efficient appliances and plumbing devices are installed. The NKWD is migrating toward a performance driven asset management program that will assist in prioritizing projects.

Design of projects considers “green” measures such as reduced energy demands and chemical feed requirements and pervious pavements and vegetative roofs to reduce the amount of runoff from the facility. Construction requires the use of Best Management Practices to control runoff.

Operations and maintenance programs include participating in a power shaving program with Duke Energy; maximizing pumping during off-peak hours; voluntary reuse of residuals by the contract disposal company; meter replacement program and installation of automated meter reading devices that hopefully will detect and eliminate water losses sooner; education of customers and school-age children through in-house opportunities and public outreach; leak detection of line losses; and recycle and/or additional treatment of streams generated during the treatment process to send to the head of process or discharge to surface water.

Technological Approaches: System Architecture

What would the Ideal be?

From SD1’s perspective, an ideal situation with respect to system architecture (with an emphasis on water/sewer/storm water service) would be based on a reduced demand on the public water and sewer system through water conservation, distributed treatment and advanced treatment processes that improve quality of effluent discharged to the watershed, and other techniques so the impact of storm water runoff is minimized. This would reduce energy demand for pumping, reduce O&M costs associated with a system that is designed to meet this lower demand, and improve water quality of receiving streams. Further, a regulatory system that is more scientifically-based with respect to water quality issues and recognizes opportunity costs would be helpful in developing an infrastructure system that is more sustainable.

What Building Blocks are in Place?

Through system consolidation, sewer/storm water utility service throughout a majority of Northern Kentucky is provided by a single entity. This has allowed for the development of greater technical expertise by the system owner/operator as compared to prior years.

What Impediments Exist?

For a variety of reasons (plentiful water source, lack of appropriate incentives, public support), the level of support for more sustainable methods of water, sewer, and storm water utility service is less than ideal. Also, the current regulatory structure (federal, state, and local) is not always consistent with distributed infrastructure concepts. Lastly, the vision of USEPA's sustainable infrastructure is not well understood globally and the level of expertise in sustainable infrastructure approaches among the local engineering community (which is more familiar with traditional development concepts) is less than ideal.

What are Potential Solutions to Existing Challenges?

Changing the current situation will require changes in incentives for customers and utility service provides, changes in the regulatory structure, and changes in the level of understanding/support among the public. Level of understanding can be increased by conducting training of state regulators and utilities and developing documents or guidance manuals and tools for assisting utilities with implementing programs that use sustainable infrastructure practices.

Regarding Four Supporting Components

1. Integrated Planning

What would the ideal be?

From SD1's perspective, an ideal situation with respect to planning would involve a more regional approach to sustainability issues across Northern Kentucky with a better recognition of the interaction between different types of infrastructure (water, sewer, storm water, power, transportation, etc.).

What building blocks are in place?

As a regional utility, SD1 has good working relationships with the local jurisdictions, Planning and Zoning agencies, community groups, and other utility service providers across the Northern Kentucky region. In many respects, these coordination efforts have been driven by the fact that SD1 recognizes the fact that it cannot effectively pursue its overall goal of water quality improvement without the support and involvement of these parties.

What impediments exist?

While these working relationships are good, the sheer number of entities involved can hinder progress on some issues. The perceived threat of regionalization by competing agencies or privatization can stifle cooperation between entities. Also, the level of understanding and support of water quality issues by all involved parties is not always great. The incentive and existing structure for integrated planning efforts between different utility service providers is sometimes less than ideal.

What are potential solutions to existing challenges?

Improvements to the current situation would likely require more centralized planning efforts (such as the consolidation of Planning and Zoning functions into a small number of groups) and an improved level of understanding among all parties about all issues involved with respect to more sustainable planning.

2. Regulatory and Programmatic Change

What would the ideal be?

From SD1's perspective, an ideal regulatory/programmatic situation would be based on reasonable, flexible, and scientifically-based federal regulations affecting sewer and storm water utilities. Also, ideal local regulations that affect water quality would be developed with the input of all necessary parties with everyone operating from a basis of clear understanding of the issues.

What building blocks are in place?

SD1 is responsible for developing regulations and construction standards with respect to sewer and storm water infrastructure. These regulations and standards are developed with input from the various stakeholders of the region (local jurisdictions, Planning and Zoning (P&Z) entities, local engineering community, etc.).

What impediments exist?

Planning in Northern Kentucky is managed through a relatively large number of P&Z entities. In general, there are few legally established structures that require coordination between these P&Z groups and SD1 with respect to sewer or storm water issues. Further, the codes of these P&Z groups (subdivision regulations, zoning ordinances, etc.) often have direct impact on water quality issues. Given the current level of coordination between SD1 and the local jurisdictions of Northern Kentucky, there is less attention given to water quality issues through the planning process than is ideal.

From SD1's perspective, federal and state regulations related to sanitary sewer service are sometimes overly restrictive and lead to the allocation of funds toward projects that yield minimal results. For example, all sanitary sewer overflows are deemed "illegal" by the USEPA with little recognition of the complexity of those problems. Many of SD1's SSOs are small volume overflows that occur during relatively large rainfall events and represent a minimal source of pollution into streams that are impacted by many other sources of water quality impairment (failing septic systems, urban runoff, loss of riparian corridor, etc.). The elimination of such SSOs often requires the use of funds that could provide more benefits if they were directed into other water quality improvement projects.

The NKWD has observed inconsistencies in how different USEPA regions approach compliance with the regulations. For example, one region does not allow sediments removed during treatment to be returned to the river while another region permits this practice.

What are potential solutions to existing challenges?

At a national, state, and local level, regulatory improvements would likely require legislative changes at all levels. These changes would provide a better recognition of the opportunity costs associated with any particular requirement and understanding of the need for close coordination between water, sewer, and storm water utilities with local government and Planning and Zoning organizations.

3. Community Engagement

What would the ideal be?

From SD1's perspective, an ideal community engagement situation would be based on a local population that understood, valued, and supported water quality issues. Further, this situation would also involve the public's active participation in small-scale projects and improvements (roof downspout disconnection, residential rain gardens, water conservation practices, etc.). If a key objective is to improve water quality of receiving streams, which benefits the inhabitants and aquatic life within the streams as well as recreational uses and drinking water providers, then methods for reducing contaminants in the discharges should be considered. This effort involves education of the public on the impacts of their actions and participation from all producers of wastes that end up in sanitary and storm sewers.

What building blocks are in place?

SD1 routinely engages with the public on issues such as treatment facility site location, rate adjustments, updates on our Consent Decree planning efforts, and public education associated with the storm water utility program. One area of note is the fact that up to 3,000 school-age children visit SD1 annually as part of the public education component of the storm water program. These visits provide an opportunity to see the various constructed stormwater BMPs located on SD1's site (green roof, permeable pavement, bioswales, wetlands, etc.).

What impediments exist?

In many respects, Northern Kentucky is a politically conservative area where environmental issues do not receive significant attention. In addition, water and sewer fees in this region have generally been low relative to other regions of the U.S. This often produces a situation where SD1 rate adjustments needed to make water quality improvements are not strongly supported.

Also, pretreatment programs that require dischargers to treat wastes to high water quality standards are costly to those entities. An aggressive program could be a deterrent to economic development if other communities being considered by the company do not have similar programs.

What are potential solutions to existing challenges?

Given SD1's current efforts, there appear to be relatively few options that the District could implement in the short term that would yield significant results. Nationwide public education on water-related issues (water shortages, impacted quality of surface waters, etc.) might be more helpful. Also, improvements in access to the surface waters of Northern Kentucky, through Park District/City projects, could generate a better understanding of current water quality challenges. Over the long-term, SD1's storm water public education program will likely yield more public support of water quality improvements across the region.

Dedicated federal funding of more sustainable sewer/storm water projects could also be helpful through the construction of more visible projects and the importance of the jobs associated with that work.

4. Management and Financing

What would the ideal be?

From SD1's perspective, an ideal management and financing situation would allow for the most cost-effective allocation of funds toward water quality improvements (sanitary sewer or storm water projects) at a level providing benefits that are necessary and supported by the public. In addition, this ideal structure would provide incentives for water conservation and other practices to minimize the need for new or improved infrastructure (particularly gray infrastructure).

What building blocks are in place?

SD1's management structure is reasonably well-positioned to make decisions across local, watershed, and regional scales. Given our service area (three counties, 30+ jurisdictions), oversight structure (Board appointed by each of the three County Judges Executive), and the fact that SD1 also operates a storm water management function, we are generally able to direct resources toward the most significant regional water quality problems. SD1's rate adjustments (sanitary and storm water) require approval from the Board and Judges Executive; there is no requirement for approval from the Kentucky Public Service Commission. SD1 has its own ratemaking tools, and performs its own billing based on data provided from several Northern Kentucky water utilities. This structure allows SD1 to be flexible in its planning and project selection processes; more so than many public utilities.

What impediments exist?

SD1 is similar to most other sewer utilities in that its primary revenue source is from customer billing, which is based on water usage. This structure provides little incentive for SD1 to encourage water conservation. Our traditional financial management approaches also present challenges with respect to the consideration of "true costs" of providing sanitary sewer and storm water utility services. For example, biosolids generated at SD1 treatment plants are hauled to landfills for disposal. The costs recognized in our financial projects cover O&M expenses associated with that hauling as well as capital costs associated with the required equipment. There is no consideration given to the fact that the trucks used for hauling have an air quality impact.

Given Northern Kentucky's location along the Ohio River, many of the water quality issues we face have an interstate component. The current structure of coordinating these interstate interests is not as strong as we would like.

What are potential solutions to existing challenges?

New approaches to revenue generation could provide an opportunity to better incentive sustainable practices. Such changes in revenue structure would likely require changes at the state level.

A better recognition of interstate interests (i.e., Ohio River water quality) would likely influence some areas of SD1's management decisions.

CASE STUDIES ON
NEW WATER INFRASTRUCTURE PARADIGM
WERF/EPRI Research Study

Pima County/Tucson – Pre-Retreat Information Integrated Planning

(Key concepts: multi-objective decision-making; triple bottom line evaluation; watershed planning tools' administrative support structure)

1. Integrated Planning

Located in Southern Arizona, the City of Tucson and Pima County face unique water resource and land use issues as a Sonaran desert community with a rapidly growing population. The metropolitan area of eastern Pima County has a population of over 1,000,000 people and was ranked the 52^{nd} largest metropolitan area in the United States. By land area the metropolitan area covers more than 700 square miles while Pima County itself covers approximately 9,200 square miles. Pima County lies in the heart of the upper Sonoran Desert, an environmentally rich and diverse ecosystem. Regional planning and management of water resources is essential in the arid southwest as planning and managing growth is critical to creating a sustainable water future and economic growth. There is a need to increase water conservation measures and maximize the use and re-use of locally renewable water resources including effluent, greywater and stormwater. At the same time there is a need to balance human, environmental, and economic uses for water.

What would the ideal be? (Goals and Objectives)

- Water management models that balance human, environmental and economic ideal needs for water.
- *Strengthen the nexus between land use planning, water resources and infrastructure planning*. For a sustainable community, comprehensive land use planning must consider the water resources while providing respect for the environment, agreement on population and urban form for the future and infrastructure planning.

- *Regional agreement on future growth*. Agreement across jurisdictions on policies for directing future growth to areas that are deemed to be the most appropriate for development that are integrated with sustainable water policy decisions. These agreements must include the allocation and funding of sustainable water resources.
- All applicable jurisdictions and regulatory agencies 'on the same page,' working together toward the same planning goal(s).
- The paradigm of water and wastewater utilities simply serving growth, whatever its size and location has to be changed.
- *Ensure sustainable water resources and supplies for current and future populations*. Strengthen the City/County and regional cooperation around water and planning issues. Ensure organizational flexibility and resource adaptability in a changing planning environment. Match water source and water quality to water use ie. potable system, reclaimed system, stormwater harvesting and aquifer recharge.

What building blocks are in place? (Foundation)

- *The Sonoran Desert Conservation Plan (SDCP)*. The SDCP was adopted by Pima County in 2001, and defines goals for protecting the cultural and natural heritage within Pima County. The SDCP has implications for sustainable water planning including: (1) the importance of floodplain functions and the need to pursue a more integrated management approach among various floodplain management programs and agencies, land use planning agencies and across jurisdictions; and (2) a great deal of inventory work was completed helping expand understanding of where some of the remaining stream ecosystems are that can be affected by groundwater pumping, hydro-geology, and the distribution of species and water supplies in eastern Pima County.
- *Water and Conservation Policies.* City and County policies support conservation of future water supplies for human, economic, and environmental purposes, such as replenishing the aquifer with Central Arizona Project (CAP), increasing the use of locally renewable resources, reducing groundwater pumping in areas that contain groundwater dependent ecosystems, maintaining target water levels for groundwater, streams, and springs, avoiding or mitigating the environmental impacts of developing new water resources, and continuing to reduce overall demand.
  - Water conservation has been a critical component of Tucson Water's planning process for several decades. Many programs have been implemented to encourage greater water use efficiency.
  - The County has policies in place that direct new development away from sensitive, groundwater dependent ecosystems. Additionally, policies are in place that require the evaluation of water resource impacts at the rezoning and comprehensive planning stages of new development.
  - Specific opportunities are already in place, such as the Conservation Effluent Pool (CEP), to ensure that the City and County commit water to a balanced set of uses reflective of the quality of life values of existing residents. Continue to identify specific high priority areas for environmental restoration taking into account the quality of riparian habitat as well as multi-benefits that may accrue from recreation park use and ground water augmentation.

   - Water policies are in place in the various jurisdictions. These include:
      - Pima County Comprehensive Plan
      - Pima County Sustainability Initiative
      - City of Tucson Sustainability Framework
      - City/County Water and Wastewater Infrastructure, Supply and Planning Study (Water Study)
- *Smart Growth Initiative.* The State of Arizona enacted smart growth legislation in 1998 and 2000 that requires municipalities and counties to plan for and address land use, environmental planning, water resources, energy, transportation, cost of development, and growth areas. In response, the City of Tucson General Plan and Pima County's Comprehensive Plan were developed to address these issues and incorporate policies and strategies to create a sustainable community.
- *Shared Community Goals*. The County, the City of Tucson, as well as all cities and towns within the metropolitan area, have planning departments intended to enhance community life in their jurisdictions.
   - Pima Association of Governments section 208 Clean Water Act Area-wide Water Quality Management Plan is in place.
   - Drought response plans, conservation plans, etc. have been prepared by the various entities based on their respective needs/resources.
- *Master Regional Infrastructure Plans.* Utilities, such as Tucson Water, the Regional Flood Control District and the Regional Wastewater Reclamation Department, have planning divisions to help plan for future work and identify Capital Improvement Projects (CIP) needs.
   - Tucson Water has employed rigorous cost-benefit analysis in its water conservation programming and evaluation efforts.
   - Pima County has a comprehensive Regional Wastewater Facility Plan (2006) for future treatment and conveyance needs, which considers regulatory requirements, asset management, growth, administration, and financial needs.
   - With the U.S. Corps of Engineers and U.S. Geological Survey, a watershed master plan for the Santa Cruz River and its tributaries has been developed to evaluate water resources, flood control, water quality, and environmental needs in Pima County.

