CHAPTER THREE

Headwaters

Headwaters—defined simply as the source, or upper part, of a stream—are traditionally visualized as pristine, remote, free-flowing streams, unpolluted and relatively unaffected by human activities.

In some parts of the country, that vision still bears some connection to reality. Embarking on a 540-mile trip down the entire length of the Chattahoochee River in Georgia, Joe and Monica Cook wrote in the *Georgia Journal*:

"We began our journey the day before on a sub-freezing morning in Chattahoochee Gap, 3,500 feet above sea level, where the river oozes to life from a spring surrounded by huge poplars and occupied by salamanders. The mountain's early spring fireworks—bloodroots and violets—brightened our path, but it took us six hours to travel less than four miles. Now the river's cascades and falls are frequent and growing in size, the banks of the gorge steeper and more crowded with underbrush.

"Above the roar of the water, we hear the voices of fishermen, and I scramble down to their spot and ask them if they know the river's course for the next few miles.

"One, wearing an Atlanta Braves cap, and casting with a spinning reel at the clear water, turns, bewildered. 'I went in there once,' he said, pointing to the deepening gorge. 'Fell on a rock and busted my knee cap. It took me seven hours to get out to a hospital. I can give you a ride to the other side. The truck's just at the top of the hill.'

" 'No thanks' I said, still determined to beat our way through. 'We'd rather walk.'

"Our trout fisherman friend was right. Shortly after leaving his spot, we ran into a nearly impassable wilderness—a crunch of wild water and mazes of rhododendron thickets and dog hobble, a low-growing shrub so named because dogs are likely to get tangled in it. So are people. Rhododendron thickets are often referred to as 'hells.' We now know why. They are hell to travel through. We abandoned our plan to follow the river itself, opting to follow the U.S. Forest Service road running along high ground above the gorge. That three-mile stretch of water is the only part of the river we haven't seen."

With the exception of Alaska, however, civilization is usually not far from even the wildest headwaters. Just a few miles downriver, the Cooks arrived in Helen, a booming lumbering town from 1910 to 1940. Helen became a ghost town after the timber was exhausted, but has since revived as an "alpine village" that attracts some three million tourists annually.

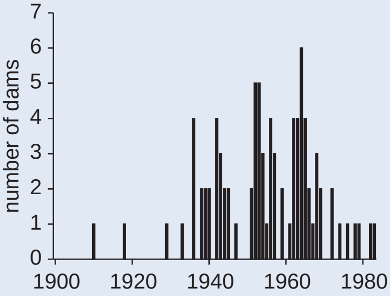
Box 3.1
Dams and Dam Construction

There are now more than 75,000 dams higher than 6 feet in the United States, both in the upper and lower reaches of rivers. The reservoirs behind these dams cover about 3 percent of the nation's land surface. In a given year, 60 percent of the United States' entire river flow can be stored behind reservoirs.

Most of this construction occurred between the 1930s and 1960s (Box Figure 3.1). Between 1935 and 1985, over 600 federally funded flood-control projects were built.

Only 2.7 percent of the nation's dams are owned by the federal government. The Corps of Engineers manages 555 dams. The Interior Department's Bureau of Reclamation manages 348 dams with a total storage capacity of 245 million acre-feet of water (an acre-foot is equivalent to 325,851 gallons of water).

Box Figure 3.1 Dates of Closure of U.S. Dams with Reservoir Capacity of a Million Acre-feet or More, 1900-1983

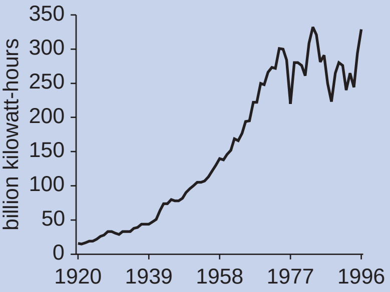


Source: Graf, W.L., "Landscapes, commodities and ecosystems -- The relationship between policy and science for American rivers," In Water Science and Technology Board, *Sustaining Our Water Resources* (National Academy Press, Washington, DC, 1993).
Note: Data are for the contiguous United States.

