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Water Futures

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Perusing headlines across the United States, I am reminded of the poetic refrain of Samuel Coleridge: "Water, water everywhere, nor any drop to drink." The refrain referenced oceans, but it seems increasingly applicable as so many parts of the Nation struggle with water challenges. A National Research Council report of few years ago opined: "Abundant supplies of fresh drinking water can no longer be taken for granted."

While not all issues I faced while at the U.S. Department of the Interior were water issues, many of the most contentious included water as a central source of conflict. Let me just delineate a few. The Klamath Basin hit the headlines shortly after I arrived in Washington. Hydropower, endangered species, agriculture, fisheries, and tribal heritage all converged on a collision course centered on water. As I left the Interior Department in 2009, the Bay Delta in San Francisco was in the headlines and careering toward calamity as resource managers considered the fate of delta smelt, salmon, wetlands conservation, municipal water, agricultural irrigation, and flood control. Glen Canyon Dam, Lake Powell, and Lake Mead all face contests over power supplies, irrigation, recreation, endangered species, and cultural resources. Even in the East, the Interior Department found itself amid battles among Georgia, Florida, and Alabama over water flows in the Apalachicola, Chattahoochee, and Flint watersheds in a tug of war over the water needs of municipalities, agriculture, hydropower generators, endangered species, and ecosystems more broadly. Throw a dart on the map, and we see communities that face water challenges. Laws, regulations, markets, cultures, and technologies all converge as these challenges unfold.

These challenges are not new, but they may increase in frequency and intensity. Several trends complicate 21st century water management challenges. Perhaps no challenge is more perplexing than that of climate change and its effects on water. Climate effects on water fall into six impact clusters. These include:

- Potential changes in the amount of precipitation
- Potential changes in the timing of precipitation
- Potential changes in the form of precipitation—rain versus snow
- Potential changes in the distribution of precipitation
- Potential changes in rainfall intensity
- Potential changes in the frequency of intense rainfall events

These effects come with potential corollary effects. Specifically, we may see changes in the duration, extent, distribution, intensity, and frequency of drought. We may also see changes in groundwater/surface water interactions. We may see changes in the volume and velocity of runoff, and we may see impacts on water quality.

Warming may increase drought severity. Generally, 20th-century water flows were unusually stable and revealed less severe drought than the historic record. Our laws and practices for managing water largely emerged in this relatively stable context.

What's the bottom line of this brief discussion? Changes in water flows, timing, and form are highly complex, location-specific, and highly dynamic. Even without climate change, precipitation can range from half the long-term average in a dry year to double the long-term average in a wet year in western states like Colorado.

What are the implications of these trends for water managers, water users, and policy makers? Across the Continent, some places are expected to be wetter; some drier. Some locations will have more snowfall; some less. Some will experience more extended and intense drought; other places less severe droughts.

Despite these variations, some key themes emerge and present implications for response strategies. Along with many of these management challenges emerge many legal, policy, and regulatory issues. I will borrow from a Colorado study on the effects of climate on water to summarize eight water management challenges.

First are challenges of water supply infrastructure (including reservoir operations, flood control, and stormwater management) that arise from changes in flows, intensity, and timing of precipitation. Changes in the timing and magnitude of runoff affect diversion, storage, and conveyance structures.

Second are challenges of water demand. Hotter temperatures can raise evapotranspiration, resulting in higher water needs for irrigation. Warming temperatures can lengthen the growing season, increasing water demand.

Third are challenges of water quality. Changes in water temperature affect water quality as do changes in the pace and amount of stormwater runoff. So, too, changes in in-stream flows can affect water quality.

A fourth challenge resides at the intersection of energy demand and water supply costs. Many sources of energy are water intensive. Water infrastructure can be energy intensive, especially in parts of the West that rely on pumping water long distances across changing elevations.

