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NEW APPROACHES IN DECENTRALIZED WATER INFRASTRUCTURE

by

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ABSTRACT AND BENEFITS

Abstract

Decentralized water technologies and designs, such as water-efficient appliances, rooftop rain gardens, and onsite wastewater treatment and reuse, are the keys to enhancing the performance of the nation's aging centralized water and sewer systems and to assuring adequate water supplies and healthy ecosystems into the future. Decentralized systems also create a host of other benefits for communities, including energy savings, improvements in air quality, creation of green spaces, restoration of streams, aquifers, wetlands, and habitat, and stimulus for new green companies and jobs.

In spite of these multiple benefits, however, there is a realistic fear that inertia and drag in the public-private institutional framework of water infrastructure could forestall the adoption of decentralized designs. This project was intended to explore the various pressures or drivers—as well as the impediments—for a change in the fundamental "paradigm" of water management. A series of workshops with experts and advocates was convened to explore the institutional issues and to tease out various new strategies for jump-starting and easing a transition.

Recommended strategies include incorporation of water concerns into the Green Building movement and funding of community demonstration projects. A second strategy is to support a multi-faceted conversation about sustainable water infrastructure with academics, entrepreneurs, engineers, activists, public bureaucrats and managers, and the public. Finally, as more is learned about what works and what does not work, and as the new approach becomes better-understood and better-known across a broad range of constituencies, there can be enough of a groundswell of support for a serious restructuring of water institutions and policies.

This restructuring will include: an integration of planning, funding, and regulations across the currently segmented fields of water, stormwater, and wastewater; an expanded role for the private sector in technology development, systems management, and finance; a closer link between professional practice and community pa[illegible]

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Decentralized vs. Centralized Systems

The advantages of decentralization emerge as reuse is emphasized. Using and reusing water at the local site costs less than piping water in, wastewater out, and treated water back in for reuse. In addition, many of the new values being discovered from decentralization, such as green space, are by definition local and dispersed throughout the community.

Localized and integrated capture, use, treatment, and reuse of water would mimic how nature itself uses water. Nature moves water and minerals through large cycles of cloud formation, rivers, and groundwater flows, but it also uses, stores, reuses, and cleans water at the local level to support complex and abundant webs of life.

Until now, our centralized, big-pipe infrastructure has relied on an industrial model of specialization and economies of scale. This industrial model has more than adequately protected the public from pathogens and floods, largely by storing and piping clean water long distances into population centers and then transporting wastewater pollutants away.

But the approach is also wasteful, environmentally disruptive, and ultimately not sustainable as populations increase and more and more land is developed over time. Climate change-related extremes of heavy storms and droughts will place even greater stresses on this centralized, natural-manmade water system that we have uncritically built piece by piece.

Steps Toward Decentralization

A first essential step in realizing the potential for decentralized technologies is to transform the way professionals, advocates, and the public think about looming ecosystem crises and the unsustainable practices currently embodied in the water infrastructure. This transformation in thinking is difficult when conventional water engineering has been considered one of society's greatest accomplishments in public health and in clean water quality protection.

But, changing the infrastructure from an industrial model to a "biomimicry" model also entails a daunting set of changes in the governance and institutional framework of water management.

Sectors of the economy where public bureaucracies are closely intertwined with the private sector are much more difficult to transform than in a private market alone, where the "creative winds of destruction" can sweep aside outmoded products and practices. A realistic fear is that inertia and drag in this public-private institutional framework in water could actually forestall a transition to more sustainable technologies and designs.

This Project

This project was intended to explore the various pressures or drivers—as well as the impediments—for a change in the fundamental "paradigm" of water management. A series of workshops with experts and advocates convened to explore the institutional issues and to tease out various new strategies for jump-starting and easing a transition. They discussed key topics of science and technology development, market restructuring, and public participation.

Case studies and workshops showed that there are

- Scattered drivers for a paradigm shift in water management, including increasing drought conditions, flooding and wet weather pollution, and sprawl development
- New ways of thinking about biomimicry and market transformations
- Niche successes in building decentralized system alternatives by community activists and entrepreneurs

Some impediments to change are:

- Government funding and regulations that have been built up to support the traditional infrastructure
- Distorted pricing of water
- Risk aversion
- Conventional attitudes and expectations of the public
- Management utilities that are oriented around big-pipe infrastructure in public rights-of-way

Attempts to leverage one or another driver or to break down one or another impediment at a time are ineffective because there are so many interlocking pieces of the traditional paradigm that work to "lock-in" the approach.

Paradigm Innovation

The first essential strategy is to create spaces for multi-faceted "paradigm" innovation to occur. These initiatives include developing the water component in the Green Building movement where new products and new markets have already been successfully created in the parallel fields of energy and construction materials and supporting community demonstration projects where new institutional models can be structured for management, financing, and regulation.

These projects, over time, will clarify how the localized and integrated biomimicry model works to create multiple community values and engage new partners. Essentially, the trio of decentralized water-efficiency, stormwater retention and reuse, and wastewater treatment and reuse has the potential to reduce dramatically the amount of water taken out of aquifers and streams and to reduce wet weather runoff and sewer flows going back into the environment.

Another critical component of the new infrastructure is that it creates multiple other benefits as well, many of them from the plants and trees that "green" the cities and towns. Other resource benefits accrue from integrated, closed-loop planning where energy and nutrients are captured for reuse instead of being wasted.

Mimicking complex interdependencies of species in nature applies to the way that society can restructure its decisions and actions in water, as well. By expanding the participation of the private sector, community organizations, and the public, a significantly richer set of alternatives emerge. Conversations amongst diverse groups typically lead to much more creative and productive solutions than leaving the issues to a specialized profession.

In nature, individual species survive by "opportunistically" finding a niche in the web of life. Similarly, participants in a biomimicry model of infrastructure would find ways to take value from the model and simultaneously create value for other participants. For example, the private sector can make money from installing decentralized systems or inventing new technologies while reducing water use and enhancing green space in the process.

Conversation

A second strategy is to support a multi-faceted conversation about sustainable water infrastructure with academics, entrepreneurs, engineers, activists, public bureaucrats and managers, and the public.

Group	Course of Action
Researchers	Study the imminent water quantity and quality crises the nation will be facing and link those crises to the differential impacts of centralized, decentralized, and hybrid infrastructure alternatives. Dramatically improve the performance of membranes, telemetry, and ecosystem monitoring
Engineers	Develop collaborative design processes that generate creative, multiple benefits solutions
Activists	

Chapter 1

INTRODUCTION

Over the last decade, interest has grown in decentralized technologies and designs to provide water, stormwater, and wastewater services. Rural areas have used onsite wells and septic systems for years. However, these systems have been largely viewed as temporary solutions.

As the density of development increased, the modern and permanent model of infrastructure to protect public health was highly centralized water and sewer pipes and treatment plants along with large-scale stormwater drainage systems.

In the US, these "big-pipe" systems were built in cities starting in the 1800s. By reducing public exposure to polluted waters and floods, this infrastructure has been seen as a great public health achievement. The Clean Water Act in 1972 and the Safe Drinking Water Act in 1987 introduced more stringent requirements for wastewater treatment plants and water treatment plants. As a result, the 1970s and 1980s saw significant improvements in surface water quality.

More recently, the role that decentralized technologies and designs could collectively play in providing a more "sustainable" water, stormwater, and wastewater infrastructure has begun to be discussed. Concerns are growing that conventional, centralized infrastructure cannot meet the rising demands of population growth and urban/suburban land development without threatening the collapse of natural water hydrologies and ecosystems. Decentralized systems and reform in agricultural practices are the key innovations for reducing the demand for new water supplies and for lightening the ecological footprint of the infrastructure.

Trio of Decentralized Technologies and Designs

In general, the focus in decentralized systems has been on the various technologies and designs, or "appliances," in the separate spheres of water-efficiency, stormwater, and wastewater. The use of these systems has still been on the margins of the traditional, centralized model. Various alliances and Environmental Protection Agency (EPA) programs have emerged to advance these technologies and designs. Arguments have been made for how widespread use of these decentralized systems could enhance the performance of the existing infrastructure or provide multiple other benefits to communities.

Generally, the customer has been the homeowner or developer/builder, and municipalities have used both incentive programs and mandates to encourage the installation of the technologies, particularly in new construction.