Like the Cooks, many Americans are drawn to the nation's untamed rivers and landscapes. For Norman Maclean's fictional Montana family in *A River Runs Through It*, "there was no clear line between religion and fly fishing." And for many other Americans, the river experience is an essential part of the human experience. Americans increasingly are visiting the nation's great rivers and landscapes; since 1980, for example, visits to the National Park System are up nearly 40 percent.

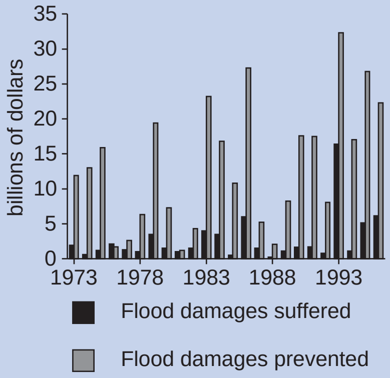
Aside from tourism and outdoor recreation, many other activities occur in headwaters areas, notably logging, min-

Figure 3.1 U.S. Conventional Hydroelectric Power Generation, 1920-1996



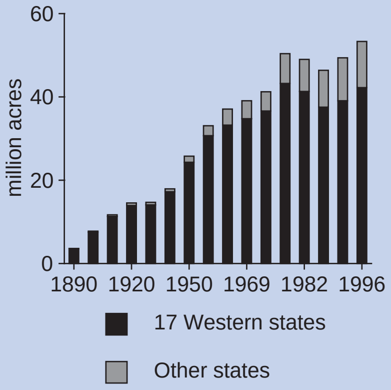
Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996* (DOE, EIA, Washington, DC, 1997) and earlier reports.
Note: Excludes pumped storage facility production.

Figure 3.2 U.S. Flood Damages Suffered and Prevented, 1973-1996



Source: U.S. Army Corps of Engineers, *Annual Flood Damage Report to Congress for Fiscal Year 1996* (USACE, Washington, DC, 1997) and earlier reports.

Figure 3.3 U.S. Irrigated Farmland, 1890-1996



Source: See Part III, Table 7.11.
Note: 1890-1992 data are for years coinciding with the Census of Agriculture; 1996 data are estimates.

ing, and farming. In addition, it is usually in the upper reaches that most rivers begin to lose their natural character.

TAMING THE RIVER

The age of the free-flowing river is largely over in the lower 48 states, with virtually every river regulated by dams, locks, or diversions (Box 3.1).

There are a host of reasons to build dams. They provide water for cities, farms, and industries; help control floods and manage flow; improve navigation; generate electrical power; and provide opportunities for recreation. In 1996, for example, hydroelectric power generated 329 billion kilowatt-hours of electricity, or 11% of U.S. electricity generation. (Figure 3.1). Hydroelectric powerplants in the Columbia River and its tributaries produce 75 percent of the Pacific Northwest's electricity.

Dams have improved the dependability of water supplies, particularly for arid and semiarid regions. In many instances, dams have reduced the risk of catastrophic floods (Figure 3.2). Since dams were built across rivers in the Connecticut River Valley, no floods have occurred like the ones that crippled the towns of Bolton and Hartford in 1927 and 1936. But, as evidenced by the destructive floods of recent years, dams have not completely eliminated the risk of major floods.

Water diversions have also played an important role in the nation's agricultural development. Each year, for example, 8.2 million acre-feet of water are diverted from the lower Colorado to homes and farms in California and Arizona through aqueducts that cross hundreds of miles of intervening desert. None of this water reaches the Gulf of California. By 1996,

Aerial View of the Snake River.

