Soft Path Integrated Water Resource Management

Training, Research and Development Needs

National Decentralized Water Resources Capacity Development Project

Soft Path Integrated Water Resource Management: Training, Research, and Development Needs

Arlington, Virginia
February 19–20, 2002

National Decentralized Water Resources Capacity Development Project (NDWRCDP) Research Project

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CITATIONS

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EXECUTIVE SUMMARY

On February 19–20, 2002, a workshop was convened in Arlington, Virginia to discuss "Distributed and Nonstructural Water and Wastewater Systems: Charting 'Soft Paths' to Integrated Water Resource Management." The following assessment of problems and opportunities in water resource management was developed.

According to participants in the workshop, the 1972 Clean Water Act and the 1986 Safe Drinking Water Act subsidized expanded construction of sewer and water lines and treatment plants to protect public health and the water quality of rivers, lakes, and coastal waters, and of the nation's drinking water supply. Drainage systems, channels, and levees built by the U.S. Army Corps of Engineers and by local engineers prevent and control flooding of developed areas.

In spite of localized successes of this capital-intensive "transport water and wastewater away" approach, workshop participants proposed that the country will confront increasingly serious water resource challenges in the coming decades. Projections indicate that the "gap" in local expenditures for repair and replacement of the aging urban water and wastewater point source infrastructure will be in the hundreds of billions of dollars. Nonpoint sources, including urban stormwater and agricultural runoff, contribute to the majority of remaining water quality problems. Widespread drought conditions and depleted aquifers in 2002 also contribute to concerns about looming water supply crises throughout the country.

Workshop participants argued that the timing is right for a major rethinking about whether the traditional capital-intensive engineering solution—to build more pipes at longer distances to transport water and wastewater, to treat water and wastewater at central plants, to build deeper channels and higher levees, and to dig deeper wells—is the appropriate and only response to these challenges.

Distributed and nonstructural approaches that rely on or mimic natural functions of retention and treatment at or near the source can in many instances be less costly, more sustainable solutions for new infrastructure in developing areas. In existing urban areas, a blending of the traditional "hard path" and the newer "soft path" approaches might be the optimal solution.

There has also been a typical "stovepiping" or compartmentalization of water, wastewater, stormwater, and flood control, with increasing inefficiencies and more projects at cross-purposes. Integrated planning and management of these water-related projects has the potential to meet future needs at much less cost to taxpayers and ecosystems.

The economic benefits of utilizing integrated soft path approaches identified by participants include the potential for significant cost-savings in construction, operations and maintenance (O&M), and financing charges. In addition, distributed and nonstructural projects create local jobs and a rich set of secondary benefits for communities, including restoration or preservation of stream corridors, open space, and recreation areas. They provide better tools to manage

growth and preserve community character. In some settings, soft path methods may also be the only viable option where no engineered hard path solutions can protect valued ecosystems, such as fish habitat.

This report summarizes the discussions and outlines the training, research, and development recommendations of the workshop, which included experts who are well-versed in both traditional centralized and newer distributed approaches and technologies. This workshop was sponsored by

- National Decentralized Water Resources Capacity Development Project (NDWRCDP)
- Joyce Foundation
- Coalition for Alternative Wastewater Treatment
- Clean Water Network
- National Rural Electric Cooperative Association

Several different scenarios and motivated actors in an emergence of soft path practices were sketched out, including

- **Scenario A**—Leadership by small communities in blending water and wastewater into a pragmatic, long-term vision of development
- **Scenario B**—Adoption by urban utilities, motivated by water shortages and high costs of replacing hard path infrastructure, of integrated approaches to restore and preserve a natural water "mass balance"
- **Scenario C**—Refinement of innovative approaches for rainwater retention/filtration, wastewater treatment, and reuse on individual properties or in cluster systems
- **Scenario D**—Reform of planning and regulations to promote more flexible, integrated water and infrastructure development
- **Scenario E**—Advocacy by environmentalists of an ethic that supports restoration and preservation of natural ecosystems

Training, Research, and Development

High priority training, research, and development needs for advanced integrated water resource management and use of soft path technologies and management that were identified in the workshop include

- "Micro-scale" designs and technologies that integrate wastewater, stormwater, landscape and other low-impact development tools, and reuse/reclamation and water conservation systems at the individual site or cluster system level
- "Macro-scale" cumulative impact models that integrate wastewater, stormwater, landscape and other low-impact development tools, and reuse/reclamation, and water conservation systems at the community, watershed or regional level, and that accurately predict water hydrology and fate and transport mechanisms for pollutants causing public health and environmental risks

- True cost calculations comparing monetary and non-monetary costs of soft path and hard path infrastructure
- Utility and other management models and approaches to integrated hard and soft path water infrastructure, and new tools such as asset management and environmental management systems
- Innovative policies, regulatory and management mechanisms which integrate soft path and hard path solutions across water resource sectors and other aspects of public interest, including:
  - Sustainable community initiatives
  - Total Maximum Daily Loads (TMDLs), trading programs and other market incentives
  - Environmental stewardship projects
  - Innovative utility and management structures
- Approaches to engaging the public and key stakeholders, such as engineers, realtors and builders, elected officials, environmental organizations, and others, in building a stronger water quality ethic and stewardship

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1 INTRODUCTION

On February 19-20, 2002, a workshop was convened in Arlington, Virginia to discuss "Distributed and Nonstructural Water and Wastewater Systems: Charting 'Soft Paths' to Integrated Water Resource Management." Thirty-five experts from across the country participated, including engineers, government officials, environmental advocates and other professionals. Participants were knowledgeable about decentralized wastewater, distributed stormwater, low-impact development, non-structural flood control, and other "green" infrastructure solutions to water quality or quantity problems, as well as conventional water resource infrastructure. The list of workshop participants is included in the Appendix.