Examples of this "trio" of technologies and designs, and their promoters include:

Water efficiency and conservation

Stormwater retention and reuse

Decentralized wastewater treatment, reuse, and resource recovery

Water Efficiency and Conservation

The following approaches have been advanced by groups such as the new Alliance for Water Efficiency, which is a consortium of appliance manufacturers and environmental organizations:

- Water-efficient appliances, such as washing machines and low-flow toilets
- Landscaping practices and plants that use less water
- Point-of-use water treatment devices that reduce the demand for potable, drinking water
- Water meters and pricing that provides incentives for consumers to reduce their use of water

Peter Gleick at the Pacific Institute and Richard Pinkham at the Rocky Mountain Institute have helped shape the arguments for decentralized water-efficiency, or what they have called the "soft path."

The EPA has established a program to advance labeling and standards, called Water Sense, and one of the Four Pillars for a Sustainable Infrastructure is to help municipal utilities advance water-efficiency in their systems.

Generally, the argument for enhancing the performance of the traditional, centralized infrastructure has been to use water-efficient appliances and conservation practices as a means to reduce the demand for new water supplies, particularly in arid regions of the country. However, as in similar energy-efficiency programs, the new appliances and landscaping have often been of higher quality and design for the customer, as well.

Stormwater Retention and Reuse

The following approaches have been advanced by organizations such as the Low Impact Development Center and the Center for Watershed Protection, primarily for new "Greenfield" development:

- Rain gardens or rooftop plants
- Tree planting programs
- Cisterns to collect rainwater
- Reuse of stormwater for toilet-flushing, irrigation, and other non-potable uses
- Low-impact development designs for subdivisions, which allow for stormwater retention and filtering onsite

Recently, the EPA has established a "green infrastructure" program in collaboration with municipal utilities and environmental organizations, and has funded Sustainable Cities, a partnership of landscape architects and other non-governmental organizations (NGOs).

The arguments for decentralized stormwater systems have been to enhance water quality protection, on the one hand by reducing the impact of new development in rural and suburban areas, and on the other hand, by reducing stormwater overflows and runoff in urban areas with combined sewers.

However, advocates of green infrastructure have also pointed out the additional benefits of rain gardens and trees, including beautification, open space, better air quality, reduced heat island effects, and others. Stormwater can also be used for non-potable water purposes.

Decentralized Wastewater Treatment, Reuse, and Resource Recovery

Decentralized wastewater can be treated, reused, and provide resources in the following ways:

- Onsite and cluster wastewater treatment technologies and designs that produce high-level treatment at small scales
- Reuse of treated wastewater for toilet flushing, irrigation, firefighting, and other uses
- Recovery of energy from the organics in

A birds-eye view of rural and suburban areas would be of continued reliance on onsite and cluster water, stormwater, and wastewater systems. Water-centric subdivision planning, in particular, would push toward off-the-grid efficiencies and a minimal impact on natural water flows and hydrologies in the watershed.

Both the urban and greenfield infrastructure would be integrated with energy and nutrient recovery from the wastewater.

Patterns of Decentralization

Table 1-1: Description of Patterns of Decentralization

Pattern	Description
Onsite and Neighborhood Use and Reuse	Closed-loop water systems in residential and commercial buildings, where water is used efficiently and where stormwater and wastewater are treated and reused for landscape irrigation, toilet flushing and cooling
Green Infrastructure	Rain gardens that trap stormwater and sustain trees and plants. These plants restore beauty and improve air quality, moderate energy flows, and provide potential food sources
Smart Growth	Patterns of neighborhood development that interconnect nature and the built environment, preserve open space, and respect natural drainage flows
Green Cities	Restoration of natural cycles of water infiltration and evaporation in cities and towns through localized treatment and groundwater recharge, trees, parks, and roof gardens, and stream daylighting and restoration
Watershed Restoration	Restoration of natural watershed flows and functions through localized water use and recycling into natural wetlands, groundwater, and air. These systems will restore and preserve habitat and wildlife
Climate Moderation	Slowing of global warming through rehydration of soils and vegetation that absorb heat and increase water vapor in the atmosphere

Multiple Community Benefits

Decentralized water and wastewater infrastructure creates the following benefits:

Lower costs and reduced demand for wastewater and stormwater facilities as well as water supply—costly water supply enhancements can be avoided through onsite water use efficiencies, wastewater reuse, and rainwater harvesting. Impacts of droughts can be moderated

Lower costs of maintaining existing infrastructure—flow rates in existing water and sewer systems can be reduced through decentralized efficiencies and reuse in office buildings and infill developments

Lower costs for new infrastructure—new developments can be accommodated with targeted small-scale infrastructure that is competitive with centralized infrastructure and with more benefit to the community and the environment

Greater resilience—small-scale treatment units are more resilient than centralized systems in hurricanes and floods and less vulnerable to accidents and terrorism

Ecological restoration—decentralized systems can reduce the discharge of pollutants, replenish aquifers, and restore streamflows and habitats

Resource efficiencies—small-scale treatment units can save on energy costs and recycle nutrients into landscaping and agriculture

Community benefits–green infrastructure has been shown to improve air quality, preserve open space, and create local jobs

Private financing—small-scale treatment units on individual properties can be financed privately, thereby saving money for municipalities

International competitiveness—American advancements in sustainable water systems can be utilized in developing countries, such as China and India, and high-tech research, manufacturing, and engineering jobs can be created in the US to serve these markets

Difficulties Inherent in Shifting to a New Hybrid Infrastructure

As advantageous as decentralized water, stormwater, and wastewater infrastructure can be, there are numerous institutional impediments to its adoption. In a private market, a good new product can begin with a niche market and quickly transform an entire sector, as can be seen with cell phones replacing landlines or automobiles replacing horse-drawn carriages. In a heavily regulated, public-private market like the water field, however, no process as economists have described as the "winds of creative destruction" exists.

Innovators have trouble selling their products and services in a system in which regulators, municipal utilities, engineers, unions, and other entrenched bureaucracies or interests can refuse to alter the rules and practices or retrain in new approaches. Often just one of these constituencies can block a new approach that a majority of local stakeholders might support.

In recent years, the EPA and others have adopted an incremental approach to incorporating decentralized systems into the traditional paradigm by providing information and guidance to communities on a number of decentralized technologies, such as low-impact development, decentralized wastewater treatment, and most recently, water-efficient appliances and green infrastructure.

This siloing of thinking has helped to keep decentralized systems at the margins of conventional practice, as for example, when the role of improved decentralized wastewater systems is still largely focused on rural, unsewered areas.

This project has taken a more radical approach, which suggests that sustainability of the nation's core infrastructure in urban, suburban, and rural communities will be achieved when decentralized systems have become the centerpiece of future responses to water quantity and quality crises, both in enhancing the performance of the existing infrastructure and the building of new infrastructure.

Paradigm Shift Needed from the Old to the New Infrastructure

Participants in decentralized infrastructure discussions have begun to refer to a need for a wholesale paradigm shift in the water field. American Heritage Dictionary defines a "paradigm" as a pattern or model, or as a set of assumptions, concepts, values, and practices that constitutes a way of viewing reality for the community that shares them, especially in an intellectual discipline. The term "paradigm shift" has been used to signal the scope and nature of change that

- Andy Lipkis, TreePeople: *The Case for Integrated Urban Watershed Management, Los Angeles*

November 10, 2005—Science and Technology Needs and Opportunities

- Julian Sandino, CH2MHill: *Changing Infrastructure Paradigms: An International Perspective*
- Robert Siegrist, Colorado School of Mines: *Current Research Efforts and Potential New Directions*
- Mary Hansel, Carollo Engineers: *Biomimicry—Learning from Nature's Consummate Engineers*
- Keith Carns, EPRI Community Environmental Center: *Current Research Efforts and Potential New Directions*
- Mike Luzier, National Association of Home Builders Research Institute: *Market Transformation Strategies*

December 12, 2005—Funding, Planning and Regulatory Reform

- Peter Shelley, Conservation Law Foundation, Boston, Massachusetts Water Initiative: *Water Quality and Supply in Massachusetts*
- Andy Lipkis, TreePeople Center for Community Forestry, Los Angeles
- Jim Stebbins, Project Design Consultants, San Diego: *Building Blocks of Sustainable Development*
- Kyle Dreyfus-Wells, Chagrin River Watershed Partners, Ohio: *Implementing Low Impact Development in the Chagrin Watershed*
- Craig Lindell, Aquapoint, Inc, Massachusetts: *Distributed Sewer: The Demand Side*