What impediments exist (Challenges)

- *Water Scarcity*. Water supplies are increasingly scarce in the southwest, competition for remaining supplies will likely become fierce, and the population continues to grow. The region is dependent on pumping Colorado River water uphill 336 miles through the CAP canal system. Colorado River water may be compromised by regional shortages resulting from continued growth and global climate change. Historical pumping patterns have lowered localized groundwater tables resulting in a significant reduction in riparian ecosystems.
- *Water Management.* In the past water managers in Arizona have followed a traditional model which emphasizes human and economic needs and did not take into account the environmental needs for water.

- *Cost of Growth.* The cost of accommodating growth – both monetarily and environmentally – have the potential to be extremely high. A full and comprehensive planning process is needed.
- *Groundwater Quality.* Water quality may decline with increasing demand (parameters such as salinity, arsenic, selenium and nitrate may become larger issues).
- *Environmental Impacts.* Environmental issues such as land subsidence and additional riparian habitat degradation could occur if demand for groundwater increases.
- *Complex Jurisdictional and Land Ownership Issues.* In the western United States, counties tend to be large, encompassing a number of varied communities including cities, towns and Indian Nations. Pima County encompasses approximately 9,200 acres, an area larger than Massachusetts, of which 85% is federal, state or Indian land. Each of these communities has its own needs and planning departments. Each community needs to make its own decision regarding its future, but this can also cause fragmented and short-sighted planning.
- *Community and Utility Planning Areas.* Planning areas are not congruent, and many times are overlapping. Different jurisdictions may have different planning goals and rules. Each jurisdiction is in competition for tax dollars and revenue in order to ensure the growth and viability of its respective constituents. County, City and Town planning departments tend to focus on transportation, shopping and business/industry planning. Potable Water, Wastewater and Reclaimed water tend to receive less focus by land planners.
- *Uncertainties Related to Climate Change.* We are in a time of uncertainty with global warming, climate change, and drought, which can potentially affect local water demand, local rainfall, and future flows in the Colorado River Basin. Recent drought events regionally, nationally and even internationally demonstrate the need for our community to be strategically prepared for sustained drought conditions. Sustained drought coupled with climate change could affect the community's ability to address drought impacts on a social, economic and quality of life basis.

  Because of the level of uncertainty we face, an adaptive, flexible, and regularly updated scenario planning approach is required to ensure we are prepared as a community for sustained drought. There is less need for certainty in forecasts than there is for a regularly monitored credible range of drought possibilities that the utilities and the community can prepare for.

  A multi-pronged preparedness strategy can make the community more resilient to a variety of possible future scenarios and include such approaches as diversification of water supplies, water demand management (including increasing reliance on locally generated non-municipal delivery options such as water harvesting), and development and maintenance of necessary infrastructure.

  Elements of this planning approach are already underway. For example, the CAP's "ADD Water" process is considering the reliability of acquiring, developing and distributing water to enhance the reliability and the diversity of currently available water sources to meet future demands. Preserving readiness in the groundwater system by regular maintenance on wells, pumps, and reservoirs allows the Utility to bring these facilities into service if needed due to a shortage related to drought. In addition, maintaining adequate recharge facilities adds reliability to water supplies in times of drought. Use of scenario planning methods within this multi-pronged approach will further enhance the flexibility of water utilities to respond to drought impacts within the region.

- *Uncertainties.* Planning needs to account for uncertainty in a dynamic and sometimes turbulent planning environment. Population growth and trends can be predicted, but where and when growth occurs depends on many economic drivers. Even the natural environment is dynamic and subject to potential change due to wildfires and floods, as well as climate change impacts. Adaptive management is essential.
- *Unfunded Mandates.* Issues with unfunded mandates, such as the need to meet Clean Water Act requirements, water quality standards and the stormwater management program goals, strain the community's ability for local finance of the necessary improvements.
- *Major challenges identified in the City/County Water Study:*
  - Historical pattern of providing infrastructure based on demand without evaluating what areas are most suitable and sustainable for future growth.
  - Lack of infrastructure and funding mechanisms to deliver wet water to potential future growth areas.
  - Assured water supply rules that allow for growth to occur without wet water access to locally renewable water resources, resulting in on-going groundwater depletion with potential negative impacts to local watersheds (e.g. subsidence and damage or loss of groundwater sensitive ecosystems).
  - Lack of community consensus on the allocation of water for environment.

What are potential solutions to existing challenges? (Opportunities)

- *Adaptive Management*. Implement an adaptive management approach which includes use of best management practices for water resource management, and analytical tools such as comprehensive quantification of costs and benefits and scenario planning. It would also consider the legal rights and protections for people and ecosystems and commitment to sustainability.
- *Sustainability Model.* A sustainability model is needed in which environmental water needs are identified and the proper amount of water is allocated to ensure environmental systems remain healthy. Environmental protection and restoration efforts are a regional benefit. Costs of environmental restoration projects should be shared equitably by all beneficiaries in the region.
- *Financial Planning and Investments.* Employ full cost-benefit analysis before pursuing acquisition of additional resources. Full costs should consider such things as non-local environmental effects, environmental justice issues, and comparing additional water costs to those required for investing in the use and re-use of locally renewable water resources – effluent and rainwater. Acquiring additional water should be evaluated in comparison to investments in local resources such as stormwater recharge, greywater systems, rainwater harvesting, expansions to the reclaimed system, and constructed recharge of our effluent. Water conservation and additional water resources are seen as two sides of the same coin.

More conservation means less need for additional water. By encouraging greater water-use efficiency, water conservation programs can have a significant impact on the timing of critical decisions on water resources and system-planning projects.

- *Shared Goals.* The City and County develop shared water efficiency goals and strategies for new development at the sub-regional and neighborhood scales. Shared water efficiency goals are integrated into the sustainable growth strategies of the City/County land use plans (i.e. the City's General Plan and the County's Comprehensive Plan).
  - More use of multi-jurisdictional teams to coordinate means and goals.
  - Education of land use planners in the County, City and Town Planning Departments regarding the importance of water, wastewater and reclaimed water with regard to sustainable economic growth.
  - Foster a continued sense of watershed stewardship and partnership.
- *Land Use Plans and Development.* Planning Departments should have a wider planning vision to include water/wastewater/reclaimed/stormwater sections that are tasked with linking the valuable water resource to economic viability, and coordination with the various water and wastewater utilities.
  - Land and Utility planning should match the most effective and resource efficient water source with particular sites and needs.
  - Incorporate the consideration and evaluation of the use of reclaimed water, graywater and rainwater harvesting into the City and County development review processes.
- *Infrastructure and Resource Planning*. Greater use of scenario planning methodology when engaging in regional, integrated planning to ensure regional adaptability in a rapidly changing planning environment.
- *Community Involvement.* It is important to build upon substantive stakeholder engagement efforts of the past, such as the City of Tucson's Water Community Conservation Task Force process, and continue the community conversation about quality of life values and the role water plays in maintaining and enhancing all aspects of quality of life.
  - Identify incentives to conserve and develop voluntary ways for customers and residents to earmark water savings to specific projects that preserve options for the future and improve current conditions, such as expanding aquifer augmentation efforts, expanding green spaces (e.g. more ballparks and parks), and allocating water to sustain or restore riparian areas.
  - Develop more consistent public education with community involvement to further promote an ethic of sustainability and resource conservation.

2. Technological Approaches

(Key concepts; multi-objective decision-making criteria, triple bottom line evaluation, full cost accounting; distributed infrastructure; source control; new technologies)

General:

Pima County and the City of Tucson have typically embraced testing of new technologies, standardization of equipment as well as conservation measures, in an effort to maximize benefits (minimize cost and increase productivity/quality) as well as provide for long-term sustainability.

New Technologies:

- Pima County Regional Wastewater Reclamation Department (RWRD) is presently evaluating a biosolids treatment process that may save capital as well as operations and maintenance costs, while also moving from a class B to class A biosolids.
- The Flood Control District is continually evaluating new stormwater technologies to determine their applicability to local conditions and requirements, as well as the desert Southwest stormwater needs.
- Tucson Water promotes pilot testing of new technologies, such as arsenic removal from groundwater.

Standardization of Equipment:

- RWRD has standardized on the use of oxidation ditch processes for its subregional facilities for operational efficiencies.
- Tucson Water has standardized on the use of one type of sodium hypochlorite feed pump (174 sites) to streamline operation and maintenance, as well as spare parts storage.

Conservation Measures:

- Customer rebates are available for installation of low-flow toilets.
- Methods to slow storm flows, allow local recharge and beneficial use of storm flows are being implementing. These include promotion of individualized home rainwater collection systems, development of stormwater collections systems, as well as regional facilities.
- RWRD makes beneficial use of its biogas for electrical production.
- A number of solar power facilities continue to be installed at water and wastewater facilities to offset power use.

What would the ideal be? (Goals and Objectives)

Overall:

- Continue to pursue energy efficiency and expand use of renewable energy in water utility operations to include the following:
  - Conduct routine energy audits to assess energy consumption
  - Conduct periodic reviews to ensure the use of appropriate energy technology.

- Examples would include reduction of carbon-dependent power systems and increasing reliance on alternative technologies such as hydroelectric power generation at pressure reducing stations and/or expanded solar power use and increased use of bio-gas. As carbon-based energy costs increase and environmental off-setting factors become increasingly important, expanded use of alternative power-generating technologies will become increasingly viable (triple bottom line).
- Utilize diverse energy resources to increase operating flexibility and manage costs.
- Determine the utilities' carbon footprint and look to reduce at existing and proposed facilities (triple bottom line)
- Increase integration of GIS technology with multi-dimensional modeling analyses for such applications as preparing spatial population projections, transportation analysis, wastewater system improvements, potable and reclaimed water system improvements and trouble-shooting, groundwater flow and aquifer management, stormwater analysis, sediment transport assessment, and so on.
- Optimize methane and solar power generation opportunities. Look to future possibilities such as using wastewater for algae growth for bio-fuel and co-generation using bio-solids.

Potable Water:

- Establish the financing and build the necessary infrastructure to attain 'wet-water' supply sustainability by 2020 by fully utilizing currently available renewable supplies, acquiring additional supplies to increase supply reliability and meet projected future demand, and expand conservation and demand management programs to increase water use efficiencies.
- Protect and enhance the quality of Tucson Water resources by implementing programs to meet all regulations; conducting water quality monitoring of currently non-regulated compounds/emerging contaminants to characterize water resources; continuing participation in regional salinity management issues; enhancing the source water protection program; and continuing coordination with agencies to promote remediation of groundwater contamination/superfund sites which pose threats to the Utility's water supply. (Water Department-General Plan Policy)
- Reduce the vulnerability of water supplies to potential threats by investing in, installing, and maintaining appropriate security technologies; maintaining and updating vulnerability assessments; maintaining and expanding the cross-connection control program; investing in real-time water-quality analytical capabilities within the potable system to monitor and manage potential security threats, and adopting/revising policies to protect water quality and system integrity.
- Update and expand use of SCADA to remotely optimize system operations, to monitor facility performance, and to expand proactive maintenance management activities.

Reclaimed Water System:

- Use reclaimed water to the fullest cost-effective extent possible to offset potable use thereby providing for a more sustainable potable water system.
- Convey the Water Utility's remaining reclaimed water supplies to recharge facilities to strategically augment the regional aquifers for later wet-water use in order to ensure wet-water sustainability in future years.

Water Reclamation Facilities (Wastewater Treatment):

- Produce high quality reclaimed water product on a reliable basis.
- Pre-treat to effectively screen problematic compounds.
- Use regional or sub-regional treatment plants where appropriate in the future.
- Use reclaimed water in conjunction with harvested stormwater in multi-purpose facilities combining irrigation of parks, recreation, wildlife and recharge.

Stormwater:

- The metro area's naturally vegetated water courses are preserved as an amenity as wildlife habitat and as a BMP for runoff.

What building blocks are in place? (Foundation)

Potable Water System:

- System is both 'distributed' (with over 200 groundwater wells) and centralized with extensive infrastructure to recharge, store, and recover the Utility's renewable Central Arizona Project supply allotment for potable supply.
- The Central Arizona Project is a 336-mile aqueduct through which Colorado River water is conveyed from Lake Havasu to Tucson; the total pumping lift to Tucson is about 2,300 feet. Because of the technical engineering capacities of the CAP aqueduct system, Tucson Water and the greater metropolitan area is becoming more dependent on precipitation in the Colorado River watershed than it is on the physical availability of the other locally-derived water resources.
- The renewable Central Arizona Project supply provides over 50% of the potable water served in Tucson Water's Service Area. It is expected that sufficient infrastructure will be in place so that the Central Arizona Project allotment will be fully utilized by 2020.
- Tucson Water's already built recharge, subsurface aquifer storage, and recovery facilities provide multiple benefits.
  - They provide a means to utilize renewable water resources through a hydrologically sustainable resource management program.
  - They also serve as treatment facilities taking advantage of Soil-Aquifer-Treatment processes which significantly improve the quality of the source water without the use of chemicals.

  - Finally, these facilities provide the vehicle to recharge surplus supplies and put them in long-term aquifer storage to prepare for anticipated shortage declarations on the Colorado River.
- Central Arizona Project recovery performance capability is monitored by SCADA technology in order initiate preventative maintenance.
- Tucson Water's access to Central Arizona Project water makes it possible for its service area to achieve hydrologic sustainability within the next ten years.
- Steps are being taken to evaluate emerging contaminants through various research foundations.
- The Utility is engaging in the Central Arizona Project's ADD Water program to acquire additional supplies via the aqueduct to increase resource reliability as well as meet increases in projected water demand.
- The Utility has initiated steps to increase water use efficiencies by expanding its water conservation program in consultation with a community-based conservation task force.
- The Utility has established a program to replace aged meters in the potable system to obtain more accurate water delivery information, ensure more accurate billing, and reduce system losses and costs.
- The Utility has established a cost-effective program to slip-line pipes and mains that have exceeded their design life or which would otherwise need to be replaced due to wear/corrosion.