The workshop was facilitated by Christopher Serjak, of S. Christopher Associates, with the following purposes:

- **Information exchange** about the opportunities for distributed and nonstructural solutions, and recent advances in technology and management in each of these sectors
- **Tracing interrelationships** of soft path approaches in an integrated water resources context (similarities in technology, management, reuse potential, pricing incentives)
- **Identification of common barriers** to advancement of integrated soft path approaches with an emphasis on federal wastewater financing biases
- **Development of various "scenarios"** for an integrated soft path future
- **Identification of opportunities for collaborative efforts** to promote reform in water resources financing, regulation, management (utilities and private sector involvement), assessment and monitoring
- **Formulation of recommendations for federal policies and practices**

An earlier report, "Distributed and Nonstructural Water and Wastewater Systems: Charting 'Soft Paths' to Integrated Water Resource Management" focused on outlining recommendations for federal policies and funding, including reform of the Clean Water State Revolving Fund (SRF) to encourage expanded use of soft path technologies and management.[1]

This second report stems from the workshop and focuses on implications for training, research, and development needs and priorities to advance the state of practice and use of integrated water resource management and soft path approaches. Since the February 2002 workshop, a number of the needs identified are incorporated into specific proposals for FY03 federal funding.

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[1]Nelson, Valerie I. and Christopher Serjak. 2002. "Distributed and Nonstructural Water and Wastewater Systems: Charting 'Soft Paths' to Integrated Water Resource Management: Recommendations for Federal Policies and Funding". Coalition for Alternative Wastewater Treatment. Gloucester, MA.

Part II of this report describes the five scenarios developed before and during the workshop, along with the obstacles to their fruition. Part III presents the training, research, and development needs that emerged in the workshop. Priorities are listed in the areas of Environmental Science and Engineering, Management and Economics, Regulatory Reform, and Training and Education, which are also the topics for the existing NDWRCDP research subcommittees.

Overview

Water resource management in the U.S. has been dominated in recent decades by "hard path" centralized infrastructure solutions, including sewer collection systems and treatment plants, stormwater collection and underground storage tunnels, centralized water lines and filtration plants, and stream channeling and dams for flood control. Permitting, funding, and management of these systems are segregated into separate agencies, rather than integrated into a holistic watershed framework.

A premise of the workshop was that this reliance on centralized solutions constructed without regard to the broader watershed and groundwater forces at work in the ecosystem has cumulatively led to major unintended consequences and environmental damage. Sewer collection systems and point-source discharges move locally supplied water and infiltration/inflow water great distances to point-source discharges. The system has led to depleted aquifers, saltwater intrusion in the coastal zone, and dried-up streambeds.

Sewer systems have also promoted growth and development, accompanied by large-scale increases in stormwater runoff and leaking sewer pipes that constitute a major source of drinking water contamination. Channeling to control floods has led to disruptions in natural systems for water purification. Failure to fully utilize cost-effective water efficiency and distributed water reuse measures exacerbates the surface and groundwater impacts on water supply systems.

In recent years, much progress has been made in the development of decentralized or distributed approaches to water resource protection. These approaches hold great promise to achieve water resource protection at substantially lower cost than traditional centralized technologies, and entail far fewer adverse impacts to public health and the environment when considered in an integrated framework. Distributed, "green" solutions to sewage and stormwater treatment rely on and blend into large, natural surface water and groundwater systems that have evolved and stabilized over centuries. Centralized approaches constitute a much larger disruption of these natural systems than decentralized approaches.

"Soft path" infrastructure solutions are appropriate both for new areas of housing development and for remedial "fixes" when urban centralized water or wastewater infrastructure is in disrepair. Rather than replacing centralized systems, a blended, distributed approach may be more cost-effective.

Barriers to Soft Paths

"Hard path" infrastructure solutions to water resource protection have become conventional practice supported by government agencies, training of professionals and other influences. Numerous barriers exist to the promotion of "soft path" approaches, regardless of the evidence of superior environmental and public health protection and greater cost-effectiveness involved. The objective of the workshop was to bring together practitioners in all soft path and hard path activities to share information and articulate mutual agendas. Potential scenarios for evolution of the field were developed, along with recommendations for how to remove barriers to these scenarios.

The Soft Path Approach

Many of the most promising new approaches to water resource management are inherently distributed or decentralized systems. These systems (to varying degrees) make extensive use of the environment's own natural processes and assimilative and treatment capacity. Such regimes are often referred to as "Soft Path" approaches because they rely on managing and protecting water resources near the point of use.

Integrated Water Resource Management

The soft path water resource management field has many "sectors" or "disciplines", including

- Decentralized wastewater
- Drinking water
- Distributed stormwater
- Low-impact development
- Non-structural flood control
- Other disciplines

Integrated water management means that planning for each of these sectors is conducted within the context of all other sectors. Too often, facility planning fails to consider all the direct and indirect impacts on other sectors. In this context, soft path approaches will often have distinct advantages over centralized infrastructure, since there is less impact on natural processes and better assimilative and treatment capacity.

