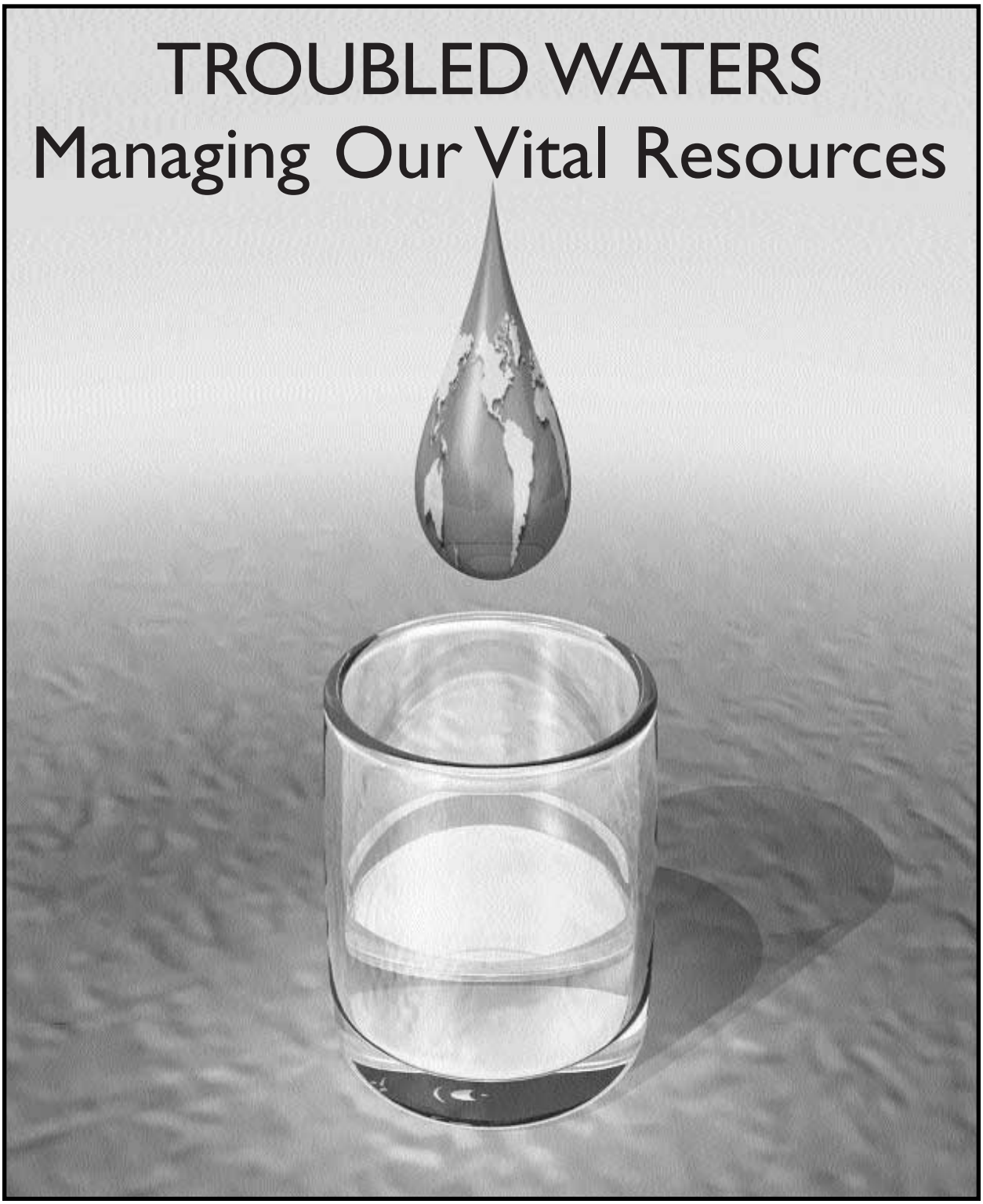
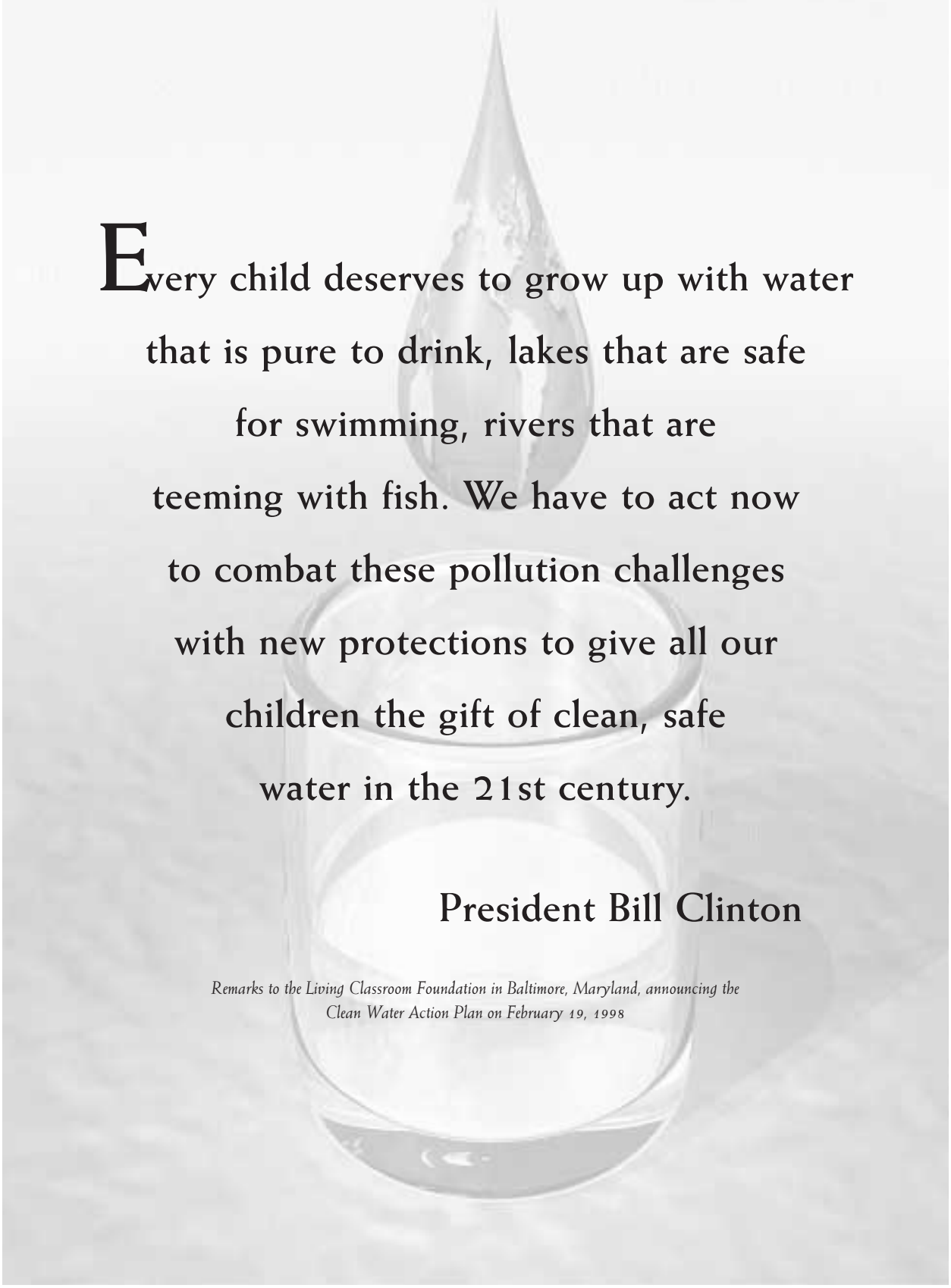
global issues

March 1999 Volume 4, Number 1

TROUBLED WATERS
Managing Our Vital Resources





Every child deserves to grow up with water that is pure to drink, lakes that are safe for swimming, rivers that are teeming with fish. We have to act now to combat these pollution challenges with new protections to give all our children the gift of clean, safe water in the 21st century.

President Bill Clinton

Remarks to the Living Classroom Foundation in Baltimore, Maryland, announcing the Clean Water Action Plan on February 19, 1998

global issues
An Electronic Journal of the U.S. Information Agency
March 1999 Volume 4, Number 1

table of contents

TROUBLED WATERS
Managing Our Vital Resources

focus

commentary

reports and documents

departments

GLOBAL ISSUES

An Electronic Journal of the U.S. Information Agency

ejglobal@usia.gov

USIA's electronic journals, published and transmitted worldwide at three-week intervals, examine major issues facing the United States and the international community, and inform foreign publics about the United States. The journals — ECONOMIC PERSPECTIVES, GLOBAL ISSUES, ISSUES OF DEMOCRACY, U.S. FOREIGN POLICY AGENDA, and U.S. SOCIETY AND VALUES — provide analysis, commentary, and background information in their thematic areas. All journals are translated into French and Spanish, and selected issues appear in other languages — notably Arabic, Portuguese, and Russian.

Current or back issues of the journals can be found on the U.S. Information Service (USIS) Home Page on the World Wide Web at "http://www.usia.gov/journals/journals.htm". They are available in several electronic formats to facilitate viewing online, transferring, downloading, and printing. Comments are welcome at your local USIS office or at the editorial offices:

Editor, Global Issues (I/TGIC)
U.S. Information Agency
301 4th Street, SW
Washington, D.C. 20547
United States of America.

You may also communicate via email to:

ejglobal@USIA.gov.

FOCUS

THE QUIET REVOLUTION TO SAVE OUR AQUATIC ECOSYSTEMS

By Bruce Babbitt
Secretary of the Interior

I would like to reflect upon our stewardship of aquatic landscapes: the rivers, lakes, and wetlands that link and nourish the watersheds we inhabit. It is the Nature Conservancy (a non-profit international environmental organization) that has sounded the alarm, warning that our freshwater and wetland ecosystems are among the world's most imperiled. For example, one of its recent publications reports the startling news that roughly one third of all fish, two thirds of all crayfish, and three quarters of the bivalve freshwater mussels in America are rare or threatened with extinction.

After five years of first-hand experience with watersheds throughout the country, I share its sense of urgency. We cannot continue with piecemeal efforts. Instead we must undertake to restore entire watersheds, using new methods, creating partnerships, and calling for renewed public participation. We must undo and reverse ecological damage that has accumulated over the years.

To illustrate both the urgency of our task, and the possibility of success, I would like to discuss several large scale restoration efforts that we have begun in this administration and then relate them to efforts underway at many levels all over the country. For I believe that watershed restoration is a powerful new idea with the capacity to transform our relation to the lands and waters that sustain us.

This administration began in South Florida because it was the most visible and urgent of many impending watershed disasters. Everglades National Park was subsisting on life support in urgent need of attention. That life support system, consisting of a few small projects designed to pump more water through the desiccated hydrologic arteries of the park, was barely keeping the patient alive. With each passing year the natural monitors of the patient's health — great flocks of wading birds, egrets, anhingas, storks, and herons — had begun to flatline.

The Everglades were quite simply the victim of a long campaign to "drain the swamps" — swamps that once poured their overflow waters south into the Everglades and Florida Bay. Draining the swamps was the engineering equivalent of the medieval practice of treating patients by bleeding them. And in the process of severing and bleeding these hydrologic arteries, they were draining the very life out of the Everglades.

Our strategy, to restore the Everglades ecosystem

by reconnecting those hydrologic arteries, began by bringing all the Federal agencies together behind a common restoration plan. Our able co-leader is the Corps of Engineers, ironically a pioneer in the early efforts to de-water these same landscapes of South Florida. We soon learned, however, that for effective watershed restoration, we needed state and local partners. In 1994, the Florida legislature, at the urging of Governor Chiles, passed the Everglades Forever Act that created a $1,000-million fund to clean up the contaminated agricultural runoff that was causing much of that problem. The Florida commitment, backed by an outpouring of public support, prompted Congress to legislate support for the largest watershed restoration plan ever undertaken.

Our South Florida restoration effort still has a long way to go, but we have already learned some important watershed restoration rules that should apply all across the country:

- First, the most basic lesson is about the nature of water. Water doesn't stay still for very long. It is always in motion, from sky to land, across and through the land, out to sea, and back to sky in an endless cycle. And that means that you can't efficiently restore just one piece of a river; to fix any one part, you have to consider the whole watershed.

- Second, the only way you can fix a watershed is by creating partnerships — between governments, between landowners large and small, among all the stakeholders on the watershed. Just as all parts of a watershed are related, so must all residents of that watershed be part of the restoration effort.

- Third, watershed restoration must be a visible process that captures and holds public attention. Every community values its native heritage and believes in its future. And they are ready to support bold restoration plans.

But however bold watershed efforts have been so far, however they have enriched the quality of life, they are nothing like what they can become in the next 20 years.

Large-scale, federal-state-local partnerships demonstrate the full potential of watershed restoration, especially its power to capture the public imagination. It can make allies of sworn enemies. It can produce funding out of nowhere. It can reverse harmful trends with such speed and to such a degree that may surprise us.

Consider the Central Valley of California, a basin of complex river systems that, on the East Coast, would extend from Massachusetts all the way down to South Carolina. The great campaign there was not "drain the swamps," but rather "water the desert." As that desert valley bloomed into vast tracts of irrigated agriculture, the rivers shriveled and dried up.

As rivers like the San Joaquin disappeared into irrigation canals, the great salmon runs that once reached into the foothills of the Sierra Nevada Mountains disappeared. Salt water began to invade the delta. Agricultural drainage laced with selenium killed and disfigured thousands of migratory birds at the Kesterson refuge. The water wars continued for half a century as Californians quarreled, unable to resolve the conflicts that divided urban water users to the south, farmers in the Central Valley, and fisheries advocates in the north.

The watershed restoration of California bears a striking parallel to that in Florida. First, the administration put the federal house in order. Then we joined together with state agencies, irrigation districts, farmers, environmentalists, and fishermen to negotiate a restoration framework — known as the Bay Delta Accord. Coordinating our efforts, the legislature in Sacramento placed a restoration bond issue — also $1,000 million — on the ballot in 1996. In a year of austerity, tight budgets, and conservative fiscal policy it passed with ease. Armed with such strong public support we went together to the Congress, which in 1997 provided matching funds. The result was, again, a massive restoration program to bring California rivers and wetlands back to life by dedicating water to restore and maintain stream flows, re-watering wildlife refuges, moving levees back so that rivers could flow free across their natural flood plain, and screening irrigation canals to protect migrating fish.