Photo Credit:
USDA—94CS3964

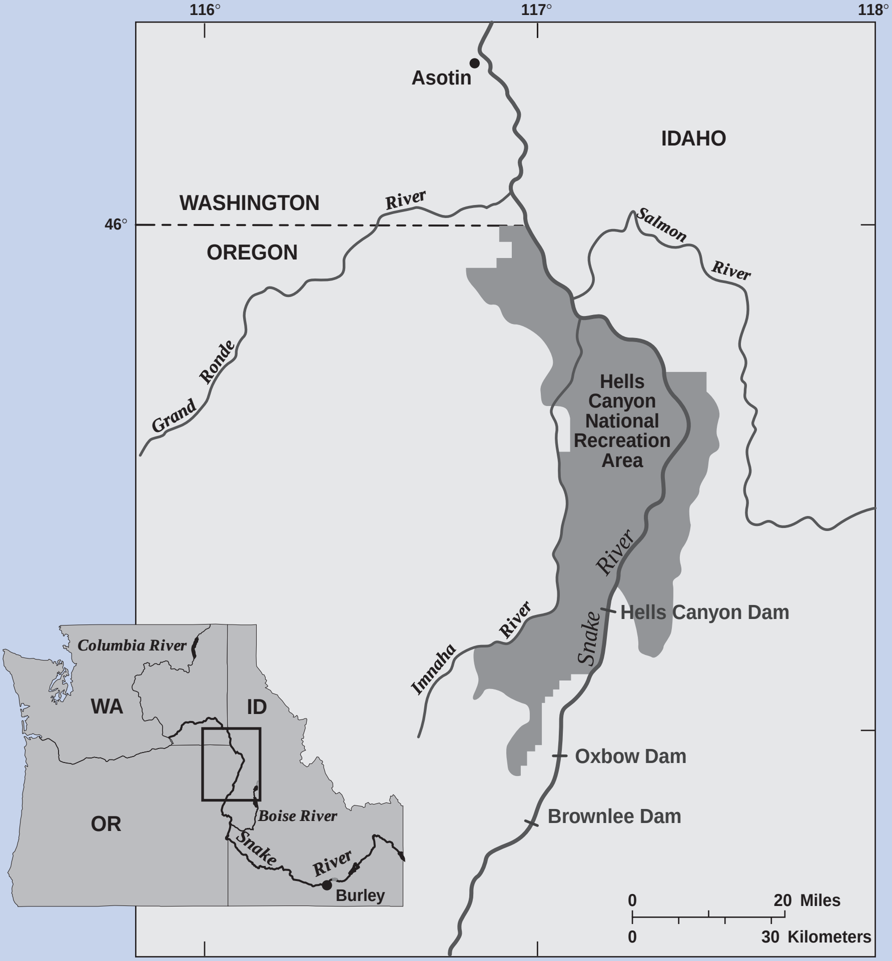
some 42.2 million acres in 17 Western states were irrigated, with another 11.1 million irrigated acres in the rest of the nation (Figure 3.3).

As dams became bigger and more expensive, more potential benefits were needed to justify the costs of dam construction. The Glen Canyon Dam in Arizona was initially conceived as a project to balance the water allocations between the upper and lower basin states of the Colorado River. To justify the initial price tag of $325 million, additional benefits such as water conservation, downstream distribution, and hydroelectric power (and subsequently recreation and flood control) were added to the dam's operating criteria.

Dams and the Environment

Dams have a variety of environmental impacts. The process of dam construction and subsequent impoundment of waters results in the loss of riparian areas, wetlands, and upstream forestlands. The river emerging from a dam is not the same river entering its reservoir. Its daily discharge may vary wildly and be hotter or colder. Its seasonal pattern of high spring floods and low winter flow may be severely inhibited. The sediment-free waters may scour the downstream bed and banks or rob lower reaches of needed replenishment. A completely new succession of riparian plants and animals may move into the river and valley below the dam. Fish migrations are blocked or