December 13, 2005—Public Awareness and Action

- Harry Wiland, Eden's Lost and Found Filmmaker, California: *Grassroots Change*
- Brent Haglund, Sand County Foundation, Wisconsin: *Promoting Environmental Stewardship*
- Ken Jones, Green Mountain Institute, Vermont: *Success in Small Communities and Rural Areas*
- Nancy Lee, Social Marketing Services, Inc., Washington: *Social Marketing and Sustainable Development*
- David Johnston, What's Working, Colorado: *Engaging Diverse Culture in a Common Project*

January 19, 2006—Final Synthesis Workshop

- Core group of organizations re-convened. One of the objectives was to develop an agenda of priority short-term research and development, institutional reform, and outreach projects

Stakeholders

Stakeholders who participated in one or more workshops included:

John Berdes, Shore Bank Enterprise

Matt Byers and Linda Bonner, National Onsite Wastewater Recycling Association (NOWRA)

Bill Cagle, Orenco Systems

Todd Danielson, Loudoun County Sanitation Authority

Glendon Deal, US Department of Agriculture

Mark DeKay, University of Tennessee

Scott Drake, East Kentucky Power Coop

Alex Duran, National Association of Homebuilders Research Center

Alex Echols, Conrod Communications

Ray Ehrhard, EPRI Community Environmental Center

Steve Ellis and Autumn Hanna, Taxpayers for Common Sense

Doug Fogel, Butte County Public health

Karl Rabago, Houston Advanced Research Center

Paul Schwartz, Clean Water Action

Vance Severin, Butte County Environmental Health

Frank Shephard, Woods Hole Data Base, Inc.

Nancy Stoner, Natural Resources Defense Council (NRDC)

Heather Whitlow, Casey Trees

Richard Wright, American Society of Civil Engineers

Workshop Findings

This introduction will summarize the key workshop findings that pertain to the larger concerns about a shift to a new sustainable water paradigm. Specifically, three questions covered in this report are:

What are the critical "drivers" or pressures for a shift in the paradigm?

What are the institutional and other "impediments" to a shift in the paradigm?

What are key strategies to amplify the pressures for change and to leverage the critical tipping points of cascading effects or crystallizing impacts?

Note: For more detail on workshop proceedings and summary findings and conclusions, click on the title of the workshop from the Homepage.

Drivers for Change in the Paradigm

In the workshop series, three major pressures for change in the paradigm emerged:

Water crises and other new societal demands on the infrastructure

New ideas and design concepts

Niche innovations by advocates and entrepreneurs

Impediments to Change in the Paradigm

The following impediments to change emerged in the workshop discussions:

Government policies, funding, regulations built around centralized infrastructure

Distorted pricing of water

Balkanization of agencies

Municipal authority and a limited role for the private sector

Pervasive risk aversion and minimal research funding

Stakeholder support for conventional solutions

Lack of local models that combine technology, management, financing, and customer acceptance

Opposition from threatened entities

Classic market failures, such as lack of information, fragmentation

Strategies to Trigger and Ease a Paradigm Shift

A basic strategy for a water paradigm shift emerged in the workshops:

Create spaces for local paradigm models to emerge, such as in green building and demonstration projects in cities and towns

Support conversations and research among engineers, utility managers, non-governmental organizations, academics, and the public

Incrementally begin work on reforming the big government structures of research, funding, and regulations

Drivers for—and Impediments to—Decentralization

The following table shows drivers for decentralization and the impediments to attaining it.

Table 2-1: Drivers and Impediments in Decentralization

Drivers for Decentralization	Institutional Challenges and Impediments to Decentralization
Water crises and other new societal demands on the infrastructure	
Droughts and water supply shortages	
Water quality and habitat degradation	
Climate change and resilience	
Aging infrastructure costs—repairs and expansion	
Alternatives to sprawl development (promoted by sewers and large-lot septic systems)	
Quality of life in urban and rural communities—pervasive gray infrastructure	

Scattered and Siloed Innovation—Current Picture

Various characterizations of the current decentralized water infrastructure field were discussed in the workshops:

1 The current new decentralized paradigm development is scattered across the country and still generally siloed into water, stormwater, or wastewater.

At the Palo Alto meeting on Viable Business Models for Decentralized System Management, the conclusion was that *"a variety of players are emerging in a fragmented market, with each 'doing their own thing'."* Each area of the country is generating different models for wastewater and stormwater management, based on different issues and needs, such as densely developed coastal areas compared to new construction in the South and Midwest.

The problem now is getting businesses up and running, while in the future the challenge will be to regulate companies to achieve fair pricing and consistency with balanced growth plans. The Washington, DC workshops also characterized change as *"significant local action and innovation happening ad hoc at the local level."*

In Palo Alto, discussions suggested that management of wastewater (private sector) is also a completely different model from management of stormwater in urban areas (voluntary and public sector).

2 As a result, the key elements of a new decentralized water paradigm are unclear.

In DC, participants agreed, *"There is no model approach, institutional structure, clear principles, or full understanding of soft path (e.g. decentralized) application. The fact that the tools, benefits, and systems regarding soft path water are not clear enough raises important short- and long-term planning issues."*

Participants agreed there is still no clear sense of uniting core principles and values that are needed to bring a coalition together.

3 It is difficult to create a new model or paradigm in the midst of the old approaches.

As one participant characterized it, developing the new water paradigm is like *"building a car in a bicycle shop."* The current moment is *"interesting and complicated"* in the view of different actors. Therefore, we are dealing with a complicated change paradigm. We need *"to set funding and pilots so it begins to settle over time into a set of effective processes."*

Key Pressures for a Paradigm Shift

The workshop case studies and discussions provided descriptions of external pressures to move beyond the existing water paradigm. These forces highlight both the inadequacies of the existing approach and suggest new structures in a more sustainable paradigm.

Water crises and other societal demands on the infrastructure

New ideas and design concepts

Niche innovations by advocates and entrepreneurs

These drivers are discussed in the next chapter.

Chapter 3

DRIVERS FOR A DECENTRALIZED PARADIGM

Climatic and societal forces will eventually lead to the collapse of the current, centralized water infrastructure. These pressures, as well as solutions, were emphasized in the workshops.

Water crises and other societal demands on the infrastructure

New ideas and design concepts

Niche innovations by advocates and entrepreneurs

Water Crises and Other Societal Demands

The workshops provided examples of how a number of separate water crises and societal demands were beginning to highlight the costs and inadequacies of the current infrastructure approach of siloed and big-pipe systems, as well as the benefits of decentralization. In time, as climate change exacerbates the extremes of droughts and storm events, the entire hydrological cycle will need to be addressed with new restorative infrastructure designs. For the moment, however, there are a series of separate "doors" or entry points into questioning whether the current paradigm of centralized infrastructure is sustainable.

Droughts and Water Supply Shortages

Solution: Use water-efficient appliances, harvest rainwater for non-potable uses, and treat gray water and blackwater for non-potable reuses.

Several of the presentations in the DC workshops highlighted the growing concerns for water supply shortages across the US and the use of the trio of decentralized technologies to reduce the demand for and increase the efficiency of use of water, in particular of potable water.

> Andy Lipkis, from TreePeople in Los Angeles, began his career over twenty years ago with tree-planting programs throughout the city. Over time, he and his colleagues began to realize that urban forestry was an important tool in dealing with LA's increasing water demands. The city spends a billion dollars a year to bring fresh water from hundreds of miles away. However, rain gardens and cisterns that capture stormwater could provide an alternative source of water, in particular for landscaping. This stormwater retention and reuse could also reduce some of the costs of channeling stormwater flows into the matec-0.0po

Peter Shelley, from the Conservation Law Foundation in Boston, described the artificially-created water supply shortages that have resulted from construction of a huge regional wastewater system and ocean outfall in Eastern Massachusetts. Shelley described the *"one time water use model,"* that essentially "throws away" rainwater and groundwater. Little rainfall is returned to aquifers, and the groundwater system is drained by old and leaky sewer lines. As a result, streamflows are very low in the summer and communities are experiencing water shortages from the depleted aquifers. The state has had to impose more stringent water allocations, which is surprising for an area with more than adequate rainfall. The city of Brockton, south of Boston, has also chosen to build a desalination plant to make up for the groundwater losses. Shelley's suggested prescriptions included:

- Linking the value of ecosystem services to the users
- Engineering upgrades to reduce infiltration and inflow
- Keeping stormwater and wastewater local
- Providing financial incentives for local, decentralized infrastructure
- Restricting inter-basin transfers of water
- Mandating the development of municipal and watershed water in/water out budgets, flow trading, etc.
- Integrating environmental organizations at the state level

James Stebbins, of Project Design Consultants in California, described a proposed community called Rancho San Juan in Monterey, California, where the goal was for *"no imported water."* The proposed plan used the limitations of water supply in California as a starting point for a "water-centric" design that used onsite water only and that minimized the use of potable wate

Water Quality and Habitat Degradation

Solution: Use decentralized systems to slow and reduce runoff, to keep wastewater effluent out of surface waters, and to take less water out of and/or to recharge local streams and aquifers.

