June 28, 2011

Science Advisory Board
U.S. EPA-ORD

Members of the SAB:

Thank you for the opportunity to submit comments on the draft research plans for EPA-ORD, which you will be discussing on June 29-30, 2011. The Water Alliance is a multi-stakeholder network of experts and advocates that have been thinking about water sustainability and new approaches to water management. Members have knowledge of both U.S. and international practice and leading-edge research. (www.water-alliance.org)

We would like to commend the EPA Office of Research and Development for taking a "systems" approach to a new research strategy and agenda for the Agency. We would like to offer both over-arching concepts and practical suggestions for research projects. In particular, we would urge that an ambitious research program explore both complex natural and human systems at all scales, from global to watershed to region to municipal to neighborhood district to facility to home, and develop and pilot new integrated design strategies in resource management, infrastructure, and urban development.

The Water Alliance recognizes the statute-related obligations of EPA-ORD research, but hopes that a growing space can be created for systems-related research that integrates water, air, energy, and climate, human health, toxic chemicals, sustainable communities, and environmental justice concerns. From the perspective of the Water Alliance, water is so interrelated and so central to each of these areas, as described further below, that a proper focus on optimizing the health and value of water will provide insights and offer better solutions across a wide range of Agency responsibilities.

BALTIMORE CHARTER FOR SUSTAINABLE WATER SYSTEMS

The philosophy and approach of the Water Alliance was initiated in the 2007 Baltimore Charter for Sustainable Water Systems, which asserted that fundamental life systems are in danger of collapse from the ways that societies have focused in the past on

managing water to protect ourselves from diseases, floods and droughts. In the future, new approaches will need to be developed that explicitly work with and mimic nature. What is required is a fundamental shift in the way that society looks at and acts in relation to water, which is the "heart of all life". There is no life without water.

While the focus of the Baltimore Charter was on management of water, we believe that our approach applies to the larger global Commons in air, water, soils, biodiversity, and other ecosystem processes and cycles. In essence, mankind has focused on the provision of goods and services and public health protections without sufficient regard for the accumulating damages and threats to ecosystem functions, as well as to society. These losses include depleted water supplies for potable, commercial and industrial uses, eutrophied lakes and estuaries, loss of habitat, desertification, drying and degradation of soils, depletion of phosphate stores needed for growth of plants, toxic overload in the environment, energy use and disrupted evaporation cycles contributing to climate change, gray and unproductive cities and towns, and others.

Siloed and Disconnected Infrastructure

The core of the problem is in the operating principles of professional practice, the economy, and governance, which silo and subsidize the provision of services and largely disregard externalities. The siloing and specialization of functions led to huge industrial-scale enterprises, such as centralized water and treatment grids, which were at "least direct cost" and maximized "economies of scale". These systems have imposed greater and greater disruptions and harm to ecosystems, with related costs to society, as well as to the economy, as the financial costs of maintaining the systems has grown and as fewer and fewer jobs have been required to run these industrial "monoliths".

As population grows and climate change produces more droughts and floods, this disaggregated and disconnected model of infrastructure will be less and less capable of providing necessary services, nor or protecting the global Commons. And, political conflicts and tensions will intensify, as the financial costs rise and demands increase to mitigate the damages that the industrial model itself has created in poisoned and disrupted life systems. Marginalized populations in both rural and urban areas will bear the brunt of these rising costs and unhealthy ecosystems.

Fortunately, a new "systems" approach and set of operating principles, along with major advances in science and technology, offer a path to sustainability. In essence, there needs to be "design with complexity", involving infrastructure that works with and mimics nature, and institutions and policies that reflect the interrelationships and interdependencies of resource use and economic and social well-being. We have already entered an era of promising "experiments" in a few arenas, such as use of green infrastructure to manage stormwater, but a wider and more concerted program of pilot projects and research grounded in systems thinking and practice will likely lead to "leapfrog" advances throughout the water and related resource sectors.