Reclaimed System:

- Reclaimed water is a renewable water supply and its annual availability increases as the Tucson community grows.
- The existing centralized reclaimed-water system is operated by Tucson Water and delivers approximately 13,000 acre-feet in 2008 to meet non-potable system demand in its service area. This constitutes approximately 10 percent of the Utility's total water demand in 2008.
- The centralized system currently serves a large area and can accommodate additional water sources (such as from a distributed water reclamation plant or from remediated groundwater treatment sources) in order to provide non-potable supply to potentially new reclaimed water users.
- Plans are in place to expand Tucson Water's existing reclaimed facilities to meet projected reclaimed water system demand and fully utilize the Tucson Water reclaimed allocation.

Water Reclamation Facilities (Wastewater Treatment):

- There are three centralized metropolitan treatment facilities and eight distributed outlying treatment facilities in eastern Pima County. Roger Road WRF is the main source of water for the reclaimed system. Randolph WRF is exclusively reclaimed water. Ina Road WRF will provide an additional reclaimed water source in the future. The existing distributed sub-regional treatment facilities are beyond the reach of the existing reclaimed system unless significant infrastructure is constructed. Green Valley WRF provides most of its reclaimed water to a local developer for recharge and/or reuse. Other similar opportunities may exist for small reclaimed systems that utilize the resource from the sub-regional treatment plants to provide for nearby users.

- Pima County has consistently received gold, silver and special awards for its treatment operation and water quality.
- Pima County, through its Regional Optimization Metropolitan Program (ROMP) program, is in the process of upgrading two major multiple WRF's to expand capacity, to increase flexibility, and to meet the facility BADCT requirements of ADEQ.

Stormwater:

- Pima County has experience operating wetlands environmental restoration and Stormwater harvesting projects, one of which received a national environmental NACWA award.
- The City of Tucson operates an MS4 that has received national recognition for its public outreach/education and flood safety programs. EPA audit in 2006 gave the City's MS4 program high marks.
- Pima County's Regional Flood Control District operates with independent taxing authority and ability to develop regional flood control projects.

What Impediments Exist (Challenges)

General:

- Payback period for many energy generating systems (such as solar, hydroelectric at water pressure reducing stations) is not yet viable, and utilities have limited funding to spend on the 'basics' let alone energy generating systems.
- Multiple and overlapping jurisdictions/service areas have lead to fragmented infrastructure planning and uneven applications of new technologies.

Potable Water System:

- Increasing stringency of water-quality regulations for drinking water supplies will create technical challenges in future years, especially in areas where there are distributed sources (wells) of supply. This increasing stringency is in part being driven by recent advances in analytical technology that have greatly improved the ability of laboratories to quantify the presence of substances in extremely small concentrations.
- There can be a significant time lag between detection of emerging contaminants, full understanding of the public health impact, development of regulation, and deployment of appropriate treatment technology.
- The need to maintain total organic carbon of imported water supplies at the low existing system levels in order to keep the production of disinfection byproducts at the currently low levels. This will allow the utility to continue utilizing chlorine rather than chloramine, for instance, as the secondary treatment disinfectant of choice.

- The need to further assess technical improvements in conservation technologies and evaluate their appropriateness.
- Managing the salinity of imported Colorado River Water may become an issue in future years (be it initially on the potable or later on the wastewater treatment side) in order to maintain aquifer water quality and minimize impact on customer appliances.
- A potential shortage on the Colorado River could, in time, translate into reduced access to the Central Arizona Project allocation(s). This may make it necessary to tap into and/or import other renewable sources of supply, at great cost, to off-set losses associated with shortage.
- The need to develop a hydrologically sustainable groundwater pumping plan to ensure long-term productivity of the regional aquifers and minimize environmental impacts associated with additional land subsidence and habitat losses. This in part requires greater regional coordination as a primary operating goal.
- Continue to explore opportunities to acquire and import additional water resources to increase the reliability of currently available water resources and to meet projected future water demand. The additional supplies may require an expensive upgrade to the Central Arizona Project's delivery infrastructure and added redundancy to ensure supply reliability.
- Maintaining and replacing existing potable infrastructure will become increasingly expensive and problematic in future years. Potential opportunities to repair and extend the life of existing infrastructure as opposed to replacing it will need to be explored—such as the slip-lining of aged galvanized pipes/mains.

Reclaimed System:

- Usage is quite variable, ranging from over 31 mgd in the summer to virtually 0 mgd on wet rainy days in the winter. It is difficult to accept flows from water reclamation facilities when reclaimed usage is very low.
- Wastewater is permitted/treated to a lower class for discharge than the reclaimed system is permitted to distribute. So the reclaimed system includes additional treatment to bring the reclaimed water up to acceptable permit levels, for its ultimate use.
- Costly improvements will need to be made to the Tucson Water reclaimed water system in order to fully utilize their effluent entitlement through aquifer augmentation/indirect potable-reuse water-management plan. It is unclear at this time if the financial resources and sufficient pubic acceptance will exist before the need becomes acute.
- Cost structure for reclaimed water cannot compete with groundwater pumped by a user with their own water right and well.

Water Reclamation Facilities (Wastewater Treatment):

- Locations of the existing sub-regional facilities are not close enough to the existing reclaimed system to connect to the system.
- Increasingly stringent water-quality and environmental regulations.

- The two main regional WRF's are located down gradient from most of the metropolitan area. Reclaimed water must then be conveyed significant distances up gradient for use.
- Funding for treatment plant upgrades is a continual challenge.

What are potential solutions to existing challenges? (Opportunities)

General:

- Promote other forms of funding or incentives (such as expansion of tax incentives) for utilities to take advantage of distributed energy generating facilities, such as solar power, or hydroelectric generation of electricity at pressure reducing stations (between potable water zones or use of bio-gas).

Potable Water System:

- Invest in research which could reduce the time lag between detection of emerging contaminants and effective treatment. It would also be helpful if the regulatory rule development process is both sensitive to the time lag issue and financially contributes to its timely resolution.
- Continue to monitor the effectiveness of Soil Aquifer Treatment to ensure reductions of total organic carbon continue.
- Further explore innovations in conservation technologies, such as high efficiency toilets and other low-water use appliances, to reduce *per capita* potable water use in future years.
- There will be a need to fully integrate locally-generated wastewater effluent into a water resources portfolio. This in turn will entail a significant upgrade in treatment capabilities as part of a water management program which relies on indirect potable reuse of municipal wastewater or the treatment and use of impaired waters (such as contaminated ground water).
- Continue to store as much Colorado River Water as possible in recharge and recovery facilities in order to offset future possible shortfalls, be they due to temporary drought or climate change.
- Increase public education regarding the actual expected impacts of drought conditions on the Colorado River allocation to the Tucson metropolitan area.
- Construct recovery well fields and expand conveyance capability of infrastructure to deliver renewable water supplies to more distant points of use.
- Continue to promote conservation and innovative technologically-based ways, in all water-use sectors, in order to increase efficiencies and reduce indoor and outdoor water use. Promotion of such technologically-based improvements could include wider use of more efficient in-house water fixtures, on-site rain-water harvesting, increased on-site gray-water use, and more efficient drip-irrigation systems.
- Promote greater coordination between potable water treatment and wastewater treatment to optimize regional salinity management.

Reclaimed Water Systems:

- In addition to the use of recycled reclaimed water to meet some non-potable demand, provide for alternate uses of municipal wastewater effluent to reduce discharges into the river channels.
- Achieving a higher level of treatment could potentially make reclaimed water available to more users and would reduce the regulatory burden associated with managing its use.

Water Reclamation Facilities (Wastewater Treatment):

- Work toward beneficial use of reclaimed water from sub-regional water reclamation facilities. Where facilities are not close to the existing reclaimed system, a subregional reuse system could be developed (which might eventually connect to the larger existing reclaimed system, for more sustainable distribution of reclaimed water).
- Work toward identification of suitable uses for reclaimed water with a goal of beneficial use for all reclaimed water. Permitting levels should be congruent with reuse needs.
- Consider new bio-solids options, such as co-composting with garbage, environmental reclamation or co-generation.
- High quality reclaimed water could attract industrial users, for example cooling tower use and solar power generation.
- Recharge, reuse, and environmental restoration satisfy green infrastructure and low-impact development requirements that EPA is adding to MS4 program and other regulatory programs. Emphasizing this type of project may create some flexibility in regulatory constraints.
- Investigate opportunities to obtain constructed recharge credits for projects in Santa Cruz River by utilizing low-tech solutions, such as spreader dykes, T-levees, and small check dams to increase infiltration.
- Look at opportunities for reuse/recharge at sub-regional reclamation facilities.
- Increase the coordination of wastewater treatment and reclaimed water treatment to optimize treatment efficiencies and economies.
- Research to determine the effective improvement that will occur from the ROMP upgrades with regard to more effective removal of emerging contaminants.

Stormwater:

- On tributary watercourses, build additional riparian restoration projects where Stormwater harvesting is supplemented with reclaimed water to accomplish environmental restoration in conjunction with reuse for parks, recreation, wildlife, and recharge benefits.

3. Management and Financing

(Key concepts: financial incentives; market mechanisms; dedicated planning funding; diverse funding sources; integrated management and institutions; responsible funding and rate-setting)

Overview: Financial Planning is a critical component for the City and County. The ability of each entity to identify system requirements and fund those requirements is a fundamental component of maintaining each entity in a self supporting sustainable manner. The City and the County each face challenges based upon their own unique structures however; they both follow the same fundamental principals that govern water/wastewater utilities in the financial planning process.

What would the ideal be? (Goals and Objectives)

Potable Water: Revenue from water sales and other fees provide the cash required to operate, maintain, and expand the Utility's systems. In addition, a financial plan is established which meets the Mayor and Councils water policies related to debt service coverage (1.75%) as well as the reserve requirements.

Reclaimed Water: The pricing for reclaimed water should be established in accordance with cost of service and also include the social, environmental, and economic benefits to the community.

***Wastewater*:** Revenue from user fees provides a stable cash flow which covers annual operation, maintenance and capital replacement expenses as well as the 1.2 revenue/expense debt service coverage ratio. Connection fees for new development raise sufficient revenue to fund debt service for growth related CIP projects as well as any necessary pay-as-you growth –related projects.

What building blocks are in place? (Foundation)

- Organizational Structure of the water, wastewater and stormwater entities including management and financial functions and the respective citizen advisory committees which review and recommend financing and rate revenue needs.
- Financial Policies of the Pima County Board of Supervisors and City of Mayor and Council.
- Established financial planning processes including the development of annual and five-year financial plans and capital improvement plans.
- Rate setting in accordance with national standards as developed by AWWA and established water and wastewater financial consulting firms.
- Independent analysis is solicited for verification of community needs.
- New development pays "cost of growth" though construction and dedication of infrastructure and payment of growth-related fees and hook-up charges as well as plan review and inspection fees.
- Users are responsible for rehabilitation and regulatory-related expenses. Both Tucson Water and RWRD have embarked on significant rehabilitation programs to existing infrastructure, including pioneering CMOM program, CCTV evaluation/prioritization and GIS mapping of 3,500 miles of pipes and manholes. RWRD is the first Wastewater utility in the nation to utilize the ODOwatch odor control monitoring and detection including e-nose sensors. Tucson Water replaced over 172 miles of old galvanized steel mains in its system over the last 14 years. In addition, 48 miles of cast iron mains were rehabilitated over the same time period.

- RWRD Conveyance Division was the first enterprise (public or private) in the United States to receive three management standard certifications simultaneously -- for ISO 9001:2000 for Quality, ISO 14001 for Environmental and OHSAS 18001 for Safety.
- Individual golf courses pay for extensions of the reclaimed system to their property as well as for the reclaimed water itself and internal irrigation facilities.
- The Regional Water Study is educating the public on connections between expenses, mandates and revenue requirements.

What impediments exist (Challenges?)

- Political nature of rate setting.
- Community response to bonding agreements.
- Limitations resulting from financial policies.
- Some large groundwater users have no incentive to move away from the use of groundwater (via their own wells) and move over to the potable and/or reclaimed systems. Using their wells can deplete the groundwater, but the cost of transitioning to the use of public potable or reclaimed water exceeds the cost of pumping groundwater.
- The City has limited options for funding of potable and reclaimed water expansions outside the City of Tucson water service area.
- Cost of reclaimed water resource is perceived as high relative to groundwater.

What are potential solutions to existing challenges? (Opportunities)

- Enhance/broaden funding mechanisms for water and wastewater infrastructure.
- Establish National Water, Wastewater and Stormwater Trust Fund and/or Infrastructure Bank to facilitate funding through grants and loans to jurisdictions across the county.
- Restructure earmark process for EPA, Corps of Engineers and Bureau of Reclamation.
- Investigate the possibility of Pima County obtaining funding for reclaimed projects outside the City of Tucson service area to use for reclaimed system expansion needs for servicing County properties outside the Tucson Water service area.
- The County and City have funding options, such as the City's use of General Obligation bonds, which could be used for reclaimed system expansions, but these require voter authorization.
- Increase/enhance public outreach to educate customers regarding financial policies of the Utilities and need for bonding.

4. Community Engagement

(Key Concepts: multi-level engagement mechanisms; sustainability plan and benchmarking; capacity building)

A significant community engagement process related to water resource management and policy making is currently underway in conjunction with the joint City/County Water and Wastewater Infrastructure, Supply and Planning Study Water (Study). The long term goal of this multi-year Study is to assure a sustainable community water source given continuing pressure on water supply caused by population growth, climate change, and possible drought conditions. A joint City/County Oversight Committee was appointed to guide Phases 1 and 2 of the Study. All Oversight Committee meetings are open to the public. Future phases of the Study will seek to engage the greater Tucson Metropolitan area in identifying shared values, goals and preferred options for a sustainable water future.

Additionally, state law, or resolution of the elected bodies, establishes many additional public participation requirements for both the City and County. For example, the Pima County Comprehensive Plan requires public participation, including a number of advisory committees, as part of its adopted implementation strategy. Similarly, the City of Tucson develops and implements public participation plans when updating its General Plan.

Other examples of current committees specific to water, wastewater and stormwater are provided below under building blocks.

What would the ideal be? (Goals and Objectives)

Key goals and objectives contained in City/County adopted policies and/or emerging in the context of the Water Study include:

- Maintain and expand a strong public information and involvement program that provides mechanisms for incorporating community dialog into water-related decisions throughout the program, including public participation in funding of water related decisions.
- Provide early and on-going opportunities for public participation in water policy and planning and decision-making.
- Maintain and expand public involvement in water conservation.
- Use a variety of public participation methods to ensure full access to accurate information and multiple opportunities for input and dialogue with planners and decision makers.
- Ensure the public participation process is open and inclusive, and fosters engagement among a balanced cross section of the public, including the traditionally underserved populations such as low income, minority, elderly and disabled.
- Inform and solicit feedback from the public of how their input is being used throughout the decision making process.
- Build community capacity and communication through education, training and on-going relationships.
- Further heighten water awareness in the community.