That all sounds like a complicated and often messy

political task. But it boils down to simple and timeless values. Thirty six centuries ago, Emperor Yu of China advised, "To protect your rivers, protect your mountains." That same rule applies today. To restore our aquatic species, let us look beyond the water's edge out onto the land that borders it. For the two are inseparable. What happens on that land inevitably is reflected in our streams and rivers:

- In the Pacific Northwest: To replenish trout, coho, chinook, and sockeye salmon we looked past the water's edge to create large connective forested buffers along banks of streams and tributaries in over five and a half million hectares.

- In Chesapeake Bay: To stop fish kills from a bacteria called pfiesteria, we are offering incentives to landowners to return the borders of their farms to buffers of native trees and vegetation that sop up fertilizers and animal waste before they can drain into river estuaries.

- In the Sierra, Rockies, and Appalachians: To replenish native aquatic species in a half million kilometers of streams, we match federal funds and land management experts with local private and nonprofit projects to restore the damaged mountains which bleed into them.

- In Western range lands: To bring back rare native trout and to protect the endangered willow flycatcher, we have joined cooperative range partnerships to modify livestock grazing rotations, build riparian fences, and replant willows and aspen, now yellowing in the sun.

The watershed restoration movement is a powerful force, moving in many directions, some of them unexpected. One example is the emerging national debate about whether some existing dams should be dismantled as part of watershed restoration efforts.

Until very recently there was not much concern for effects of dams on our natural environment. Today, looking back on decades of one-dam-at-a-time river modification, we are coming to see the cumulative effects: The Colorado River no longer runs to the sea. Its great delta, about which Aldo Leopold wrote such moving essays, is now a vast dry salt flat. Celilo Falls, the most storied of all Indian ceremonial and fishing sites, has vanished beneath the placid reservoirs of the Columbia River. In the Sierra Nevada, the Truckee River was plugged to raise Lake Tahoe an extra 1.8 meters. Even in Yosemite National Park, John Muir's sacred "Cathedral," they dammed the Merced River at Mirror Lake in order to provide visitors with a better reflection of Half Dome.

Only now have we come to appreciate the systemic costs of building more than 75,000 dams in this country in this century alone. We pay these costs in many forms: The destruction of salmon runs in New England and the West; the crashing shad and herring runs of the Susquehanna River; the vanishing wetlands that sustain migratory birds in the Mississippi Flyway; beach erosion in the Grand Canyon; and lost nesting and gathering habitat of sandhill cranes and shorebirds along the Platte River in Nebraska.

For these reasons it is appropriate to think of dams as having a ledger with both benefits and environmental costs. And as part of watershed restoration efforts it is always appropriate to ask whether a given dam can be operated in a more river friendly mode.

The Grand Canyon is one place where we have asked that question and answered in the affirmative. Last year, the Bureau of Reclamation opened the gates and sent a huge surge of water, an artificial flood, crashing down through the Colorado River. The idea behind that was to mimic the natural spring flooding of the pre-dam river so as to stir sediment up and rebuild eroded beach habitat downstream in the Grand Canyon.

And on occasion a careful look at the ledger of costs and benefits may bring us to conclude that a dam should simply be removed.

In 1992, Congress authorized a study of the removal of two small 70-year-old dams at the mouth of the Elwha River. These dams blocked salmon runs of 300,000 from spawning up 112 kilometers into the heart of Olympic National Park. The Park Service, after careful study, has concluded that forgoing a small amount of energy

in an area where electric power is now in surplus would be a small price to pay for restoring one of our great national parks to its pristine state, where the streams are again swarming with wild salmon, providing food and sustenance for bears, bald eagles, raptors, and, of course, for the human spirit.

In the final analysis, however, the restoration of our streams and watersheds lies in the hands of the communities of people who live and work on that watershed. And there are more and more examples of people coming together, gathering the stakeholder groups such as farmers, woodland owners, power companies, local industries, developers, and environmentalists to begin the process of looking first into their river, with fresh eyes in a different light, then following that water as it moves up through its tributaries and out across the landscape to ask: How do we restore a healthier watershed? What can we do to improve it?

President Clinton, in his State of the Union address, announced his intention to designate 10 American streams as National Heritage Rivers. His purpose is to recognize outstanding efforts by local communities who come together to reclaim their river heritage by restoring waterfronts, cleaning up rivers, protecting riparian zones, replenishing fisheries, and managing watersheds to maintain healthy waters.

By his Heritage Rivers initiative, President Clinton is reminding us that local communities and individual citizens are the moving spirit of watershed restoration. Americans are once again awakening to the connection between their communities and the natural environment. We are once again gathering by the waters, seeking renewal of land and spirit. All of our rivers are Heritage Rivers — they flow through our lives and our history as surely as they flow from highland to tidewater. And in that process we are discovering that we have the power to forge a new and more respectful relation with God's creation.

CHARTING A NEW COURSE TO SAVE AMERICA'S WATERS

An interview with J. Charles Fox, assistant administrator of the Office of Water at the U.S. Environmental Protection Agency (EPA).

Fox says that the United States is restoring the water quality of its rivers, lakes, and streams by charting a new course that emphasizes collaborative strategies built around entire watersheds and the communities they sustain. Fox was interviewed by Jim Fuller.

Question: President Clinton has said that 40 percent of our nation's waters are still too polluted for fishing and swimming — 25 years after the U.S. Congress passed the Clean Water Act. How much progress is being made in combating water pollution?

Fox: We have made significant progress in this country. We have invested literally thousands of millions of dollars in water pollution control over the last 25 years. In 1972, the Potomac River was too dirty for swimming, Lake Erie was dying, and the Cuyahoga River in Ohio was so polluted it caught fire. Since the enactment of the Clean Water Act, we've made tremendous progress in improving the general quality of our nation's rivers, lakes, and streams. We've doubled the number of waterways that are safe for fishing and swimming, reduced industrial discharges by millions of pounds a year, and more than doubled the number of Americans served by adequate sewage treatment. But we still have a long way to go. And that's what the Clean Water Action Plan is all about — making the commitment as a nation to have waters that are safe for fishing and swimming.

Q: What is the Clean Water Action Plan?

A: The Clean Water Action Plan is a major new initiative announced by President Clinton in February 1998 to improve the water quality of the nation's rivers, lakes, and streams. To carry out the initiative, the president has allocated $651 million in the fiscal year 2000 budget — and has called for a total increase of $2,300 million over five years to clean up watersheds across the country. In fact, we have doubled the amount of money that's available to reduce what we call nonpoint source pollution, which is the polluted runoff that comes from farms, city streets, and other sources that contaminate our waters.

The administration is also focusing on a series of drinking water initiatives built on the Safe Drinking Water Act amendments enacted by Congress in 1997. These initiatives call for over $2,000 million in annual financial assistance to state and local governments to upgrade their drinking water systems so that people can have confidence that when they turn on the tap, they're getting water that is safe for drinking, bathing, and showering.

Q: How is the Clean Water Action Plan different from previous attempts to deal with water pollution?

A: There is excitement over the Clean Water Action Plan for a number of reasons. Number one, for the first time it brings together the different programs of all the agencies of the federal government to try to solve water pollution problems in this country. It has become obvious that EPA alone can't deliver clean water to the American public. We can only accomplish this to the extent that we work together with the Department of Agriculture and the Department of Transportation. So the Action Plan is very exciting

from that standpoint. It is also exciting in that it provides new money to all our agencies — money that is then provided to state governments so that we can work collectively on achieving water quality goals.

One of the most significant developments is that for the first time, we are looking at the entire watershed. That means we're no longer just looking at the problems coming from an individual factory or farm. Instead, we're looking at all the different water pollution problems affecting a region or community — from forest to farm to urban neighborhood — so that we can tailor-make our solutions to the unique problems of that region. And we've had tremendous success in working with the state governments. I was quite surprised to see that within only six months of the president's announcement of the Action Plan, we received priority watershed plans from all 50 states and many Indian tribes. It is very exciting to see that kind of enthusiasm. Everybody seems to realize that working together to solve water pollution problems is in everybody's interest.

Q: What are some of the actions called for by the Clean Water Action Plan?

A: The Action Plan includes 111 major new actions to restore and protect our water resources. These are specific action items that each agency must respond to within certain timeframes. Those commitments take us into the next century. The focus is on trying to combat polluted runoff from sources such as city streets, suburban yards, and farms. For example, working with the Department of Agriculture, we will for the first time issue discharge permits for literally thousands of animal feeding operations — such as large hog farms, cattle farms, dairies, and poultry houses — that produce significant amounts of manure that ultimately gets into our waters. This joint strategy will also include recommendations for new regulations that will apply to animal feeding operations, as well as voluntary actions that can be taken by smaller farmers around the country.

Another action item calls on EPA to develop new water quality standards to ensure that beaches are safe for swimming, and a new Internet-based system to provide the public with online information on whether or not their beaches are safe. The Internet will also be used to provide information on the health of aquatic systems in more than 2,000 watersheds nationwide.

We are also trying to do a better job of educating people about their relationship to water quality. In urban areas, for example, homeowners will often change the motor oil in their cars and pour the used oil down a storm drain, thinking it will be treated at a sewage treatment plant. However, many storm drains are connected directly to a local waterway, and so pouring the oil into a drain is just like pouring it into a river. We want to educate people about how they can contribute to solving water pollution problems.

Q: The Action Plan also provides increased incentives to farmers and other landowners to adopt practices that protect water quality. For example, would you discuss how farmers are encouraged to create protective forest and grassland buffers along rivers and streams?

A: One of the interesting technological advances that we've seen in the water pollution control area is that some of the techniques that were used to protect our water quality in the 1930s and 1940s actually make a lot of sense today. By installing what we call buffer strips along waterways we can, on the one hand, reduce the amount of pollution that is running off a farm field into a stream, and, on the other hand, create riparian areas along stream corridors for wildlife to live. These buffer zones — which can be anywhere from 3 to 60 meters in width — can also provide essential nutrients to the fish and offer benefits for flood prevention and control, while reducing pollution that's going into the water. It's a wonderful technology.

Q: How important is the restoration of wetlands in the fight against water pollution?

A: One of the president's action items calls for the creation of 40,000 hectares of wetlands a year beginning in 2001. This includes a 50 percent increase in wetlands restored by the U.S. Army Corps of Engineers. That's an ambitious goal. And what it says is that we need to do a very good job in improving and expanding wetlands as opposed

to simply watching their demise, which is what we've been doing in this country for the last 100 years. There are just a fraction of the wetlands today that existed 200 years ago. We now know that wetlands are an incredibly important part of our ecosystem — that they provide flood control, wildlife habitat, and water quality benefits. Many Americans are now realizing that they also provide an enjoyable place to watch birds. These are very different values than we had even 50 years ago, when wetlands were thought of as swamplands that needed to be drained to protect against mosquitoes. And so we are working aggressively to expand wetlands areas. This will require significant new financial commitments from government for land acquisition and creating partnerships with states and owners of agricultural lands where many of these wetlands are going to be restored. We're hopeful that working together we will be able to achieve the president's goal.

Q: What would you point to as the biggest success story in fighting water pollution?

A: One of the most outstanding successes that we've seen in the last 25 years has been the improvement in municipal sewage treatment capacity throughout the United States. Under the provisions of the Clean Water Act, we have invested over $75,000 million to construct and upgrade sewage treatment facilities, nearly doubling the number of people served with secondary treatment — a basic level of sewage treatment — to more than 150 million. We do a very good job of controlling water pollution from municipalities through sewer systems. At the same time, we understand that our municipalities need to continually invest in this kind of basic infrastructure if we are going to achieve our water pollution goals in the future. And that's a challenge because infrastructure investments are incredibly expensive; they also represent difficult decisions for state and local governments to make. But they are tremendously important decisions for the future of our nation's waters.

We have also seen increasing investments in water pollution control technology around the world. In that regard, we have an elaborate and increasingly successful partnership with Mexico to address water pollution problems along the U.S.-Mexican border. This has been, in fact, a fairly significant initiative by this administration. We've provided tens of millions of dollars to improve and upgrade sewage treatment plants for residents on both sides of the border. We also have a number of bilateral forums that have made a lot of progress working on priority environmental problems. Having said that, there are still many challenges that we face in the U.S.-Mexican border region — an area of both our countries that traditionally has been underserved by basic water infrastructure. The people that live in that area have very significant needs that must be met.

Jim Fuller writes on environmental topics and other global issues for the United States Information Agency.

FRESHWATER: WILL THE WORLD'S FUTURE NEEDS BE MET?

An interview with David Foster Hales, deputy assistant administrator of the Global Center for Environment at the U.S. Agency for International Development (USAID).

Hales says that water is a serious and critical component of sustainable development; in many instances it is the most critical limiting factor. Hales was interviewed by Jim Fuller.

Question: Would you discuss the attention being given by USAID and other organizations to managing whole watersheds or river basins in an integrated manner — a strategy referred to as Integrated Water Resources Management?

Hales: In the United States and many other countries the concept of watershed management is not particularly new or controversial. It's an effort to understand the role water plays as part of a natural system, and then finding ways to get water to play a more effective role. Instead of withdrawing more water from the system, the idea is to get more out of the water that's in the system. Since water can be reused many times, the availability of water for human use depends mainly on how it is used and how the water resource system is managed.

We look at water as a serious and critical component of sustainable development — in many instances it is the most critical limiting factor. So as we look at economic growth, environmental sustainability, biodiversity, food security, and health and child survival issues, ultimately we come back to the question: how much water is there? And the effort that we make as an agency — and I think that natural resources agencies in most countries are now making — is to understand the limits of what can be done with available water. There are real limits. Anticipating those, and trying to find ways to change the way we use water so that we create more flexibility in the freshwater system is what we mean by Integrated Water Resources Management.

Q: Can you give an example of improving the efficiency of water use?