Figure 3.4 The Snake River in Oregon, Idaho, and Washington

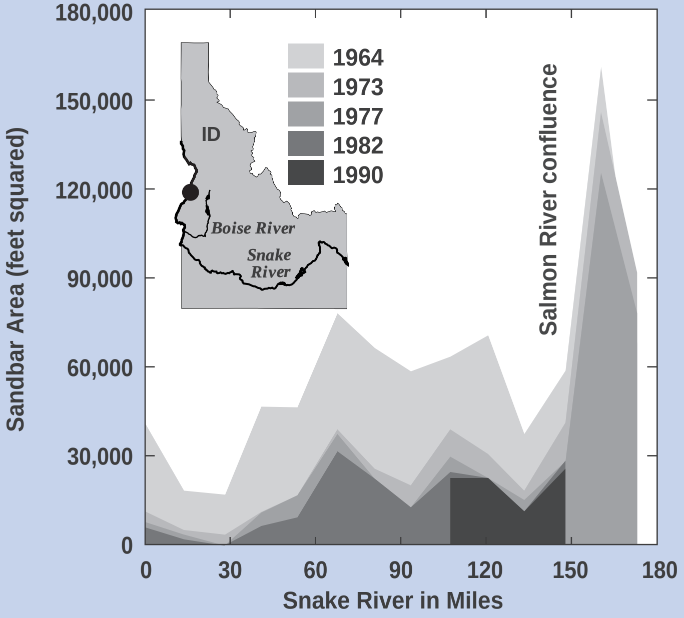


Source: Collier, M., R.H. Webb, and J.C. Schmidt, *Dams and Rivers: A Primer on the Downstream Effects of Dams,* USGS Circular 1126 (USGS, Tucson, AZ, 1996).

severely disrupted. Native fishes may die or be severely stressed. Water quality may be improved or impaired.

A recent report by the U.S. Geological Survey, *Dams and Rivers: Primer on the Downstream Effects of Dams*, looks at several regulated rivers, including the Snake, Chattahoochee, Platte, Green, and Colorado rivers. Each of these rivers highlights a particular use of a dam or a particular downstream effect.

Figure 3.5 Sandbars on the Snake River in Hells Canyon



Source: Collier, M., R.H. Webb, and J.C. Schmidt, *Dams and Rivers: A Primer on the Downstream Effects of Dams,* USGS Circular 1126 (USGS, Tucson, AZ, 1996).

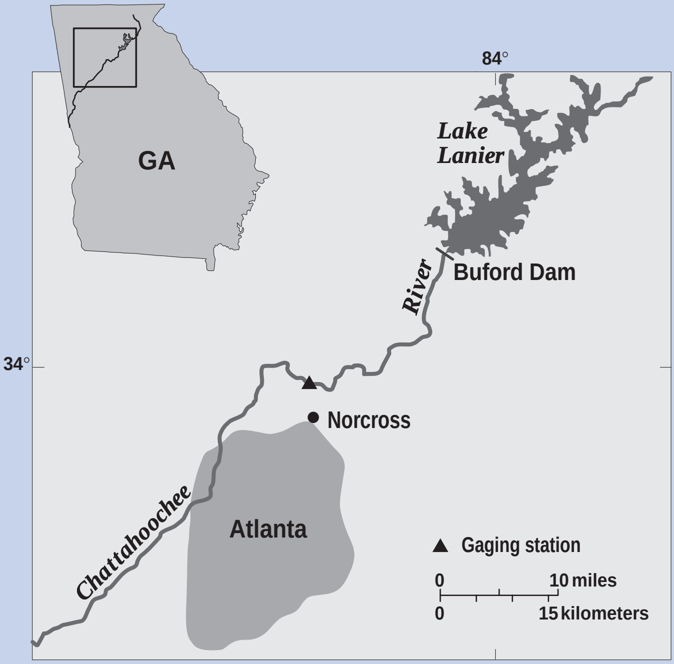
Snake River. The Snake River in Oregon, Idaho, and Washington, is the most extensively dammed river in the West (Figure 3.4). The generation of hydroelectic power has severely changed the normal dynamics of the river's flows. Dams on the Snake block historic salmon migratory runs, and frequent high releases have caused depletion of sand downstream from the dams.