What building blocks are in place? (Foundation)

Public Participation through City/County Advisory Committees/Task Forces

- **Citizens Water Advisory Committee (CWAC):** This 15-member advisory committee meets monthly and advises the City of Tucson Mayor and Council on water utility related issues such as water rates, budget development, long range planning, and capital project implementation.
- **Regional Wastewater Reclamation Advisory Committee (RWRAC):** This 13-member advisory committee meets monthly and advises the Pima County Board of Supervisors on budget development, long range planning, and capital project implementation**.**
- **Tucson Water Conservation Task Force:** Tucson Water established a Community Conservation Task Force (CTF), with representation from a wide range of stakeholders, to ensure its conservation strategies were effective and broadly supported by the community. Conservation measures were evaluated from both a water savings and cost effectiveness perspective and the evaluation results helped the CCTF develop a list of recommended conservation measures.
- **Local Drought Information Group (LDIG):** This is a county-level group that coordinates drought public awareness, provides impact information to local and state leaders, and develops, coordinates, and implements local mitigation and response options.
- **City of Tucson Stormwater Advisory Committee:** This Committee advises the City of Tucson Mayor and Council in development and application of the City's Floodplain Management Ordinance, Stormwater Management and the Wash Protection Ordinance.
- **The Capital Improvement Coordinating Committee:** This is a broad based committee of 25 people representing all jurisdictions and the public at large. They have regular public meetings.
- **Pima County Office of Community Participation:** The office supports public information and public relations efforts of Public Works departments in the County.
- **The Science Technical Advisory Team of the Sonoran Desert Conservation Plan (SDCP)**: This nine member group of scientists provides science-based stakeholder input relative to the implementation of the SDCP.
- **Environmental Quality Advisory Council:** The Environmental Quality Advisory Committee is made up of 10 members in the field of environmental protection including air pollution and control, water quality protection, solid waste and hazardous waste. The Committee make up includes professionals and members of the regulated community. They advise Pima County's Department of Environmental Quality and the Board of Supervisors in development and application of environmental programs, rules and regulations.
- **Flood Control Advisory Committee:** Because of the regional nature of the Flood Control District, the Flood Control Advisory Committee includes representatives of all local jurisdictions as well as 5 professional members. They advise the District and the Board on floodplain, riparian and stormwater regulations and standards and serve as a technical review board for variances and appeals. They also assist the District in developing and prioritizing projects for the District's capital improvement program.

Regional Public Participation through Pima Association of Governments

Pima Association of Governments (PAG) is the Tucson Metropolitan Planning Organization for eastern Pima County. PAG provides technical data and information and planning services in the areas of environmental and transportation planning for its member jurisdictions which include the City of Tucson, Pima County and all other incorporated jurisdictions and tribal governments in the eastern Pima County region. PAG conducts regional public participation efforts on behalf of its member jurisdictions. In the area of environmental planning, PAG has several standing committees that deal with issues of wastewater, water quality, and regional wastewater management planning (208 Plans). These committees meet monthly, are open to the public and include representation from PAG member jurisdictions and stakeholders. PAG's public participation efforts are governed by a public involvement policy adopted by its regional council that establishes guidelines based on national best practices for early, on-going and continuous public participation. The principles and goals of this policy are shared by all its member jurisdictions.

Public Hearings at Elected Official Meetings

Public participation is undertaken as part of the development of new ordinances and standards and final adoption of these regulatory requirements typically includes a public hearing before the elected body (i.e. City Mayor and Council and County Board of Supervisors).

Public/Stakeholder Participation in Infrastructure Planning

- Updates to the *City of Tucson General Plan* and the *Pima County Comprehensive Plan* include early and on-going public participation efforts.
- Tucson Water and Regional Wastewater Reclamation Department customers can request presentations to homeowner and other association events on virtually any potable, wastewater or reclaimed topic. Both utilities provide a speakers bureau in conjunction with the regular updates of their long range plans including the *Tucson Water 2050 Plan*, and the RWRD *Regional Optimization Master Plan.*

Access to Information

- Joint City of Tucson Website for Water and Wastewater Study: www.tucsonpimawaterstudy.com
- Tucson Water website:
- City of Tucson Website
- Regional Wastewater Reclamation Department website:
- Regional Flood Control District Website
- Sonoran Desert Conservation Plan website
- Tucson Water Bill Inserts
- Use of electronic media Cable 12 channel for Access Tucson)

- Open Meeting Law (Posting of notices of public meetings)
- Customers can also request tours of the various potable, wastewater and reclaimed facilities
- Public Service Announcements

Education and Training (Community Capacity Building)

- Tucson Water Outreach and Education Programs
  - **Zanjeros:** This is a technical assistance program providing water auditing services to Tucson Water customers
  - **Customer Support Unit**
  - **Public Information Program:** This includes distribution of printed materials and Participation in community events.
  - **Education and Training Programs:** This includes programs for school children and training programs for teachers and adult education programs that focus on workshops on desert landscaping methods and improving irrigation techniques. The adult programs are broken into homeowner and professional landscape categories.
- Stormwater public education and outreach by Tucson Department of Transportation, PAG and Pima County Department of Environmental Quality
- Pima County Regional Wastewater Reclamation Department partners with other departments and jurisdictions on education and outreach efforts.

Outside agencies providing education and training:

- Water Casa
- UA Extension Service
- Water Resources Research Center
- Arizona Water Institute
- ADWR Groundwater Users Advisors Council
- Tucson Regional Water Coalition
- Southern Arizona Water Users Association

What impediments exist (Challenges)

- Complexity of issues – need to frame issues clearly and accurately such that the public has a good understand of the issue and prepare in formats that are accessible to multiple audiences.
- Citizens located outside City limits, but within the Tucson Water service area sometimes feel that they do not have the same representation regarding rate increases, or other water issues, since they cannot vote on City initiatives.
- Regional public consensus is lacking on public values regarding issues related to sustainable water resource planning and management such as quality of life trade-offs associated with conserving water, the priorities and appropriate balance of human, environmental and economic needs for water, and the acquisition of future water supplies. Funding for community outreach and public participation is very limited.

What are potential solutions to existing challenges? (Opportunities)

- Build on work of City/County Water and Wastewater Study by translating technical papers into issue papers that can be used in other public forums.
- Incorporate public input on key water sustainability issues into the processes for updating the Pima County Comprehensive Plan and the City of Tucson General Plan
- Stakeholder and the public provide valuable input to the community engagement process *but must be involved* in all aspects of the process *including budget and finance.*
- In conjunction with public participation efforts planned for the Pima County Comprehensive Plan and City of Tucson General Plan updates, engage the community in a conversation about quality of life values and the role that water plays in maintaining and enhancing all aspects of quality of life.
- Build on the learning and relationships established with participants in the City/County Water and Wastewater Study in future efforts related to planning for a sustainable water future.

5. Regulatory and Programmatic Change

(Key concepts: regulatory reform; sustainability codes and ordinances; incentives; public investment)

Three over-arching goals guide our community's efforts with respect to regulatory compliance and administration of policy and code at the local level:

- Protecting Public Health
- Preserving and Enhancing our Natural Desert Environment as Our Community Grows
- Securing Sustainable Water Resources for Our Community's Future

We continue to adapt to a changing landscape of regulation and program development. Many of the primary water-quality and water use regulatory requirements have become more stringent over the years. This increasing stringency is driven, in part, by recent advances in technology, for example new laboratory detection limits that are able to quantify trace levels of unregulated organic pollutants or the design of new, low water use, residential appliances. There is inherent uncertainty and complexity in balancing the various regulatory requirements with one another, and uncertainty increases when the requirements are continually evolving. Changes to one regulatory requirement often affect the way in which compliance with other regulations can be achieved.

Assuming the trend of more stringent regulation will continue, more elaborate water-quality treatment and water quantity management programs may have to be implemented. Some examples of areas where adaptation must occur to keep pace with regulatory change are listed below:

Protecting Public Health

- Emerging Contaminants of Concern, such as 1,4 Dioxane and various pharmaceutical compounds offer challenges for water quality managers because standards have not been set and epidemiology is uncertain**.** However, drinking water regulation incorporates monitoring for unregulated contaminants and the list of monitored parameters in wastewater facility permits continues to grow.
- Existing standards for compounds such as Arsenic, Selenium, and THMs are tightened as more health impact data become available.
- Evolving water quality permit programs, for example Stormwater MS4 permits, continue to expand their monitoring and water quality control requirements. Stormwater inspections, wastewater pretreatment programs, and drinking water wellhead protection activities are examples of an expanding role for local government in pollution prevention.

Preserving and Enhancing our Natural Desert Environment

- Endangered Species Protection is addressed with Habitat Conservation Plans providing a predetermined path that project planners can use to mitigate potential harm. However, both the endangered species list and our understanding of which habitats are valued can change.
- Increased pumping of alluvial aquifers in areas of shallow groundwater can stress riparian areas. State regulation is progressing toward greater restriction on groundwater pumped from wells adjacent to streams by identifying this water as surface water.
- Surface water discharge of reclaimed water is regulated by three separate sets of numeric standards and three separate sets of technology-based treatment standards. Each set of standards is subject to periodic revision.
- Development standards and land use codes are the primary mechanisms available at the local level for managing water quality and environmental impact. These tools sometimes offer a difficult fit for shoehorning regulatory approaches developed at the national level.

Securing Sustainable Water Resources

- The State has been in the process of adjudicating surface water rights on the Gila River since 1974. The outcome could impact availability of some water supplies in current use.
- ADWR is currently developing the Fourth Management Plan to cover the period of 2010-2020 for the Tucson AMA. A new plan is developed every 10 years, and each plan further tightens water conservation measures.
- Water is generally not regulated for salinity, but in our western arid setting, salinity increases with each additional cycle of water use. In the future, increased salinity in some our water supplies may require additional treatment prior to use.
- ADWR encourages local water management agencies to participate in drought contingency planning. Drought conditions in the arid West are an unpredictable reality that can complicate the regulatory picture and call for additional water management flexibility.

- Reclaimed water is a key component of the community's future water resource picture. Arizona's wastewater reuse regulations were revised in 2001 and will likely be revised again in the next few years. It is important that the community offer active stakeholder participation in development of these regulations.

What would the ideal be? (Goals and Objectives)

- Maintain and operate water, wastewater and stormwater systems/facilities in compliance with all regulatory requirements**.**
- Appropriate water quality and quantity regulations for arid west eco systems.
- Remove program conflicts between regulatory mandates.

What building blocks are in place? (Foundation)

- *Significant Federal and State regulatory/permitting requirements are in place* for water, wastewater, reclaimed and stormwater systems through EPA, ADEQ and DWR, including:
  - Arizona Department of Environmental Quality (ADEQ) regulates the City's reclaimed water system through permits which include a "Type III General Permit – Reclaimed Water Agent" and various aquifer protection permits (APP's)
  - ADEQ also regulates wastewater treatment facilities through APP's.
  - The Arizona Department of Water Resources (ADWR) regulates the City's reclaimed water and potable water systems through the Tucson Active Management Area (TAMA) Management Plans which include regulation of underground storage facility permits, water storage permits, and recovery well permits.
  - ADWR is also responsible for the groundwater savings programs in which approved facilities may replace groundwater use with reclaimed water or effluent use on a one-for-one basis.
  - Section 208 Plan Amendment (regional wastewater planning)
  - Reclaimed Water Use Permits
  - AZPDES Discharge Permits
  - Sewage biosolids regulation under Section 405 of the Clean Water Act
  - ADWR Regulates underground storage
  - 404 Permits
- Local/National code requirements/restrictions are in place, such as the National Plumbing Code.
- Pima County and the City of Tucson have adopted water policies that govern the reclaimed water system including:
  - New turf facilities and golf course development shall use effluent or reclaimed water for irrigation purposes.

What impediments exist (Challenges)

- Regulations stipulate treatment processes required to meet reuse standards, rather than just stipulating water quality requirements to meet the various reuse classifications. This can result in unneeded processes/costs for wastewater treatment.
- Sovereign Indian Nation water quality requirements are beginning to affect wastewater treatment levels/needs. These are much greater than those required by State regulation, and could result in significant economic impacts.
- Effluent ownership – SAWRSA (for Indian Nations benefit) has ownership of a large portion of the effluent generation from the metropolitan wastewater treatment facilities. The remaining ownership is split between Pima County, Tucson Water, Metro Water and the Town of Oro Valley.
- Regulations that allow discharge of chlorinated potable water to the environment, but do not allow discharge of chlorinated reclaimed water to the environment.
- Regulations that may unduly restrict the use of reclaimed water. One example is the plumbing code restriction that reclaimed water cannot be used for toilet flushing in residences.
- ADEQ’s surface water quality standards are set up for aquatic ecosystems, but in many of our discharge settings we have exclusive terrestrial and ephemeral environments.
- ADWR’s groundwater savings facility policy prevents getting in-lieu recharge credits for hooking existing users in proximity to Tucson’s water reclaimed water distribution system.
- In some instances, water rights issues regarding stormwater may prevent its capture, use and recharge.
- Multi-benefit projects are confusing to the regulators. Regulations are often conflicting between reuse, APP, AZPDES, Stormwater, etc.

What are potential solutions to existing challenges? (Opportunities)

- Jointly advocate for policy and rule changes (through ADEQ and ADWR) to overcome regulatory barriers to maximizing the use of reclaimed water:
  - Alternative operational and permitting strategies to achieve a Class A+ or equivalent rated reclaimed system
  - Use of groundwater savings facility credits to attract new reclaimed customers
  - Alternative permitting requirements for riparian restoration projects
- Expand the usage of effluent to maximize its benefits to offset potable use as well as environmental needs.
- Regulatory changes to dissuade the use of groundwater when other renewable sources, such as reclaimed water, are available.

D
PROJECT RETREAT PROCEEDINGS

Tetra Tech, under sponsorship from the Electric Power Research Institute (EPRI), organized and facilitated a retreat in Hebron, Kentucky from June 1 through June 3, 2009 for the purpose of gathering input toward the development of a new paradigm for water infrastructure management.

Retreat Participants

Attendance at the retreat was comprised of sponsors, Tetra Tech research team members, representatives from the two selected case study communities, and invited advisory panelists. A list of participants is provided below appearing in alphabetical order by last name.