A: By far the greatest use of water, worldwide, is irrigation. Agriculture is responsible for some 70 percent of global water use and most of that is for irrigation. Probably half of that amount is wasted before it reaches the intended crop due to inefficient, outdated irrigation systems. To shift to more efficient technologies, such as drip irrigation, lining of irrigation canals, or precision sprinkling, is one way you can create more water in the system — because you're wasting less. And you can do that without sacrificing food production. According to current projections, 3,500 million to 4,000 million people will live in countries that cannot produce their own food by 2025. If we can find ways to manage water more effectively for industry and agriculture, and for basic needs such as drinking water, then we create more sustainability in that system, which is certainly in our national interest.

Q: Are we succeeding in finding ways to manage water more effectively?

A: I wish I could give you a straightforward answer to that question. I think — through a confluence of partnerships with industry and private sector and non-governmental organizations in other countries — we are succeeding in raising the salience of the issue. But if you had asked me that

10 years ago, I would have given the same answer. I thought we were succeeding 10 years ago. And yet I still see inefficient agricultural systems; I still see us building large dams — none of which, in my opinion, could ever pass a positive cost benefit test. They are almost always going to be subsidized. At the same time, we're not investing in efficient irrigation systems — every one of which would pass the cost benefit test in terms of jobs, economic benefit, and increased food security. So we're not succeeding in matching up resources to the problem. I think we are succeeding in getting people to understand potentially how severe the problem is, but we haven't taken the next step that goes from believing something to doing something about it.

Q: Can you give a few examples of how USAID is working to improve the quality or quantity of water resources in other countries?

A: In South Africa, where the government is really struggling to take a strategic approach to water problems, we are doing a lot of work to better understand the hydrology of the watersheds, providing models, and making that information available to the South Africans. They can then make management decisions based on how the water is used and how much water there is in the watershed. The Famine Early Warning System in place throughout southern Africa is another effort we're making to help farmers predict or anticipate when it's likely to rain and how much rain they're likely to have. In other countries, like Egypt, we're working with water measurement and modeling systems that help determine river flow.

We're also working on water quality issues. Cities and industries poison water. That's what pollution is. Whenever we dump stuff into the water that's not good for humans and other living creatures we're poisoning that water. So we have programs around the world that are helping cities learn how to both reduce the amount of pollution and also finance water treatment systems that will purify the water, similar to the kind of systems we have in North America.

We also promote the preservation of forests upstream in the watershed, which helps to regulate the water and keep it clean. If you destroy a watershed in its upper reaches everything will change, including the availability of fish, all the way down to where the water reaches the ocean. We also have programs in countries that emphasize the value of protecting wetlands along rivers — because the wetlands are not only an incredible source of life and richness, they are also the cheapest way to purify water and the cheapest form of water retention to help avoid floods.

So when water is taken out of a river, we work with countries on how to most effectively use the water for irrigation systems, use the water for industrial purposes, use the water for human consumption, and how to clean it up when it is put back into the system. Literally at every one of those stages the U.S. government has projects overseas, investing about $300 million a year to increase the effectiveness of water management and reduce pollution.

Q: What would you say are the most severe problems facing freshwater resources in the developing world right now?

A: I'd say one of the biggest problems centers on the building of large dams and large engineering projects that change the course of rivers for the purpose of navigation and sometimes for flood control. With dams you lose fisheries above and below the dam — fisheries that provide livelihood and food for a lot of people. Currently a third of the freshwater species in the world are endangered — that's a fairly staggering figure. In most instances, countries also lose transportation and a tremendous amount of the best agricultural land in the world. Dams also displace cities and people, because many people choose to live near rivers. The dams themselves provide substantial benefits for a very limited period of time. No dam is permanent. They all silt up at some point. Egypt's Aswan Dam provides hydroelectric power. At the same time, as a result of the dam changing the freshwater flow upstream, we've seen a tremendous die-off of fisheries along the Nile River and an 80 percent reduction in the sardine population of the Mediterranean Sea.

Another major problem in many countries is uncontrolled agricultural runoff, along with the overuse of fertilizers and pesticides, and siltation

due to bad land-use practices that cause erosion. And from a pure human perspective, the biggest problem is probably industrial pollution. An incredibly tiny amount of something as simple as gasoline can pollute an incredibly large amount of water. In many instances, awareness of the kinds of poisons that are going into the water and what those poisons do to human beings is not as great in developing countries as it is in Europe or the United States.

Q: According to a report by The Johns Hopkins University School of Public Health, 48 countries will be affected by water scarcity by 2025. Do you think it may already be too late for some water-short countries with rapid population growth to avoid a water supply crisis?

A: Most people tend to think that water is free, and grow up thinking that there is a lot of it. Both are myths. Water is not free and there is not very much of it. If you look at the globe from outer space it looks like a water planet. However, while 70 percent of the globe is covered with water, only 3 percent of that is freshwater. Twenty percent of that freshwater is in the U.S. Great Lakes alone. Only 1 percent of the land surface of the entire world is made up of freshwater ecosystems. And probably half the world's population live near those freshwater ecosystems. Try to think of a city that's not built on a river. It's hard to imagine a place where we have not changed the nature of freshwater systems. And we now use, in one form or another — agriculture, industry — more than half of all the annually available freshwater in the world. So with the world population increasing at about 90 million people a year, the crunch is coming. Water is going to be a serious limitation.

Certainly, by the middle of the next century, there will be only three or four countries that have not experienced a major crisis due to water scarcity. The United States will be one of those that is affected — one of those countries that will have to deal with a major water scarcity problem. It is not too late for us to take action to more effectively and efficiently use water resources so that we can avoid the worst impacts of that scarcity. Scarcity will exist, but scarcity is a relative term. Depending on what freshwater systems are involved, possibly we could work through the scarcity with relatively little pain. Or it could be the kind of scarcity that forces people to move off the land as they did during the "dust bowl" that took hold in the south central United States in the 1930s.

Q: Is there anything specific we can do to avoid these water scarcity crises?

A: I think there's a lot we can do to avoid the worst aspects of water scarcity. But it's going to require much more investment than we're now putting into it, and it's going to require substantially more courage on the part of political leaders than has been demonstrated for some time.

The first thing we need to do is educate the public and corporations to make sure they understand the value of water. We also need to educate government officials so that they truly understand the consequences of allowing a plant to be built without appropriate pollution controls or the real cost of building a massive dam. We also need to invest in the capacity to do several things — to manage water, to understand what's happening in water systems, and to anticipate increases and decreases as a result of climate change — investing in these things in the developing world and even in the United States is probably the most important investment that we could be making right now.

Jim Fuller writes on environmental topics and other global issues for the United States Information Agency.

COMMENTARY

WATER SCARCITY IN THE JORDAN RIVER BASIN

by Mélanne Andromecca Civic

In the Jordan River basin, freshwater scarcity results from multiple factors and most severely affects Israel, Jordan, the West Bank, and the Gaza Strip. The eastern and southern parts of this region are semi-arid to arid, receiving as little as 50 to 250 millimeters of rainfall per year — dryer than Phoenix, Arizona — according to a new report jointly produced by the Israel Academy of Sciences and Humanities, the Palestine Academy for Science and Technology, the Royal Scientific Society of Jordan, and the U.S. National Research Council (NRC).

The most rainfall of the region, 1,000 millimeters, occurs only in a small area of highlands in the northwestern section. The estimated total renewable water supply for the region is approximately 2,400 million cubic meters per year, while water use averages 3,000 million cubic meters, according to a 1998 study compiled by the U.S. Geological Survey for the Executive Action Team of the Middle East Water Data Banks Project — a cooperative research project of the Israel, Jordan, and Palestine water services. The resulting deficit is met by extracting water, without recharge (replenishment) capability, from groundwater sources and underground aquifers.

Water use varies throughout the region. Israel's use is greatest, although only marginally greater than Jordan's, estimated at 2,000 million cubic meters. Usage on the West Bank and Gaza Strip is the lowest, one tenth amount, according to the NRC Joint Report. The daily allotment per person for drinking water in the Jordan River basin is lower than anywhere else in the world, according to a 1997 Food and Agricultural (FAO) report. Severe water rationing is not unusual during summer months in high population areas. The summer of 1998 and winter of 1999 were unusually dry. For several weeks during the summer, residents of Amman, Jordan, received municipally supplied water only two days a week. In March 1999, Israel ordered a 25 percent cut in supply to domestic agriculture and announced that it would be unable to meet this year's allocation transfers to Jordan from the shared Sea of Galilee and the Jordan and Yarmouk Rivers, committed to under the 1994 Treaty of Peace.

Nationalistic patterns of water usage and politically charged territorial assertions compound the region's competition over freshwater resources. Meanwhile, the over-exploitation of existing sources and harm to natural ecosystems in the basin compromise the recharge capacity of the system. Some progress has been made in recent years in regional cooperative management, equitable apportionment, and equitable utilization. However, gains generally have been trumped by the increasing stresses of urban development and other forms of human encroachment on natural

ecosystems. Critical ecosystem water resource threats include: draining of wetlands for agricultural and housing development uses; pollution of freshwater by industrial activities and untreated human waste; and contamination of rivers, aquifers, and lakes due to run-off from fertilizers and pesticides.

The combination of political strife, resource overuse, and contaminated sources means that freshwater scarcity in the Jordan River basin will reach a critical level in the near future. Consumptive use of freshwater tends to increase at twice the corresponding rate of population growth, according to a 1997 United Nations study entitled "Comprehensive Assessment of the Freshwater Resources of the World." If present rates of population growth and agricultural and industrial development continue, within the next 20 to 30 years all of Israel's and Jordan's freshwater will be needed for drinking water demands alone. Agricultural applications will receive only reclaimed sewage, and industry will have available only costly desalinated seawater. Currently, approximately 310 million cubic meters of reclaimed sewage wastewater is used in the region — 250 million cubic meters in Israel and 60 million cubic meters in Jordan — and as much as 1,800 million cubic meters may be available in the future, according to the NRC Joint Report. However, large-scale use of reclaimed wastewater itself is unsustainable because it can result in high mineral infiltration of soils and surface and ground-based freshwater sources.

Unilateral Water Development and Management

The political conflict endemic to this region is a major factor leading to nationalistic-oriented, unilateral, and unsustainable water management of the river basin. The individual national water development schemes that have evolved are the result of centuries of distinct local cultural and religious practices combined with historical influences. Legal impacts are also numerous and diverse, including the ancient Jewish and Islamic religious and social laws, the laws of the Greco-Roman Empires, the Ottoman Empire, and colonial British Mandatory rule — and, since 1948, international principles of apportionment and utilization.

During the initial years following the independence of Israel, 1948-1955, the various basin states were unable to reach agreement on any regional development or water apportionment plan. The governments of Israel, Jordan, Syria, and Egypt, as well as representatives of the United Nations and the United States, each formed proposals. The country proposals were domestically focused and therefore unacceptable regionally for practical and political reasons. Acceptance of the international plans was problematic because they presented novel approaches to water sharing and apportionment, and because a regional cooperative approach would, by definition, require the Arab League's acceptance of Israel as a legitimate state and resource user. Intense political conflict led to the rejection of all of these proposals, although the Johnston Plan has served since 1955 as an informal guide for some aspects of water allocation and use within Israel and Jordan. The Johnston Plan assimilated the proposals of the Arab League and Israel, and drew upon emerging international law principles, applying equitable considerations of existing beneficial use and planned future need. It assigned the largest share of the basin water to Jordan, followed by Israel, with a much smaller share to Syria, and the least amount to Lebanon. It gave each state sole authority to decide where and how to use its share of the water.

With formal rejection of the apportionment proposals, each state within the river basin proceeded with its national plans for water development. These plans tended to address immediate domestic needs and economic expansion, and created direct competition for and over-exploitation of shared water sources. Competition and scarcity contributed to security concerns. Many scholars assert that at least a dozen cease-fire violations between 1951 and 1967 can be attributed, in part, to conflicts over the region's freshwater supply. In 1955, Israel created the National Water Carrier to channel flow from the Jordan River for distribution to the expanding population of southern Israel and the Negev desert, and utilized the Johnston Plan's proposed allocations. Israel's population was growing at a rapid pace due to the greatly increased influx of post-World War II European Jewish refugees, and its development and plans outpaced those of its

neighbors. By means of the National Water Carrier, Israel hoped to provide potable as well as irrigation water to all parts of the nation. Syria and Jordan responded in 1964 by beginning construction of a dam to divert the flow of the waters of the Yarmouk and Baniyas Rivers of the basin and to defeat operation of Israel's National Water Carrier. These tensions contributed to the 1967 war when Israel bombed and destroyed the dam before construction was completed, and occupied the Golan Heights, the West Bank, and the Gaza Strip.

The territory acquired by Israel in the 1967 War radically changed its military and water security, and significantly expanded Israel's riparian access to and territorial control over the Yarmouk and the Jordan Rivers. The occupation increased Israel's direct physical control of freshwater by nearly 50 percent through three major sources: the headwaters of the Jordan River, including half the length of the Yarmouk River; the recharge region of the Mountain Aquifer; and the upper riparian territory of the Baniyas River. Israel was then able to complete the National Water Carrier, as well as extensive irrigation projects. Jordan also completed a major dam project at the eastern tributaries of the Jordan River, south of the Yarmouk, and develop a water distribution system.

Inroads to Regional Management

It was not until the mid-1990s that a shared-use approach would be productively considered. The Israel-Jordan Treaty of Peace of 1994, and the Agreement on Cooperation in Environmental Protection and Nature Conservation Between Israel and Jordan (Environmental Agreement) of 1995 are bilateral agreements calling for a cooperative approach for sharing and developing the Jordan River. The 1994 Israel-Palestinian Liberation Organization (PLO) Agreement on the Gaza Strip and Jericho Area, and its successor, the Interim Agreement on the West Bank and Gaza Strip (Interim Agreement) address cooperative water and sewage development. The 1996 Declaration of Principles for Cooperation Among the Core Parties on Water-Related Matters and New and Additional Waters (Declaration of Principles for Cooperation) is a multilateral agreement signed by Israel, Jordan, and the Palestinian National Authority.

The peace treaty acknowledges the insufficiency of freshwater sources for the region, and calls upon the parties to act in the "spirit of cooperation" in resolving short-term water shortages. Proposals integrated into the treaty anticipate joint construction planning and management of a storage dam on the Yarmouk, and the cooperative management of the groundwater of Emek Ha'arava. Specific allocations of water from the Yarmouk and Jordan rivers informally incorporate international equitable utilization principles. The treaty additionally provides for a Joint Water Committee to function as the implementing body of the Program of Action, to oversee water allocation, storage, water quality protection, information transfers and data sharing, and generally to coordinate action in alleviating water shortages.