Benefits of Soft Paths

Typically, comparisons of the construction and maintenance costs of water and wastewater infrastructure are at the forefront of investment decisions. Often, calculations show distributed and nonstructural system approaches to be less costly. However, soft path infrastructure can also produce other benefits for communities, including:

- Financial savings by spreading investments out over time (avoiding loans), and by integrating projects into road, park, and building budgets
- Ability to target wastewater and stormwater solutions at problems that currently exist, without creating the infrastructure for rampant, uncontrolled growth
- Creation of local jobs
- Restoration and preservation of open space (used for treatment), recreation areas, fish habitat, stream daylighting
- Increased property values for those who live near this "green" infrastructure

2 ALTERNATIVE SCENARIOS FOR INTEGRATED "SOFT PATH" WATER RESOURCES MANAGEMENT

Prior to the February 2002 workshop, telephone interviews were conducted with approximately 12 of the 35 participants to identify common themes about the issues, problems, opportunities, and obstacles to integrated “soft path” water resource management. These interviews generated five different “scenarios” or “endpoints” for an idealized state for water quality management. Each scenario poses a different “solution” to how water resource management can be accomplished in a more effective manner, and engages a different set of motivated actors in developing the scenario. The scenarios are not intended to be either comprehensive or mutually exclusive or an accurate prediction of what the future might be. They are presented as a useful tool to facilitate a more careful examination of a broad range of water resource management issues. Each scenario describes a setting where existing scattered efforts would mature and be disseminated more widely by motivated constituencies.

- **Scenario A**—Leadership by small communities in blending water and wastewater into a pragmatic, long-term vision of development
- **Scenario B**—Adoption by urban utilities, motivated by water shortages and high costs of replacing hard path infrastructure, of integrated approaches to restore and preserve a natural water “mass balance”
- **Scenario C**—Refinement of innovative approaches for rainwater retention/filtration, wastewater treatment, and reuse on individual properties or in cluster systems
- **Scenario D**—Reform of planning and regulations to promote more flexible, integrated water and infrastructure development
- **Scenario E**—Advocacy by environmentalists of an ethic that supports restoration and preservation of natural ecosystems

Prior to the workshop, participants ranked these five scenarios in terms of advisability and likelihood. During the first day of the workshop, break-out groups further developed the content of each of the scenarios and identified potential barriers to its realization. Presentations were then provided to the full group, along with opportunities for questions and comments. Each breakout group provided recommendations for training, research, and development projects to break down these barriers. Part 3 of this report includes a synthesis of the high-priority recommendations.

Scenario A—Pragmatic Integration

The first potential soft path forward lies in the inventiveness and pragmatism of small-town America trying to solve problems without the expectation of much outside financial help. In Scenario A, individual communities lead the charge to soft path water resource management, in part to avoid large capital projects that are beyond the reach of the local tax base, and in part as a tool to stimulate development consistent with preserving community character and protecting natural resources. Prior to the workshop, this scenario was ranked as the most likely to emerge. By the end of the workshop, it was ranked next to last.

Many small communities already face significant water quality and supply issues, whether they are located in arid regions typically associated with such issues (the Southwest) or in areas not often associated with water supply issues (the Southeast and Northeast), but that have been experiencing drought conditions in recent years. It is also not uncommon for small communities to have pressing, overlapping needs to

- Upgrade, expand or install a system for wastewater
- Develop plans for stormwater systems
- Take steps to ensure reliable water supply in order to sustain economic development
- Safeguard the health of the populace

Specific problems requiring attention include

- Increased number of contaminated wells
- Failing septic systems
- Polluted streams, lakes, or beaches
- Depleted water supplies
- Problems attracting new industry

Small communities do not have the economic resources to build large centralized transport and treatment systems for water, wastewater, stormwater, and flood control. Under Scenario A, they deploy solutions that build on the existing infrastructure of individual septic systems and solve more than one problem at a time, such as simultaneously addressing both stormwater and wastewater.

Under Scenario A, small communities have readily embraced pragmatic approaches. The move to soft paths, while serving a larger ecological, public health, and environmental goal, is more driven by this pragmatism and economic reality than by some altruistic goal. Communities could find that the move to soft path serves both goals. The federal government and progressive states under Scenario A require communities to develop long-term plans that consider the relationship between stormwater, wastewater, water supply, flood control, and other water issues. Communities are held accountable to meeting the objectives in these plans, and are required to update their strategies as new techniques for better water resource management are developed, and as the communities water resource management requirements change. Small communities would find soft path approaches a valuable part of those plans.

Scenario A communities make use of decentralized wastewater systems, artificial wetlands to provide treatment for parking lot runoff, and green strips to reduce agricultural impacts on water bodies. They might even explore water reclamation for irrigation of recreational lands or in small areas where the population is relatively concentrated. Wetlands, existing or constructed, could play an important role in flood control as well.

Communities would require expert assistance from water/wastewater engineering firms that specialize in such multi-objective, multi-media approaches. Engineering firms would likely develop a broader set of tools and capabilities to offer to small communities, including financial planning, economics, natural resource protection, and landscape design, along with engineering. The small to mid-sized community would become an increasingly important market segment to such firms, alongside traditional municipal customers. In particular, because of the linkages with growth issues, planners would be much more prevalent in engineering firms.