Infrastructure That Mimics and Works With Nature

The Baltimore Charter asserts an approach to water management that “mimics and works with nature”. Natural systems create an abundance of value, resilience, and diversity, where species are interdependent and one species‘ waste is another species‘ resource. The genius of science and design in the 21st Century is in unlocking the complex patterns and processes of nature and of applying these lessons to “smart, clean, and green” infrastructure, settlements, and buildings.

In practical engineering terms, this new approach in water includes: provision of potable-quality water for drinking water and direct human contact purposes only; prevention of pollution before it gets into the waste stream (including the wholesale re-engineering of some products through green chemistry to mitigate or eliminate ecological damage); reduction of energy needs by avoiding the pumping and long-distance transport of water and wastewater; wastewater recycling and non-potable, “fit for purpose” reuse instead of disposal; rainfall harvesting; energy and nutrient recovery from wastewater; habitat and natural system restoration; re-vegetation to restore evapo-transpiration capacity; and restoration of green infrastructure in urban areas to help beautify cities and revitalize neighborhoods.

A birds-eye view of the new infrastructure would reveal “networks” of decentralized and re-purposed and at times hybridized, centralized systems. These engineered and green networks mimic the natural systems of nodes and links in nature, where water both recycles and supports life at a local scale, but also is a linkage and transport mechanism across a landscape and with the atmosphere.

Some of the innovative treatment and resource recovery technologies would be “embedded” in subdivisions, apartment complexes, or individual homes and offices. Other functions would be taken over by vegetative “green infrastructure”, such as green roofs and walls, trees and swales along roads, and restored streams and wetlands. Water and sewer lines might be slip-lined and re-purposed for potable or reclaimed water, storage, and heat recovery. Monitoring and control technologies would be key elements in managing the system and in protecting public health. Incentives and regulatory mandates will be required to ensure that these sustainable practices are adopted and that the remaining watershed and global “externalities” are also addressed by developers, homeowners, industries, and municipalities.

Leading-edge infrastructure experts are also suggesting integration and co-engineering to include transportation, solid waste, buildings, and other urban infrastructure. The lessons of nature suggest that such integration will lead to further significant synergies of design, cost-savings, and an abundance of positive benefits for society. For example, an “eco-block” incorporating architectural innovations, wind and solar power, green roof and wall cooling, rainwater harvesting, water reuse and energy recovery, and nutrient recycling into community gardens, can be nearly “off the grid” in both energy and water, and can be located at transportation “hubs”. These new infrastructure

designs have the potential both to improve the quality of life in urban and rural communities and to begin to protect and, over time, to restore the ecological Commons.

RECOMMENDATIONS FOR EPA-ORD RESEARCH

EPA-ORD can dramatically advance the understanding of complex and interdependent ecological, social, and economic systems and the development of systems designs and practices for municipalities, developers, industry and agriculture, property owners, and policymakers. The Water Alliance attempts to bridge and promote conversations across academia, engineering, utility management, business, civil society, and government. The following recommendations reflect our common understanding of high-priority research and development needs of innovation leaders in their respective communities of practice. All relate to aspects of and would be supportive of a “systems approach” and “design with complexity”.

Research on the Water Commons

The Baltimore Charter challenges all water managers to think, plan, and implement in a broadened problem statement. We have assumed that first cost is the primary decision-making driver in each siloed project. We need to expand the set of objectives that guide capital spending. Restoring the Water Commons means accounting for the links between water and climate change, quality of life in communities, energy use, land use, nitrogen and phosphorus cycles, toxicity, and biodiversity. It means thinking of all of these pieces as part of one plan -- water supplies, stormwater management, flood control, energy, transportation, solid waste, chemical use and dispersal, jobs, quality of life -- rather than as separate projects. In particular, we need to be mindful of the critical “hard-wired” thresholds in the Earth’s environment, and respect the nature of the planet’s climatic geophysical, atmospheric, and ecological processes.