> Steve Moddemeyer, from Seattle, described the ongoing demonstration project efforts in Seattle to retain stormwater with cisterns, rain gardens, and soil storage as a way to manage stormwater runoff. Rain can overwhelm the city's sewer system, leading to flooding and contamination of streams with special protection for salmon. The city is looking to these distributed approaches as complements to, or even substitutes for, expensive combined sewer overflow (CSO) controls.
>
> Kyle Dreyfus-Wells, from the Chagrin River Watershed Partners, Inc. in Ohio, described their efforts to implement conservation or low-impact development practices, to *"minimize long-term infrastructure costs and maintain natural resource function."* This rural area of Ohio is beginning to see adverse effects of poorly designed "suburbanization," where flooding and water quality impairments are now more common. The Partners are working with towns to implement decentralized stormwater techniques, such as smaller driveway culverts, rain gardens, rain barrels, bioretention, and others. They have been funded by the Lake Erie Water Commission in its efforts to preserve Lake Erie water quality. The State of Ohio supports both "engineered" and "natural" systems.

Related Examples and Studies

These two cases are examples of widespread interest in stormwater management through distributed retention and low-impact development, which has led to a recent collaborative initiative in "green infrastructure." The EPA, NRDC, the Low Impact Development (LID) Center, National Association of Clean Water Agencies (NACWA), and others have agreed to investigate and promote the use of natural systems to retain stormwater.

Tracy Mehan facilitated an EPA workshop on integrated watershed management in 2006, which also highlighted the emerging concept among the attending utilities. A new International Water Association (IWA) book, "Cities of the Future," by Vladimir Novotny of Northeastern University and Paul Brown of CDM (Novotny and Brown 2007), has also focused on use of the trio of decentralized infrastructure as a means to achieve water quality improvements in urban areas.

Similarly, NRDC's recent report on water and climate change, "In Hot Water," identifies the trio of decentralized infrastructure as being more sustainable than large piping networks in California. The trio can reduce the energy requirements for piping water and wastewater long distances and can make the water system more resilient to the predicted droughts and heavy rainfall events brought by climate change.

Research in Slovakia has also focused on impacts of water and wastewater infrastructure in drying soils and vegetation (Kravcik 2007). By depleting groundwater and moving wastewater out of basins and into oceans, there is less moisture content for cooling and water vapor in the atmosphere, which is a key factor in moderating global temperatures. Ultimately, deserts can be created by such patterns. More study is needed on the significant role of infrastructure designs in exacerbating global warming trends. The U.S. Geological Service has established a climate change research center at Princeton University, which is researching this link, among others.

Aging Infrastructure Costs—Repairs and Expansion

Solution: Use decentralized systems to reduce flows and thereby avoid big new water supply or wastewater treatment system costs.

Several participants suggested that the high costs of maintaining the conventional infrastructure were playing an important role in a greater interest in the trio of technologies in urban areas.

> Andy Lipkis described the public desire to eliminate waste and duplication in the conventional "rapid conveyance" systems of the past and came to see that rain gardens and cisterns could provide lower-cost services for both water supply and stormwater management.
>
> The Solaire building in Battery Park, New York City, includes a wastewater and stormwater treatment system designed by Ed Clerico, which provides non-potable water for toilet flushing, landscaping, and laundry. This system is supported by the city of New York, because, by reducing flows in the existing water and sewer systems, it helps both to avoid large expenditures on new water supplies and on combined sewer overflows.
>
> Ken Jones of the Green Mountain Institute suggested that middle class communities are *"motivated primarily by how much wastewater management will cost and who is going to pay."*

Participants in the workshops also expressed at several points the view that the financial costs of decentralized vs. centralized options would ultimately be the most important factor in a shift towards decentralization. As they summarized, *"crises may drive site-based actions (floods, boiled water and health advisories, growth/development explosion, etc.), but overall, the major driver is all about long-term costs."* At a later workshop, the following statement was made: *"Vibrant local level decentralization of water management will be driven by development responding to the issues of cost and timesaving."* Low impact development practices have shown that developers can both save money on stormwater infrastructure costs and sell the lots for more, because homebuyers value green space.

Alternatives to Sprawl Development (Promoted by Sewers and Large-Lot Septic Systems)

Solution: Use water conservation, low-impact development, and onsite and cluster wastewater systems to underpin appropriate development patterns (sewers and large-lot septic systems promote sprawl development)

As stated above, Kyle Dreyfus-Wells described for the Chagrin River, the value of low-impact development and stormwater management practices in developing areas of the country. Several other speakers discussed the demand for more sustainable infrastructure in Greenfield developments, both for water quality and other environmental protection needs, and for finding lower-cost alternatives to conventional hard path infrastructure.

Keith Carns from the Electric Power Research Institute described an emerging interest, in places like East Kentucky, for sustainable community design including distributed power generation and use, stormwater management, water use, and wastewater disposal.

Kevin White described the recent emergence of the cluster wastewater system model in the Mobile, Alabama suburbs, where developers benefited from higher property value, lower infrastructure costs, and effluent reuse for landscape irrigation. Utilities also found cluster systems to be more efficient than extending sewer lines to new subdivisions.

Craig Lindell described an example of a decentralized wastewater system installed in a suburb south of Boston, and suggested that this was a model for infrastructure that was *"flexible and adaptive, performance based, modular, scaleable, readily deployable, and designed and piped for redundancy and seasonal efficiency."* Lindell argued that this new decentralization option gave unsewered communities the opportunities to allow *"planning to be incremental, continuous, adaptive, and reflective."*

Ken Jones also posited that affluent communities are interested in alternative wastewater approaches to achieve growth management.

Two University of Tennessee professors, Tracy Moir-McClean and Mark DeKay, attended the workshops and handed out a Beaver Creek Watershed Green Infrastructure plan, which also shows how developing areas can utilize decentralized infrastructure. Similar to Dreyfus-Well's description of the Chagrin River, traditional development in the Beaver Creek watershed is leading to increased flooding, polluted streams, sprawl, open space loss, habitat fragmentation, and degraded rural character. Moir-McClean and DeKay have developed a concept of an integrated pattern of settled areas and stewardship lands and corridors that would both protect natural resources and enhance the quality of life for residents. Green infrastructure and nonstructural alternatives are seen as the least costly and most effective ways to reduce floods.

Related Examples and Studies

Support for the EPA's recent "green infrastructure" initiative is similarly built around multiple benefits from stormwater retention, including:

Sustainable Hydrology at the Site Level—Local Expertise and Value

Craig Lindell described decentralized infrastructure as *"enabling the site to define the technologies, processes, organizational structures, and operating skills that will most effectively achieve the desired environmental results."* Decentralized systems, he suggested, *"provide local government and its managers a variety of 'solution tracks' that meet the economic demands of a dynamic and growing economy, as well as the preservation of receivi*

Related Examples and Studies

Amory and Hunter Lovins of the Rocky Mountain Institute, and Paul Hawken have written of similar design principles in *Natural Capitalism* (Hawken *et al*. 1999). David Del Porto has also suggested: "*nature's model shows us that comple*

Market Evolution—Nothing is Inevitable

Valerie Nelson presented the concepts of Michael Porter, author of *Competitive Market Strategies* (Porter 1980), from the Harvard Business School. Porter has suggested, based on his extensive research on the evolution of markets, that *"nothing is inevitable and much depends on luck and the skills of participants"* in moving from an "infant" industry to a "mature" industry.

Early Adopters and Diffusion

Mike Luzier, from the National Association of Home Builders Research Center (NAHBRC), described the Center's research on the diffusion of technology in the housing sector. Luzier described the industry as slower to adopt than industries in general, for reasons that are similar to the decentralized water infrastructure sector.