The Environmental Agreement, although not ratified, nevertheless demonstrates the recent reconsideration of cooperative management of shared natural resources between Israel and Jordan. Article One articulates the spirit of cooperation: "The parties shall cooperate in the fields of environmental protection and conservation of natural resources on the basis of equality, reciprocity, and mutual benefit....They shall take the necessary measures, both jointly and individually, to protect the environment, and prevent environmental risks...in particular those that may affect or cause damage to...natural resources...in the region." Article Five outlines various programs of cooperation including the exchange of information, the sharing of scientific and scholarly data, and the promotion of joint scientific and technical research, as well as joint development projects. Article Ten provides for establishment of a Joint Committee on Environmental Protection and Natural Resources Conservation. The Joint Committee is to propose new projects, as well as monitor existing projects and the general performance of both parties.

The Interim Agreement on the West Bank and Gaza Strip establishes, in Article 40 of Appendix B, general principles for cooperation in water and sewage development, and provides for a joint water committee and joint supervision of shared resources, as well as cooperative enforcement teams.

The Declaration of Principles for Cooperation was the product of negotiations and cooperative studies of the Multilateral Working Group on Water Resources formed in 1992 to advance the Middle East peace process. The working group also endorsed the Water Data Banks Project in 1994 to regionally share and verify data, and to standardize collection techniques. The Water Data Banks Project promotes the regional management and protection of water resources with participation by scientific and technical experts from the several basin states.

Water Reform Priorities

Despite the consensus reached in these agreements in cooperative management, joint conservation, and equitable sharing, little practical movement in addressing the water scarcity problem has been taken over the past five years. The recent NRC Joint Report and the Middle East Water Data Banks Project mark the first two cooperative scientific projects among the various basin states, addressing the most critical water scarcity concerns and presenting practical suggestions. These reports and other scientific and independent studies assert that to avoid critical water scarcity in the Jordan River basin, reforms must be implemented on several fronts.

First, the basin states must continue progress toward a genuinely cooperative and integrated multinational and multi-use scheme of regional water sharing and development. The water basin is widely accepted as the natural and rational unit for the management and planning of river development, as opposed to the artificial management units imposed by political boundaries. Basin-wide management is also a cornerstone of equitable sharing and utilization principles and is integral to the Helsinki Rules of 1967 and the International Law Commission Convention on the Law of the Non-Navigational Uses of International Watercourses of 1997 (ILC Water Convention). However, neither classical nor modern international law principles of transboundary water sharing have been fully embraced by this region, due in part to the distinct cultures and highly volatile and complex political and security issues. Political tensions and the practical disparity of unbalanced bargaining alliances inhibit achievement of bilateral, multilateral, or regional agreement. Israel in particular may resist a regional management scheme in which it could find itself outnumbered by allying Arab states.

Second, information and technology sharing among and between basin states benefits region-wide.management The process of engaging scientists and other experts in collaborative management, development, and conservation efforts builds communication networks and, over time, may contribute to easing political tensions. Collaboration and information sharing also serve to verify reporting accuracy, which is critical to sound decision-making.

Third, conservation, not only of the water supply and delivery systems, but also of the ecosystem will reduce unnecessary waste and prevent further deterioration of water supplies. Aging and outdated water supply systems in Israel and Jordan lose as much as half of the transported water through leaks and excessive evaporation, according to the NRC Joint Report. Encroachment on wetlands, lakes, streams, and forests by urbanization destroys natural recharge sites — trees and other plant life that control erosion and filter water; lakes and streams that help diffuse toxins; and organisms that assist in decomposition of certain pollutants. Over-pumping of lakes and aquifers, and agricultural use of reclaimed wastewater leads to saline and other mineral encroachment into normally freshwater sources.

Despite recent progress, many problems remain. Nationalist-based interests, economic development, and unchecked water source exploitation continue to prevent optimal utilization of water in the Jordan River Basin. The critical nature of this resource, the ever-dwindling supply of freshwater in this basin, and the irrevocability of inappropriate policy measures require unified, definitive, and ecologically sound changes to current policies and practices to insure an adequate future water supply for all peoples of the region.

The author is an environmental intelligence analyst at the U.S. Department of State and has a master of laws degree in international and comparative law from Georgetown Uuiversity Law Center.

EVERY PRECIOUS DROP: STRETCHING WATER SUPPLIES

An interview with Sandra Postel, director of the Global Water Policy Project, a private research group and a senior fellow at the Worldwatch Institute, a research organization that reports on emerging global problems.

Postel says that looming water shortages in many parts of the world have the potential to spark domestic instability and international conflict. She has a forthcoming book to be released later this year entitled, "Pillar of Sand: Can the Irrigation Miracle Last?" Postel was interviewed by Charlene Porter.

Question: How do diminishing water supplies threaten social and political stability?

Postel: Some of the basic indicators of water problems and issues related to water supply — both physical and numeric indicators based on population and water availability — suggest that there are signs of trouble with regard to meeting all the demands for water we see coming ahead. If water shortage ends up, for example, causing food prices to increase, we know that rising food prices are a sign of social instability. We've seen that in a number of places just over the last few years — when governments, for one reason and another, have had to remove subsidies for food, we've seen riots in the streets in a number of countries. So anytime there's an increase in food prices in a poor country, you risk social instability. We've seen it happen in countries like Indonesia and Jordan; there were problems in India this year just from the price of onions.

The other clear sign of political instability has to do with what's occurring from increasing water demands in water-scarce river basins, where rivers are shared by two or more countries. A number of hot spots of potential water dispute exist where populations are continuing to increase rapidly, and where there's no treaty yet in place that determines how the river water should be shared by those countries.

The Jordan basin, the Nile basin, the Tigris-Euphrates river basin, the Amu Dar'ya and Syr Dar'ya rivers in the Aral Sea basin in Central Asia — these are areas where the demands for water are increasing. If you add up the estimated demands for river water in each of those areas, you find that they typically exceed the amount of water in the river.

For example, in the Nile basin, there is no way that Ethiopia, Sudan, and Egypt can all achieve their irrigation goals; there is just not enough water to go around. And there is as yet no water sharing agreement, no treaty, that includes all the key countries that sets out how that water should be shared. With populations expected to grow in each of these river basins by between 40 and 70 percent over the next 30 years, there will be increasing competition for a limited amount of water.

Q: Against that backdrop of potential instability, let's examine some of the solutions for effective water conservation and improved efficiency that you've studied. Let's start with the process of desalinating water. In one of your previously published articles, you wrote that some Arab nations are turning oil riches into water. What are the inherent long-range problems you see with desalination?

A: The cost. Desalination is very energy intensive. It takes a lot of energy to remove salt from water. It's an expensive source of supply, and that's why you tend to find it in places where energy is

readily available and relatively inexpensive. That's why I made the comment about turning oil into water, because very few other places can afford to do that. About half of all the desalination capacity is in the Persian Gulf region. At the moment, we're getting less than two-tenths of 1 percent of global water use from desalination, so it's a very small share.

I would see that share increasing because the costs are coming down and water constraints are becoming more severe. So the combination of improving technologies and rising costs of water would suggest to me we will see more desalination, but I still think, for the foreseeable future, it will be a relatively minor source of supply just because it will remain too expensive.

There's no way you could imagine irrigating with desalinated water. It's just way out of line with what farmers could afford to pay. And, of course, irrigated agriculture is far and away the biggest user of water. So I still see it as a last resort supply for drinking water, and not something that's going to really save us in terms of dealing with the seriousness of the water problem.

Q: Let's turn to water conservation issues in urban areas. Obviously, urban areas around the world have diverse situations as far as water supply goes, but generally speaking, what do you see as being some of the most effective techniques on the horizon for trying to encourage water conservation and more efficient use of supplies in major urban areas?

A: This is a big challenge. Many of these cities in developing countries have 10 to 20 million people. Mexico City has 15 million people. And it's very difficult to provide the infrastructure to supply that many people in a concentrated area with water; then equally difficult to collect the wastewater from all those households; then treat it; and then release it to the environment.

The infrastructure challenge with urban water supply is huge and very much of it is still unmet. Especially in the rapidly growing mega cities. You've got so many people in a concentrated area, and finding enough water within a reasonable distance of the city to supply that many people is very difficult. That's one part of the challenge. The other part is that, unlike irrigated agriculture where the water doesn't have to be of super-high quality, you need to have treated water, and then you need to somehow deal with the wastewater. This involves treatment plants and pipes and all kinds of expensive infrastructure.

So just keeping up with the rates of growth we're seeing in these cities is a big, big challenge. We've got about 2,500 million people living in cities now. And that's projected to double by 2025. There will be an estimated 5,000 million people in 2025. This is a really big challenge.

Many of the mega cities are having a difficult time with water supply and wastewater. If you look at most of these cities, they're not treating more than 10 percent — at the most 20 percent — of their wastewater. Most of the wastewater is still being released to the environment untreated in these mega cities. The rivers flowing through these areas are very, very polluted. Water quality is deteriorating as a result of industrial and municipal wastewater contamination. It's sort of a double whammy — you've got a water supply problem to begin with, and then you end up polluting some of the supplies you do have, rendering them unusable. Water quality and water quantity problems go hand-in-hand in these areas.

To me, the real tragedy is that, in the urban sector, the very poorest people generally lose out completely because they don't have access to piped-in water. The very poorest members of these cities in developing countries often have to pay a significant share of their income to buy water from vendors because they don't have access to the public water supply. These are people in the shanty towns on the outskirts of cities. Some of them spend a quarter of their income paying for water from vendors who bring it in by truck twice a week or so. So there's a huge inequity here: society subsidizes the piped-in water for urbanites, but it's the very poorest people who don't have any piped-in water at all who end up spending a huge share of their income for water. A very big problem.

The one thing that's important in these cities is that they build an efficient infrastructure into the urban water systems from the beginning, that they use the most efficient appliances and fixtures at the

household level that are available. Again, this is not generally being done.

In the United States, we now have a law that all new toilets, faucets, and showerheads that are manufactured have to meet a certain standard of efficiency. I think this type of policy would be very important in these rapidly growing developing countries, because it stretches the water supply right from the start. When you've got a household able to live with 30 percent less water than a neighboring one, that gives you more water supply to work with.

Q: Let's move on to water subsidy policies and how modification of those may encourage more conservation.

A: This is a big problem. Farmers in particular are getting heavy subsidies for irrigation water. It's difficult to find a situation where farmers are paying more than 15 to 20 percent of the real cost of the water. Generally, they're not getting enough incentive to use water efficiently in many cases. And so pricing water in a way that does give a better signal to farmers would be an important step in moving toward a more efficient use of irrigation water.

This is a complicated subject because in much of the Third World, water is not really delivered on demand as it is here. Water is sent through a canal and you take it when it's your turn. You don't have much of an option for using water differently. But where you do have water on demand, pricing structures can greatly influence how efficiently a farmer uses water.

I do think it would be difficult, overnight, to start charging the full cost of water. That would be very disruptive and could throw farmers out of business. Crop prices are very low. But there are various ways of structuring water prices to encourage farmers to use water more efficiently without causing an undue burden on them.

One of the programs that I've seen in California involves a pricing structure. This is in an irrigation district where they wanted to cut down on the amount of drainage that was causing contamination problems. What they did was price 80 percent of a farmer's prior use of water at the same level it had been in the past; but then they imposed a steep increase for the next 10 percent of overall usage; and a really steep increase for the last 10 percent. So it encourages farmers to try to reduce that use by 10 or 20 percent to avoid those steeper charges. It seemed to work. There are creative ways to do it without creating an undue burden on the farmer.

We've seen that where incentives exist, farmers do respond. Where they are able to, they do invest in more efficient technologies. We've certainly seen that, for example, in parts of Texas where the Ogalala Aquifer has been depleted — farmers have put in more efficient irrigation systems and reduced their water use.

What I'm seeing now are that low-cost methods of drip irrigation, which is a very efficient way of delivering water directly to the roots of crops, have been developed that allow this technology to spread much more widely than what we would have earlier thought. There's certainly potential for the traditional drip irrigation systems to be used much more widely than they have been. In addition to that, these low-cost systems can now make drip irrigation available to small farmers, and poor farmers who often are the ones who have a scarce water supply to begin with and can benefit from technologies that allow them to spread that water more widely.

I visited some of these systems in India last year, particularly in the hill areas of the lower Himalayas in northern India, where farmers have water scarcity problems in the summer. They routinely said to me they would be able to double their crop land area if they had enough water. So drip irrigation allows them to take the water supply they do have and maybe get twice as much use out of it by allowing them to use it more effectively. These kinds of things have not been pushed that much; they're just starting to get attention.

Q: Besides drip irrigation, are there other new types of irrigation methods that may offer promise for the future?

A: Sprinkler technology is another good one that could be used more widely. Micro sprinklers in

particular. Once again, I'm thinking of the small farmer. Particularly in developing countries, irrigation technology has generally been geared toward larger farms. The canal systems often deliver water to farmers on small plots, but where surface water is unavailable and farmers have to rely on ground water, they typically have had trouble accessing ground water for small plots because the technologies are too expensive. The micro irrigation technologies, the small-scale drip, and micro sprinkler can benefit the small farmer, and they tend to be efficient ways of using water.

The micro sprinkler is not that different from a regular backyard sprinkler. You move it around the acreage you've cultivated, move it around six or seven or eight times on an acre of land to irrigate your crops. You can use it on a crop like wheat that isn't appropriate for drip systems, but it tends to be more efficient than a gravity-based system using flooding or a furrow-based system. You deliver less water more uniformly so you can water the crop with less water than with flooding furrows and ditches.

Improving efficiency in water supply systems overall is dependent on getting incentives right, and getting the institutions working better is a key thing. And more farmer involvement, more accountability throughout the system so that when farmers pay more for water they should see an improvement in their system.

These kinds of things — they sound sort of mundane, but they are so important to the way things work.

Charlene Porter writes on global issues for the United States Information Agency.