Table D-1
Participants in the June 1 – 3, 2009 EPRI-sponsored retreat in Hebron KY

Name	Affiliation	Role
Blake Anderson	Blake Anderson Consulting	Advisory Panelist
Nick Ashbolt	USEPA – Office of Research and Development	Advisory Panelist
Kimberly Brewer	Tetra Tech	Research Team
Paul Brown	CDM	Advisory Panelist
Trevor Clements	Tetra Tech	Research Team
Ed Clerico	Allied Environmental	Research Team
Edward Curley	Pima County, Arizona	Community Rep.
Victor D'Amato	Tetra Tech	Research Team
Glen Daigger	CH2M Hill	Advisory Panelist
Elizabeth Dietzmann	Inman and Strickler	Research Team
Scott Drake	East Kentucky Power Cooperative	Advisory Panelist
Jim Gibson	Sanitation District #1 of Northern Kentucky	Community Rep.
Bob Goldstein	Electric Power Research Institute	Sponsor
Robert Goo	USEPA – Office of Wetlands, Oceans & Watersheds	Advisory Panelist
Mary Hansel	Carollo Engineers	Advisory Panelist
Jamie Holtzapfel	Sanitation District No. 1 of Northern Kentucky	Community Rep.
Larry Klein	City of Covington, KY	Community Rep.
Jim Kreissl	Consultant	Advisory Panelist
Melodee Loyer	Tucson Water	Community Rep.
Steve Moddemeyer	CollinsWoerman	Advisory Panelist
Jeff Moeller	Water Environment Research Foundation	Advisory Panelist
Dan Murray	USEPA – Office of Research and Development	Advisory Panelist
Valerie Nelson	Coalition for Alternative Wastewater Treatment	Advisory Panelist
Bob Pitt	University of Alabama-Tuscaloosa	Advisory Panelist

Table D-1
Participants in the June 1 – 3, 2009 EPRI-sponsored retreat in Hebron KY (continued)

Name	Affiliation	Role
Sharmili Reddy	Northern Kentucky Area Planning Commission	Community Rep.
Linda Reekie	AWWA Water Research Foundation	Advisory Panelist
John Scheben	Northern Kentucky Water District	Community Rep.
Ron Schmitt	Sanitation District No. 1 of Northern Kentucky	Community Rep.
Paul Schwartz	Clean Water Action	Advisory Panelist
Melany Seacat	Pima County, AZ	Community Rep.
Suzanne Shields	Pima County, AZ	Community Rep.
Julie Smoak	Kentucky Dept. for Environmental Protection	Advisory Panelist
Scott Struck	Tetra Tech	Research Team
Tina Taylor	Electric Power Research Institute	Sponsor
Jim Turner	Sanitation District No. 1 of Northern Kentucky	Community Rep.

Retreat Agenda

The retreat agenda was organized to first orient the collective group to the existing circumstances of each community, then to look at potential goals and objectives for sustainable water infrastructure including system architectures for each community, followed by discussion on how each community might move toward those visions, and then to expand the discussion to the broader paradigm that would be flexible enough to apply to any community. The specific agenda is summarized below in the table by date and timeframe.

Table D-2
Retreat agenda

Day 1 – June 1, 2009	Plenary Session in Concorde D & E Room	
1:00 – 2:45 pm	□ Workshop overview/introductory remarks/participant introductions □ Northern Kentucky Community overview and vision □ Tucson-Pima County Community overview and vision □ Community breakout session overview and instructions	
2:45 – 3:00 pm	Break in D & E Foyer	
	N. Kentucky Breakout Group Concorde D & E Room	**Tucson-Pima Co. Breakout Group Concorde F**
3:00 – 5:00 pm	Technological approaches/system architecture: review existing; small group exercise	Technological approaches/system architecture: review existing; small group exercise
5:30 – 7:00 pm	Group dinner in C & D Foyer	
7:00 – 7:45 pm	Technological approaches/system architecture: consolidate small group ideas into overall proposed approach	Technological approaches/system architecture: consolidate small group ideas into overall proposed approach
7:45 – 8:45 pm	Whole group debriefing on proposed approaches for both communities	

Table D-2
Retreat agenda (continued)

Day 2 – June 2, 2009	N. Kentucky Breakout Group Concorde D & E Room	Tucson-Pima Co. Breakout Group Concorde F
7:00 – 8:00 am	Group breakfast in C & D Foyer	
8:00 – 9:15 am	Integrated planning	Integrated planning
9:15 – 10:00 am	Share discussion on Integrated Planning with whole group in Concorde D & E	
10:00 – 10:15 am	Break in D & E Foyer	
10:15 – 11:30 am	Community engagement	Community engagement
11:30 – 12:00 noon	Share discussion on Community Engagement with whole group in Concorde D & E	
12:00 – 1:00 pm	Lunch in C & D Foyer	
1:00 – 2:15 pm	Regulatory/Programmatic change	Regulatory/Programmatic change
2:15 – 3:00 pm	Share discussion on Reg./Prog. change with whole group in Concorde D & E	
3:00 – 3:15 pm	Break in D & E Foyer	
3:15 – 4:30 pm	Management & financing	Management & financing
4:30 – 5:15 pm	Share discussion on Management & Financing with whole group in Concorde D & E	
6:00 – 8:00 pm	Group dinner in C & D Foyer	
Day 3 – June 3, 2009	**Closing Session in Concorde D & E Room**	
7:00 – 8:00 am	Group breakfast in C & D Foyer	
8:00 – 9:45 am	Review highlights of each community case study, commonalities and foundation for a new water infrastructure management paradigm	
9:45 – 10:00 am	Break in D & E Foyer	
10:15 – 11:30 am	Discuss ideas for broader framework for a new paradigm to apply to other communities	
11:30 – 12:00 noon	Identify follow-up steps needed	
12:00 noon	Adjourn	

Plenary Session – June 1, 2009 1:00 p.m. to 2:45 p.m.

Retreat Objectives

After introductions of the participants, two primary objectives were identified for the retreat:

- Objective 1: Gather information and input to support development of document outlining a new paradigm for water infrastructure management.
- Objective 2: Obtain information to help complete two community case studies that examine how each community might move forward from where they are today to achieving a vision for where they want to be in the future regarding sustainable water infrastructure.

Roles for the Retreat

The role of each participant group was reviewed:

Research Team – facilitation, expert knowledge sharing, and intake/documentation of information generated by community and advisory panel representatives.

Community Representatives – 1) provide background information on their community and its perspectives, identifying building blocks and challenges/questions for consideration by the Research Team and panelists; and 2) participate in discussion with the Research Team and Advisory Panelists to provide real-world community perspective.

Advisory Panelists – apply knowledge and experience to provide constructive input to help answer the core research questions to support development of a new paradigm:

- What would the ideal be? (specific objectives for paradigm and its components)
- What building blocks are in place? (foundation)
- What impediments exist to moving forward with those objectives? (challenges)
- What are potential solutions to existing challenges? (opportunities)

All retreat participants were asked to work together as a team rather than to advocate individual positions or agendas.

General Definitions and Principles

For the purpose of the retreat, participants were asked to accept the general definitions and principles applicable to sustainable communities that were established following the pre-retreat teleconference (see page 1-1 for reference).

Northern Kentucky Community Overview

Jim Turner, the Capital Improvements Program Manager for Sanitation District No. 1 of Northern Kentucky (SD1), began the overview of the Northern Kentucky community. The area served by the District covers 229 square miles and is comprised of three counties – Boone, Kenton, and Campbell. The current population of these counties is approximately 350,000 with the City of Covington being the largest municipality at 40,000 people. The overall growth rate for the area was 27 percent between 1990 and 2008, with Boone County experiencing 100 percent growth during that period. A portion of the area is known as the "golden triangle for its economic activity; it is home to the Cincinnati Airport (Delta/Comair hub) and Northern Kentucky University, as well as significant businesses including Fidelity Investments, Toyota, and Citigroup.

SD1 was established as a special district in Kentucky and has been in existence for over 60 years. It is responsible for providing sewer services to most of the Northern Kentucky region, and it also oversees stormwater management for the region. SD1 oversees more than 1600 miles of sewer pipeline, and two regional water reclamation facilities with a third under construction. It currently has 50.5 MGD of treatment capacity which discharge to the Ohio River and Twelve-mile Creek (which eventually flows into the Ohio River). The average sewer bill for a family is roughly $30 per month. The typical stormwater fee is about $4.50 monthly.

Many of the areas near the City of Cincinnati have older sewers that are in deteriorating condition. The system is prone to inflow and infiltration (some reasons unique to area), and it has limited capacity to handle wet weather flows. Combined sewer overflows (CSOs) from 97 locations have totaled an estimated 1.8 billion gallons annually. Another 240 million gallons annually is attributed to sanitary sewer overflows (SSOs) at 126 locations. This has contributed to a number of streams being placed on the State's 303(d) list of impaired waters for bacteria and dissolved oxygen. Other causes of impairment in the area include urban stormwater runoff, septic systems, agricultural land runoff, and severe stream bed erosion.

SD1 is under a Consent Degree with USEPA and the Kentucky Department of Water, with a compliance deadline of December 2025. They are required to develop "Watershed Plans" every five years that describe how the District is to address both CSOs and SSOs. These plans have led to the development of sustainability initiatives including gray, green and watershed controls. Green infrastructure includes low impact development (LID) with techniques such as green roofs and biofiltration.

Other challenges include a significant number of homes with septic systems where conditions are not suitable (shallow rock, transmissive soils); however, this may be an opportunity to look at other distributed onsite systems. Unique construction methods in the area make managing wastewater and stormwater challenging, as does inheriting sewer systems previously designed, installed and maintained by others that are aging.

Mr. Turner summarized building blocks and challenges for sustainability of water infrastructure in Northern Kentucky. It is helpful that SD1 handles both wastewater and stormwater, and covers multiple local jurisdictions. This allows SD1 to look at problems more holistically (versus when the region had multiple cities handling all of their systems with their own concerns). Additionally, the District is able to put resources into examining sources other than CSOs and SSOs to characterize how others can help with water quality. The Consent Decree provides a driver for this more comprehensive watershed-based management approach. As mentioned earlier, they are emphasizing green infrastructure which integrates the societal and economic concerns with the environmental. They also have a power sharing program with Duke Energy to work on energy savings at peak demand times during the day. SD1 and Duke Energy are also exploring the potential for a facility that would use biosolids to generate energy.

Mr. John Scheben, the Design Engineering Supervisor for the Northern Kentucky Water District, then spoke about water supply and infrastructure for the region. They represent the largest water district in Kentucky and are the third largest water provider in the state. The county judges appoint the Board overseeing the district, but water rates must be approved by the Kentucky Public Service Commission which can cause problems at times.

The Water District operates three water treatment plants and oversees 20 storage tanks, 15 pump stations and 1,192 miles of water main pipes. The plants draw their water out of the Ohio and Licking rivers, and water is provided for about 300,000 people. Service includes the Cincinnati metropolitan airport.

Their challenges include aging infrastructure (water mains are over 100 years old in some areas). Federal mandates (an estimated additional 5-year cost of $88 million out of the $212 million budget) are resulting in dramatic increases in water rates to the community. There also are areas where the Safe Drinking Water Act and the Clean Water Act come into conflict.

Building blocks and opportunities include the Asset Management Program and expansion of the southern area where new concepts could be employed. The Water District is placing more attention on "green" project design, particularly in energy efficiency and chemical feed management. They are replacing old meters with new models that help better track use and can support conservation efforts.

Tucson – Pima County Community Overview

Mr. Ed Curley, Strategic Planning Manager for the Pima County Wastewater Reclamation Department, began the overview for the Tucson – Pima County community. Suzanne Shields, Director and Chief Engineer for the Pima County Regional Flood Control District, spoke briefly regarding floodplain management and stormwater. Melodee Loyer, Managing Engineer for Tucson Water, touched on water conservation and water storage elements. Melaney Seacat, Pima County Coordinator for the City/County Water and Wastewater Study, added background information on the joint study and its status.

Pima County covers 9,200 square miles (an area roughly the size of the State of Massachusetts) of arid western land in Arizona. Approximately 42 percent of the county is Native American land, 44 percent is public land, and only 14 percent of the land is in private ownership.

The population in the county is roughly one million, with 742,000 living in the City of Tucson. There is rapid growth around Tucson, including satellite areas that pose special problems for utilities.

The arid west is defined by rainfall. Annual rainfall recorded in the metropolitan area averages about 12 inches. There are three distinct rainfall seasons: June to September is characterized by intense thunderstorms; October to November has occasional storms from Pacific hurricanes; and December to March can have large slow-moving storm fronts. Pima County's drainages all flow northward. Despite the intensity of storms, they are infrequent and drought conditions frequently pose challenges to the region.

Tucson's potable water system serves approximately 800,000 customers and is comprised of 212 production wells and 65 water storage facilities. The City also has a reclaimed water system comprised of 160 miles of pipeline, 5 reservoirs, a 10 million gallon/day (MGD) filtration plant, and recharge and recovery facilities. Reclaimed water is used at approximately 820 sites including 18 golf courses, 47 parks, 61 schools and 704 single family residences. Pima County adds 11 wastewater reclamation facilities (3 metropolitan and 8 sub-regional), including over 3,400 miles of sewer pipe, 64.8 million gallons per day of treated wastewater, and about 30 dry tons per day of biosolids to be applied to agricultural lands. In addition to irrigation uses, reclaimed effluent is utilized for riparian restoration and aquifer recharge.

Currently, 66 percent of the total water volume used in Tucson-Pima County comes from the Central Arizona Project where Colorado River water is diverted to groundwater storage facilities for future use, eleven percent comes from local groundwater, 14 percent reflects reclaimed effluent, and the remainder is from a replenishment district and incidental recharge.

There are significant water regulatory challenges associated with arid Arizona land. All of the water is allocated or owned through water rights. This includes groundwater rights and effluent entitlements.

Water quality issues in the region include high levels of salinity (from the Colorado River water), impacts of nutrients, pesticides, perchlorate and endocrine disrupter compounds (EDCs). Additionally, rainfall can be so intense that stormwater runoff overwhelms internal storm drains causing flooding, and erosion and sedimentation in stream channels. Wildfires also alter watershed conditions and subsequent runoff quality.

Other challenges that Tucson-Pima County face include regulatory requirements (the Clean Water Act was generally created for non-arid lands). The community believes that improved science and policy are needed for effluent-dependent and ephemeral streams.

With regard to its sustainability initiatives and vision, the community cites the Pima Association of Governments (PAG) as its foundation. The PAG is comprised of the cities, towns and Indian tribes and was established in 1972 to focus on cross-jurisdictional planning, including water quality and population growth. Both the City and County have established smart growth legislation addressing areas of land use, environmental planning, water resources, energy, transportation and more. The guiding vision for the City and County is to lead by example through their own sustainable practices, including renewable energy (with focus on solar), alternative fuels, waste reduction, green purchasing, water conservation and management, and paying attention to social wellbeing.

Recently, the City and County have been working on a joint Water and Wastewater Infrastructure, Supply and Planning Study. Core goals of the study are to

- Assure a sustainable community water source given continuing pressure on water supply caused by population growth.
- Identify and agree on basic facts related to the condition and capacity of water, wastewater and reclaimed water infrastructure, and the ability of the infrastructure to accommodate existing and future population within the city and county service areas.