The industry

- Is highly-fractured with lots of small companies
- Is highly regulated at the local level with diverse regulations
- Heavily depends on subcontracting with low barriers to entry
- Is fraught with liability issues
- Lacks good data on customer preferences

The early adopters among builders need:

- Widespread demonstration of new technologies—multiple examples and geographically diverse
- Simple explanations of complex ideas—explain in a minute or two the main ideas
- Objective sources of information

Luzier described the Center's use of an adoption-diffusion model to organize its work (Conversation with Michael Luzier, NAHBRC). Substantial research is put into understanding the values and behavior of customers, and what products sell well and why. Homebuilders recognize that in their5.5(-)-1 "(Conversatina(ognsTT11 3J/TT9i154nform)w7r)]TJ 5TT9i154nform

Social Marketing

Nancy Lee, of Social Market Services, discussed lessons about social marketing, as *"the use of marketing principles and techniques to influence a target audience to voluntarily accept, reject, modify, or abandon a behavior for the benefit of individuals, groups, or society as a whole."*

In general, a social market strategy targets

Greens—have the value and the behavior

Sprouts—have the value, but not the behavior

Browns—do not have the value or the behavior

Greens and sprouts just need to be told or shown what to do. Browns, on the other hand, are unlikely to change their behavior.

Lee presented a number of recommendations for how government could more effectively change private behaviors, including:

Overcoming barriers to change by creating better options and simpler choices

Making messages vivid, personal, and concrete

Getting pledges and using credible messengers

Lee suggested a few lessons for changing the behavior of the early adopters, including:

Promote single, simple doable behaviors

Understand and overcome barriers

Include tangible objects and services

Find a price that matters

Make access easy

Use effective communication techniques

This model was followed in the last five years, with city and the EPA support for green building pilots in New York City (EPA). A green building ordinance for large commercial buildings was adopted last fall, and the city has begun to turn its attention to wastewater recycling in housing projects in Battery Park. The city is exploring incentives, such as lower sewer rates when such recycling occurs.

Clayton Christensen at the Harvard Business School has also described how even the best companies with high-quality products and good customer ratings can be blind-sided by upstarts from other countries (Christensen 1997). "Disruptive" innovations, or paradigm shifts, are started by entrepreneurs outside the established field.

Malcolm Gladwell, in his widely-read book, *Tipping Point*, argues that in a complex and open society there are key individuals who, by virtue of their networks and leadership roles, can transform markets (Gladwell 2000). This concept was discussed at a 2005 Palo Alto conference on long-term management of soft path infrastructure, where it was agreed that educating a broad range of market participants was probably less effective than reaching a few key leaders in the field (Nelson 2006).

Integral Market Transformations

Cynthia Mitchell from Australia also suggested that a "leapfrog" can be achieved in water infrastructure designs, similar to the transition in telephones from land lines to mobile phones (Mitchell 2004). Synergies can be achieved from integration and co-evolution of energy, water, transport, and communications, where collaborative design can make *"the sum of the parts more than the whole."*

David Johnston, of What's Working, presented a definition of a market as a *"system that has definable rules, players and interactions that lead to financial transactions for products or services. Systems have predictable behavior that takes in-depth understanding in order to intervene to achieve a predictable change in outcome."* In the case of green building, he cited the three market forces important in driving adoption are market dynamics, buyer motivations, and stakeholder influence.

Johnston described the failures in the typical approach to green building:

Seeing something wrong (resource depletion)

Finding someone to blame (big bad business)

Preaching to the choir (environmentalists)

Wondering why things don't change

Conventional remedies include:

Adopting new regulations to "force" change

Blaming the homebuilding industry for building conventional housing

Inventing new green approaches and assuming that they will be adopted

Working through environmental groups to stimulate the market, as opposed to working with a range of stakeholders in the building industry

Johnston described an alternative "Integral Model for Market Transformation," which is based on understanding and leveraging the interests and behaviors of stakeholders, including both buyers and suppliers.

Market transformation occurs when the public sector, the non-profit sector, and the private sector are in alignment. Strategies can include policies and ordinances, ratings systems, websites and networking.

The San Francisco Bay Area "Build It Green Program," for example, includes builders and remodeling companies, product manufacturers, environmental non-profits, members of an affordable housing coalition, and a range of municipal agencies.

Social Transformations and Changes in Values

According to David Johnston, a key element in the projects of What's Working is the use of market segmentation concepts according to Don Beck's "Spiral Dynamics" approach. There are six basic stakeholder worldviews within people, organizations, and markets, each with different value systems and behaviors.

Johnston's examples of these worldviews, with color codes, and how they can be motivated for green building include:

Table 4-1: Johnston's Worldviews

Color	Cultural Synergies	Social Marketing
Purple	Concern with family security and health	Target their concern for protecting air quality for their children
Red	Values of personal express, individuality, "beating the system"	Target their desire for self-reliance (off the grid), unique use of straw bale construction

Ecological Stewardship and Local Activism

Brent Haglund, Director of the Sand County Foundation (SCF) in Wisconsin, described Aldo Leopold's philosophy for land conservation in 1939: *"A land ethic, then, reflects the existence of an ecological conscience, and this in turn reflects a conviction of individual responsibility for the health of the land"* By 1949, Leopold had come to understand that a land ethic was also needed for conservation on private land to work: *"When land does well for its owner, and the owner does well by his land; when both end up better by reason of their partnership, we have conservation. When one or the other grows poorer, we do not."*

The Sand County Foundation (SCF) has focused its projects on developing partnerships and approaches for conservation management on private property. Looking for alternatives to regulation, which Leopold saw as a last step when all else had failed, SCF advocates and develops pilot programs incorporating local solutions that empower citizens, allow for adaptive management and learning, and that use market approaches and incentives.

The SCF believes that affecting powerful, long lasting change comes from fostering community learning; empowering individuals to take action; and actively advancing responsible citizenship. Leopold's best friends were socialists and right-wing activists. Overcoming those differences will require building new and unlikely partnerships.

Community Environmental Justice Activism

Harry Wiland of Edens Lost and Found, described the PBS documentary series *Edens Lost and Found*, which describes efforts to improve the quality of life through urban "greening" in four American cities: Philadelphia, Chicago, Seattle, and Los Angeles. The series also shows how media can be used to reach a wide audience with a compelling message. Along with other media, such as website community-action guides, education curricula, and outreach, this series helps the story get out in ways that the government cannot. *"The film series is the rock in the water that has caused a ripple of information and influence outward."*

Described in each program are examples of local citizens envisioning sustainable urban

Connaughton posited that environmental reform is embedded in a "Quiet Revolution" of millions of people, including academics, business, citizens, and government at the local level. These innovators are starting to collaborate to find new solutions that would "harmoniously balance environmental, social, and economic needs for future generations." The main elements of this new environmental approach are:

Focus on results

Strengthening of personal and corporate "stewardship" of the environment

Reliance on private market mechanisms, such as performance standards and incentives

Innovative technologies

Science-based decisionmaking based on identification of highest risks

Shift from federal to local responsibility, or "ownership," of environmental solutions

Shift from enforcement to voluntary compliance

These themes of private stewardship and local control are being implemented in a variety of programs across federal departments and agencies. As such, they serve as the backdrop for the EPA's national innovation strategy (EPA 2004), the Department of Interior's Water 2025 (US Department of Interior 2003), and the administration-wide support for "cooperative conservation" partnerships (US Department of Interior 2005).

Leopold's heirs in ecological stewardship and new environmental justice movements are two strands of this "quiet revolution," but there are others. Themes of local cooperation and community-building are also found in more progressive circles, such as the Bioneers or Ecological Engineering networks.

Entrepreneurship—Niches of Unmet Demand in the Market

As Craig Lindell pointed out in his presentation, the inability of existing institutions to respond to new demands has created opportunities for new businesses and markets to emerge. Four types of entrepreneurs have surfaced: management companies (discussed in the Palo Alto workshop); equipment manufacturers; architects and planners; and developers/builders.

At the Palo Alto workshop, Jerry Stonebridge of Stonebridge Environmental, Inc. and Tim Bannister of TCW Wastewater Management described their private companies installing decentralized wastewater companies, and Ed Clerico of Applied Water Management described a utility management approach to cluster system installation and maintenance.