MANAGING WATER SCARCITY SOUTHWESTERN STYLE

By Rita P. Pearson

Arizona, located in the southwestern part of the United States, is one of the nation's driest states, with an average rainfall of 18 centimeters per year. Arizona is part of the Sunbelt, a band of states in the southern part of the United States that are among the fastest growing states in terms of population. Many older Americans are choosing to retire in these states. Arizona also offers a range of recreational activities that make it attractive to new residents. All of these elements constitute an enormous challenge for the state's Department of Water Resources as it tries to address an expanding need for a finite and increasingly valuable natural resource.

Since before recorded history, humankind has thrived in Earth's harshest, most hostile environments only when a reliable, clean water source is available. In the American Southwest, the hottest and driest part of the country, a sufficient water supply has enabled a modern society to grow where otherwise it would not.

As the person responsible for managing the water supply in Arizona, it is my task to make sure our 4.7 million people have a dependable supply of clean water for personal use, agriculture, industry, and recreation.

Unlike mineral resources, water is in some sense a "renewable" commodity. However, we cannot control where rain occurs or how quickly the snowpack melts, so greater flexibility is warranted in water management policy than, for example, in managing a forest ecosystem, where trees can be cut, replanted, and later harvested on a specific location.

At the Arizona Department of Water Resources (ADWR) we:

- administer state laws related to water quantity;
- manage the use of surface and groundwater resources under state jurisdiction;
- explore methods of augmenting water supplies to meet future demands;
- manage floodplains and non-federal dams; and,
- develop policies that promote conservation and equitable distribution of water.

Specifically at ADWR, we negotiate with federal and state agencies to guarantee Arizona's long-term Colorado River water supply. Concern over possible water shortages has resulted in the initiation of studies to augment the Colorado River by weather modification and vegetative management. Exotic methods of augmentation such as desalination of seawater have been evaluated, but high costs make these schemes infeasible at this time.

LOCAL PHILOSOPHY

Under the U.S. government structure, primary responsibility for water resource management rests with the individual states. Federal agencies oversee the interrelationships among the states, especially where a multi-state resource such as the Colorado River is concerned. The federal government is our partner in many ventures. But if history has taught us anything in this century, it is that local planning and local responsibility over water supplies usually works best.

The essential advantage in a system such as this is our ability to adapt administrative policies to local conditions. For example, in Arizona, even though there are common climatic and topographical characteristics, the hydrological conditions vary widely. In one desert region, there is such an abundance of groundwater that it is prudent to allow the aquifer to draw down significantly. In a neighboring region, however, there is a serious groundwater overdraft. If the national government were in control of management policy, it would be difficult to mold policy in a timely manner to provide the best oversight of the resource. With management at the state level, this is not so daunting a task.

The federal government took the lead in the first half of this century by initiating a number of large water-development projects in the western United States. Huge dams were constructed on mighty rivers such as the Columbia and the Colorado. The U.S. Department of the Interior still manages many of these projects.

However, the states and local governments that make use of the water are the primary managers. In general, state agencies work to establish firm, dependable supplies of water in their jurisdictions. The state agencies execute contracts with other governmental entities for supplies of surface water from rivers and reservoirs.

In our regulatory role, we set rules for drilling wells and establish safe limits for pumping water from underground. Certain areas of our state, for example, have experienced severe depletion of the water supply, so it has become necessary to impose strict limits on future pumping.

At the municipal level, city water departments ensure the water they deliver to residential and industrial customers meets health and quality specifications. The cities also set water rates for their various residential and industrial customers. Agricultural users generally obtain their water through quasi-governmental agencies such as locally formed irrigation districts. Survival of agriculture is an important goal, so surface water supplies delivered to farmers are heavily subsidized. In this way, farmers are able to get the large quantities they need at prices much lower than municipal customers pay. As you might imagine, food prices depend heavily on the cost of essential resources such as irrigation water.

GROUNDWATER

For a desert environment that receives only about 18 centimeters of rain annually, Arizona has a surprising amount of water. We are blessed with huge underground water tables, called "aquifers," where massive quantities of good water have been stored for millions of years. About 40 percent of the water used in Arizona comes from these groundwater basins. Conservation of this difficult-to-replace asset for the future is our great challenge.

Throughout this century, groundwater has been pumped out more rapidly than it is being replenished, creating a condition called overdraft. To reverse this trend, the state of Arizona enacted the 1980 Groundwater Management Act. Authorities recognize the Act as one of the most progressive groundwater management initiatives in the nation. The goal of the groundwater code is to reach "safe-yield" by 2025. Safe-yield is a condition where the amount of groundwater withdrawal equals the amount of aquifer recharge (when there is a balance between water being taken out and water coming in to the aquifer).

We have designated five groundwater basins where overdraft is occurring as "active management areas" (AMAs). Eighty percent of Arizona's population resides in the five AMAs. Authority to commence residential and industrial development in these areas is subject to the ability to demonstrate an assured water supply for 100 years.

A number of groundwater recharge projects, under the direction of the Arizona Water Banking Authority, will be undertaken to replenish the aquifers. It takes a long time to rebuild a depleted aquifer, if, in fact, replenishment is possible.

SURFACE WATER

In our largest metropolitan area, Phoenix, we have a network of canals based upon irrigation ditches laid out and dug 800 years ago by the original

Native American inhabitants of the Valley of the Sun, the Hohokam Indians. These ancient engineers were master surveyors, and they determined exactly where canals needed to be dug to provide a gravity-flow system of irrigation for their crops.

When the Phoenix area began to grow about 130 years ago, the new inhabitants set out to improve and modernize this ancient canal system. The dirt ditches have been lined with concrete, and additional kilometers of waterways have been dug throughout the vast Valley of the Sun and beyond. Today, a liter of water that enters Arizona at Parker Dam on the Colorado River can travel upwards of 800 kilometers before it is used in the southern part of the state.

The Salt-Verde and Gila watersheds in the eastern mountains and the Agua Fria River in the central mountains fill a chain of lake reservoirs that serve the dual purpose of storage and recreation. Rain and the melted mountain snowpack offer thousands of boaters, swimmers, and fishermen a cool respite from summer heat on these desert lakes and rivers, while at the same time the water is being drawn down for municipal and industrial purposes.

In times of excess runoff on the watersheds, these lake reservoirs cannot hold all the water available. Although we do not like to do it, a significant amount of water is released from the dams and it is not uncommon to see normally dry riverbeds running from bank-to-bank with rushing water. We presently are incapable of recapturing this water, and it generally flows down the Salt-Gila system to Yuma, where it enters the Colorado River just above the U.S.-Mexican border.

COLORADO RIVER

Phoenix and Tucson, our state's principal cities, must supplement the water from these watersheds. A 536-kilometer concrete canal, the Central Arizona Project, channels water from the Colorado River to Phoenix and Tucson. This great engineering feat was made possible by a dedicated, forward-looking group of citizens and elected representatives who were able to envision what Arizona might become if a large and predictable water source were available.

The Colorado River begins in the Rocky Mountains in the state of Colorado and courses more than 2,300 kilometers to the Sea of Cortez in Mexico. Originally, the Colorado was a wild and untamed river. At one time, it even broke through levees in California and formed what is now called the Salton Sea. To control the river and bring some regularity and dependability to bear, the U.S. government in the 1930s built Hoover Dam. It was construction of this dam, and the later Glen Canyon Dam upstream, that made possible the modern-day miracles of the urban desert. Because the Colorado River is so vital to the southwestern United States and Mexico, it has become one of the most regulated and managed rivers in the United States.

Seven states (Arizona, California, Nevada, Colorado, Utah, New Mexico, and Wyoming) and the Republic of Mexico draw life-sustaining water from this mighty river. Each year, more than 7.5 million acre-feet of water (one acre-foot is about 1,238,800 liters) are allotted to Arizona, Nevada, and California - the Lower Basin states.

The Lower Basin allotment provides water to more than 17 million people and to more than 1 million acres of farmland. Hydroelectric plants on the river generate about 12,000 million kilowatt-hours of electricity annually.

As large as the Colorado system is, the potential for water shortages on the river is real. When the allotment agreements were reached, the annual Colorado flow was estimated at 18 million acre-feet. Today we know the annual flow is more in the neighborhood of 14 million acre-feet, so it is easy to understand how oversubscribed the river will be when it is utilized fully.

Surface water from rivers, lakes, reservoirs, and elsewhere is apportioned through a hierarchy of rights under a doctrine of "prior appropriation."

In the United States, prior appropriation is a concept unique to the Western states. Simply put, prior appropriation means "first in time, first in right." In other words, the first person to put the water to beneficial and reasonable use acquires a right superior to later appropriators. This person or their successors have the right to use a specified amount of water for a stated beneficial use each year, subject only to the rights of prior appropriators.

Although the allocation of the Colorado River was not subject to the doctrine of "prior appropriation," in order to get federal funding to build the canal system to deliver Colorado River water to our state, 1.5 million acre-feet of Arizona's allocation is the "junior" use.

In years of drought, we may be required to take less from the river than our 2.8-million acre-foot allotment. This will work a hardship for our citizens, so we actively encourage conservation techniques and efficiency.

EFFLUENT WATER

A fourth supply of water, obtained through the re-use of so-called "gray" water, will play an increasingly valuable role as people become more comfortable with the idea of using recycled effluent water. Reclaimed water is the one increasing water source in our state. As our population and water use grows, more treated wastewater will be available. Reclaimed water is treated to a standard of cleanliness that permits us to use it for a variety of purposes, including golf courses, parks, industrial cooling, and maintenance of wildlife areas.

Initially, there can be a natural human resistance to a program of reusing wastewater. There are a number of strategies being developed to make this more acceptable. Most of the effluent projects under way do not envision turning this into a supply for household uses. There is a wide array of other potential uses for effluent. Indeed, our department is working on plans that will permit housing developers to obtain their assured water supplies by agreeing to exchange the effluent from the residential projects for surface or ground water.

In addition, there are other sources of effluent besides household wastewater. Industrial operations are large users of water, so it makes sense to recapture and reuse significant quantities of this water. Also, frequently there are large quantities of runoff from agricultural irrigation that can be captured, treated, and reused. We believe the people we serve expect us to be imaginative, resourceful, and creative in our management practices.

USERS

Agencies such as ADWR are responsible for delivering water to a variety of users. A complex hierarchy of water rights controls who is entitled to share from the common supply.

Native American Tribes. About 28 percent of Arizona's land — an area the size of Austria — is held in trust for Native American tribes. Many tribes have lived in the region for hundreds of years. The fact that Native American water rights claims are usually very senior and, in many cases, unquantified demonstrates the importance of resolving this issue.

There are two means by which Native American water rights claims are resolved in Arizona: negotiation of water rights settlements and the adjudication of water rights.

Establishing Native American water rights is an important point of negotiation among state and federal agencies, in addition to the tribal interests that claim allotments of water. States throughout the nation are negotiating with Native American tribes to settle claims to water for tribal purposes.

The United States Supreme Court in 1908 determined that federal reservations for Native Americans were allocated enough water at the time the reservations were established. Within Arizona's surface water law doctrine of prior appropriation, the priority date of the water right corresponds to the date a reservation was established. Generally in Arizona, this time precedes extensive non-Native American settlement, so Native American water rights are senior to rights held by non-Native American users.

Until these rights are quantified, non-Native American water users with junior water rights face considerable uncertainty when planning their long-term water use.

Agriculture. Farmers in rural areas have long-established claims to groundwater supplies, and they sometimes make complicated agreements to identify and perpetuate their claims to water for their crops.

Through common associations such as irrigation districts, farmers enter into delivery contracts with

other quasi-governmental agencies such as the Central Arizona Project, which delivers Colorado River water, and the Salt River Project, which manages the surface water from the Salt-Verde region.

The hierarchy of water rights places a high value on seniority, and thus creates an active market in the sale and purchase of these rights. Before 1919, a non-Native American person acquired a water right in Arizona by one of two methods: simply by putting the water to a beneficial use, or by posting a notice and recording a water right claim with the county recorder. Therefore, the records of early rights took on a variety of forms.

In 1919, the state legislature enacted the Public Water Code, establishing procedures for developing a right to use appropriable, or public, water. Since then, no right to use surface water can be acquired except by following this strict statutory procedure, which has remained substantially unchanged.

Cities. In the cities, municipal governments have claims on water supplies. In a growing Sunbelt state such as Arizona, municipal water interests will be in negotiations for decades to come in order to assure reliable sources of water. It is part of our long-term strategy that agricultural water rights will be converted to municipal and industrial rights as our state becomes more urbanized and the scope of agriculture diminishes.

Rita P. Pearson is director of the Arizona Department of Water Resources.

THE BERMEJO RIVER FLOWS BEYOND ITS BANKS

By Charlene Porter

In the mythology of ancient times, earth, sea, and sky were the domains of different gods, each deity a separate entity with a sphere of its own. Land, water, and air were also viewed distinctly in the early practice of environmental management. Just a few decades ago, specialists tended to focus on a single problem — air pollution or wastewater discharges or toxic dumping — with little recognition of how one problem could affect the other. Increasingly today, environmental scientists are recognizing how the different elements of the natural world interact, and how they defy the national boundaries drawn by humankind.

In the Bermejo River Basin, shared by Argentina and Bolivia, a new approach to environmental management is being tested as a means to a better life for the many impoverished people who live there. Assessing resources and demands in an entire river watershed, the approach aims to integrate environmental and development concerns in a plan for the region's future. With financial support from international backers, Argentina and Bolivia are conducting a wide-ranging study of a border-spanning watershed that sprawls over 190,000 square kilometers. The two countries want to learn how to make better decisions about development, decisions that will preserve the environment and improve economic opportunity for the 1.2 million people of the region.

"This is the main objective, to identify the specific actions that can be taken to resolve problems of development and use of natural resources in a better way," says Jorge Roucks, a regional planner with the Unit of Sustainable Development and Environment at the Organization of American States (OAS). From its Washington, D.C., headquarters, the OAS is serving as the executing agency, manager, and funding partner in the Bermejo project, which is also receiving financial support from the Global Environment Facility and the United Nations Environment Program.

"There are many requirements for bettering the region that they must resolve using the water of the Bermejo," Roucks says. The Bermejo River Basin project will lead to a plan for sustainable development in the area.