The Stockholm Resilience Center has recently organized an international consortium of experts, including from the United States, to study nine “planetary boundaries” or thresholds, beyond which our planet cannot recover. Mismanagement of water is a pressure on a majority of these boundaries, including climate change, biodiversity loss, nitrogen and phosphorus cycles, global freshwater use, land use, and chemical pollution. EPA-ORD support of this systems research should be a priority.

While the work of the Resilience Center does not specifically include social and economic concerns, these should also be brought into studies of the Water Commons. Water management has been a significant factor in the graying and pollution of cities and towns, with tremendous loss of physical and emotional well-being of residents. Urban streambeds were typically used to remove waste products and many have been covered to lay sewer lines at these low elevations, and stormwater drainage systems have piped water rapidly away from cities. New studies on broad measures of public health reinforce the importance of water-related factors, such as air quality, bio-diversity, temperature control, recreational opportunities, and aesthetics of restored streams, trees and other vegetation in cities and towns.

Similarly, the economies of cities and towns have suffered from an industrial-scale and least-cost focus in infrastructure planning. A “green” approach can save money and provide additional benefits, as described further below. But in addition, embedded and natural systems infrastructure networks depend heavily on highly-skilled engineers, architects, construction laborers, landscapers, etc. for installation and ongoing maintenance. And, technology innovation can lead to the formation of start-up companies and production jobs, while enhancing the competitiveness of the U.S. economy.

Understanding Ecological Flows and Processes at All Scales

While global ecosystem thresholds and boundaries are of paramount concern for long-term sustainability of human life on earth, it is also necessary to understand ecological flows and processes at lower scales. Continuing research on watershed functions is of value, but these studies also need to “internalize” aspects of the global Commons. For example, while a typical watershed approach has focused on mitigating phosphorus pollution, internalizing and responding to a global threat of phosphorus depletion would require a shift in focus to phosphorus recovery.

It is also productive to think about integrated resource flows and ecologies of cities and towns, as well as of neighborhood districts and buildings. In the design of the Solaire complex in Battery Park, New York, for example, the site was viewed as a “sub-watershed”, where all water and energy flows were projected under various development scenarios. These models serve as the foundation for architectural design and engineering that “optimize” the value of water in producing multiple benefits and cost-savings on the site.

Examples of these transformative shifts where nature’s design principles are being applied are now widely appearing in manufacturing, energy, and agriculture. As companies investigate manufacturing processes, they are discovering that efficiency improvements and capturing of resources instead of generation of waste can actually save money. In the energy sector, energy-efficient appliances and clean sources of wind, solar, vegetative cooling, and building design can save money, reduce greenhouse gases, and generate jobs. In agriculture, complex plant and livestock rotation and harvesting can utilize solar energy and recycle nutrients, thereby avoiding expensive petroleum-based fertilizers, and producing healthier food with less runoff. Such farming practices actually increase the health of soils, rather than deplete them.

Technologies and Designs that Work With and Mimic Nature

While “green” infrastructure for stormwater management has emerged as a valuable and relatively well-known approach in recent years, there are numerous other natural systems-based approaches that should be explored throughout the water sector. The key is to ground the research in natural system design principles, such as efficiency, closed loops, localized management, abundance, and also beauty. EPA-ORD support

would be valuable, in particular because many approaches are “non-proprietary” and will not be explored in the private sector.

An important opportunity is the immense productivity of natural systems that can be captured by society in ways that involve far less environmental degradation than the linear model of mining or “extracting” resources, using once, and dumping wastes. Constructed wetlands and on-sIte soils treatment are examples of low-cost and low-energy treatment options for small communities, which also replenish groundwater. Trees and rain gardens are effective alternatives to conventional drainage pipes and lagoons or underground storage tanks for stormwater management. Rainwater can be harvested and used on-site, thereby reducing the need for importing water through long-distance water lines.

Water demand can be reduced dramatically in homes and industry, both through water-efficient appliances or production processes, and more importantly, wastewater can be treated and reused for multiple non-potable purposes. Water conservation and reuse can lower the energy and treatment costs of a municipal drinking water utility and the energy costs of running appliances, in particular hot water heaters, in homes. In a growing metropolitan area, these reductions in water demand can forestall the need for new extractive reservoir and water transport projects and new coal-fired or nuclear plants.