Lindell's company, Aquapoint, both sells cluster wastewater technologies and installs systems. Jim Stebbins, from Project Design Consultants, represented the architectural design community, which is working with developers and builders to implement "water-centric" subdivisions.

Chapter 5

IMPEDIMENTS TO CHANGE IN THE PARADIGM

The following impediments to change emerged in the workshop discussions:

Government policies, funding, regulations built around centralized infrastructure

Distorted pricing of water

Balkanization of agencies

Municipal authority and a limited role for the private sector

Pervasive risk aversion and minimal research funding

Stakeholder support for conventional solutions

Lack of local models that combine technology, management, financing, and customer acceptance

Opposition from threatened entities

Classic market failures–lack of information, fragmentation

Government Policies, Funding, and Regulations That Are Built Around the Traditional Infrastructure

Government plays a significant role in perpetuating the traditional, centralized approach. Regulatory structures were devised which assumed that modern sanitation and safe drinking water could only be provided through centralized distribution or collection and treatment. Progress in small towns was achieved, for example, when public water lines were extended to all homes, or when failing private septic systems were replaced by public sewers and point-source treatment plants. Federal subsidies to local projects from a host of federal agencies were built around those assumptions as well.

What this means is that local water protection advocates typically have to ask their communities to buck federal and state regulators, as well as give up federal subsidies, if they are to advance a soft path solution.

Federal, state, and local policies, funding, and regulations were repeatedly discussed in the workshops as barriers to decentralization.

One particularly interesting comment was: *"What are we up against with the local regulatory system in the US? It's like swimming in quicksand, very difficult to get acceptance."*

Other comments were:

"Regulations are a huge problem right now. The current structure is not integrated, so it silos drinking water, wastewater, and stormwater projects and prevents the integration that is a driver in the cities or a source of ferment in the cluster system approach."

"The regulatory system is problematic because it is a typically prescriptive, uncooperative approach. However, if the regs are right, then it can be a driver to get things done. Others thought that prescriptive codes are ok, but a lack of prescriptions for innovation remains problematic."

Related cases and studies

An increasing number of workshops and reports are identifying government policies and regulations as a significant barrier to sustainable infrastructure. These include two recent WERF reports on barriers to use of decentralized wastewater systems and on sustainable water resources management (Etnier 2007; Thornton 2005).

Distorted Pricing

Peter Shelley introduced his presentation on the disruptions of conventionally-engineered infrastructure in Eastern Massachusetts by quoting Garrett Hardin's *Tragedy of the Commons*,

Removal of subsidies for conventional infrastructure would make decentralized systems much more competitive, since they are typically unsubsidized. This newly-competitive market position would stimulate much more research and innovation by manufacturers and developers. Most importantly, decentralized systems have a lighter footprint in the environment and entail many more community benefits. A full accounting of all resource costs and benefits, including such factors as energy impacts, green space, jobs, etc. would dramatically increase the use of DWSW technologies.

These themes recurred in presentations and discussions in the workshops. Andy Lipkis pointed out that the direct costs of distributed stormwater infrastructure were higher than for

Jim Stebbin's project in Monterey suffered from the same balkanization of agencies. Various elements of the "water-centric" plan needed approval from the planning department, public works, or environmental health. Much of the plan was not adopted because one feature or another was turned down by just one of those three agencies. For example, use of gray water was approved by planning and public works, but not by environmental health. Permeable paving was approved by planning and environmental health, but not by the public works department. These regulatory barriers, of course, are a tremendous disincentive for developers.

Kyle Dreyfus-Wells also noted the problems for local communities in the Chagrin River Watershed of dealing with the separate bureaucracies if the US Army Corps of Engineers for flood control and the Ohio EPA for water quality.

Craig Lindell quoted Jim Nemke, from the Metropolitan Madison Wisconsin Sewer Authority, as saying:

Municipal management of the traditional infrastructure is an appropriate match of services to need. Water and wastewater utilities that centralize treatment and distribution in a community are prime examples of what economists would call public goods or natural monopolies, where provision by more than one provider is not realistic.

But, when individual or cluster treatment units are dispersed across many private properties, there is no structural necessity for one municipal utility to manage these services. Rather, a classic competitive market with multiple customers and multiple suppliers can be developed, ideally under public oversight that protects public health and the environment.

Of fundamental importance is the fact that decentralized, "soft path" infrastructure is usually on private property, whether at individual homes, subdivision developments, or commercial properties. In contrast, conventional treatment plants and conveyance systems are on public land and in public rights-of-way. This location of systems on private property, interestingly enough, both helps to explain the slow adoption of decentralized alternatives by mainstream utilities and engineers, and the unique opportunities for new private sector models to develop.

The presentations at the Palo Alto workshop on viable business models were intended to be "early adopters" in the areas of onsite wastewater system management, cluster wastewater system management, and urban distributed stormwater management.

Valerie Nelson described material from Michael Porter's book,

A series of National Decentralized Water Resources Capacity Development Project (NDWRCDP) research projects, including studies of asset management and "barriers" in the engineering profession, also presumed that the "utility" model for individual home units was the desirable approach.

Risk Aversion and Lack of Support for Innovation

Because of public health concerns, the water and wastewater field has become cautious and risk-averse over time. Engineers and builders are concerned about liability. Politicians are concerned that innovative approaches may fail, as well. Craig Lindell described a decentralized system market analysis exercise that identified the risks of innovation as the "deepest driver" for blocking change. Public health regulations, he found, were the point of "greatest resistance."

There are public concerns about how soft path systems work over time, their life cycle, and who funds it. The paucity of specific monitoring creates intolerance for innovation.

The regulatory system is problematic because it is a typically prescriptive, uncooperative approach.

Ordinarily, society will cover the risks and costs of innovation through publicly-funded research and demonstration projects, or through carefully-managed innovation in the private sector. But, as Julian Sandino, of CH2MHill described, the US has drastically cut back on research funding since the 1980s, and privately-funded research has fallen in parallel.

For lack of research, Bob Siegrist pointed out that there remains:

> A lack of fundamental understanding of the science governing common systems and emerging technologies
>
> Absence of mathematical models that can be employed as part of a rational design practice
>
> Limited infusion of ideas, techniques, and technologies from complimentary disciplines and programs

National groups have, in general, been forced into a defensive mode by Supreme Court cases that have questioned the reach of Clean Water Act jurisdiction into “non-navigable” streams and wetlands, and by large proposed cutbacks in Clean Water and Drinking Water SRF funding by the current Administration. These realities have focused virtually all the NGO energies on attempts to pass the Clean Water Restoration Act, which would clarify the inclusion of isolated streams and wetlands, and on restoring CWSRF funding, as well as passing of a new Clean Water Trust Fund, proposed by the WIN network.

Lack of Robust Models or Packages

One of the problems with advancing decentralized systems is the lack of robust models or “packages” that have been demonstrated. Because th

Classic Market Failures—Lack of Information and Fragmentation

The suggestion was made in the last workshop that: *"The soft path approach is a classic example of market failure and lack of information. There are great examples out there (e.g. Seattle, Portland). It's not clear how to get these examples scaled up and documented. How can we learn from the rest of the world? Garnering and distributing new information is the critical opportunity we have."*

The suggestion was made to:

> *"Capture case-based examples in a rational way and put them in a clearinghouse. Put order on the chaos of a fragmented market."*
>
> *"There are public concerns about how soft path systems work over time, their life cycle, and who funds it. The paucity of specific monitoring creates intolerance for innovation."*

Related Cases and Studies

Economics literature has recently included work on the distortions in the market created by imperfect information. In general, both demand and supply sides of the market cannot respond appropriately to achieve appropriate market equilibrium. Consumers do not understand product qualities and prices, etc. These problems have become the justifications for the EPA to produce guidance documents, fund conferences and websites, etc. as a means to provide the proper information to municipalities, consumers, and companies.

A second problem identified in the literature has been the fragmented markets created by widely-divergent local regulations and codes. Venture capitalists and large manufacturers do not enter the market for decentralized technologies until they see large national markets. Barring the imposition of national codes, a useful project is development of voluntary national standards, which are quite likely to be adopted by many states and localities. As one workshop participant suggested, *"The variety of multiple regulations, codes, and standards at the local level creates disincentives. The national model building codes provide a good example of an entire industry moving to uniform standards."*

Summary—Drivers and Impediments

The three drivers for a water infrastructure paradigm shift—ecosystem stresses and societal demands, new ideas and designs, and niche efforts by NGOs and entrepreneurs—are, as workshop participants suggested, still preliminary and scattered. However, population increases, land development, and climate change are all forces that will intensify and highlight the flaws in the traditional paradigm.