The region has abused resources in the past, according to Enrique Bello, an agricultural economist at the OAS. "It has a history of destructive practices: deforestation, over-grazing, loss of soil cover, and erosion." Of all of these, erosion may be the single-most damaging factor; Bello even describes some places as being "like a moon landscape."

The loss of topsoil through erosion can destroy farmland, depriving farmers of their livelihood. Steady deposits of soil in the river block its channels, impeding navigation. The Bermejo flows into the La Plata river system, which Roucks calls the economic artery of the entire region. Thus the abnormally high sedimentation in the Bermejo is a great concern downstream also.

Significant accumulations of sediment contribute to flooding because the river overflows its banks in the rainy season when the river channel is too clogged to carry the flow. In February, the provincial government of Corrientes-Argentina issued a warning to people throughout the Chaco Province of northeast Argentina predicting a possibility of heavy rain and flooding through April. Last year, seasonal floods caused millions of dollars in lost crops.

Seasonal drought brings other hardships to the Tarija region of Bolivia at the headwaters of the Bermejo river. Low rainfall makes agriculture unproductive, and many farmers become temporary refugees, leaving their arid lands to subsist in some other way in Argentina.

Development as well as environmental concerns take a prominent place in the Bermejo River Basin project. Richard Meganck, director of the OAS Unit of Sustainable Development and Environment, says, "You could leave that basin as it is and allow conditions to deteriorate, and opportunities would be lost over time. Or you can invest to improve the situation and provide more opportunity. We define development as improving the quality of life, improving a person's lot in life."

Providing alternative livelihoods for people whose current activities threaten environmental conditions in the Bermejo basin is a major goal. Overlogging in the jungles is one environmentally damaging activity that the people of the region should reconsider to preserve both the forest and the river. Enrique Bello says, "The jungle is the most important area for the feeding of the river because of the rains; and if you lose this forest you lose one of the most important sources of the feeding of the river. To preserve this forest is a main issue."

The study will explore ecotourism as one strategy for forest preservation and increased economic opportunity. Bello describes ecotourism as "an activity that uses the forest, but doesn't destroy it." A related component of the study will also assess a proposal to link two national rainforest parks, one in Argentina and one in Bolivia, with a land corridor, enlarging the habitat for tropical species.

Such a binational park is in keeping with the cooperation that Argentina and Bolivia have demonstrated in their efforts to improve conditions in the Bermejo watershed. That cooperation was institutionalized in 1995 with agreement on a treaty creating the Binational Commission for the Development of the Upper Bermejo River Basin and Grande de Tarija River.

The OAS has been working with the two countries for nearly 20 years, attempting to improve conditions in the watershed. Bello says, "The Argentineans know that whatever happens upstream in Bolivia is going to affect them so they're going to work together on this."

It's a philosophy the OAS has applied throughout Latin America. Meganck says, "Years ago we started working on a watershed basis. Water doesn't respect a political boundary, nor do watersheds always respect political boundaries...and that meant we had to get agreement between or among countries...such that you are managing a resource in an integrated fashion."

The OAS is working with a variety of Latin American binational partnerships in managing water resources. Peru has engaged in separate watershed partnerships with three of its neighbors, Colombia, Brazil, and Bolivia. Brazil and Colombia have an agreement in the use of the Tabatinga-Apaporis Axis. Costa Rica and Nicaragua are working together in management of the San Juan River basin.

These and most other countries in the hemisphere sent representatives — water managers, academics, and technical experts — to Panama March 21-25, 1999, for the Third Inter-American Dialogue on Water Management. The conference was organized by the OAS-sponsored Inter-American Water Resources Network. "This conference will give us a detailed framework for the future, for the management of water resources, for the role of government and civil society in this task," said Meganck in advance of the meeting.

Efforts to find new answers in the Bermejo River basin are motivated by a new integrated form of environmental science, the economic hardships of the people of the region, and a new economic dynamism inspired by Mercosur, the Mercado Comun del Sur or Common Market of the South. Argentina, Brazil, Paraguay, and Uruguay formed the alliance in 1994 to strengthen economic development through integration.

The Mercosur agreement also places a special emphasis on social justice, efficient use of available resources, and preserving the environment. OAS economist Bello says this agreement will nudge the

region beyond low level agriculture into a higher level of investment and industrialization than it has ever known before.

Reliable and well-managed water resources will be critical to that development, and to improvement in the way of life for the people of the Bermejo watershed region. Richard Meganck says the cooperation that Argentina and Bolivia are demonstrating is the only reasonable course for nations to follow as they attempt to manage their water resources. He says, "Water has risen to the top of the international agenda. It's either going to encourage investment or it's going to lead to war. So we better do it right."

Charlene Porter writes on global issues for the United States Information Agency.

REPORTS AND DOCUMENTS

WATER-WISE: A WELL OF FACTS

If the world's water supply is compared to one gallon (3.8 liters), freshwater would make up 4 ounces (118 milliters) or 3 percent, and readily accessible freshwater would make up 2 drops. (Miller, G.T. 1998. *Living in the Environment,* 10th Edition. Wadsworth Publishers, Belmont, California)

••••••••

Humans beings already use approximately 54 percent of all accessible surface water runoff (usable, renewable freshwater). This is expected to increase to 70 percent by 2025. (Postel, Daily & Ehrlich. 1996. "Human Appropriation of Renewable Fresh Water." *Science* 271:785-788)

••••••••

Today, at least 400 million people live in regions with severe water shortages. By the year 2050, it will be 4,000 million. (Hinrichsen, D., B. Robey, and U.D. Upadhyay. 1998. "Solutions for a Water-Short World." *Population Reports,* Series M, No. 14, Johns Hopkins University School of Public Health, Population Information Program, Baltimore, Maryland)

Just a 10 percent improvement in efficiency of water delivery for irrigation systems could conserve enough water to double the global amount available for drinking. (*Environment On-line,* http://solstice.crest.org/environment/eol/water/water7.html)

••••••••

Nearly 40 percent of the world's people live in more than 200 river basins that are each shared by at least three countries. (Serageldin, I. 1995. "Toward Sustainable Management of Water Resources." The World Bank, Washington, D.C.)

••••••••

Some 450 cubic kilometers of wastewater are carried into coastal areas by rivers and streams every year. These pollution loads require an additional 6,000 cubic kilometers of freshwater to dilute the pollution, an amount equal to two-thirds of the world's total stable runoff. (Hinrichsen, D. 1998. "The Ocean Planet." *People and the Planet* 7(2):2-4)

By 2025 population projections indicate that 75 percent of the world's population (6,300 million people) could reside in coastal areas. (Hinrichsen, D. 1998. *Coastal Waters of the World: Trends, Threats, and Strategies.* Island Press)

••••••••

In Asia, approximately 86 percent of all freshwater use is for agriculture, 8 percent for industry, and 6 percent for domestic purposes. (European Schoolbooks (ES). 1994. *The Battle for Water: Earth's Most Precious Resource. ES,* Cheltenham, UK)

••••••••

Asia, with 60 percent of the world's population, has only 36 percent of global freshwater runoff, and 80 percent of that occurs in floods from May to October, exceeding man-made storage capacity and making it difficult to capture. (Clarke, R. 1993. *Water: The International Crisis.* MIT Press, Boston, Massachusetts)

Over the next two decades, population increase alone — not to mention growing demand per capita — is projected to push all of the Near East into water scarcity. (Hinrichsen, D., B. Robey, and U.D. Upadhyay. 1998. "Solutions for a Water-Short World." *Population Reports*, Series M, No. 14, Johns Hopkins University School of Public Health, Population Information Program, Baltimore, Maryland)

••••••••

Asia's rivers average 20 times more lead than the rivers in the industrialized world, and average 50 times more bacteria from human feces than WHO guidelines allow. (Kristof, N.D. 1997. *New York Times* 11-28-97, "Across Asia, a Pollution Disaster Hovers," p. A1)

••••••••

About 500,000 Asians per year die from dirty water and poor sanitation. (Kristof, N.D. 1997. *New York Times* 11-28-97, "Across Asia, a Pollution Disaster Hovers," p. A1., citing WHO and The World Bank)

REVIVING THE WATERS: CLEANING UP AMERICA'S GREAT LAKES

In 1969, a floating oil slick on the Cuyahoga River burns for hours in Cleveland, Ohio, where the waterway empties into Lake Erie — one of the five American Great Lakes that make up the world's largest system of inland lakes. Newspapers declare "Lake Erie is Dead."

In 1970, mercury pollution in Lake Erie and other waterways in the Great Lakes system bordering Canada and the United States leads to a ban on fishing in parts of the region. A chemical plant in Canada is thought to be the source of potentially dangerous discharges.

In 1970, the state of Michigan issues a warning to the public about consumption of fish from Lake Michigan. High levels of residues from toxic PCB (polychlorinated biphenol) are found in lake trout and salmon.

In 1972, the U.S. Congress passes the Clean Water Act.

These events through the 1960s and 1970s were critical in developing a national awareness about the damage done by unregulated industrial and wastewater discharges into the Great Lakes. The pollution of this magnificent natural resource became a celebrated cause for environmental activists, just beginning to build public support at that time. Today, substantial progress in the clean up of this unique water system is one of the nation's great environmental success stories.

The following excerpt from a report tracking the restoration of the Great Lakes was originally published in January 1998 by the Office of the Great Lakes, Michigan Department of Environmental Quality. The report is available online in full at: www.deq.state.mi.us/ogl

GREAT LAKES TRENDS: A DYNAMIC ECOSYSTEM

In 1972, the United States and Canada signed the Great Lakes Water Quality Agreement. The agreement was amended in 1978 and 1987. The purpose of the agreement is "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes basin ecosystem." Both parties, the United States and Canada, agreed to "make a maximum effort to develop programs, practices, and technology necessary for a better understanding of the Great Lakes basin ecosystem, and to eliminate or reduce to the maximum extent practicable the discharge of pollutants into the Great Lakes ecosystem." In the agreement, the Great Lakes ecosystem is defined as "the interacting components of air, land, water, and living organisms, including humans, within the drainage basin of the St. Lawrence River at or upstream from the point at which this river becomes the international boundary between Canada and the United States." The agreement represents a broad commitment to Great Lakes basin health.

OVERVIEW

The five Great Lakes hold more than 6,000 trillion gallons of water, about one-fifth of the world's fresh surface water supply. This ranks them among the 15 largest lakes in the world by surface area and volume. These lakes provide drinking water to 23.5 million people. Residents in both the United States and Canada rely heavily on the lakes for not only drinking water but also for recreation, food, and transportation.

THE WORLD'S TWELVE LARGEST LAKES

Lake	Surface Area (Km2)	Volume (Km3)
Superior (N. America)	82,100	12,230
Victoria (Africa)	68,460	2,700
Huron (N. America)	59,500	3,537
Michigan (N. America)	57,750	4,920
Tanganyika (Africa)	32,900	18,900
Baikal (Asia)	31,500	22,995
Great Bear (N. America)	31,326	2,381
Great Slave (N. America)	28,568	2,088
Erie (N. America)	25,657	483
Winnipeg (N. America)	24,387	371
Malawi (Africa)	22,490	6,140
Ontario (N. America)	19,000	1,637

Sources: The Water Encyclopedia, 1990, Herdendorf, 1982.

The open waters of the upper Great Lakes, being Superior, Michigan, and Huron, have excellent water quality overall. The only exceptions are a few degraded locations restricted to nearshore zones and mainly in urban areas. Lake Huron's water quality has improved even more in the past few years resulting from improved quality in the Saginaw Bay. Moreover, Lake Erie water has drastically improved over the last two decades.

In 1980, the focus of the activity on the Great Lakes was toxic chemicals, nutrient loading, and their effects on wildlife. The sustainability of the Great Lakes fisheries, including the impact of exotic species introduction, then became a paramount issue. Below is a summary of the most apparent trends through the early 1990s:

- Polychlorinated biphenol (PCB) levels in herring gulls and coho salmon, and in the water column of Lake Superior, had declined significantly since 1980. The trend was the same for most of the Great Lakes fish except for the coho and chinook salmon in Lake Michigan. The PCB levels in lake trout have not shown a steady downward trend since 1986. Nevertheless, contaminant levels are not simply a reflection of the environmental concentrations. Other factors such as fish lipid content, position in the food chain, and the trophic structure of the wildlife also determine the distribution of persistent organic contaminants in the environment.
- As of 1993, releases of hazardous chemicals tracked through the Toxic Release Inventory declined for the fourth straight year. This inventory requires manufacturing facilities meeting certain activity thresholds to report their estimated releases, transfers, and storages of the listed toxic chemicals. Once the Pollution Prevention Act of 1990 was passed, facilities are now directed to report additional waste management and pollution prevention activities. Requiring these added responsibilities has helped to lower the outputs of the listed chemicals.
- Phosphorus levels in the open waters of Lake Superior and Lake Michigan, along with loadings from the Detroit River have decreased significantly since the 1970s. In addition, nutrient enrichment has decreased in many nearshore waters of the lakes, with water quality dramatically increasing in these areas.
- Fish populations are drastically different since the 1800s due to the changing conditions in the Great Lakes. As a result of commercial and sport fishing, introduction of non-native species, and degradation or loss of spawning and feeding habitat, Great Lakes fish are smaller, live shorter lives, and survive in sometimes substantially reduced numbers. Great Lakes fisheries data indicate shifts in species and different species assuming dominance in the food web.

- Zebra mussel populations have increased dramatically since their introduction in the Great Lakes. Native mussel populations are being adversely affected. In Lake St. Clair, the U.S. Fish and Wildlife Service announced in 1992 that no viable native mussel populations were left. Research initiated in the spring of 1993, with the cooperation of the Michigan Sea Grant, indicated the presence of zebra mussel larvae (veligers) in 11 of 31 inland lakes studied in Michigan.

- The sea lamprey populations are essentially under control everywhere except the St. Marys River. Improved water quality (primarily from the clean up of steel and pulp and paper industries) and the creation of spawning habitat have led to sea lamprey resurgence. The search for innovative and cost-effective measures to control the lamprey continues.