Wastes can be productively turned into resources as well. Conventional wastewater utilities generally release treated wastewater into surface waters and in some instances into groundwater where dilution reduces concentrations further. But this used water and the embedded organics and chemicals can be seen as resources, not as waste. Treated wastewater can be reused for non-potable purposes such as toilet flushing or landscape irrigation. Biogas digesters can recover energy from wastewater, while composting and urine-diverting toilets can recycle nutrients into fertilizer. Oyster farms can filter out and utilize excess nitrogen in coastal waters.

Opportunities also exist in integrated design, rather than specialized thinking and practice. To paraphrase, the “sum of the conventional parts” in the traditional approach has been much less than the “whole” that could be achieved in a systems approach to infrastructure services. Integrated design can increase productivity of the larger system, while also serving the separate functional needs of the parts. For example, a recreation department and a stormwater utility can collaborate on the design of an urban park that includes trees and rain gardens. This park design can achieve multiple purposes of recreational space and stormwater retention and treatment at less cost than conventional drainage. Another way of putting this is that one agency’s “positive externalities” are another agency’s core mission, and both agencies can benefit from collaboration.

Other resources to be tapped from nature are the models for efficiency and high-performance of its organisms and systems. Biologists and chemists are looking more and more to nature for lessons on how to re-engineer products and processes. For

example, permeable reactive barriers can intercept and treat groundwater, much as natural riparian zones do along rivers and estuaries. Rotating blades based on nature's spiral designs can increase water circulation in ponds and estuaries and promote natural water-cleansing. Kidneys filter wastes without high-energy demands and researchers are seeking to mimic these processes in wastewater treatment membranes.

In addition, as Ian McHarg wrote in the late 1960's, by locating activities in the most appropriate places in a watershed, natural resource "streams of value" can be tapped with less cost and disruption. McHarg laid out guidelines for locating farms, ports, forests, wildlife corridors, and cities in places in the watershed that best matched the natural resource base or that avoid disrupting valuable ecosytems services within the watershed.

There are lessons to be learned, as well, from "networks" of "nodes" and "links" in nature that increase resilience and adaptability to shocks and stresses in the system. Hurricane Katrina and other natural disasters, along with projections of climate change instabilities, have highlighted the brittle quality of conventional water management approaches. A large centralized system is more vulnerable to damage from external shocks and equipment failures than a series of smaller, modular units, which are also put back in use much more quickly.

Integrated Designs for Neighborhood Districts and Municipalities

Pilot projects that incorporate natural system-based principles and designs at the district and municipal scales are a priority for the Water Alliance. A few cities have begun to explore and understand the cost-savings and benefits of integrated, multi-benefit infrastructure. Cities in British Columbia are starting to look at integrated water and energy planning, such as satellite wastewater treatment at pumping stations that can lower energy costs for the water utility and generate revenue from biogas recovery and water reuse. Los Angeles has calculated millions of dollars of savings from coordinating stormwater, solid waste, and drinking water around a rainwater harvesting approach. Seattle has started to experiment with long-term capital planning exercises that involve all relevant agencies in water, energy, public health, recreation, and transportation in the development of integrated projects.

A particularly promising scale for integrated design and infrastructure is at the neighborhood or "district" scale. Portland has developed a program for "eco-districts", Seattle is exploring innovative designs at the Yessler Terrace low-income housing project, New York City has been supporting a variety of water innovations at Battery Park, etc. These types of projects, along with "low footprint" approaches in schools, hospitals, municipal buildings and military bases, and other facilities are all worthy of EPA support.

Multiple Benefits/Economics of Integrated Design

A pilot project to assess the full benefits of a green infrastructure approach in Durham, NC will have value as a model for communities to assess . However, it would be useful to explore the economics of numerous other innovations in the water sector and to search for potential benefits within a common framework.