Biomimicry offers useful lessons on how a more sustainable infrastructure can be created, both in lightening the environmental footprint and in creating a higher quality of life in communities.

Central organizing principles, seen in the workshops, need to be in placing water at the center of design for multiple functions and benefits and in creating openings for new constituencies and the private sector to participate and create new value.

In the coming years, it will be important for the internal structures of a new paradigm to be more rigorously developed. Moving from a specialized and centralized model of infrastructure to an integrated and localized model means that a host of additional benefits can be achieved for the environment and for society, as well. A systematic search for joint resource efficiencies in water, stormwater, wastewater, and energy has only just begun, and the means and benefits of greening cities and more livable communities are in their early stages. Biomimicry offers lessons for how to harness the creative impulses and energies of new participants as well. The process of engaging multiple constituencies in solving problems with fresh eyes and in harnessing the motivations of the private sector and civic activists has also just begun.

While students of paradigm shifts acknowledge that the process of change is inherently unpredictable, this project suggests several large new strategies for triggering and easing such a shift. In the past, conversations about decentralized systems have been kept on the "margins."

Strategically, a larger, holistic conversation about the sustainability of water-related systems must begin, with integration as a hallmark of that conversation:

- Integration of water quantity and water quality concerns
- Integration of water, stormwater, wastewater, energy and other infrastructure planning
- Integration of the trio of decentralized systems at the building and neighborhood scale
- Integration of environmental services with other community benefits, such as job creation and quality of life improvements
- Integration of the private sector and civil society into the creation of a more resilient and more productive infrastructure paradigm
- Integration of surface water, groundwater, rainfall, soil moisture, and climate interactions

Chapter 6

STRATEGIES TO TRIGGER AND EASE A PARADIGM S

Create Spaces for Local Paradigm Models to Emerge

Keith Carns stressed that *"a cross-functional approach to the planning of the development of integrated infrastructure—water, stormwater, energy, wastewater—was needed."* Craig Lindell stated, *"If we are going to consider water in holistic and integrated terms, we need to consider infrastructure in holistic and integrated terms. We need technologies, organizations, partnerships, processes, skills, legislation and regulation—an entire architecture—that is equally holistic in its approach."* Lindell urged a search for a range of local options

Green Building

One of the six priority recommendations of the workshop participants was linking the soft path water field to the "green building" movement and development of similar "standards" and "ratings"

Opportunities

A number of discussions turned to the opportunities in new subdivision and infill developments:

> *"There is a growing interest in green infrastructure—a movement—that can be tapped; we need a galvanizing force that varies by localities and a convener of key stakeholders."*
>
> *"We need to understand the values of constituencies and appeal to those values—find common ground, blending natural values with fast track cost-based approach in subdivision development."*
>
> *"Focus on new development. We need data regarding resource protection effectiveness and reduction of costs and sell it from a social marketing perspective."*

Green Building Challenges

Green building projects need to demonstrate new technologies and designs and their technical performance, as well as how to engage partners in the building sector, understand their motivations, and build new alignments of interests. Periodic references were made during the workshops to the success of the green building movement. The following elements are involved:

Technical

- What are the goals/elements of sustainability in water/wastewater/stormwater/reuse infrastructure and how are these met by building or subdivision-level technologies, whether separately or in combination?
- Can energy be saved or generated from these systems (methane, hydrogen, etc)?
- Can nutrients be recaptured?
- How close to "off-the-grid" can these systems be?
- What are the "risks" of technologies failing?

Costs and Benefits

- What are the direct and indirect costs of the old vs. proposed approach?
- What benefits of parks, aesthetics, etc. accrue to the community at large?

Context

- What difference does it make where the building or subdivision is located?
- How can a rating or other system incorporate the fact that soils, climate, hydrology, habitat, etc. vary so widely across a watershed or across the country?
- Do we understand the cumulative impacts of decentralized systems and how do we account for location?

Practical

- Will builders be willing to incorporate these systems into their business?
- Who will design these systems?
- Are there the skills out there to do this kind of work?
- How complex are the designs?
- Will homeowners accept these technologies?
- Will they be willing to pay more?
- Is there additional value?

Institutional

- Will regulators permit these systems?
- How can long-term maintenance be assured?
- How will banks and mortgage lenders look at these systems?
- Are there public funds available?

Motivational

- Who cares enough to work for incorporation of these approaches?
- Are there clear "sustainability" benefits that would lead environmental NGOs to work to advance this approach?
- Would builders see a market advantage to working with the new approach?
- Will the decentralized technology industry back this approach?

Community Demonstration Projects

One of the six priority recommendations of the workshop participants was support for pilot and demonstration projects in federal facilities and in local communities.

New and infill green building developments can be major tools that a municipality could take to improve water infrastructure performance. In these projects, integrated designs of water-efficient appliances, stormwater retention and reuse, and wastewater treatment and

Similar Challenges as Green Building

Community demonstration projects need to respond to a similarly broad set of challenges as described above for Green Building, and develop a broad set of new stakeholder alliances and roles, as well.

Motivational

- Will there be public support for new approaches, based on an alignment of different values and interests among segments of the community?
- Will environmentalist NGOs support innovation?
- Will developers and the business community support innovation?
- Will local contractors support pilot projects?

Paradigm models

- What are new, robust models, where a package of installation, maintenance, financing, regulatory oversight, and customer acceptance have been shown to work for a given technology?
- For example, green roofs can be installed, managed, and financed by the private developer, and the municipality can provide financial incentives, "social marketing," and oversight inspections
- Cluster wastewater systems can be managed by private utilities
- Water-efficiency appliances can be sold directly to homeowners, and developed and marketed by large corporations

Conversations and Research

There is a need, at the national level, for promoting widespread conversations and research within and among a range of stakeholder groups, including academics, engineers, utilities, NGOs, and the private sector. Some of this conversation can emerge in Green Building and community demonstration projects. But, each group also needs to have its own internal conversation about what a shift to decentralized systems would entail and what their role in the paradigm shift would be. A collaborative conversation is needed, in particular, to develop a common "frame" and language of values and benefits.

Workshop participants concluded:

> *"A vision and benefits statement for the soft path approach is needed. The group should seek in further conversation the identification of common benefits of the soft path approach, priority work areas, and strategies to achieve specific goals. Demonstrate to stakeholders, including the engineering and architectural community, contractors, regulators, and homebuyers, of the affordability, popularity, and*

> *"There is a key values set underlying the soft path water movement that has to do with fair access to resources, housing, environmental justice, and quality of life. A different framing that frames convergences of key issues in powerful ways may provide more leverage than a single-issue approach."*

David Johnston also highlighted the need for a common perspective among various groups. *"While there are different places to intervene in a system, the key is to have a mindset or a paradigm out of which the goals, rules, feedback and structure arise. Changing the market forces requires a 'core of intelligence' in each of the stakeholder groups (Sector Leaders)."*

In one of the workshops, it was concluded that an upstream approach will be necessary that influences how people think about water tec

Academic Research Community

Workshop participants recommended multi-disciplinary research in these areas:

Table 6-1: Areas Recommended for Multi-Disciplinary Research

Area	Example
Basic research	Applications from biology
Impacts/effects	Climate change, nutrients
Land use/ecosystems	Growth control/natural ecosystem services

The Federal Role in Supporting Conversations and Research

Support for these multiple conversations and research is an appropriate role for the federal government through a series of low-cost, short-term measures to facilitate and coordinate better information to assist local decisionmakers and community stakeholders in the water sector. These include:

Guidance manuals

Evaluations of new products and designs

Education through conferences, newsletters, and training

Labeling and standard-setting initiatives

Participants asserted: "*The feds are good at collecting, organizing, and making information available in effective and efficient ways (e.g. building data bases). They can also help to centralize best management practices, link agencies and funding sources. Feds could help with facilitating the costing and pricing of soft path approaches and funding pilot demonstration programs.*"

Build Support for Big Government Shifts—A Long-Term Strategy

Workshop participants recognized that large-scale government impediments to adoption of decentralized systems existed, and that because the field is relatively undeveloped, it is hard to mentum could be built over time for driving change.

Build Mo praum for Change

"More common goals among vari to interest groups will drive more regulatory reform—environmental activists, planners, developers, and public desires"

Partnerships can help.