The Great Lakes watershed continues to have problems with persistent bioaccumulative toxics such as PCBs, chlordane, mercury, and dioxin. Based on the amount of PCB uptake by fish, water quality standards are not being met for PCBs in Michigan waters of the Great Lakes. Since the 1970s, when many persistent bioaccumulative toxics such as PCB and DDT were banned, levels of these toxics in Great Lake fish tissues have declined. However, the rate of this decrease in measured toxics appears to have slowed in the last few years. Currently, contamination from these persistent bioaccumulative toxics is believed to come primarily from in-place pollutants resulting from historical discharges and atmospheric deposition.

Also, the loss of coastal wetlands and shorelines has accelerated. The wetlands and shorelines that existed in the Great Lakes basin are only a fraction of the system that occurred two centuries ago. For example, an 80 percent loss on Lake St. Clair, a 70 percent loss on Lake Erie, and a 50 percent loss of coastal wetlands in Saginaw Bay have been reported.

Wetland loss changes the biological and chemical make-up of the waters that pass through them to the open waters of the Great Lakes. The adverse effects to wetlands from dredging, draining, diking, pollution (particularly sedimentation), and water level management have contributed to degradation of Great Lakes water quality and the decline of fish and wildlife populations dependent on the coastal and river mouth areas of the Great Lakes.

Very little is known about recent changes in the abundance of coastal wetlands based on surrounding conditions. Regulatory programs at both the state and federal levels have essentially achieved a "no net loss" goal for coastal wetlands, at least in terms of direct losses from land use changes. High water levels, wave erosion, and other natural processes are more likely to be responsible for any significant changes in coastal wetlands.

The National Oceanic and Atmospheric Administration, in cooperation with the U.S. Geologic Survey, is updating obsolete shoreline maps of the Great Lakes. They discovered that offshore sand of southwest Lake Michigan shore, which provides protection for the underlying glacial till and for the bluffs along the margins of the lake, was thin to non-existent in many areas, due to geologic processes during the past 50 years. They intended to study the processes affecting sand movement in order to better determine the most effective long-term shoreline and property protection measures. The study, initiated in 1991, took place from St. Joseph, Michigan, south to Michigan City, Indiana.

Great Lakes policy has expanded from one that was focused on chemical pollution toward a broader view that also encompasses physical and biological threats, including habitat destruction and exotic species introduction. In the 1992 National Water Quality Inventory Report to Congress, the U.S. Environmental Protection Agency reported that 95 to 100 percent of the rivers and inland lakes assessed in Michigan received a "good" rating. However, there are still problems that remain. The major problems associated with Michigan rivers are fish consumption advisories, siltation, and contamination by metals and bacteria. The reports identified significant concern in the assessed areas primarily demonstrated by the existence of public health fish consumption advisories.

All Michigan waters of the Great Lakes fully support secondary contact recreation (non-swimming), agriculture, industrial, and navigation uses. Less than two kilometers of Great Lakes shoreline is not meeting swimming use requirements due to beach closings related to bacterial infestation of Lake St. Clair. However, local health departments routinely issue total body contact advisories in areas downstream of combined sewer discharges to the connecting channels (e.g. St. Marys River). Some water at the intake in Saginaw Bay also is not meeting drinking water standards. Aquatic life use, as inferred from fish collected in 1994 and 1995, is not fully supported due to fish consumption advisories for the Great Lakes. However, some fish consumption advisories have been revised, removed or relaxed.

SUMMARY

The general long term trends of the Great Lakes are:

Chemical

Toxic: General decrease of concentrations in water over the last 20 years. However, the rate of decrease has slowed. Open water sediment concentrations have decreased. Localized area problems and some chemical specific issues still exist.

Conventional Pollutants: Nutrient levels have decreased. Dissolved oxygen levels have improved. Chloride and nitrogen levels appear to be increasing.

Physical

Land Use: Continued loss of coastal wetlands occur in some areas; residential and commercial areas are expanding; agricultural lands are declining. Land use decisions in the Great Lakes basin impact the quality of the Great Lakes.

Water Levels: Projected water levels are high and show no immediate return to the long-term mean.

Biological

Fish: Some improvements in Great Lakes fisheries have been realized. Contaminant levels in fish have decreased, but the rate of decrease has slowed. Habitat destruction and introduction of exotic species are a serious concern.

Birds: Great Lakes fish-eating birds have shown population increases, the important limiting factor being physical habitat.

Exotic Species: Nonindigenous aquatic species such as the zebra mussel, ruffe, round goby, spiny water flea, sea lamprey, and others have the potential to cause significant ecological harm.

Human: Human use of the Great Lakes has increased, while potential impacts of Great Lakes-induced health effects are still a potential concern due to bioaccumulating persistent chemicals.

The trends identified in this report represent both positive effects of historical efforts to control environmental stressors in the Great Lakes and reason for concern due to the fact that the downward trends for many chemicals may be leveling off and the impact of changing land uses on Great Lakes water quality. This information should be celebrated for the progress it documents while encouraging continued effort to improve our valued Great Lakes ecosystem.

TOWARD A BLUE REVOLUTION

By Don Hinrichsen, Bryant Robey, and Ushma D. Upadhyay

Reprinted from *Population Reports,* September 1998

The world needs a Blue Revolution in water management, just as we need another Green Revolution in agriculture. Time is of the essence. Dwindling freshwater supplies per capita are threatening the health and living standards of millions of people in a growing number of countries, as well as undermining agricultural productivity and industrial development. Achieving a Blue Revolution will require coordinated policies and responses to problems at international, national, and local levels.

INTERNATIONAL RESPONSES

Countries have agreed to numerous recommendations at international conferences on water over the past 20 years. For the most part, however, the international development community and national governments have yet to turn these words into action.

The first international conference to draw attention to the coming water crisis was in 1977 — the United Nations Water Conference held in Mar del Plata, Argentina. Several others have followed, including the Global Consultation on Safe Water and Sanitation for the 1990s, held in New Delhi in 1990, and the International Conference on Water and the Environment, held in Dublin in 1992.

The Dublin Water Principles, agreed to at the 1992 conference, summarize the principles of sustainable water management.

- Principle No. 1: Freshwater is a finite and vulnerable resource, essential to sustain life, development, and the environment.
- Principle No. 2: Water development and management should be based on a participatory approach, involving users, planners, and policymakers at all levels.
- Principle No. 3: Women play a central part in the provision, management, and safeguarding of water.
- Principle No. 4: Water has an economic value in all its uses and should be recognized as an economic good.

More recently, in 1997 a comprehensive assessment of global freshwater resources, based on a series of expert background analyses, was prepared for the fifth session of the UN Commission on Sustainable Development. As a 1998 report of the secretary-general states, "The assessment concludes that water shortages and pollution are causing widespread public health problems, limiting economic and agricultural development, and harming a wide range of ecosystems. Those problems may threaten global food supplies and lead to economic stagnation in many areas of the world. The result could be a series of local and regional water crises, with serious global implications."

Making Needed Investments. Turning principles into practice will be difficult. Most countries need massive investments in sanitation and water supply infrastructure. In the developed world, for example, the United Kingdom must spend close to $60,000 million building wastewater treatment plants over the next decade in order to meet new European water quality standards. This amounts to about $1,000 for every person in the country. Hungary faces similar problems. One-fifth of the country's population is not connected to a functioning sewer system. Hungary will need to invest about $3,500 million over the next two decades to connect all of its citizens to wastewater treatment plants.

In developing countries, one of the most pressing problems is the overwhelming need to invest

heavily in sanitation facilities and the provision of clean water. The World Bank has estimated that over the next decade, between $600,000 million and $800,000 million will be required to meet the total demand for freshwater, including for sanitation, irrigation, and power generation. Of this huge amount, the World Bank will be able to lend only $35,000 million to $40,000 million at most. The remainder will have to come from a combination of public funding and private investment. It will be difficult, if not impossible, for most developing countries to finance the remainder, however. In Latin America alone, for instance, it is estimated that investments in water resources management and infrastructure will require $100,000 million over the course of the next two decades.

Avoiding International Conflicts. An important part of any international water management strategy is to help countries that share river basins fashion workable policies to manage water resources more equitably. A water-short world is an inherently unstable world. Nearly 100 countries share just 13 major rivers and lakes. More than 200 river systems cross international borders. Conflicts can arise, especially where countries with rapidly growing populations and limited arable land collide over access to shared freshwater resources.

The case of India and Bangladesh demonstrates how international river basins can be managed to meet demand in the face of scarce water supplies. The Ganges, the subcontinent's largest and most important river, rises in Nepal and flows 2,240 kilometers through three densely populated Indian states — Uttar Pradesh, Bihar, and West Bengal — before entering Bangladesh and flowing into the Bay of Bengal. The river affects the lives of 500 million people, many of whom depend on the river for subsistence agriculture and fishing. After half a century of bitter rivalry over access to the waters of the Ganges, India and Bangladesh signed a 30-year water-sharing agreement in December 1996. Both countries have proclaimed a new era of water management.

The agreement, if implemented fully, will provide Bangladesh with a guaranteed minimum amount of water during the dry season, especially the three driest months of March, April, and May. The new treaty sets 10-day periods during these three months when India and Bangladesh will alternately have access to an agreed-upon amount of the water reaching the Farakka Barrage, a huge dam built by India in 1974 in an effort to claim as much of the water for its own use as possible before the Ganges enters Bangladesh. In order to insure implementation of the agreement, a team of inspectors from the two countries will monitor the flow rate at the Farakka Barrage during the dry months.

Critics argue that, if the agreement is to work over the long term, India must begin to manage the Ganges watershed much better than it does now. Deforestation in Nepal and northern India has greatly increased the amount of sediment washed from the hills into the river during the monsoon season, clogging waterways and increasing the incidence of damaging floods. Unless ways can be found to capture more stable runoff during the wet season for use during the dry season, Indian farmers might be tempted to take all the water they can get from the river during the driest months, putting the agreement in jeopardy.

Despite such caveats, the fact that two neighboring countries have successfully negotiated and reached a comprehensive agreement over such a contentious issue is a positive sign. It promises to permit downstream Bangladesh a more equitable supply of water from the Ganges and to foster better water management practices in upstream India.

NATIONAL RESPONSES

In water-short countries, national governments need to give water resources management their highest priority. Crafting and implementing a national water strategy is essential to sustainable development. Such a strategy should include four elements:

- Adopting a watershed or river basin management perspective, especially in water-short regions (also appropriate as an international response, since watersheds frequently cross national boundaries);
- Instituting a workable water infrastructure so that national, regional, and local water needs can be met within the context of a national water policy;

- Enacting and enforcing water legislation and regulations that conserve water and value the resource properly according to type of use; and,

- Connecting water management to the needs of agriculture, industry, and municipalities, and meeting public health requirements for proper sanitation and disease prevention.

A Watershed Management Perspective. Watershed management refers to managing an entire land area served by all the rivers and aquifers that drain into a particular body of water (such as a semi-enclosed bay). River basin management is essentially the same concept applied to one river system, although the two terms are used interchangeably.

The United States defines a watershed as the entire area drained by a river system or one of its major tributaries. The United Kingdom defines a watershed as the divide between river basins, a potentially much larger area. No matter how it is defined, "we need to see a river or lake, along with its entire watershed and all its physical, chemical, and biological elements, as part of a complex, integrated system," according to Janet Abramovitz of the Worldwatch Institute.

Everyone has a watershed address: we all live in basins that drain rainwater into streams and rivers that eventually send the water back to the sea or into inland lakes. The people living in most of these addresses have radically altered the natural drainage systems around them. Tampering with watersheds has proved ruinous for many developing countries, where hillsides denuded of vegetation empty tons of soil into water courses every year, causing floods during the wet seasons and suffocating aquatic life during the dry seasons.

Deforestation has ruined land and altered climates, causing less rain to fall in some areas. In others, rainwater runs off so fast that little can be collected for use. In sub-Saharan Africa, for example, the albedo effect — the drying of the landscape as a result of the wholesale clearance of tropical forests and poor farming practices — has resulted in below-average rainfall over the past 40 years compared with the century as a whole.

Watershed or river basin management pays multiple benefits. The economic value of ecosystem maintenance is high. The value of an intact floodplain, for instance — including its fisheries, wildlife, recreation, and natural flood control effects — has been calculated at close to $5,000 per hectare. Another estimate puts the value of one hectare of wetland at $15,000.

Ideally, a comprehensive watershed management plan mobilizes communities and individuals and gains broad public acceptance at the national level. Watershed management is not easy to accomplish, however. It is a complex and contentious process that involves many stakeholders with competing views about water use. Not many countries have been able to initiate workable watershed management strategies. The Chesapeake Bay, the largest brackish water estuary in North America, has one of the few comprehensive watershed management plans in operation anywhere.

A number of other countries also have instituted river basin management schemes or are in the process of doing so. The Murray-Darling River Basin Commission in Australia, for instance, is an intergovernmental organization whose main aim is to coordinate the management of water resources across state borders within the Murray-Darling River Basin, the country's largest river system. The commission's technical abilities are comprehensive, covering river management and ecology, environmental impacts, finance and administration, and communication. All development activities within the river basin fall under the jurisdiction of the commission, and all government agencies connected to water management and its uses must collaborate.

In India, as a result of the 1987 National Water Policy Act, the states of Rajasthan and Gujarat are setting up a committee to regulate and control water use in the Sabarmati River Basin, which encompasses parts of both states. The average amount of water available in the Sabarmati River Basin amounts to no more than 360 cubic meters per person per year, making it one of the most water-stressed regions in the country. Water is not only a very limited resource, but it is also increasingly polluted by irrigated agriculture.

To deal with these problems, the committee will regulate and manage water resources in the entire river basin, with a structure that gives a voice to representatives from each major water user group. The committee hopes to establish broad popular and institutional support and a structure capable of ensuring that polluters are fined and that major users pay a fair price for water. If the system works, it may be extended to other water-short areas of India with high population densities.

Freshwater supplies that originate in mountainous areas also can be better protected and managed at their source, observes Mountain Agenda, a nongovernmental organization interested in sustainable mountain development. According to the organization, in humid areas the proportion of water generated in mountains can comprise as much as 60 percent of the total freshwater available in the watershed areas, and as much as 95 percent in arid areas.

Building Institutional Capacity. Managing watersheds and river basins sustainably means building institutional capacity, including the creation of cross-sectoral data collection and monitoring systems. Capacity-building is a key theme of international organizations promoting change, including the World Bank, the United Nations Development Program, and the Global Water Partnership. To build capacity, the following measures are needed:

- Assessing national capacity-building requirements. It is vital for governments to know the capacities of their water sector agencies as a first step toward improvements.