The study has multiple phases that will collectively produce the foundation for community sustainable infrastructure.

Existing building blocks include several cooperative initiatives including constructed recharge, environmental restoration via stormwater management, ecosystem restoration and environmental preservation. Future opportunities include additional preservation and restoration under the Sonoran Desert Conservation Plan recently developed; designing and implementing appropriate floodplain management and stormwater management policies and practices in the Santa Cruz River watershed; and optimization of wastewater management under the County's Regional Master Plan that includes a blueprint for sustainable wastewater management.

Technological Approaches/System Architectures – June 1, 2009, 3:00 p.m. to 8:45 p.m.

Northern Kentucky

Community Objectives

- Reduce demand on the water and sewer system
- Have distributed treatment to improve quality of effluent and improve efficiency
- Improve quality of effluent for public health and environment
- Reduce long-term O&M costs
- Have regulations that reflect conditions
- Educate the community to improve awareness
- Reduce energy demand
- Improve energy independence
- Enhance public health through dual distribution systems of potable and non-potable water and distributed wastewater systems
- Restore the natural water balance
- Improve water quality and quantity and riparian health
- Use customer rater or tax affordability criteria for water, sewer, and stormwater long-term planning

Building Blocks

Through system consolidation, sewer/stormwater utility service throughout a majority of Northern Kentucky is provided by a single entity. Water supply is also provided on a regional basis by a single entity. This has allowed for the development of greater technical expertise by the system owner/operator compared to prior years.

Challenges

- For a variety of reasons (plentiful water source, lack of appropriate incentives, public support), the level of support for more sustainable methods of sewer and stormwater utility service is less than ideal.

- The current regulatory structure (federal, state, and local) is not always consistent with distributed infrastructure concepts.
- The level of expertise in sustainable infrastructure approaches among the local engineering community (which is more familiar with traditional development concepts) is less than ideal.

Therefore, changing the current situation will require changes in incentives for customers and utility service provides, changes in the regulatory structure, and changes in the level of understanding/support among the public.

Opportunities

Highest Priority and Most Promising Technologies

- Green Infrastructure
  - Green roofs, rainwater harvesting, etc.
- Water Conservation
  - Ohio River as supply source (maximize for non-potable uses)
  - Don't use more water than you need
- Buffers and other techniques, wetlands, stream restoration
  - Specific green techniques focused on streams and watersheds
  - Large scale stream restoration projects
  - Constructed wetlands
- High Efficiency Pumps
  - Design while thinking of maximizing efficiency
- Decentralized water/wastewater treatment
  - As the system expands we get into pockets that are harder to serve. Rely more heavily on technologies such as rainwater capture that does not require piping and movement
- Resource Recovery – taking the products in the waste stream and utilizing them (waste screening)
  - Biosolids, fats, oil, grease

Tucson – Pima County

Community Objectives

Pima County and the City of Tucson generally embrace testing of new technologies and standardization of equipment as well as conservation measures with the aim of maximizing benefits and providing for long-term sustainability. Community objectives identified and discussed with advisory panelists included:

- Work to "get off the grid" (eliminate dependence on Central Arizona Project and Colorado River water)
  - Produce high quality reclaimed water product on a reliable basis
  - Use reclaimed water to the fullest cost-effective extent possible to offset potable use
  - Use reclaimed water in conjunction with harvested stormwater in multi-purpose facilities combining irrigation of parks, recreation, wildlife and groundwater recharge
  - Convey remaining reclaimed water supplies to recharge facilities to augment regional aquifers
- Achieve a symbiosis between the built environment and natural environment
- The metro area's naturally vegetated water courses are preserved as an amenity, as wildlife habitat, and as a BMP for runoff
- Integrate water management with energy and other resource management initiatives
- Update and expand the use of SCADA to help optimize operations

Building Blocks

- The joint Tucson – Pima County Water and Wastewater Infrastructure, Supply and Planning Study provides a vision and strategy for providing the area with a sustainable water supply for the foreseeable future
- Tucson Water has already built distributed recharge and subsurface aquifer storage and recovery facilities
- Pima County's Regional Wastewater Reclamation Department (RWRD) makes beneficial use of its biogas for electrical production
- A number of solar power facilities continue to be installed at water and wastewater facilities to offset power use
- SCADA technology installed for Central Arizona Project and program to replace aging meters in the potable water system
- An existing network of reclaimed water systems (meeting about 10 percent of total water demand)
- Existing reuse of wastewater and stormwater for selected nonpotable uses including irrigation and wetland/riparian restoration
- Water and ecological conservation were important before they became "cool," which makes it easier to work with and reach out to the public on these issues

Challenges

- Rainfall events are rare, but often torrential when they do occur – challenge for capture and reuse
- Demand for reclaimed water usage is highly variable, ranging from over 31 MGD in summer to virtually zero in the winter

- Community wants "green" options, but wants to see short-term payback; payback period for many energy generating systems (e.g., solar, hydroelectric at water pressure reducing stations) is not yet viable
- Groundwater levels are decreasing, and management of this is out of the control of City and County; Tucson is a relatively small portion of the total Pima County area. Many people/entities continue to pump groundwater, further depleting aquifers in the region
- Land use impacts on water use that are outside of Tucson-Pima County control include the mining industry and agriculture, which when combined, use more water than the City and County together
- Salinity levels in the CAP water require additional treatment and pose issues for public consumers
- Having water sources located near reuse opportunities
- Treatment improvements needed to fully utilize effluent entitlement through aquifer augmentation/potable-reuse are quite costly
- Regulatory: standards for arid west
- Fragmented institutional organization has led to uneven applications of technologies

Opportunities

- Link land use planning with system architecture to be more water-centric (i.e., mix of natural and physical infrastructure)
- Bring demand closer to the supply of locally available water; where facilities are not close to the existing reclaimed system, a subregional reuse system could be developed
- Establish water conservation in the mining and agricultural communities
- Closed loop greenfield development at multiple scales
- Repurpose flood control to provide resource water; develop better technology for desert treatment of stormwater including protection of cisterns from first flush
- Build on existing restoration projects; place near supply sources and integrate with local community open space areas
- Reuse wastewater for potable use
- Integrate solar with water and wastewater infrastructure to reduce energy cost
- Integrate "smart" systems in homes and businesses to take advantage of the conservation ethic in the region
- Develop greater understanding of arid hydrology and ecology to support greater use of biomimicry technologies
- Consider new bio-solids options such as co-composting with garbage, environmental reclamation, or co-generation

Integrated Planning – June 2, 2009 8:00 a.m. to 10:00 a.m.

Northern Kentucky

Community Objectives

Achieve a more regional approach to sustainability issues across Northern Kentucky, with a better recognition of the interaction between different types of infrastructure (water, sewer, storm water, power, transportation, etc.).

Building Blocks

As regional utilities, SD1 and the NKWD have good working relationships with the local jurisdictions, planning and zoning agencies, community groups, and other utility service providers across the Northern Kentucky region. In many respects, these coordination efforts have been driven by the fact that SD1 and NKWD recognize that they cannot effectively pursue the overall goals of water quality improvement and planning for adequate water supply service without the support and involvement of these parties.

Challenges

While these working relationships are good, the sheer number of entities and number of local comprehensive plans in the region can hinder progress on some issues. Also, the level of understanding and support of water quality issues by all involved parties is not always great. The incentive and existing structure for integrated planning efforts between different utility service providers is sometimes less than ideal.

To strengthen integrated planning, the regional SD1 and NKWD need

- A mechanism to influence zoning for water quality protection and managing water from a watershed approach
- Stronger coordination between the Sanitation District and the Water District on sustainability policy and infrastructure planning/investment
- A statewide effort for integrated water planning should link to small watershed scale
- Joint communication and collaboration between the State's divisions of water, wastewater, and stormwater; local efforts need to link to state efforts
- A transportation planning link, at local and state scales, to water, wastewater, and water planning
- Local leadership (a champion)
- Mechanisms to measure, evaluate, and determine success/failure and change in direction. This should include indictors and benchmarks.
- Presentation of sustainable technologies and protection of sensitive areas in a way that appeals or is more palatable to the development community

- From a political perspective, challenges to integrated planning include the fact that developers tend to serve on, or lobby, city councils and planning commissions. As such, there is a bias in how decisions are made on land use planning favoring new development.

Opportunities

- Complying with SD1's consent decree with USEPA will mean significant rate increases if conventional practices are used in the future. Such rate increases would provide an impetus and incentives for more sustainable technologies.
- The upcoming update of Kenton County Comprehensive Plan will include sustainability planning. Invite state Department of Water representatives to participate. Use this as a model for the rest of the region.
- In the future, have a more strategic approach to Comprehensive Plan updates so the process is not so resource/time intensive. Use the indicators and benchmarks to determine which areas need to be adjusted.
- Create an opportunity for joint master planning with the SD1and NKWD staff and commissions.
- Educate developers on the benefits of sustainable technologies and conservation or protection of certain sensitive areas

Tucson – Pima County

Community Objectives

Located in Southern Arizona, the City of Tucson and Pima County face unique water resource and land use issues as a Sonaran desert community with a rapidly growing population. Regional planning and management of water resources are essential in the arid southwest as planning and managing growth are critical to creating a sustainable water future and economic growth. The following objectives were identified for moving the community forward:

- Improve community ability to react to dynamic, sometimes chaotic, circumstances that are not always handled well by linear planning processes within individual water programs (silos) to ensure sustainable water resources and infrastructure for current and future populations
- Develop ability to look farther into the future (e.g., 50 years) and then manage forward movement
- Develop better understanding of how complex systems work and establish capability to conduct portfolio analyses through development and application of assessment tools that link objectives (desired outcomes) to management options via indicators (quantifiable metrics)
- Strengthen the nexus between land use planning, water resources and infrastructure planning

Building Blocks

- The Sonoran Desert Conservation Plan highlights floodplain and stream functions and relationship to hydrogeology and groundwater pumping
- City and County water and conservation policies
- Smart growth planning requirements in Arizona; Pima County has developed an integrated tool to carry out these requirements
- The joint Water and Wastewater Infrastructure, Supply and Planning Study and master regional infrastructure plans

Challenges

- Historical emphasis on human and economic needs for water management does not take into account environmental needs for water
  - Historical pattern of providing infrastructure based on demand without evaluating what areas are most suitable and sustainable for future growth
  - Lack of community consensus on the allocation of water for environment
- Factors tend to force focus on the current problems
- Determining what is a functioning system when looking at performance standards
- Lack of tools can stymie planning process because there is insufficient backup for ideas
- Strong planning process requires strong leaders – what happens when leaders leave a community?
- There has been an historical disconnect between land use planning and water infrastructure planning – typically involves different agencies/authorities
  - Lack of infrastructure and funding mechanisms to deliver wet water to potential future growth areas
- Planning areas are not congruent and compete for tax dollars and revenue
- Local capacity is frequently strained to address the expectations of it with regard to infrastructure management; cost of full and comprehensive planning process to accommodate growth is extensive

Opportunities

- Have community define tactical principles reflecting desired outcomes and communicate them simply and clearly to the public; multiple components confuse the public – need to provide a comprehensive picture for the community to develop a better understanding of how complex systems work
- Establish a platform/forum for planning across community programs
  - Make greater use of scenario planning methodology when engaging in regional, integrated planning to ensure regional adaptability in a rapidly changing planning environment

- Implement an adaptive management approach and develop tools that support integrated planning including life cycle costs and risk assessment
- Link water infrastructure planning to land use planning
  - Match most effective and resource efficient water source with particular sites and needs
  - Incorporate use of reclaimed water, gray water and rainwater harvesting into the City and County development review processes
- Have the City and County develop shared water efficiency goals and strategies for new development at the sub-regional and neighborhood scales
- Have the development community evaluate impact on water resources from proposed projects
- Use public demonstration projects incorporating sustainability principles and addressing multiple objectives (e.g., start with river parks and school properties)

Community Engagement – June 2, 2009, 10:15 a.m. to 12:00 p.m.

Northern Kentucky

Community Objectives

Ideal community engagement would result in a local population that understands, values, and supports water quality and water supply issues. The public would actively participate in small-scale projects and improvements (roof downspout disconnection, residential rain gardens, water conservation practices, etc.).

Building Blocks

Through its stormwater permit compliance program, SD1 has an award winning public education program. SD1 manages the stormwater program on behalf of 33 cities and 3 counties. It developed interlocal agreements with all the cities and worked with them to come up with the stormwater requirements. Public education and outreach weaves throughout everything that they do. The program includes

- A public "BMP" park where field trips are made. It was built with contractors and developers in mind but turned into this outreach project. SD1 hosts tours for engineers, community groups, etc.
- An educational program taught in 61 schools in elementary schools (4th and 5th graders); response to the program was so overwhelming, high school classes have been requested and college classes will be offered soon; the course is about point sources, wetlands, pollution, etc.
- Waterific: tailored for 6 graders; 20 minute lesson about water in multiple booths in one location; just finished their 9th event; typically 250 students a day attend (depending on how many days the event lasts)

- An award program for children, supported by a grant from Wal-Mart, to complete a stormwater-related project
- Recognition program for schools going above and beyond
- Adult Education: workshops for stormwater; developed in a way that adults will change behaviors
- Developer Awards Program for green development and excellent construction site management practices

Challenges

Challenges center on future service affordability, political priorities, and community awareness:

- Affordable services as rates increase; facilities are rate-based and there is little that can be done with low income households.
- The region is politically conservative. Historically, environmental concerns have not been a priority (on the business side it works better for development, but residentially it is harder to implement).
- Most people don't worry about water or stormwater because it has never been a problem before.

Opportunities

Develop community engagement around what people care about:

- Health as it relates to water quality
- Money/cost
- Maintenance
- Reliability
- Parents want to make sure their children are taken care of and will make changes if water quality will impact the future of their children
- People will pay for the changes needed for water quality if the changes can be presented in a way that you can have integration of grey and green solutions
- Conservation (for future's sake)
- Green infrastructure (the beauty of it as opposed to grey pipes)

Opportunities for strengthening outreach include

- Water Festival: food, fishing, competitions, booths with instructions about water
- Recognition for implementation
- Corporate sponsorship for pilot projects
- Credit programs for business/schools (up to 80 percent)

Tucson – Pima County

Community Objectives

A significant community engagement process related to water resource management and policy-making is currently underway in conjunction with the joint City/County Water and Wastewater Infrastructure, Supply and Planning Study (Study). The long term goal of this multi-year Study is to assure a sustainable community water source given continuing pressure on water supply caused by population growth, climate change, and possible drought conditions. A joint City/County Oversight Committee was appointed to guide Phases 1 and 2 of the Study. All Oversight Committee meetings are open to the public. Future phases of the Study will seek to engage the greater Tucson Metropolitan area in identifying shared values, goals and preferred options for a sustainable water future. As the community moves forward, the following objectives should be considered:

- Further heighten water awareness in the community and encourage community groups to work together to create synergies and a stronger power base to influence public policy on water infrastructure
- Engage the public at the neighborhood level to educate and consider options
  - Provide early and ongoing opportunities for public participation in water policy and planning and decision making
  - Use a variety of public participation methods to ensure full access to accurate information and multiple opportunities for input
  - Build community capacity and communication through education, training and ongoing relationships

Building Blocks

- General public's conservation ethic in the region
- Pima Association of Governments and the Tucson standing committees have highly effective approaches for engaging the public that include round table discussions
- Public demonstration projects
- Access to information through numerous websites and other means
- Education and training through Tucson Water, Pima County and outside agencies (e.g., Water Casa, UA Extension Service, Water Resources Research Center, Arizona Water Institute, Tucson Regional Water Coalition, and Southern Arizona Water Users Association)

Challenges

- Complexity of issues challenges developing strong understanding among the public
- Regional public consensus is lacking on public values regarding issues related to sustainable water resource planning and management such as quality of life tradeoffs associated with conserving water, the priorities and appropriate balance of human, environmental and economic needs for water, and the acquisition of future supplies.