It is important to realize cederpolitics isnot rationalized. Change only happens when there is a convergence of actors, pilots, and messages

"Greater interest group involvement is needce0in driving regulatory reform. Environmental and development groups could come cogether to drive change"

"Local demonstration projects can also help: The Kennebec River dam removal is convert it to a succes4ful larger social movement driven at the local level"

"There is an evolutionary adoption pattern—new models/approaches are t0rece0 through pilot programs (current situation). With succes4es of these pilot programs, incentives will be put in place co encourage increasce0adoption. Once regulators are comfortable cederthis is a sustainable m
encouraging more mainstream adoption"0

Assuring Equity

Discussions also suggested that some of the major public policy concerns of the future would be in assuring equity and shaping private sector involvement.

> *"Long-term issues of equity and sustainable land use development will need to be addressed."*
>
> *"Addressing the issues of a have and have not world with centralized structure systems is important, i.e. if society goes to a soft path in water, we will potentially create a bifurcated two-tiered system based on income."*
>
> *"The early adopters are almost always for affluent customers. There is an inequity here because the new stuff is paid for by the rich. But there needs to be federal and state support to low income communities. Communities should build in a method to get to lower income areas. There is not planning now for growth or land use. This means that we are allowing a lot of sprawl development across the country."*
>
> *"Balance public good with commercial interest—must have accountability/public oversight, audits are necessary."*

Overarching Themes

Several overarching themes were also posited for change in government policies and practiD[24 Talic g:J/TT9 1 Tf10.9591 0 0 10.98 108 524.143m0 Tc0 Tw[0069-]Tj/TT11 1 Tf0.7555 0 TD( )Tj/TT8

Shelley's discussion of the Tragedy of the Commons and problems of distorted pricing in water were also the underpinning for two of the six priority recommendations made at the final workshop:

> Research on full monetary and non-monetary benefits and costs of soft and hard path approaches and pricing or other mechanisms to better align local decisions with long-run environmental and economic sustainability
>
> Exploration of how to tie federal subsidies and permits to an integrated water supply and water quality plan in a watershed

Potential Federal Role

Other characterizations of a potential federal role were:

> *"The federal government provides for equity, a clarity in the regulatory scheme drives market forces, R&D is a federal role, federal 'champions' provide credibility, the federal government acts as a role model, for example in federal facilities."*

Recommendations were to:

> *"Change federal accounting to encourage innovation by allowing commingling/integration of funds and activities; issue an executive order requiring audits, inventories, links of soft path programs across agencies; in the long-term eliminate the single purpose mentality through sustained leadership, funding, and regulatory authority; change to performance specifications vs. specific criteria."*

The following points were made at one of the December workshops:

> *"Without a strong federal leadership role, what is happening locally will be ad hoc and diffuse and the old centralized paradigm is likely to continue."*
>
> *"There is an important need for the US to get back in a leadership role regarding water management. Without large R&D to make this happen, the US approach of innovation will be piecemeal."*
>
> *"The federal government can take more of leadership role in science, technology, and opportunities for exporting knowledge overseas."*

Role of National, State, and Local Agencies

National, state, and local agencies can promote the development and adoption of sustainable water systems by the following measures:

> Long-term research
>
> Financing incentives
>
> Regulatory reform

Long-Term Research

The public sector is uniquely positioned to take the lead in supporting long-term research in the following areas:

Micro-scale biology that over time will facilitate breakthroughs in treatment technologies and controls

Macro-scale ecological studies to improve watershed-scale management

Social and economic studies and large-scale demonstration projects that will support the evolution of institutions and practices, such as

- Expansion of green building and sustainable water system markets
- Private sector management and maintenance of decentralized systems
- Adaptive and performance-based approaches to regulations and ordinances
- Collaborative neighborhood design
- Greater participation by individuals and communication networks in the adoption and diffusion of sustainable practices

Collaborative funding of research projects can include public agencies, non-profit foundations, private companies, and academic institutions.

Financing Incentives

Governments are now typically financing large-scale public water supply, drinking water, wastewater, stormwater, and flood control projects without considering decentralized system

Chapter 7

THE FOUR WHITE PAPERS

Each of these five themes or ways of thinking about the decentralized, or soft path, water field that emerged from the workshops and literature is incorporated in the Four White Papers that follow. Key findings and recommendations were:

Institutional Challenges and Opportunities

Advocates of decentralized systems have argued that small-scale, integrated technologies work and are more sustainable in the environment. The failure of mainstream institutions to adopt these technologies is increasingly attributed to institutional and market barriers. The framework of institutions needs to be altered and expanded in the following key respects if decentralized and closed-loop systems are to be adopted over time:

Integrated water resource management—management and regulations need to be integrated across the water chain. Much of the demand for closed-loop reuse of treated effluent, for example, will stem from reducing demand for new water supplies and the avoided cost of loadings to wastewater conveyance and treatment

Enhanced role of the private sector—since most decentralized systems are on private property, the role for the private sector can be much enhanced. Private property owners generally prefer to choose a private contractor to construct and manage their system, rather than a public utility. So, the market model for decentralized systems will likely involve myriad small companies or utilities regulated by public authorities, greater involvement of homebuilders and developers in adopting new approaches, and leadership from Cleantech investors and companies

Multiple community benefits and stakeholders—many of the benefits of decentralized systems are outside the water field:

- Creation of parks and green space
- Regeneration of neighborhoods and local jobs
- Restoration of habitat and healthy ecosystems
- Recapture of energy and nutrients from wastewater

Engineers and communities need to develop systems engineering approaches to triple bottom line planning, capital budgeting needs to be integrated across all municipal infrastructures, and multiple constituencies need to be involved in decisions

Continuous innovation—as in all transitions to a new paradigm, the precise

Streamlined institutional tools—new, robust models need to be developed, where a package of installation, maintenance, financing, regulatory oversight, and customer acceptance have been shown to work for a given technology. For example, green roofs can be installed, managed, and financed by the private developer, and the municipality can provide financial incentives, social marketing, and oversight inspections. Cluster wastewater systems can be managed by private utilities. Water-efficiency appliances can be sold directly to homeowners, and developed and marketed by large corporations. These demonstrated "packages" then need to be broadly disseminated in the field

New Federal Financing Directions

Federal financing programs were designed to support the conventional centralized infrastructure of long-distance water, stormwater, sewer lines, and large treatment plants. For the potential of decentralized systems to be realized in the United States, these programs need to be altered in four fundamental ways:

Research and development—restore research and development and demonstration project funding in water resource infrastructure

Integrated planning—require integrated water supply and water quality management plans as conditions for all federal water project subsidies

Triple Bottom Line Financing—require environmental, social, and economic benefits and costs, as well as embodied life-cycle costs, to be assessed for design alternatives

Subsidize private installations—support the installation of decentralized systems on private property by expanding eligibilities in the public infrastructure pools of funding, as well as in tax and other incentives for property owners

Public Education and Outreach Strategies

The EPA's education and outreach strategies, which has focused on the education of homeowners, should be redirected to include:

Search for values—explore the multiple benefits of an integrated water resource infrastructure paradigm–enhancing the "value proposition"

Early adopters—focus on early adopters and champions rather than the general public and mainstream institutions

Mediating stakeholders—work more with mediating institutions, including NGOs and other non-traditional businesses and professions, including environmental and

Sustainable Infrastructure Management

The EPA had developed the Four Pillars of Sustainability to enhance the efficiency and effectiveness of water infrastructure management. These Pillars should be expanded in the following ways:

Better management—Managers should be responding more creatively to long-run challenges of environmental sustainability and to the opportunities for increasing community benefits. Managers should also be incorporating innovative institutions and tools, such as leveraging the role of the private sector in system management and Green Building, and collaborating with multiple agencies and stakeholders

Full cost pricing—The EPA should promote true cost pricing, which goes beyond covering the costs of the infrastructure and includes long-term environmental and community externalities, such as energy savings, green space, and green job creation

Water efficiency—This labeling and marketing program should be expanded to include decentralized stormwater and wastewater reuse systems

Watershed approach—This largely water quality-oriented program should be expanded greatly to provide models for municipal water, stormwater, and wastewater utilities to work jointly on integrated water and other resource goals and management

These changes, in their overall impact, can begin to redirect the program from one that locks in the traditionally-built infrastructure to one that helps utilities move over time to a more sustainable approach.

Chapter 8

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