The Idaho Power Company uses coal-fired generating stations to provide base-load power, but obtains all of its peak power from the dams of the Hells Canyon Complex. The company waits to release water until demand is high.

The three dams of the Hells Canyon Complex are very effective sediment traps; the water emerging from Hells Canyon Dam is usually crystal clear. Prior to construction, the waters of the Snake below its confluence with the Salmon carried as much as 5 million tons of sediment downstream. But water clarity comes with a price. Since dam construction, the surface area of the beaches below Hells Canyon have shrunk by 75 percent (Figure 3.5).

Prior to dam construction, chinook and sockeye salmon would migrate up from the Pacific Ocean through the Columbia and Snake rivers to spawn in

Figure 3.6 The Chattahoochee River in North-Central Georgia



Source: Collier, M., R.H. Webb, and J.C. Schmidt, *Dams and Rivers: A Primer on the Downstream Effects of Dams,* USGS Circular 1126 (USGS, Tucson, AZ, 1996).

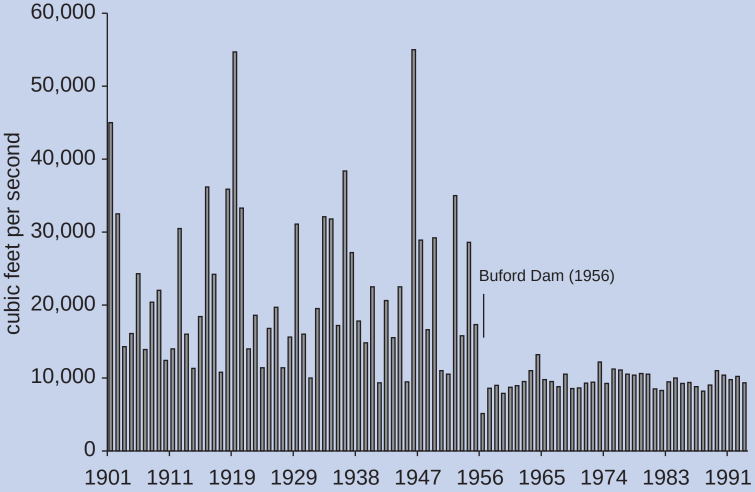
the tributary of their origin. With eight dams blocking their way up the Columbia, roughly one third or more of the total spawning population is lost. When spawning is successful, the young fish have even lower rates of success in migrating downstream. The chinook is a threatened species; the sockeye is considered endangered.

The Idaho Power Company built fish ladders and other bypass systems into each of the Hells Canyon dams, but all were unsuccessful. Today, no salmon migrate above Hells Canyon. The company also has funded fish hatcheries, but prospects for success are not bright unless additional measures are taken to move fish around the dams.

Chattahoochee River. At regular intervals, the Chattahoochee River in north-central Georgia used to rise over its banks in massive floods, carrying mud and sand across nearby farmlands (Figure 3.6). All that stopped in 1956, when the Corps of Engineers completed the $45-million Buford Dam and Lake Sidney Lanier began to fill in behind the dam.

Buford Dam has admirably fulfilled its role in controlling floods; since 1956, no destructive floods have occurred on the

Figure 3.7 Peak Flow Rates for the Chattahoochee River, 1901-1994



Source: U.S. Department of the Interior, U.S. Geological Survey, National Water Data Storage and Retrieval System (USGS, WATSTORE, Reston, VA, 1997).

Chattahoochee below Buford (Figure 3.7). The river is also the most important source of drinking water for millions of people in the Atlanta metropolitan area downstream.

The river and Lake Lanier are enormously popular with area residents. In 1990, 19 million people came to Lake Lanier, making it the most visited federally managed reservoir in the country. In 1978 Congress authorized the Chattahoochee River National Recreation Area, comprised of 14 scattered units between Buford Dam and Atlanta. The river is heavily used for fishing, canoeing, biking, picnicking, jogging, and swimming. Recreation, water quality, and fish and wildlife concerns have become important priorities in the management of the dam.