Current Obstacles to Scenario A

Obstacles to the emergence of Scenario A include

- Industry/professional resistance
- Inadequate advocacy
- Financing and regulatory

Industry/Professional Resistance

Integration of soft path water resource infrastructure at the community level requires multi-disciplinary teams of professionals. Currently, engineers perceive that profits are still higher with centralized approaches, training is not available, and best management practices and technologies have not yet been widely developed and proven.

Inadequate Advocacy

Advocacy groups have so far failed to mobilize sufficient public support to overcome the risk aversion of local officials who prefer to use traditional, well-proven technologies.

Financing and Regulatory

Federal, state, and local policy obstacles include a failure to make soft path approaches eligible for financial subsidies, particularly systems on private property. Regulatory obstacles include local ordinances prohibiting water reuse or reclamation, or not permitting low-impact development land use practices that enable high-density/open space designs, rain gardens, and other development.

Scenario B—Restoring the Mass Balance

Another school of thought suggests that the most pressing needs for integrated water resource management exist in major metropolitan areas with tightening water supplies and increasing water and wastewater infrastructure replacement costs. Many traditional practices can be viewed as both wasteful and economically foolish. Diverting rivers over long distances, making massive offshore discharges of treated wastewater effluent, and designing massive stormwater disposal systems are compromising water supplies and are, in effect, fundamental system design flaws that require correction.

In the Boston metropolitan area, for example, the logical connection between serious problems of falling groundwater levels and reduced stream flows, and the release of millions of gallons a day of wastewater and stormwater influent into the ocean has finally been understood, but only after billions of dollars have been spent on centralized infrastructure. In Tampa, Florida, restrictions have recently been imposed on pumping for water supplies. One of the key solutions being pursued is construction of a large and expensive desalination plant. At the same time, billions of gallons of stormwater run-off are discharged into Tampa Bay during the rainy season. Groundwater replenishment to preserve water supplies and non-potable use of treated stormwater and wastewater resources are not being pursued. Non-potable reuse could include

- Firefighting
- Car washing
- Toilet flushing
- Irrigation of
  - lawns
  - crops
  - golf courses
  - parks
  - median strips
  - other vegetation

Reuse could be significantly cheaper than desalination.

Under Scenario B, major metropolitan centers have learned to adapt, refit, and modify their water and wastewater systems to fit better within the natural hydrologic regime and to restore/preserve the natural “mass balance” of water in the local geography. Precipitation is captured, and wastewater reused, thereby meeting much of current and future water demand. Groundwater recharge with stormwater and treated wastewater is commonplace.

Much of this integration in Scenario B can be achieved with inherited “hard path” infrastructure, but additional benefits can be achieved by introducing soft path solutions as well. Satellite wastewater treatment facilities, for example, can be built to provide water for reuse in various districts and neighborhoods. Stormwater could be regularly captured, treated, and reused as irrigation water (or for other uses) at many points throughout the urban and suburban grid. Artificial and natural wetlands can play an important role in treating runoff. Many of these new installations also enhance the aesthetics of the city. In Staten Island, for example, New York City restored stream buffers. As a side effect, the value of adjacent properties increased.

Under Scenario B, demand reduction programs (low flow toilets, industrial/commercial rebates, differential pricing of potable versus non-potable water, and other programs) are ubiquitous. Virtually all new water and wastewater connections would be metered. In New York City, for example, a water conservation program has already been instituted combining installation of low-flow fixtures and incentive pricing. Along with measures to shift spending from capital expenditures over to increased O&M, the city has been able to keep water and sewer rate increases far below prior years.

This scenario relies heavily on new business, pricing, and market models. Customers are divided into different market segments, with higher rates for higher quality potable water, and lower rates for non-potable water. If a business wants to expand, it could be required to obtain a "mass balance" permit, and cover the full costs for its water and wastewater needs. A single, integrated metropolitan utility provides for a tightly integrated planning, design, building, operations, management, monitoring, policymaking, rate setting, and performance-based system. This utility could utilize private contracts, as for O&M, where cost-effective.

Virtually all of these management practices can be accomplished with existing large-scale and centralized water treatment and distribution solutions. These ideas can provide added benefit, however, if they are integrated with soft path alternatives. Using artificial wetlands, for example, is a much more effective way to capture stormwater than to rip up streets and construct large concrete storage vessels. Such solutions are also generally more effective as rainfall swings from near drought to flooding problems. The artificial wetlands example is also more economically effective over the long term. While they are not maintenance free, such systems are likely to be lower in O&M operating and maintenance costs than large centralized facilities with large O&M budgets.

Under Scenario B, the federal government could be the agent for rethinking the way large population centers manage water resources to evolve beyond wasteful disposal paradigms. It is reasonable to assume that over time the government will create incentives for major metropolitan areas to better manage the use of water resources and to evolve beyond wasteful disposal paradigms. Such a shift in regulatory policy might require large urban areas to revise their architectures—in favor of reuse rather than disposal—in order to better preserve the water balance in the local area. Any shift in infrastructure funding in favor of soft paths and maintaining the water balance is likely to result in rapid and significant change. Solving the problem for large urban and major suburban centers seems the best way to make significant strides toward overcoming regional water supply problems. Scenario B was ranked third most likely to emerge prior to the workshop, but the first most likely after extended discussions during the workshop.