- Current economic climate limits capacity for conducting outreach to the degree warranted; Arizona receives less federal funding for water and wastewater than Guam
- The bottom-up approach is highly effective in gaining support but it is also very time intensive
- Figuring out how to promote innovation and collectively take that risk
- How to identify and communicate a real suite of benefits for sustainable infrastructure projects and system architectures

Opportunities

- Be aggressive with working together to collectively demand change where needed.
  - Incorporate public input on key water issues into the processes for updating the Pima County Comprehensive Plan and the City of Tucson General Plan.
- Train leaders in the community to do their own round table dialogues to provide feedback that can then be used in planning and infrastructure management.
  - Build on the work of the City/County Water and Wastewater Study by translating technical papers into issue papers that can be used in other public forums.
- Build the public into the behavioral and economic model, e.g., use community challenges including signed agreements to provide in-kind services, and use public "thermometer" signage to provide an indicator for the public to see to solicit neighbor and social pressure.
- Allow individual consumers and businesses to drive to a certain future, i.e., wind power stickers on restaurants and shopping centers; engage citizens on green infrastructure for reducing CSOs, stormwater damage, etc., allowing them to grab onto the idea of greening their community.
- Move the community to a better understanding of the true cost of water.
- Establish ecosystem markets that provide alternate means to achieving goals.

Regulatory and Programmatic Change – June 2, 2009 1:00 p.m. to 3:00 p.m.

Northern Kentucky

Community Objectives

An ideal regulatory/programmatic paradigm would be based on reasonable, flexible, and scientifically-based federal regulations affecting water, sewer and stormwater utilities. Also, ideal local regulations that affect water quality would be developed with the input of all necessary parties, with everyone operating from a basis of clear understanding of the issues.

Building Blocks

SD1 is responsible for developing regulations and construction standards with respect to sewer and stormwater infrastructure. These regulations and standards are developed with input from the various stakeholders of the region (local jurisdictions, Planning and Zoning (P&Z) entities, local engineering community, etc.).

Challenges

Planning in Northern Kentucky is managed through a relatively large number of planning and zoning entities. In general, there are few legally established areas that require coordination between these groups, SD1, and the NKWD with respect to water, sewer or stormwater issues. Further, the codes of these planning and zoning groups (subdivision regulations, zoning ordinances, etc.) often have direct impact on water quality and water supply issues.

From SD1's and the Water District's perspective, the federal and state regulations related to water and sanitary sewer service are sometimes overly restrictive and lead to the allocation of funds towards projects that yield minimal results. For example, all sanitary sewer overflows are deemed "illegal" by the USEPA with little recognition of the complexity of those problems. Many of SD1's SSOs are small volume overflows that occur during relatively large rainfall events and represent a minimal source of pollution into streams that are impacted by many other sources of water quality impairment (failing septic systems, urban runoff, loss of riparian corridor, etc.). The elimination of such SSOs often requires the use of funds that could provide more benefits if they were directed toward other water quality improvement projects.

Below are examples of regulatory challenges or barriers for the priority technologies.

Green Infrastructure

- Many regulations are practice-based instead of performance-based.
- Permeable pavements are not legal.
- Many zoning and subdivision regulations pose barriers to green infrastructure.
- CSO Control Policy should be more performance-based, scientifically driven policy, looking at multiple sources.

Regulation of Water Conservation

- Plumbing codes stand as a constraint for conservation
- No individual collection of stormwater
- Health departments may have made use of grey water illegal depending on location (health codes)
- Onsite systems can separate grey water; offsite systems cannot
- Weed ordinances (essentially requiring mowing down to the streams edge) often prevent use of natural areas which increases lawn size and subsequent irrigation requirements

Decentralized Wastewater Treatment

- 100% repair area requirement poses barriers to retrofitting existing development
- Works great for new construction but in old areas it is not cost effective
- Anything serving more than one dwelling unit or establishment would be regulated on the state level

Resource Recovery

- Production costs (energy)
- Permitting process is time consuming and cumbersome

Opportunities

- Link to comprehensive plan update to indentify barriers in local ordinances.
- Scientifically-based regulations. Look at all sources of pollution in the watershed and where proper management will result in the best bang for the buck. Recognize that locally there is only so much money available and it needs to be spent wisely.
- Changes to performance based standards including multimedia solutions.
- Allow credits for removing illegal discharges.
- Coordinate training and training opportunities. Need to be vetted and technically sound. Target those people who are on the ground and help create job opportunities.
- Keep information up to date via new technologies like Website or database of knowledge: see USEPA's Wiki!
- Do pilot projects locally.

Tucson – Pima County

Community Objectives

Three over-arching goals guide our community's efforts with respect to regulatory compliance and administration of policy and code at the local level:

1. Protecting Public Health
2. Preserving and Enhancing our Natural Desert Environment as Our Community Grows
3. Securing Sustainable Water Resources for Our Community's Future

The City and County indicated that they assume the trend of more stringent regulation will continue. The community's objectives as the regulatory framework evolves include:

- Improve understanding of arid western ecology, research arid west water quality criteria, and establish appropriate regulatory standards for arid conditions
- Move from a prescriptive-based approach to a performance-based approach; accomplish this in a more holistic manner than current separated programs (silos) approach
- Move away from risk averse regulation toward support for innovation and adaptive approach

Building Blocks

- Arid West Water Quality research grant results
- Federal government's strengths in research, demonstration and funding

Challenges

- Water rights do not necessarily support water conservation (sometimes preventing stormwater capture, use and recharge) and performance-based approach.
- Regulation of water infrastructure across multiple agencies; multi-benefit projects can be confusing to the agencies where regulations conflict (e.g., reuse, AZPDES, stormwater)
- Current state of regulatory uncertainty, particularly in the permitting process
- Risk averse approach is institutionalized within most water-related regulatory agencies; in the west, determining where stormwater system ends and navigable waters begin
- Arizona regulations have prescriptive processes that are not flexible which is an impediment to innovation, e.g., method for rating reuse water
- Clean Water Act provisions meant to act as a floor (minimum) for protection are being used as a ceiling
- Regulatory changes that need to occur at the federal level are extensive (e.g., reconciling CWA and SDWA, perhaps under a Sustainability Act)
- Environmental community is afraid of losing enforcement capability; feel that they have been burned in past (e.g., project Excel)
- Sixty percent of Pima County's budget goes for social services; there are very limited financial resources to implement federal mandates
- The quantity of water related research is declining

Opportunities

- Train regulatory staff to increase understanding of sustainable water infrastructure technologies and architectures and how to implement a performance-based process
- Incorporate faster verification measures for new technologies into the more flexible regulatory process
- Review current codes for impediments and develop model codes that support the sustainable water infrastructure approach
- Make better use of instream indicators in arid west rather than relying on chemical standards
- Mandate new performance standards for new development
- Jointly advocate for policy and rule changes to overcome barriers to maximizing use of reclaimed water and to dissuade the use of groundwater when other renewable sources are available

Management and Financing – June 2, 2009, 3:15 p.m. to 5:15 p.m.

Northern Kentucky

Community Objectives

Allow for the most cost-effective allocation of funds toward water quality improvements (sanitary sewer or stormwater projects) at a level providing benefits that are necessary and supported by the public. In addition, this ideal structure would provide incentives for water conservation and other practices to minimize the need for new or improved infrastructure (particularly gray infrastructure).

Building Blocks

SD1's management structure is reasonably well-positioned to make decisions across local, watershed, and regional scales. Given the service area (3 counties, 30+ jurisdictions), oversight structure (Board appointed by each of the three County Judges Executive), and the fact that SD1 also operates a stormwater management function, they are generally able to direct resources toward the most significant regional water quality problems. SD1's rate adjustments (sanitary and stormwater) require approval from the Board and Judges Executive, there is no requirement for approval from the Kentucky Public Service Commission. SD1 has its own ratemaking tools, and performs its own billing based on data provided from several Northern Kentucky water utilities. This structure allows SD1 to be flexible in their planning and project selection processes; more so than many public utilities.

Challenges

SD1 and NKWD are similar to most other water and sewer utilities in that their primary revenue source is from customer billing, which is based on usage. This structure provides little incentive for SD1 and NKWD to encourage water conservation. Also the traditional financial management approaches also present challenges with respect to the consideration of "true costs" of providing sanitary sewer and stormwater utility services. For example, biosolids generated at SD1 treatment plants are hauled to landfills for disposal. The costs recognized in our financial projects cover O&M expenses associated with that hauling as well as capital costs associated with the required equipment. There is no consideration given to the fact that the trucks used for hauling have an air quality impact. For the NKWD, the Public Service Commission must approve rates, and the rate approval process essentially prohibits conservation pricing. Both NKWD and SD1 need better provisions to provide incentives for the right things to happen for sustainability practices.

There is a perceived abundance of water supply in the region which counters water conservation.

Opportunities

SD1 and NKWD can publically jumpstart the design and construction of the sustainable practices through incentives and public funding. There must be covenants or contracts to ensure that such facilities are maintained over the long-term or grant access for maintenance. In the short-term maintain, SD1 and NKWD could maintain public ownership of the facilities. In the long-term, they could aim toward sustainable practices becoming the standard practice with private ownership (in many cases).

How will sustainable technologies be financed?

- Green set-aside of 20 percent of $50 million Stimulus Package
- Stormwater utility revenue
- Transition of costs to other parties
- Green Fund in bills
- Checkbox to fund voluntarily on bills
- Possibility to raise rates faster than your usage is going down (as with energy)
- Waxmen Bill: $50 million amendment for water. Federal money for each of the states to set up rebates for water efficiency and water reuse systems.

Sustainable approach means that we will need to build more distributed facilities and ensure more oversight of privately owned facilities. This may require more people and management and therefore more dollars to support the program.

Tucson – Pima County

Community Objectives

Financial planning is a critical component for the City and County. The ability of each entity to identify system requirements and fund those requirements is a fundamental component of maintaining each entity in a self supporting sustainable manner. The following community objectives were identified for management and financing:

- Revenue from water sales and other fees (e.g., wastewater, stormwater) provides the cash required to operate, maintain, and expand the utility's systems; pricing for reclaimed water reflects the cost of service and also includes social, environmental and economic benefits to the community
- Develop strategic partnerships related to sustainable operations; e.g., Pima County does not want to be in the power business
- Achieve greater understanding by the public as to why things like stormwater need to be managed
- Increase role of the community in shaping type and density of building to reduce cost

Building Blocks

- Established organizational structure, financial policies, and financial planning processes including the development of annual and 5-year financial plans and capital improvement plans
- Federal set-asides for green infrastructure

Challenges

- Political nature of rate-setting; countywide financing means regional set of fees which raises issues of equity regarding who is benefiting and who is paying
- Some large groundwater users have no incentive to move away from the use of groundwater (via their own wells) to use of reclaimed or alternate sources; the cost of reclaimed water resources is perceived as high relative to groundwater
- Funding is inadequate for amount of outreach on water management that is needed
- Who will manage distributed systems, particularly on private property

Opportunities

- Creating consortiums for funding projects; i.e., leveraging funding to much greater extent than current approaches
- Push cost of "growth" onto the development industry and fund rehabilitation of sites through public cost
- Take advantage of integrated financing opportunities (e.g., using biogas to provide energy)
- Provide financial incentives for developers to use the new paradigm principles
- Brand a high bar of development (i.e., desert smart development)
- Use energy conservation savings to fund water conservation
- Conserve to enhance (e.g., earmark savings to go to environmental restoration – "Green Water")
- Mesh utility and building codes for better administration
- Use federal set-asides for green infrastructure

Discussion on the Broader New Paradigm – June 3, 2009 8:00 a.m. to 12:00 p.m.

Tetra Tech began the last day of the retreat by reviewing the next steps in developing the final report for the new water paradigm. The main points communicated were

- After the retreat, Tetra Tech will develop a draft final report that summarizes the proceedings and includes a proposed framework and recommendations for sustainable water infrastructure management.
- Tetra Tech will distribute the draft document in August for participants' review and comment; a teleconference will be held for joint dialog as part of the review process.
- Based on comments received, Tetra Tech will make changes and finalize the report for EPRI by mid-October.

The rest of the morning was used to flesh out ideas for a broader new paradigm (i.e., something that would be flexible enough to apply to communities beyond Tucson-Pima County and Northern Kentucky). Based on its synopsis of the discussion from the previous two days, the

Tetra Tech Team provided an overview of a proposed (albeit rough) outline for a 3-part paradigm as a strawman for consideration. Following the overview, retreat participants were broken down into small groups to discuss the strawman ideas, and then the whole group was reconvened to review and discuss observations and recommendations. The following subsections briefly describe the results.

Overview of Strawman Paradigm

The Wikipedia definition of paradigm was presented as "a philosophical or theoretical framework of any kind." For a strawman new paradigm, Tetra Tech proposed a framework with the following three parts:

1. Tenets: core principles to which communities would aspire to become sustainable.
2. Process: how does a community move forward in establishing a way of operating and managing in a sustainable way?
3. Support Structure: things necessary to have in place to facilitate operating in that process.