The river's double role as a source of both recreation and power poses some challenges for the river's managers. A reduction in extreme fluctuations would increase recreational safety by reducing the risk that sudden fluctuations would endanger unsuspecting fishermen, but it would diminish the dam's power generation capabilities. Dam releases could be designed to minimize downstream erosion, but power generation would suffer.

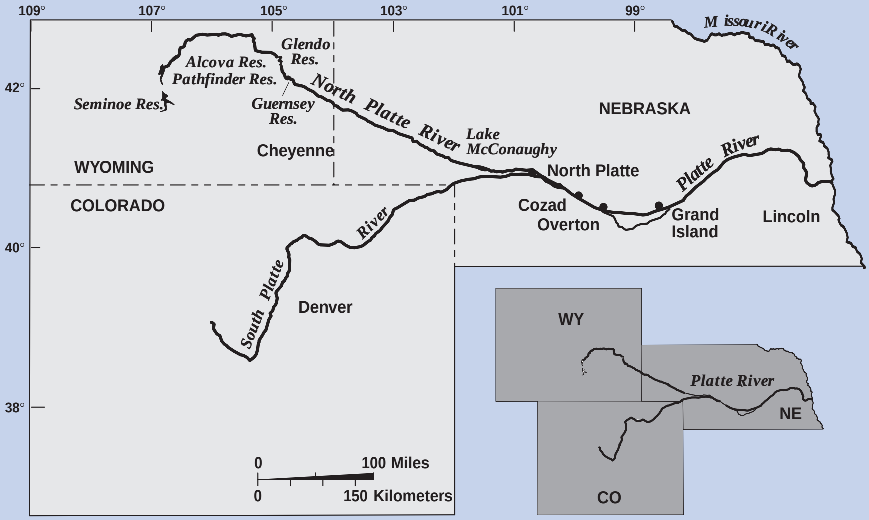
Platte River. Along the Platte River in Wyoming, Colorado, and Nebraska, some half a million sandhill cranes return to roost every February and March, seeking the river's shallow waters broken up by sand spits and islands (Figure 3.8). During the day, the birds fly a few miles to nearby cornfields that have been dormant since the previous fall's harvest. During their six-to-eight week stay on the Platte, the birds can add 15 percent or more to their wintertime body weight.

The Platte has changed substantially since the early Westward expansion. By 1885, more water had been appropriated by canal builders and farmers than actually flowed in the South Platte during the summer irrigating season. By 1917, the entire North Platte was over-appropriated during the summer months.

Dam-building began in earnest with the passage of the Reclamation Act of 1902. Six major dams storing nearly 5 million acre-feet of water were built across the North Platte, while the South Platte's dams could hold back 1.3 million acre-feet. Increased supplies of water created a new wave of canal building along the North Platte until the 1930s; after that, farmers turned to groundwater for additional irrigation. By the 1980s, annual river flows were only about one third the pre-dam average (Figure 3.9).

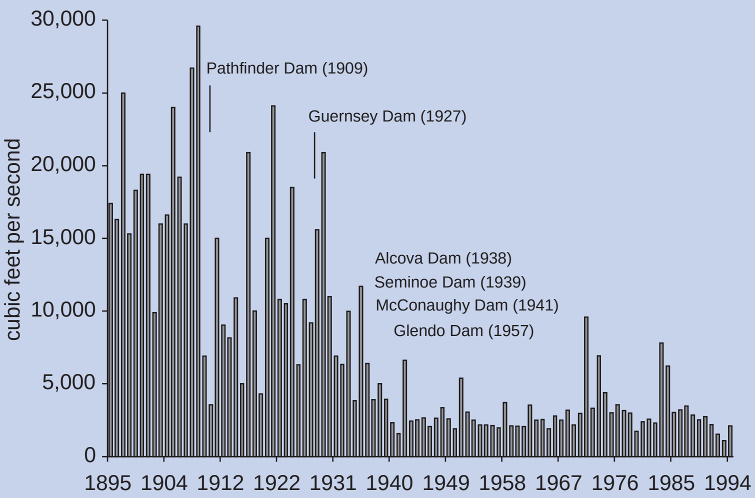
The steady reductions of both peak springtime and total annual flows have taken a toll. In the absence of floods, cottonwoods, elm, and willow successfully invaded the bare sandbars. By 1965, the 60-mile channel above Overton was only 10-20 percent of the width measured in 1865. The cranes have abandoned a bit more habitat every year, leading to increased crowding on the remaining habitat and a greater risk of avian disease outbreaks.