Current Obstacles to Scenario B

The major obstacles to implementation of Scenario B are institutional and financial. Mass balance requires the establishment of metropolitan utilities with authority over water, wastewater, and stormwater infrastructure, or, at a minimum, binding agreements to integrate planning and operations of existing "stovepiped" or compartmentalized utilities. Tremendous suburban town resistance to being merged into a larger urban authority would need to be

overcome, along with the preference of agencies in each of these sectors to remain separate. Public citizens and businesses also tend to

- Resist new and higher rate structures designed to achieve sustainable budgets
- Be leery of technologies, such as water conservation devices and metering
- Resist new maintenance and inspection requirements on their private property

Scenario C—Keep the Water On the Land

A third school of thought suggests that a broader-based grassroots change in water resource management might happen at the "micro" level of the individual home or building site. Such changes might have minimal impact early on, but could result in positive and profound changes in water quality and supply conditions across the country over the long term. Such changes can be achieved as information about effective site-level technology is developed by industry and is broadly shared, as the scientific community better understands micro-scale hydrology and treatment, and as local officials (and building codes) are updated to support adoption of these new technologies. The challenge is to work within, or closely approximate the natural assimilative capacity of each lot, rather than to channel, pipe, or otherwise transport water for treatment or assimilation into an artificially small area.

The philosophy of "Keep the Water on the Land" emerges when a comprehensive and widely accepted understanding of micro-scale wastewater and stormwater treatment and management leads to the development of safe and reliable systems, particularly for potable and non-potable reuse at the site-level. Wherever and whenever possible, builders, engineers, and technology manufacturers push for the tightest, shortest, closed loop systems possible. This means that water is drawn from local available resources and returned to the environment as near to its point of use as possible. Any individual neighborhood, town, county, or watershed would be a patchwork of very innovative, integrated, and locally customized water treatment and traditional practices. Advanced on-site treatment systems are carefully tailored to work with the local soils and hydrology to provide treatment (not just subsurface disposal) and reuse of stormwater and wastewater. In some cases even point-of-use water purification could be done at the individual home.

"Micro-scale" technologies include

- Rainwater capture and use for irrigation, toilet flushing, and other non-potable uses
- Graywater/wastewater reuse
- Optimum assimilation of rainwater in the landscape
- Multifunctional, multi-benefit technologies
- Water conservation and waterless toilets
- Alternative disinfection technologies
- Remote monitoring and telemetry

These innovative equipment and systems design concepts would be backed by stringent, well-established O&M requirements to ensure that they are continually effective. Either utilities or private maintenance companies could perform these services under public regulatory oversight. Scenario C was ranked the second most likely future, both before and after the workshop discussions.

Current Obstacles to Scenario C

Key obstacles to the emergence of Scenario C pertain to the complexity of implementation at the "micro" level, and the lack of scientific proof that complex systems will achieve performance goals on a reliable basis. Some of the major benefits of this approach stem from the use of natural soils, and from reclamation and reuse of non-potable and potable water. Knowledge of treatment capabilities of specific soils, climates, and site conditions, however, is not yet adequate for reliable design of integrated "micro" systems.

Regulatory and industry barriers can also impede Scenario C. Current regulations and building codes require hard path infrastructure and specifically disallow soft path approaches, such as reuse, stormwater retention, innovative wastewater treatment designs, and other methods. Engineers find "cookie cutter" solutions profitable and resist learning soft path approaches, which they perceive would lower profits.

Scenario D—Integrated Planning and Regulations

Scenario D suggests that there is a growing awareness and movement among the regulatory and policy community to provide a more holistic framework for water quality management. Under an overarching framework of "sustainability," a wide range of currently separable fields could be merged, including

- Water quality
- Water quantity
- Habitat protection
- Landscape and community character
- Economic well-being
- Social/cultural health

Integrated water resource management plans are developed around the natural water hydrology of the region, and actions of various agencies are coordinated under this one plan.

Under Scenario D, regulatory authorities will have to work hard to become effective water quality coaches. Becoming coaches is a significant evolution of their role that goes beyond simple rule-writing and enforcing. Although watershed management and planning have done much good alone, greater progress can come as the result of the federal government, environmental organizations, communities, counties, and geographic regions pushing for a new framework requiring integrating planning for flood control, groundwater, water supply, water

bodies, and wastewater. Significant streamlining and flexibility in the regulatory environment can make it possible for widespread adoption of soft path approaches and effective integrated water resources management.

Under Scenario D, both federal and state governments expand their tools beyond traditional regulatory and financial subsidization. The watershed management approach is emphasized, both for an integrated assessment of environmental, economic, and social conditions, and for the creation of public-private partnerships and coalitions that enhance public participation and knowledge. "Market" approaches, such as tax incentives or conservation easements on private property are utilized. Government agencies must shift substantial resources to technical assistance to local communities, watershed partnerships, and other partnership areas. Finally, regulations are still required, but there is a shift towards performance goals, so that maximum flexibility is provided for cost-effective and innovative technologies and methods. As a result, regulators would be less concerned with imposing Best Management Practices (BMPs) than with the end-goals of community sustainability. Under Scenario B, it would not be possible to trace precise impacts of alternative approaches, so assumptions would still need to be made about the general performance levels of specific technologies. This scenario was considered the least likely to emerge prior to the workshop, and third most likely after the workshop.