Terrestrial habitat, fire, and outbreak of pests present another set of challenges. Changes in water can affect the incidence and intensity of fire. Changes in precipitation patterns, timing, and amount of flows can affect riparian and wetland vegetation.

Sixth, changes in the timing and amount of flows and water temperature can also affect fish species composition, and food supply.

Seventh, long-term changes in precipitation patterns can affect groundwater recharge rates.

Finally, changing water availability may stretch the capacity of existing compacts and rights allocations and the effectiveness of "prior appropriation" water rights in allocating water in circumstances of scarcity, thereby provoking a reexamination of some long-standing legal rights and concepts.

What do all these challenges portend? Several planning and management tools become increasingly important. In a context of climate change, increasing water demands, and pressures to improve water quality, six water management strategies may be increasingly relevant.

- Flexible River and Reservoir Management
- Urban Infrastructure Greening
- Market-based water pricing
- Water Marketing
- Water Quality Trading
- Watershed Permitting

Historic alterations in river flows have been undertaken in the past to meet many agricultural and other water consumption needs and to mitigate flooding. However, river damming and flow manipulation, summarized by the U.S. Fish and Wildlife Service, have had multiple effects, including:

- Decreased low flows as a result of water withdrawn from rivers for use
- Elevated low flows to dilute pollution discharges
- Fewer small floods (2 – 20-year events) for flood control, water supply, or hydropower
- Sustained high flows for flood control
- Rapid and increased fluctuations in flow conditions for hydropower

With a changing climate, these effects could become more significant. Water managers, thus, face a question of how they might reintroduce more natural river system functioning and flow patterns to meet human needs while improving ecological functioning and climate resilience. Tools to achieve these goals include flexible river management to revise operational plans of dam systems to create more natural flow regimes and stream temperatures; improve fish passage and migration through pulse flows; and provide controlled release of floodwaters with increased use of floodplains.

Among the best examples of such management are a handful of partnerships between The Nature Conservancy and Army Corps of Engineers along the Green River in Kentucky and in other river systems in Vermont, New Hampshire, North Carolina, Virginia, Georgia, South Carolina, Texas, Louisiana, Arkansas, Missouri, Arizona, Oregon, Pennsylvania, and Colorado.

While I was at the Interior Department, the Fish and Wildlife Service began working on a Reservoir Strategy as part of the National Fish Habitat Action Plan partnership. Reservoirs in the United States have four primary functions that include provision of hydropower, flood risk reduction, irrigation, and drinking water. Reservoirs also provide many other ecosystem services values such as wildlife and fish habitat; aquaculture; recreation; transportation; and aesthetic values. The FWS Strategic Reservoir Plan calls for working with communities to manage upstream, reservoir, and downstream waters as a whole system to better fulfill a full suite of ecosystem services. Key tools in this strategy include:

- Floodplain restoration—at least in part
- Increased use of reservoir storage space rather than maintaining flood management capacity
- Implementation of more natural flow regimes

Yet each of these strategies involves complex considerations of land and water rights, responsibilities, and liabilities.

A third strategy to address water needs in a changing context is urban greening through use of increased permeable surfacing, re-establishing more natural river forms and flows, using bioswales, and other techniques that take advantage of natural rather than highly engineered systems. Urban water use and water management often remain locked within limitations of old infrastructure. This infrastructure has contributed to increased storm water runoff and has not facilitated water conservation. With paving of city surfaces has also come a loss of tree cover in urban areas. Yet trees help manage storm water by intercepting rainfall and slowing the rate at which it runs over the surface of the land and seeps into the ground. The loss of urban trees, by some estimates, has cost cities $100 billion in increased storm water management needs.

Existing infrastructure also results in extensive missed opportunities for water conservation. Most city infrastructure distributes potable drinking water for all urban water needs, from drinking water to laundry to toilet flushing to landscape irrigation. Per capita residential water consumption in the US was estimated at 161 gallons per capita per day in 1996-1998. That figure is fourfold higher than in many European nations. Some of the high U.S. water consumption may be linked to low-priced water rates. Several cities have begun to used tiered block pricing, with rates climbing as use climbs. Evaluation of such tiered pricing indicates corresponding per capita declines in water use.