Figure 3.8 The Platte River in Wyoming, Colorado, and Nebraska



Source: Collier, M., R.H. Webb, and J.C. Schmidt, *Dams and Rivers: A Primer on the Downstream Effects of Dams,* USGS Circular 1126 (USGS, Tucson, AZ, 1996).

Figure 3.9 Peak Flow Rates for the North Platte River, 1895-1994



Source: U.S. Department of the Interior, U.S. Geological Survey, National Water Data Storage and Retrieval System (USGS, WATSTORE, Reston, VA, 1997).

Hydrologists are contemplating dam releases that would open and maintain a channel adequate for the cranes, but that could mean less irrigation water for farmers upstream. Conceivably the timing of releases might be planned for periods when farmers do not need water, or farmers could switch to crops that require less water. In any event, the tradeoffs between farm productivity and crane habitat are not easy.

In mid-1997, after three years of negotiations, the Department of Interior and the states of Colorado, Nebraska, and Wyoming signed a cooperative agreement for a federal/state recovery program for whooping cranes and other endangered species along the river. The agreement provides for:

- Initiation of a basin-wide environmental study of the Platte.
- A basin-wide analysis of opportunities for water conservation and enhanced water supply.
- More effective habitat improvements based on basin-wide factors.
- Greater regulatory certainty for individual projects throughout the basin.
- Commitments to seek immediate funding for habitat activities.
- Permanent restoration and protection of 29,000 acres of habitat.
- Adjustment of Kingsley Dam operations to provide enhanced flows for fish and wildlife on the Central Platte.

- Simplification of the Endangered Species Act review process for individual water-related actions.
- Development of legal and institutional protections to help ensure that existing flows and any new water deliveries will reach the critical habitat areas.
- A means to ensure that each party contributes its fair share towards the program's goals.

Green River. Some 45,000 square miles in Utah, Colorado, and Wyoming contributes runoff to the Green River, a spectacular landscape that includes Dinosaur National Monument, Canyonlands National Park, and Glen Canyon National Recreation Area. The river's source in Wyoming's Wind River Range is 730 miles upstream from its confluence with the Colorado River in Utah's Canyonlands National Park.

Prior to dam construction, the Green's extreme variability in flow, sediment concentration, and temperature gave rise to an array of fish—some thirteen endemic species in the minnow, sucker, trout, and sculpin groups—that were unique to the Green River.

All of these species are now threatened by changes to the river since the 1960s. Some were not dam-related; for example, many non-native fish species have been introduced to the river and compete for the same food and habitats as the natives.