There are a variety of ways in which a new water management approach would cost less and deliver greater value than the current siloed and linear model, including.

- new technologies and practices can be cheaper than centralized water and sewer systems. Examples include: constructed wetlands and on-site soils treatment, permeable barriers, bio-recovery of nutrients, trees and rain gardens, rainwater harvesting, water-efficient appliances. Use of permeable barriers, oyster farming, or composting toilets can reduce costs for nutrient removal.

- reuse and recovery -- closed-loop systems can turn waste into resources and sell in the market, including used water, energy, trees and chemicals recovered from wastewater. Recent cost studies in British Columbia suggest that the market prices for these “wastes” may be high enough to turn wastewater and energy infrastructure into a profitable enterprise, where the revenue from sale of recovered resources exceeds the cost of building the infrastructure in a new way. Biogas digesters that recover energy for district heating or nearby industries, or sewer “heat mining” are particularly valuable options.

- secondary and co-benefits -- green infrastructure for stormwater retention and treatment provides substantial other services in communities, including in energy use, air quality, health, education, etc., thereby saving money and improving quality of life in communities.

- avoided costs -- water conservation and reuse technologies can allow a growing city to avoid expensive new water import or storage projects and energy plants, or to downsize combined sewer storage tunnels.

- resilience and risk-avoidance -- a large centralized system is more vulnerable to shocks and equipment failures than a series of smaller, modular units. Insurance and borrowing costs will be lower for a more reliable and resilient approach.

- green jobs and clean tech companies -- new systems entail a shift from capital-intensive to labor-intensive provision of services, and new companies will be established to develop and manufacture innovative technologies, including for export, and to provide installation and management services.

Institutional and Market Structures to Align with Systems Design

While it is important to research and pilot new “systems” technologies and designs and their associated economics, none of these approaches will be widely adopted unless supportive institutions and markets are also developed. Existing utilities, bureaucracies,

funding streams, and regulations were all built up around and supportive of the siloed and linear functions of water provision, stormwater management, wastewater treatment, and flood control. Radically new institutions and governance structures must be piloted and researched to align with the new approaches.

Of overarching significance is the quest for institutional structures that are capable of managing complexity and multiple actors, and, in particular, that occupy new high-value niches in the system.

The Water Alliance has identified a variety of needs and opportunities in this respect, including:

- financial mechanisms -- models are needed for integrated capital planning in cities and towns, investment approaches that harness private capital and entrepreneurship in the recovery of reuse and recovery values, and grant programs that encourage integrated design and innovation.

- management of private property installations -- many, if not most, of the innovations in the water sector will occur on private property, whether in yards, roofs, basements, or common neighborhood property. Utilities have been resistant to managing multiple, dispersed treatment units on private property, so new models will need to be developed for private companies or cooperatives to form and take over the tasks of installation and long-term maintenance, under the supervision of the municipality.

- asset management and “transitions” -- municipalities are faced with CSO, SSO, stormwater, nutrient, and infrastructure replacement mandates. Asset management methodologies have been advanced by EPA, in order to assess and prioritize repair and replacement strategies. But, models for how a municipality with an existing, aging infrastructure grid can slowly and systematically transition to a more integrated and decentralized approach are needed. For example, when should a failing piece of the water or sewer line grid be abandoned or repurposed, instead of rebuilt, or when should a treatment plant upgrade be avoided with construction of satellite treatment plants?

- regulatory flexibility -- many, if not most, of the innovations in the water sector will not be allowed under one or several of current local, state, or federal ordinances and statutes. A suite of “regulatory innovations” to open up the piloting and then wider adoption of new technologies and designs is essential. These could include issuances of variances by technology review boards at the local level, regulatory flexibility in eco-districts (as in the charter school movement), and flexible federal consent decrees, as are currently evolving in the green infrastructure sphere, but need to be explored in wastewater, drinking water, and other spheres.