Current Obstacles to Scenario D

Obstacles to Scenario D include a lack of public awareness about the benefits of integration and a public sensitivity and opposition to "land use" regulations or controls over use of private property. Because few people have thought through the concepts of integrated water resource management and the benefits that accrue for such an approach, there is a limited constituency for changing the current system. Beyond that, integrated water resource management requires an examination of land use impacts on water quality and quantity. New subdivision development can unfairly externalize costs from private developers and homeowners to the general public, which would experience depleted water supplies or polluted streams as a result of the development. Nevertheless, there is significant political resistance to increasing land use regulation of the private property rights of these subdivision developers and homebuyers.

Additional barriers within government include institutional compartmentalization and skewed funding. Individual agencies have a vested interest in retaining their "turf" (resources, authority, and expertise) and in not participating either in coordinated management approaches that elevate decisions to a broader framework, or in expanded public participation. Funding programs are geared toward hard path solutions and point source controls, and start-up costs for implementing new soft path approaches are high.

Scenario E—Preservation and Reliance on Natural Systems

Scenario E relies upon the power of the public and the environmental community to act as catalysts for change. Under this scenario, the public has come to recognize that there is no better way to ensure clean, safe, and plentiful water than to rely on, and work within the carrying capacity of natural systems. The expanding field of "bio-mimicry" provides scientific support for this view. Restoration of natural systems—then stewardship of these systems over the long

term—are the overriding goals. The movement toward restoration is supported by a growing push to protect undeveloped areas that have not yet been spoiled by man's presence.

Under Scenario E, environmental groups are aggressive in holding communities accountable for making steady progress toward the goals in their long-term development plans. These groups would have to be much more aware of the details and design trade-offs associated with alternative approaches to integrated water management, than they have been in the past. They would need the expertise, experience, and perspective to know when to advocate for one technical engineering and planning solution or another.

Under Scenario E, the concept of green infrastructure is widely accepted. More setback and set-aside requirements of areas where there are natural hydrologic functions are necessary. Flood plain and coastal building problems need to be well under control. Long-term planning based on an understanding of how flood plains and coastlines change ensures that building does not occur in places that are likely to be destroyed by storm events and erosion. Urban streams are valued as precious assets in the life of a city and rain gardens and green parks major elements in movements for healthy cities, exercise trails, and increased attention to aesthetic values. Wetlands are particularly valuable given their broad role and multiple uses. They are protected wherever they exist, restored wherever possible, and often constructed to provide natural treatment of stormwater and wastewater while simultaneously creating new habitat. A number of innovative engineering firms will emerge as leaders in helping communities meet the integrated water planning and natural systems challenge, though this represents a huge challenge to their core skill set and professional culture. Scenario E was ranked next to last in likelihood to emerge prior to the workshop, and least likely after the workshop.

Current Obstacles to Scenario E

Obstacles to Scenario E include the lack of good models for integrated water resource management and technologies, and the institutional rigidities that support hard path approaches. For example, fire codes, subdivision ordinances, building codes and/or permits, federal insurance, and other financial and regulatory structures don't adequately account for adverse environmental impacts.

Change also requires political advocacy, but at this point, the environmental non-governmental organizations lack sufficient awareness and resources to mount an effective campaign for integrated soft path approaches. Without more serious droughts, floods, or other water-related environmental or health crises, such as disease outbreaks, the public will not be supportive of changes that cost money. Vested interests are resisting soft path technologies or integration across agencies that cut into profits or power structures.

Most Likely Scenarios

Scenarios were ranked both before and after the workshop as to their likelihood.

Scenario	Most Likely to Emerge	
	Before the Workshop	**After the Workshop**
A	1	4
B	3	1
C	2	2
D	5	3
E	4	5

3 TRAINING, RESEARCH, AND DEVELOPMENT NEEDS

Workshop participants described training, research, and development needs to advance each of the five scenarios. These needs were related to or derived from the particular information, tools, or models that the key leaders in each scenario would need to mobilize or implement soft path integrated changes and from the barriers or obstacles were identified for implementation. Key change agents who provided leadership under each scenario were as follows:

Scenario	Key Change Agents
A	Local elected officials and engineering firms
B	Regulators, government bureaucrats, and economic development interest
C	"Visionaries" in government, academia, engineering firms, and environmental organizations
D	Same as C
E	New coalitions of environmentalists and soft path professionals and technology entrepreneurs

The needs of change agents in each of the scenarios overlapped in some key respects and were unique in others. In order to identify the highest priorities for future funding, topics were listed for each of the scenarios separately. These topics were then sorted into the major categories and subcommittees utilized by the NDWRCDP, which include

- Environmental Science and Engineering
- Management and Economics
- Regulatory Reform
- Education and Training

High priority topics were subsequently defined as those topics that were listed for four or five of the scenarios. Other priority topics were defined as those that were listed in two or three of the scenarios. Topics listed for only one scenario were not included in the remaining discussions.

These priority areas have a more pragmatic bent and less of a scientific research orientation than the training, research, and development needs identified in the 2002–2003 National Decentralized Water Resources Capacity Development Project Training, Research and Development Plan (NDWRCDP Plan) focusing on decentralized wastewater systems only. This difference is largely due to the focus in the February 2002 workshop on actual implementation of

scenarios, rather than academic research per se. In contrast, the NDWRCDP Plan incorporates material from both a similar scenario-building exercise and an earlier series of academic white papers on specific technical subjects. Finally, many topics in this analysis are similar to topics in the NDWRCDP 2002–2003 plan, but include a broader range of technologies than just on-site or cluster wastewater systems. Other topics, particularly in the regulatory reform area, are substantially different, as described below.