Tetra Tech outlined each part as follows:

Tenets

- Value water
- Achieve symbiosis of built environment and natural environment to add value and meet multiple objectives
- Increase community resilience
- Recognize true cost of maximizing cost-effectiveness

Process

- Define sustainability objectives
- Establish method of assessment
  - Establish core indicators tied to evaluating objectives at defined scales
  - Gather information
  - Conduct baseline analysis
- Establish performance standards
- Through integrated planning develop and evaluate growth and resource management scenarios
  - Apply decision tools (e.g., true cost, life cycle evaluation, risk assessment)
- Use results to inform action (e.g., public investments, outreach, regulations, rate changes, smart system implementation)
- Performance monitoring and adaptive management

Support Structure

- Administrative structure for integrated management
- Toolbox
- Regulatory flexibility
- Research and demonstration
- Funding mechanisms
- Outreach and engagement

Small Group Reports

Retreat participants were divided into four small groups to discuss the outline of a strawman paradigm and answer the question: is this proposed paradigm in the right ballpark with what has been discussed over the last two days? If the general consensus within the small group was "yes," then the group was asked to identify potential refinements and help flesh out the concepts further. If not, the small group was asked to define an alternative(s) to propose to the entire group for additional consideration and discussion. Brief summaries of each group's discussion points are provided below:

Group 1

The group generally agreed with the proposed paradigm with a few recommended revisions and additions.

- The first four tenets are good, but to convey that sustainability is never ending, a fifth tenet needs to be added: Adapt and evolve.
- Frame the process in terms of leadership and stakeholders. To be successful, you need to enlist leaders in the community who are champions, then reach out and engage the community and stakeholders. The technical staff does the support work for the process. Leaders are needed from elected officials and from within multiple agencies and community groups. The stakeholders are the community. Figure D-1 illustrates the process by which the stakeholders and "techies" work together, led by champions.
- Define key terms in the paradigm. This definition should provide guidance as to what we are looking for but not be set in stone or rigid. The definitions should acknowledge that the specifics for sustainability will vary by community.
- Include a table that compares the old paradigm to the new paradigm: what's new?
- Set up adaptive process and stress its iterative nature. Even within process, provide for iterative communication and feedback loops on technical and non-technical issues (see Figure D-2).
- Add community stakeholder expertise to the toolbox.
- The toolbox should include a range of tools from simple to complex, for small and large governments, and for a myriad of natural environments.

- The process is important, but is nothing new. It, in itself, would not generate a paradigm shift. The Tenets are the key.
- The toolbox should stress new partnerships to fund new technologies.

The group presented Figure D-1 and Figure D-2 (adapted from those used by the City of Los Angeles) to illustrate these key points.

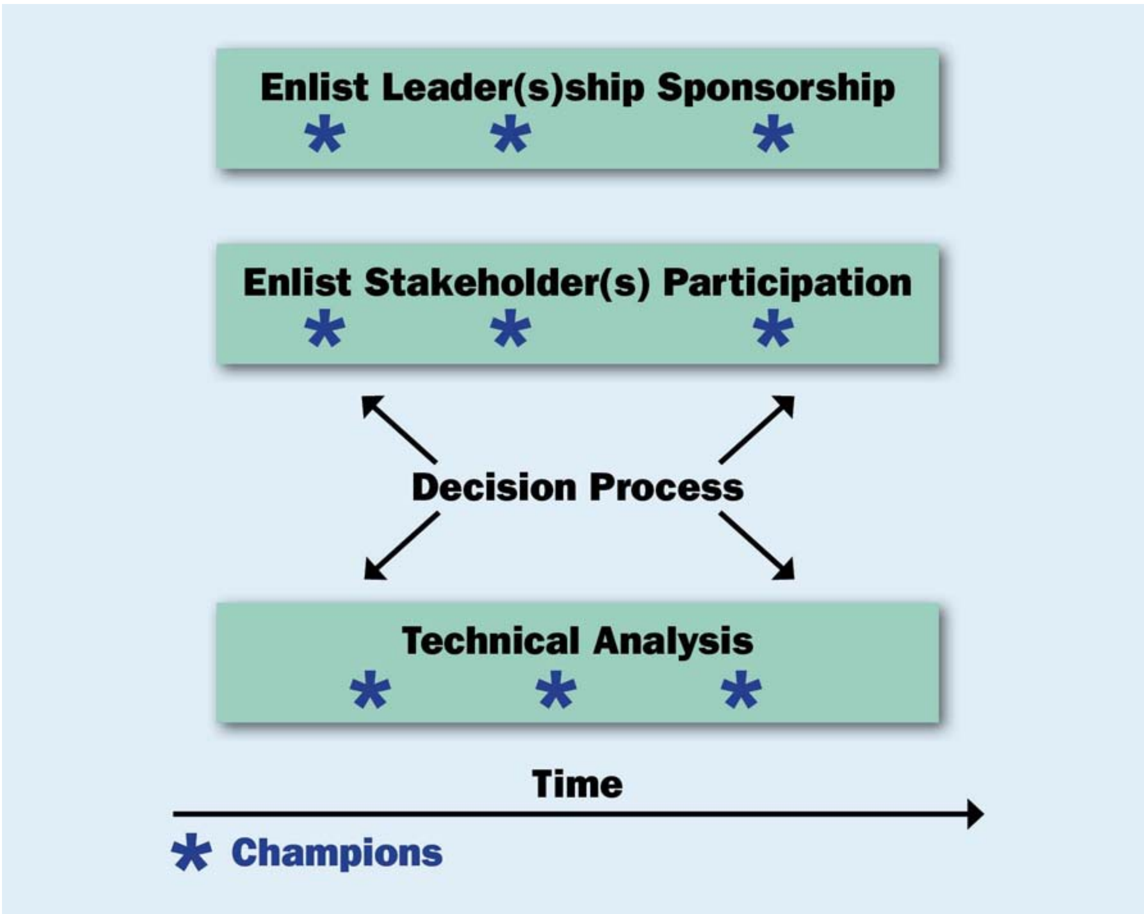

Figure D-1
A stakeholder driven process led by champions

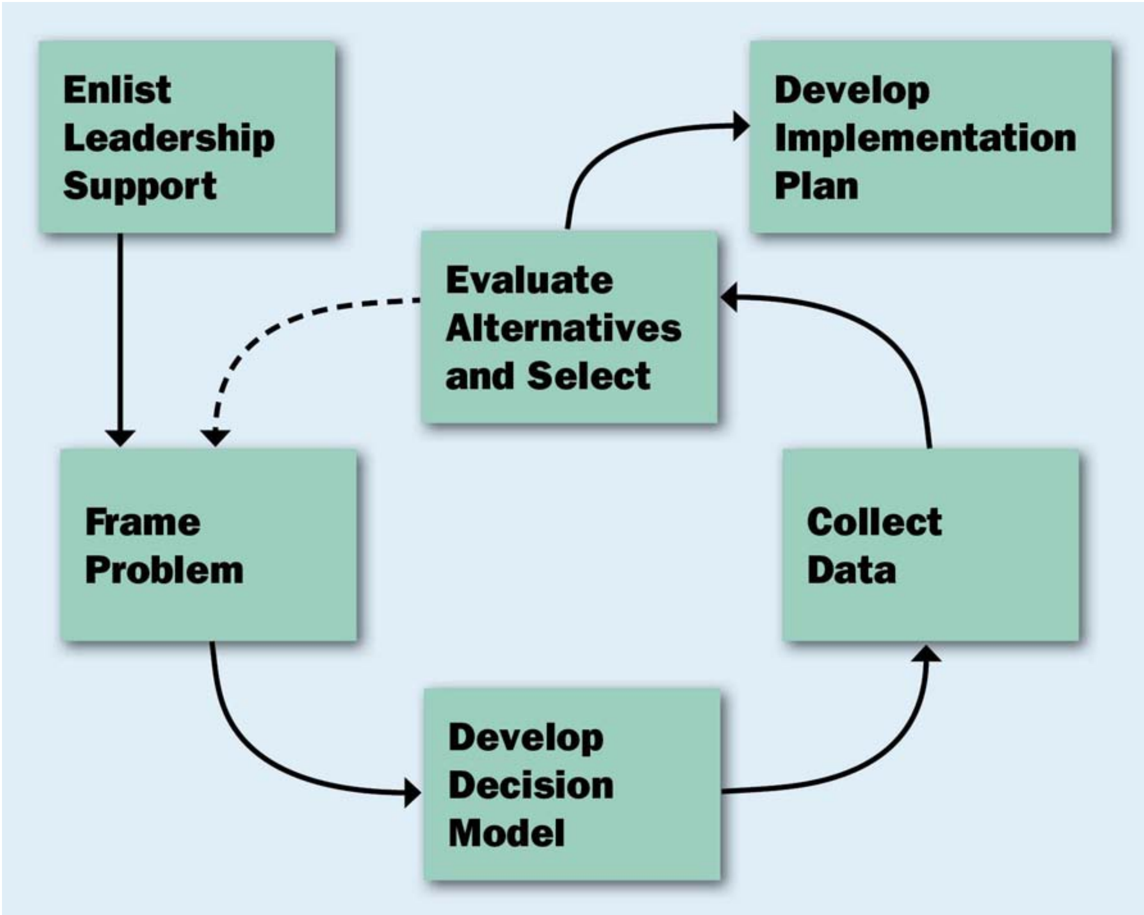

Figure D-2
A process to support sustainable water resources management

Group 2

This group presented ideas from the Swedish Urban Water Project. This project was run outside the utility, but made use of utilities when needed. Some key points or lessons learned included:

- It was an iterative process, with multiple feedback loops.
- You need a steering committee to drive the process.
- Develop a suite of options to glean ideas. Use brainstorming, lateral thinking, creative thinking, pragmatic design, and backcasting. Use lots of tools to get new ideas and use more than one tool.
- Identify where there are tradeoffs and you can blend ideas.
- Select sustainability criteria and metrics, such as years of life lost, with which you can compare outcomes.
- Look at life cycle assessments.

- Present outcomes of different options to stakeholders with a range of different skills. Highlight intrinsic variability of these options and systems.
- Stakeholders come up with suite of options.

Conclusions: The group's critique of the strawman paradigm is that it is not broad thinking enough. Process can give good results, but if you do not have a broader view of what comes at end of the process, it is like the old paradigm.

The existing paradigm is too risk averse: we throw out the creative ideas, automatically rejecting them instead of trying to figure out how the creative options work. If we quantify the risks for comparison, it would reduce the tendency to eliminate options due to average risk aversion. This is true not just for evaluation options but also for implementation. Often field engineers have deadlines and budgets; non-routine plans unravel and are not implemented.

A looped but linear process is powerful: it delivers outcomes. However it is weak because we are in a closed circuit world. Make the process more relevant: is there some way to be sure that the decision-makers own the implementation and defend it cradle to grave?

Group 3

This group changed the strawman paradigm in multiple ways. Some key points included:

- Revise the tenets as follows
  - Value the entire water cycle
  - Integrate the built environment and natural environment
  - Increase system resilience and sustainability
  - Recognize true costs and benefits
  - Inform and engage stakeholders and the broader community
- Define our goals and objectives and focus more on local conditions.
- Establishing method of assessment is important, but need to get out of linear into creative side.
- Need to develop a system or process to engage the community and stakeholders that includes developers, schools, jurisdictions, etc., in advancing tenets through "creative actions."
- The strawman process steps 2, 3, and 4 are a subset of a larger step that includes technical and non-technical development/design of alternatives. Have a separate process for creative design. We need a separate track to explore that which would never be thought of or seriously considered in a traditional planning approach. Or could have creative track with technical feedback into creative process.
- At step 5 in the process, bring creative and traditional tracks back together.

There are a lot of examples where creative initiative looks to guidance from the planning process but does not wait for it. Integrated planning process will not shape everything. Encourage communities to act on their own initiative.

Group 4

This group focused on what it considered to be the "new," water infrastructure paradigm (i.e., what the "new" is). The strawman paradigm was not clear enough for what the new paradigm itself is. The group generally felt that the proposed process is not new. It is a good one, and one that we want to continue to reinforce. People need the guidance of this process. However we needed to do more to have a higher impact. For that to happen, tenets are a critical component.

The group recommended that the tenets be revised as follows:

- Say more than "value water." Fundamental. We need to see water, wastewater, and stormwater as one single system and resource. Recognize all water as water, as a holistic system.
- The tenets should be context sensitive at all scales. For example, say "local actions have implications at every scale. Regulator environment should be performance-based and recognize local context."
- Aspire to higher objectives that achieve better outcomes.
- The land use relationship to water resource management must be coordinated. Integrate the idea of one water system integrated into the land use decisions made in local communities.
- Idea of community engagement: what is local context and broader context. The "bigger community" that needs to participate in these decisions and the values they bring needs to be reflected in the tenets as well.
- Should we be looking at new and overarching sustainability act, rewrite the CWA and SDA?
- We should list out examples of what 20 possible objectives would be. If you are going through this process and do not include any of these objectives, you should start over.
- List robust options, examples, and recommendations.
- Recognize that there is a great deal more research and science that supports the development of the paradigm. This document is a catalyst for all the work that needs to go forward. We sketch it out as well as we can and acknowledge that there is a lot more work that needs to be done to make it a reality.

Large Group Discussion

- The entire group of retreat participants discussed the ideas from the small breakout groups and what is needed to move forward in developing a recommended water paradigm. Common themes emerged from the large group's discussion:
- Bring in a broad range of stakeholders. Each community will have a unique set of major stakeholders.

- There is need for a process; however since so much of this involves infrastructure planning, engineers could strip down the process to what we are doing today. The tenets and new tools are key to a shift in water resources management.
- We need to be clear to people about what is "new" in the new paradigm. Compare it to the existing way of doing business.
- The creative process and thinking outside the box needs to be allowed and encouraged. Perhaps have someone separate from the traditional engineering paradigm run the process.
- Through tenets and examples, we need to say, "Here is what an ideal system would look like and here's what you should consider."
- The world of water is bigger than the world of water infrastructure. Need to encompass this larger context of water in the new paradigm.
- The audience for the document should be the potential community champions. Create a document they can understand and use.
- We need to emphasize collective responsibility and personal responsibility in affecting solutions.
- Stress outcomes rather than water infrastructure. We wanted to look at water in the context of the triple bottom line (environmental, social, and economic outcomes) and in language local people can understand.
- Through case studies stress common and unique issues that communities deal with, as well as different strengths and weaknesses.
- Change is risky, but the current paradigm is the greatest risk. Motivate the desire to change by fear and opportunity.
- Be clear on specific benefits and the concepts we want to advance as sustainable goals.
- We need reform at multiple scales.
- Look at risks and benefits, and invest in projects accordingly. If viewed in an integrated way, we can move money to the projects that yield the best outcomes. Regulations should allow for this "out of the silo" analysis.
- We need to animate these sustainability concepts with illustrations and concrete examples.

The research team will use the group's input to revise the proposed new water paradigm and develop a draft final report for the group's review in mid summer.

EPRI representatives thanked the case study communities for all their work in preparing for and contributing to the workshop, as well as the panelist and research team. Through the work of the two and a half days and the themes above, there are clearly similar perspectives although participants are from all parts of the country. Through finding common ground, it is EPRI's hope that the recommendations of the Final Report will facilitate prototypes being built around the country.

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