Restoring permeable surfacing and expanding tree canopy in cities can significantly reduce storm water runoff and associated contaminants from entering urban streams. With some climate models projecting increased frequency of high-intensity rainfall events, reducing storm water becomes increasingly salient to cities. In this context, urban greening presents a potentially important strategy.

These greening efforts confront policy and legal challenges. Clean Water Act compliance standards and metrics are typically premised on meeting specific infrastructure capacity requirements or other technical prescriptions. “Greening” presents an entirely different framework for managing water, one that does not readily fit into EPA’s enforcement models for water management.

At the same time, watershed permitting and trading present growing opportunities for improving water management in terms of both supplies and quality. Yet in the agricultural community, potential participants in such trades do not face federal requirements to reduce pollutants in agricultural runoff, limiting their incentives to participate in trades. Nonetheless, some voluntary trading has occurred, and states like Pennsylvania, Virginia, and Maryland have supported trading through state statutes.

But benefits of water quality trading can be considerable. In the Tualatin Basin, Oregon, four wastewater permits and one storm water permit were required. The water services district needed additional measures to meet water temperature standards. Their primary options included spending $60 million on a refrigeration system or spending $6 million to pay farmers to plant trees along 37 miles of streams using a permit credits approach. The example illustrates the potential both of a watershed approach and the utility of water quality credits and trading.

Let me conclude my discussion of water futures with a summary of major impending policy challenges. First, dispersed authorities, multiple agencies, and diverse jurisdictions make coordination and integration difficult, yet challenges of water management require greater integration. For example, the Chesapeake Bay is situated among some 128 different municipalities. Second, permitting and standards premised on mechanical and “gray engineering” solutions present an ill-fit in a context of transition to more flexible, resilient “greening” infrastructure. A third challenge is the absence of relevant data. Water rights and water allocations emerged in circumstances that prevailed 100 years ago.

The Walla Walla Washington Watershed Council presents an institutional model aimed at addressing all these issues.

The challenges of rethinking water management are illustrated by efforts to resolve Klamath Basin water challenges. While I was at the Interior Department, Michael Bogert, Counselor to the Secretary, worked on development of “Principles” for a Klamath Basin Restoration Agreement. The transactions involved 50 different signatories representing 50 federal, state, local, tribal, and private entities. Actual negotiations included 26 different organizations. The principles under consideration included removal of 4 dams, restoration of natural fish species dynamics, continued opportunities for ocean and river fish harvesting, reliable water and power supplies for agriculture, communities, and wildlife refuges, and the overall public welfare. The Obama Administration signed a Klamath Basin Agreement largely forged from these initial discussions.

Each of these elements is extremely complicated. Fish species enhancement includes reintroduction of anadromous species at certain locations and adaptive management and monitoring. Actions would occur over a 30-year period or more. Proposals include a permanent increase in water for fish management, obligations for more water conservation through a water use retirement program, and more water storage through land management and banking. The proposals include groundwater management and drought management. Overall, the initial Klamath Basin restoration discussions involved 57 high-level actions and a multitude of sub-actions. To accomplish all of these actions requires new legislation in two states, bond measures, billions in federal funding, new federal authorities for the Bureau of Reclamation, water rights assurances and resolution of water rights claims. These efforts would require creation of a cross-jurisdictional governance council.

As I contemplate the Nation's water futures, the Klamath Basin is a precursor to the kinds of complexities we can expect. These complexities will require: 1) an intensified use of science to understand system dynamics and evaluate management options; 2) policy tools focused at the watershed and landscape scales; 3) tools that strengthen adaptive responses and conservation incentives; and 4) mechanisms to enhance network, or multi-jurisdictional coordination.