Environmental Science and Engineering (ES&E)

High priorities for ES&E include:

1. Solid evidence at the "micro" or individual site or cluster system level that soft path technologies, designs, and management work reliably—performance data and monitoring of systems

2. Solid evidence and models at the cumulative "macro" level that soft path approaches will protect water quality and quantity at the community, metropolitan, or regional level—water quality data collection, assessment, and fate and transport models

3. Telemetry or remote, real-time monitoring systems both for individual systems and in the environment

Other Priorities:

4. Standardized designs and customized approaches tailored to different climates, soils, site conditions, and other characteristics

5. Solid scientific basis to technologies and approaches, modeling and other methods

6. Demonstration that public health risks from use of soft path approaches are low

A primary need for all change agents identified in the five scenarios is for documented evidence that the soft path technologies and approaches perform as intended and under all conditions, including storm events. Even "advocates" or "visionaries" who want to see greater adoption of soft path approaches and who are willing to invest time in promoting them, perceive a serious lack of objective, documented evidence on the reliability and efficacy of these systems. It was widely recognized in the discussions that professional engineers, in particular, play a central role in infrastructure choices and that engineers are generally skeptical of soft path approaches. Municipal officials are also risk-averse and, as described in Scenario A discussions, do not want to be used as "guinea pigs" for new and untried approaches. Regulators hesitate to approve new technologies without extensive documentation of performance.

The lack of solid evidence is compounded by the complexity and variability of soil-based systems for wastewater and stormwater retention and treatment. Wide variations in soil types, wet versus dry conditions, cold versus warm climates, and other variations will substantially affect the performance of systems. Experts in each region of the country typically want to know that a given design or technology works under their particular conditions. To the extent that integrated system designs incorporate stormwater treatment and control, wastewater treatment,

water conservation, and reuse, the number packages requiring investigation becomes multiplied manyfold.

Research is needed on two levels. First, at the "micro", or individual site or cluster system level. Second, at the "macro" or community/regional level. Decision makers will need greater certainty about the performance of systems at specific sites, especially in protecting public health of families using systems. In addition to performance measures for different technologies and designs, it is important to know what maintenance schedules are appropriate, what the costs of installation and maintenance are, and how homeowners react to maintenance requirements on their private property. For communities to plan for widespread use of integrated soft path infrastructure, decision makers also need reliable predictors of the cumulative impacts of systems within the broader community or region, as in the "mass balance" models of Scenario B. A comparative examination of the character, quantity, and vector/diffusion of storm runoff using hard path storm sewers versus soft path low impact development retention and treatment would be of particular value.

Various research and demonstration projects are needed to address these gaps in knowledge. First, basic scientific studies of treatment processes and mechanisms in the soils are needed to build a solid foundation for improved designs. Demonstrations of these technologies and designs in the laboratory and field sites are also needed to persuade regulators, engineers, and elected officials of their efficacy. Second, large-scale demonstration projects in communities are needed both to facilitate documentation of "macro" water hydrology/treatment effects in real-world settings, and to allow for documentation of management systems and the financial, public acceptance, and other benefits of soft path solutions. Research and demonstration projects must be implemented in different regions of the country, varying by climate, soil conditions, and other factors.

Real-time telemetry systems should be improved, so that problems can be identified and corrected before they create serious risks to the individual system or to the water supply or ecosystem.

Management and Economics (M&E)

High priorities for M&E include

1. True cost comparisons of soft path and hard path approaches (including growth, quality of life, and other non-monetary considerations)

2. Integrated community water resource decisionmaking tools—Planning, assessment, public participation, and other tools

3. Creation of multi-disciplinary teams in engineering firms, including engineers, planners, natural resource specialists, financial analysts, and public outreach specialists

Other priorities for M&E include

4. New rate/fee structures, variable demand and supply curves for different potable and non-potable water quality and use

5. Utility or other integrated water resource management models for rural or metropolitan areas, including public-private partnerships and other institutional arrangements

If public and elected officials have been persuaded that integrated soft path systems function reliably, the next major concern is the potential cost-savings these approaches can bring to individual homeowners and communities, both in short-term capital expenditures and in long-term maintenance. Many of these savings surface in an integrated analysis of costs across water, wastewater, and stormwater sectors. For example, decentralized wastewater systems are less likely to deplete groundwater resources or require acquisition of expensive new water supplies in the future.

True cost comparisons that incorporate a full range of benefits and costs not normally considered are advisable. Soft path solutions can save on financing charges by spreading investments out over time, and efficiencies can be achieved by incorporating water or wastewater construction into road, park, or other building projects. Many of the benefits of soft-path approaches stem from "non-monetary" categories, or those indirect effects that are hard to quantify and are not reflected in typical water/wastewater budgets. These benefits include, for example

- Maintenance or restoration of habitat in rural areas and green space and gardens in cities
- Greater awareness and ethic of stewardship
- Local job creation
- Increased property values for homeowners adjacent to revitalized parks or streams

Two related needs build on the "true cost" approach. First, decentralized models and tools are needed for community decisionmaking, including planning templates, means to assess and predict water quantity and quality changes, and methods to engage the public in discussions about the full range of impacts and choices. Second, engineering firms, which are the primary resource for community decision makers to assess detailed technical options, need to build the capacity to model and assess the full complexity of monetary and non-monetary benefits and costs. The current narrow focus of facilities plans is a contributing factor to the bias in engineering recommendations towards hard path solutions.