- Creating competent administrative and legal structures. The technical and administrative competence of national, regional, and local agencies responsible for water management must be strengthened before progress can be made in water management.

- Making institutions more responsive and effective. Water management agencies, both public and private, must also be able to respond to changing situations (political and social as well as environmental). Static organizations and outmoded procedures need to be overhauled, especially as countries enter the water-stressed or water-scarcity categories.

- Training senior water managers. Few hydrologists have been trained to consider water resources broadly. As well as an engineering approach to water management that considers supply needs and how to satisfy them, a demand-oriented approach is increasingly needed.

- Establishing closer ties to universities and research institutes. Since water issues embrace societal concerns and cultural values, water agencies should reach beyond the usual government channels and draw on a wide spectrum of opinion and expertise in order to assess freshwater issues and find solutions.

Valuing Freshwater Resources. Freshwater must be valued to reflect its status as a scarce resource, instead of being treated as a free or nearly free resource. As the Organization for Economic Cooperation and Development points out, proper pricing policies can encourage environmentally responsible water-use behavior as well as help to assure an adequate supply of water. To accomplish this, water should be valued appropriately in each of its various uses. The introduction of water markets and pricing mechanisms can have immediate and lasting impacts on water use.

There are several good examples of how water can be valued more appropriately than is the usual case. Chile established a water market in the mid-1980s that not only has saved water but also has enabled farmers to meet their needs by trading water rights among neighboring farms. A World Bank study of the water market system concluded that it contributed greatly to better management and fairer pricing.

Similarly, in southern California, chronically one of the most water-short regions in a water-short U.S. state, the San Diego County Water Authority has reached an agreement with farmers in the Imperial Valley area east of the city of San Diego. The agreement encourages farmers to conserve up to 200,000 acre-feet of water a year and sell it to the county, which would finance the conservation measures and pay farmers cash incentives to participate. San Diego County would benefit from

the guarantee of cheaper water, and the farmers would, in effect, be paid to conserve the resource. This approach to water management could change the dynamics of water use throughout California.

In Sao Paulo, Brazil's most populous state, where water resources already are stretched thin, increasing demands from municipalities, industries, and agriculture threaten to cripple the state's capacity to manage scarce supplies. In 1997 a draft Water Pricing Law was sent to the state legislature that could form the basis for an entirely new water management policy. Under the proposal, the price of water will be determined by the source of supply, type of use (whether municipal, industrial, or agricultural), and the availability of water. The fees collected under the policy are to be re-invested in the water management infrastructure.

Managing Water for Sectoral Needs. A workable water management system requires the institutional capacity to balance sectoral needs for the good of society as a whole and also to consider ecosystem needs. Water allocation, rather than absolute scarcity of water, often lies at the heart of national water problems. Without policies that link the supply of freshwater to competing sectoral uses, local and regional water shortages often result, and competition becomes increasingly bitter.

In developing countries, meeting sectoral demands is challenging because most lack efficient water management systems and equitable pricing policies that are based on how water resources are used. For example, although China passed a national water law in 1988, there is little coordination of sectoral water use between the Ministry of Water Resources, the river basin commissions, and the various provincial and local authorities.

LOCAL RESPONSES

Locally led initiatives are showing that water can be used much more efficiently even in water-short areas, both urban and rural. Furthermore, when communities manage freshwater resources better, they also manage soils and forests better, increase crop production, and reduce the incidence of illness and disease. Even where municipal governments have failed to finance a potable water supply or to provide proper sanitation, grassroots efforts have sometimes succeeded. Consider the following examples.

- In Burkina Faso's main agricultural area, the Mossi Plateau, a group called the "Six S's" (Se Servir de la Saison Seche en Savanne et au Sahel) has been promoting an integrated approach to water management since the late 1970s. The group encourages small-scale irrigation systems along with re-forestation and erosion control. It teaches village leaders new techniques for saving water and growing crops, provides basic hygiene education, and helps with financing for water conservation.

- Balinese rice growers have used small-scale irrigation techniques for the past 500 years. Their system is not technically advanced but instead relies on loose stone dams and weirs to collect water, which is then distributed to terraced fields using the hollowed-out trunks of coconut trees for piping. Accompanying this traditional system of water distribution is a social structure that regulates water among different communities, apportioning it according to the size of each rice paddy. The system works partly because women, the main source of paddy labor, have a hand in its management.

- In Pakistan, the Orangi Pilot Project, carried out in one of the worst slums in Karachi, was able to provide 600,000 people with a sewer system and with covered latrines. The project, which was carried out with a small amount of external funding, worked because of progressive local leadership and strong community support. But the benefits did not end with piped water. The project also increased access to better reproductive health and family planning services, which will help reduce future demand for water.

- In Honduras, six poor communities in the country's capital city of Tegucigalpa pooled limited resources to make a deal with the water utility to provide them with piped water. This scheme is notable because the price that households paid for water actually dropped as a result of the piped water connections, since residents no longer had to buy water from street

vendors, and the average household connection rate in each of the six communities was 85 percent, and the consumers themselves paid for the connections.

As this example demonstrates, even in poor urban areas clean piped water can be provided at a price that community members can afford to pay and that water utilities can accept. Recent studies in a number of countries make clear that poor people are prepared to pay for piped water and proper sanitation if given the chance. In Onitsha, Nigeria, for instance, poor households were spending up to 18 percent of their meager monthly income on water purchased from street vendors, a percentage that dropped to under 5 percent when piped water was provided.

Taking Action. Local communities should take an active part in planning and implementing water management schemes if they are to be sustainable. Poor communities, in particular, have had notable success in introducing autonomous local distribution of water, either through special arrangements with the water authority or with private vendors. Communities also have set up community-managed vending kiosks or operated small, autonomous water supply systems.

Accessibility of clean water, as has been noted, promotes better household hygiene and improves health and well-being. Access to the water supply should be as close to homes as possible and should be reliable. Plans for piping water to poor households should consider the amount of water needed, choose the appropriate level of technology, and price the water according to the ability to pay. Water supply and public health programs both should emphasize preventive health care education and encourage the use of clean water for personal and domestic hygiene.

TIME TO CHANGE DIRECTION

The world needs sustainable water management, but we are not headed in the right direction fast enough. A Chinese proverb holds that, "If we don't change course, we may end up where we are heading." Without moving in a new direction, many more areas will face water shortages, many more people will suffer, more conflicts over water will occur, and more precious wetland ecosystems will be destroyed.

While a freshwater crisis appears inevitable in many water-short regions, in others the problem could be managed if appropriate policies and strategies were formulated, agreed to, and acted on soon. The international community is paying increasing attention to the world's water problems, and a number of organizations are providing funding and assistance to help manage water supply and demand. Increasingly, mechanisms are being put in place that permit more equitable water management. Countries in water-stressed regions are introducing better pricing mechanisms, fostering community-based water management schemes, and moving toward watershed and river basin management regimes. Both the number and scale of these activities need to increase substantially.

Also, population growth has slowed, reflecting international and national attention to family planning programs, together with rising popular demand for contraception. To meet people's needs, national governments and international donors need to increase their commitment to family planning, to improving sanitary conditions, to curbing pollution, and to reducing the scourge of water-related diseases.

A vital part of a long-term solution is worldwide recognition of the links between rapidly growing populations and shrinking freshwater supplies. Recognition, knowledge, and concern can help build the political will to avert a crisis and develop the commitment needed to assure that humanity's apparently unquenchable thirst for freshwater does not exhaust the world's finite water supply.

Population Reports is issued quarterly and published by the Population Information Program, Center for Communication Programs, The Johns Hopkins University School of Public Health, Baltimore, MD

DEPARTMENTS

Bibliography

BOOKS AND DOCUMENTS

Biswas, Asit K., ed.
WATER RESOURCES: ENVIRONMENTAL PLANNING, MANAGEMENT, AND DEVELOPMENT
McGraw Hill, 1997. 737p.

Bredin, Jim, ed.
GREAT LAKES TRENDS: A DYNAMIC ECOSYSTEM
Michigan Department of Environmental Quality, January 1998. 20p.
Available on the Internet at http://www.deq.state.mi.us/ogl

Briggs, Mark K.
RIPARIAN ECOSYSTEM RECOVERY IN ARID LANDS: STRATEGIES AND REFERENCES
University of Arizona Press, 1996. 159p.

Donahue, John M.; Johnston, Barbara Rose, eds.
WATER, CULTURE AND POWER: LOCAL STRUGGLES IN A GLOBAL CONTEXT
Island Press, 1997. 396p.

Gleick, Peter H., ed.
THE WORLD'S WATER 1998-1999: THE BIENNIAL REPORT ON FRESHWATER RESOURCES
Island Press, 1998. 200p.

Hinrichsen, Don; Robey, Bryant; Upadhyay, Ushma D.
SOLUTIONS FOR A WATER-SHORT WORLD (Population Reports, Series M, No.14; Population Reports, Vol. 26, No. 1) Johns Hopkins School of Public Health, Population Information Program, December 1997. 31p.
Available on the Internet at http://www.jhuccp.org/pr/m14edsum.stm

Mays, Larry W., ed.
WATER RESOURCES HANDBOOK
McGraw-Hill, 1997. 1,200p.

Perry, James A.; Vanderklein, Elizabeth
WATER QUALITY: MANAGEMENT OF A NATURAL RESOURCE
Blackwell Science, 1996. 639p.

Postel, Sandra
LAST OASIS: FACING WATER SCARCITY
W.W. Norton, 2nd ed., 1997. 239p.

Rapport, David; and others, eds.
ECOSYSTEM HEALTH: PRINCIPLES AND PRACTICE
Blackwell Science, 1998. 372p.

Sharma, Narendra P.; and others
AFRICAN WATER RESOURCES: CHALLENGES AND OPPORTUNITIES FOR SUSTAINABLE DEVELOPMENT
(World Bank Technical Paper No. 331)
World Bank, 1996. 144p.

Simon, Paul
TAPPED OUT: THE COMING WORLD CRISIS IN WATER AND WHAT WE CAN DO ABOUT IT
Welcome Rain Publishers, 1998. 198p.

U.S. Environmental Protection Agency; U.S. Department of Agriculture
CLEAN WATER ACTION PLAN: RESTORING AND PROTECTING AMERICA'S WATERS
U.S. Environmental Protection Agency, 1998. 89p.
Available on the Internet at http://www.cleanwater.gov/

U.S. National Research Council
NEW STRATEGIES FOR AMERICA'S WATERSHEDS
National Academy Press, 1999. 350p.

U.S. National Research Council
SETTING PRIORITIES FOR DRINKING WATER CONTAMINANTS
National Academy Press, 1999. 126p.

U.S. National Research Council; and others
WATER FOR THE FUTURE: THE WEST BANK AND GAZA STRIP, ISRAEL, AND JORDAN
National Academy Press, 1999. 244p.

ARTICLES

Ashkinaze, Carole
PAUL SIMON: ON THE WATER FRONT
(Horizon, February 1999, pp. 2+)
Available on the Internet at http://www.horizonmag.com/2/simon.htm

Bequette, France
WATER: WILL THERE BE ENOUGH?
(UNESCO Courier, Vol. 51, No. 6, June 1998, pp. 42-45)

Deneen, Sally
PARADISE LOST: AMERICA'S DISAPPEARING WETLANDS
(E Magazine, Vol. 9, No. 6, November/December 1998, pp. 37-41)

McKie, Robin
UN TARGETS WATER WOES
(Journal of Commerce, December 17, 1998, p. 4A)

McNeill, Desmond
WATER AS AN ECONOMIC GOOD
(Natural Resources Forum, Vol. 22, No. 4, November 1998, pp. 253+)

Perkowitz, Sidney
THE RAREST ELEMENT
(The Sciences, Vol. 39, No. 1, January/February 1999, pp. 34-38)

Postel, Sandra
CHANGING THE COURSE OF TRANSBOUNDARY WATER MANAGEMENT
(Natural Resources Forum, Vol. 21, No. 2, May 1997, pp. 85+)

Postel, Sandra
DIVIDING THE WATERS
(Technology Review, Vol. 100, No. 3, April 1997, pp. 54-62)

Postel, Sandra
WATER FOR FOOD PRODUCTION: WILL THERE BE ENOUGH IN 2025?
(Bioscience, Vol. 48, No. 8, August 1998, pp. 629-637)

Robbins, Elaine
WATER, WATER EVERYWHERE
(E Magazine, Vol. 9, No. 5, September/October 1998, pp. 28-35)

Stevens, William K.
WATER: PUSHING THE LIMITS OF AN IRREPLACEABLE RESOURCE
(The New York Times, December 8, 1998, p. G1)

INTERNET SITES

American Rivers
http://www.amrivers.org/

American Groundwater Trust
http://www.agwt.org/

American Water Works Association (AWWA)
http://www.awwa.org/

Clean Water Alliance
http://www.cwn.org/

Drinking Water FAQs from the League of Women Voters
http://www.lwv.org/drinkingwater/question.htm

International Rivers Network
http://www.irn.org/

Kentucky Watershed Management
http://water.nr.state.ky.us/dow/watrshd.htm

National Agricultural Library Water Quality Information Center
www.nal.usda.gov/wqic/lists.html

National Drought Mitigation Center
http://enso.unl.edu/ndmc/

U.S. Environmental Protection Agency Office of Water
http://www.epa.gov/OW/

USEPA Office of Groundwater & Drinking Water
http://www.epa.gov/safewater/

United States Fish and Wildlife Service
http://www.fws.gov/

U.S. Water News
http://www.uswaternews.com/homepage.html

WWW Virtual Library - Hydrosphere
http://www.earthsystems.org/hyd.html

Water Environment Federation
http://www.wef.org/

The Water Librarian's Home Page
http://www.wco.com/~rteeter/waterlib.html

Water for People
http://www.water4people.org/

Water Science for Schools from the U.S. Geological Survey (USGS)
http://wwwga.usgs.gov/edu/

Water Wiser - the Water Efficiency Clearing House
http://www.waterwiser.org/

Watershed Management Council
http://watershed.org/WMChome/

global issues

March 1999 Volume 4, Number 1

TROUBLED WATERS
Managing Our Vital Resources