- science-based adaptive management -- in the face of great uncertainties about looming threats of planetary boundaries, about how ecosystems respond to various possible interventions, about how innovative technologies will perform, and whether

new institutional structures are viable, it is essential that models be developed for managing these risks and unknowns. In general, the risks of continuing along the current path are considered to be much higher than the risks of innovation. Detailed models for science-based adaptive management are essential, however, for guiding municipalities through this complexity and for providing permit writers with approaches that both provide room for innovation and assure significant investments are made over time.

Externalities, Incentives, and Regulations

A new paradigm in water requires a fundamental rethinking of governance and civic activism that matches in scale and scope the radical shift needed in technologies and practices. The Tragedy of the Commons is a metaphor for incorrect pricing or lack of cooperative management of natural resources and the resulting destruction of ecosystems. Current low prices for water and wastewater services encourage the wasting of increasingly scarce water resources. Failure to charge for the externalities of eco-system damage similarly encourages disruption of water hydrologies and increased releases of pollutants.

Instead of a blunt-force rise in water and sewer rates or pollutant fees, however, a more complex change in incentives and regulations is required that matches the complexity of new participants, benefits, and externalities in the new water paradigm. Subsidies, regulations, and civic advocacy all would be needed to influence more directly the behavior of new market participants in the decentralized and integrated approach, either by limiting projects or designs that collectively threaten the environment (negative externalities) or promoting projects that collectively enhance the environment (positive externalities).

New water policies could include such mechanisms as: rebates for water-saving appliances; subsidies targeted at low-income ratepayers to install new technologies; mandates for onsite stormwater management practices and stream restoration; integrated full-cost assessments for federal grants and loans; water banks, where nonprofits pay for reductions in water use; development of ecosystem service markets, modeled on carbon trading markets; support for cleantech investments; funding of academic research and pilot projects; and numerous other institutional changes, such as new leasing systems where the developer can capture the longer-term benefits of reduced water use.

The design of an optimal mix of government and other strategies will depend on calculations of the responsiveness, or “elasticity” of demand or supply, of various market players and communities to incentives and opportunities. There are types of “market failure” to keep in mind as well, where markets will underperform because individual and societal benefits and costs are misaligned. For example, participants in the market may lack necessary information, under-invest in research, unfairly usurp resources from others, exaggerate the risks of innovation, or otherwise act irrationally.

Many of the incentives and information campaigns might be considered “transitional”. Over time, pilot projects can demonstrate the reliability of new approaches, good models will have been developed for municipal planning, the costs of technologies will fall as production increases, and in general, the benefits of the new water management paradigm will be more widely understood and internalized by homeowners, companies, and municipalities. The need for special government or civic education and activism will be reduced, at least to some degree, as citizens widely understand the benefits of smart clean green practices in their own lives and in their communities.

Summary of Pilot Project and Research Priorities

The Water Alliance recognizes that innovations in system design will be piloted in the near-term by visionary municipal leadership and by a suite of developers, architects, scientists, and engineers. These authorities and experts need financial help, regulatory flexibility, and knowledge of the successes and failures of earlier pioneers in the field. They also need models for financing, management, asset management, adaptive management, and optimizing public health and economic benefits. They need to understand the role that their infrastructure and urban designs can play in restoring the Water Commons and in keeping society as a whole from exceeding planetary boundaries and thresholds. They need help in education and behavioral changes of their residents, and they need models for collaborative decisionmaking among experts, the private sector, civil society, and government.

EPA-ORD can provide tremendous assistance and guidance in this exploratory and developmental phase. Much can be learned and replicated. In the long-term, as it becomes clear what design approaches are most productive and robust, and how ecosystems and communities can be improved by adopting a systems approach, a subsequent phase of redesigning and realigning government incentives and regulations can be supported. Consideration of documented resource synergies and integrated designs, as well as better knowledge of ecosystem functions, vulnerabilities, and responses, may well lead to a consensus for amendments to the Clean Water Act and other federal statutes. But the bulk of those discussions may be put off to another day.

Thank you again for the opportunity to comment on the research agendas. The Water Alliance would be happy to provide additional background materials and suggestions.

Sincerely,

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Director