Finally, implementation of soft path approaches requires the development of new institutional mechanisms more appropriate to decentralized and nonstructural infrastructure. New rate structures should be developed to distribute costs equitably, and to also create proper incentives, such as incentives for water conservation. Homeowners in new housing developments could also be charged rates based on the actual cost of providing new decentralized service, and differential rates could be charged for potable versus non-potable water, a key factor in Scenario B.

New management models and demonstration projects are needed. Integration of water, wastewater, and stormwater functions suggests a consolidation of the separate bureaucracies,

including planning, financing, and maintenance personnel into one overarching public works department. Public-private collaboratives or utility models must also be explored.

Regulatory Reform (RR)

High priorities for RR include:

1. Development of streamlined, flexible and accountable policy and regulatory structures that support integrated water resource management

2. Design of performance-based codes and building codes that facilitate innovative soft path infrastructure development

3. Design of federal requirements for **ONE** water resource-related plan from communities and regions, and consistency among different federal regulations and funding sources

Other priorities for RR include:

4. Reuse regulations that allow for greater reuse/reclamation of treated wastewater and stormwater

5. Design of adaptive management approaches that encourage continuous review and innovation, including Environmental Management System-based and asset management approaches

All five scenarios rest on the principle that water, wastewater, stormwater, and other soft path systems are pieces in a complex, interdependent water quantity and quality system of surface and groundwater. Traditional policies and regulations that deal with each type of infrastructure separately typically fail to consider these interdependencies or externalities. The result is a highly-inefficient approach, where indirect costs and impacts are imposed on future generations or, for example, on other people downstream. These problems can cost a great deal to correct. Policies and regulations need to be changed to reflect these interdependencies.

Ideally, infrastructure decisions are made in a broad, integrated process, where all direct and indirect impacts on the environment, the economy, and the community fabric are taken into account. The overarching goal is to maximize public welfare by spending money on the infrastructure that achieves the greatest benefits at least cost.

In addition, participants in the workshop argued that prescriptive “command and control” regulations typically serve to deter innovation. If the process of securing regulatory approvals is long and costly, there are minimal incentives for entrepreneurs to invest in new technology development. Engineers do not search for cost-effective, integrated designs if their plans are not approved by separate agencies.

Several challenges to developing flexible, integrated policy and regulatory structures exist including

- The need for data and modeling to accurately predict all direct and indirect impacts from any infrastructure alternative (see topic in ES&E)
- Resistance by local governments and constituencies to being absorbed into larger regional decisionmaking structures (see topic in M&E)
- Resistance by "siloed" bureaucracies concerned about losing "turf" (M&E)
- Intense political debates about such major decisions as land use controls
- The absence of models and demonstrated successes in integrated policies and regulations

Specific models that warrant exploration include

- Development of performance-based codes
- Design of templates for integrated facilities plans
- Development of methods to synthesize all water-related regulations and funding programs
- Tailoring environmental management and asset management approaches to decentralized systems

A particular area of concern is the development of reuse/reclamation regulations and codes that adequately protect public health, but that also create incentives for integrated water use and reuse.

Training and Education (T&E)

High priorities for T&E include

1. Means to enhance public awareness and willingness to support water quality protection via soft path approaches, for example, value of clean water, willingness to pay for open space, wildlife habitat, and other areas of concern
2. Training and education of professionals and practitioners, including
   - Engineering, design, maintenance
   - Multi-disciplinary approaches
   - Asset management and reliability techniques
   - Public participation, integrated management
3. Education of important constituencies, including
   - Environmental organizations
   - Land conservation groups
   - Watershed groups

- Various national state government associations
- Counties
- Cities
- Homebuilders associations
- Engineering and public works professional organizations
- Other non-governmental organizations

4. Development of public participation procedures

Other priorities for T&E include

5. Clearinghouse of information for technology and management

6. Accreditation of professionals and practitioners

7. Outreach to professionals and practitioners

Major impediments to implementation of soft-path approaches are the lack of public awareness about water resource issues and alternatives, in general, and the lack of a public consensus or major constituency for advancing soft path technologies and practices. Public support is crucial when the inertia of conventional practices needs to be overcome, or when new and costly regulations or upgrades on private property are proposed for decentralized wastewater systems or stormwater runoff.

Public advocacy and professional organizations are largely unaware of new decentralized technologies and the advantages of integrated approaches, and are currently directing minimal time and energy to reform of conventional practices in this regard.

Professional water and wastewater engineers and planners have not received training in soft path technologies, which rely on treatment and retention in the soils or on multiple, small systems under centralized management.

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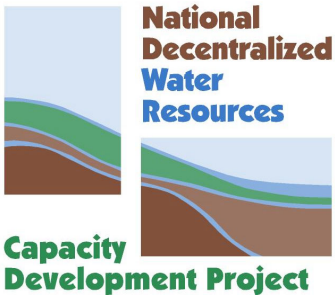

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