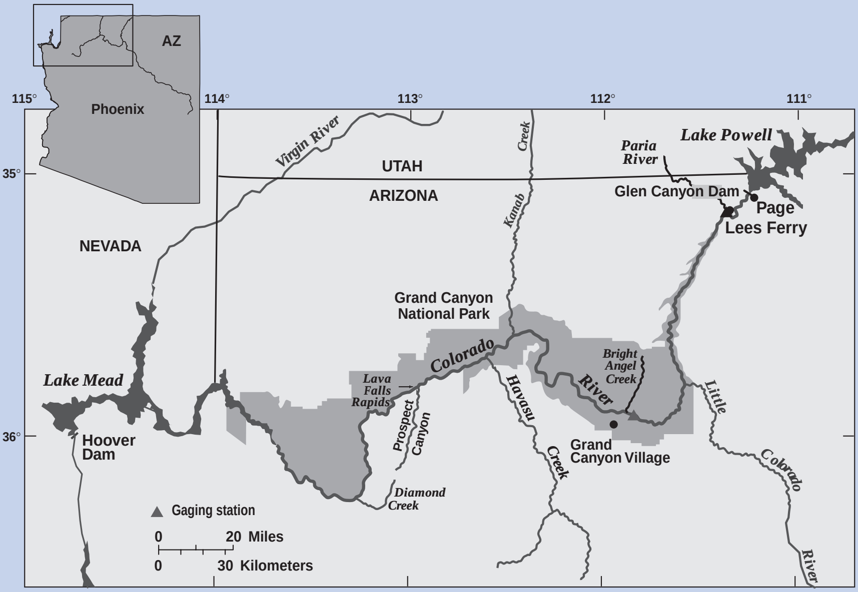
Some dam-related stresses were inevitable, while others did not have to happen. Just before the Flaming Gorge Dam was closed in September 1962, federal and state agencies dumped 21,500 gallons of rotenone into the Green River at various stations in Wyoming in an effort to kill some of the "rough" fish that might interfere with stocked trout. The effect of this experiment was to kill significant numbers of native fish, many of which are now threatened or endangered.

In the 1960s and 1970s, nearly half of the Green's total annual flow was diverted for agriculture, mining, power plants, and other uses. In 1980, the U.S. Fish and Wildlife Service used the authority of the Endangered Species Act to issue a Biological Opinion that water management had to be changed to protect the river's endangered fish species. In response, the operation of the Flaming Gorge Dam was adjusted. Dam releases are now seasonally adjusted to mimic the river's pre-dam flows and promote native fish habitat. Spring peaks are meant to facilitate spawning and protect young fish in backwaters. Studies are underway to link the creation and maintenance of habitat to sedimentary processes influenced by dam operation. Whether these changes will be enough to enable these fish to make a comeback is unclear.

Colorado River. The Colorado River and Grand Canyon National Park are among the nation's most popular destinations (Figure 3.10). John Wesley Powell took the turbulent passage down the Colorado in 1869. Today, some 22,000 people annually repeat Powell's adventure, while another 5 million view the river from the rims of Grand Canyon National Park.

Historically, an average of 12 million acre-feet of water rolled through Grand Canyon each year, with floods typically

Figure 3.10 The Colorado River Downstream from Glen Canyon Dam in the Grand Canyon, Arizona



Source: Collier, M., R.H. Webb, and J.C. Schmidt, *Dams and Rivers: A Primer on the Downstream Effects of Dams,* USGS Circular 1126 (USGS, Tucson, AZ, 1996).

occurring in May and June. Great volumes of sand were stored along the main channel; during floods, the sand would be deposited along higher terraces, creating beaches. These beaches remain an integral aspect of the river, nurturing a plant community of mesquite, catclaw, and hackberry, and providing camping sites for rafting parties.

Completed in 1963, Glen Canyon Dam was the cornerstone of the Colorado River Storage Project, a series of six dams on the Colorado, Green, San Juan, and Gunnison rivers. With Hoover Dam 280 miles downstream, Glen Canyon Dam helped provide flood control, irrigation, and municipal water supply for Arizona, California, and New Mexico. Lake Powell, a 26.7 million acre-foot reservoir created by the dam, provides recreation for millions of people every year.

In the mid-1970s, river runners and scientists noticed that some beaches were disappearing and that plant and animal life along the river was changing. In 1989, the Secretary of the Interior announced that an Environmental Impact Statement (EIS) would be required for continued operation of the dam. In 1992, Congress passed the Grand Canyon Protection Act, which stipulates that Glen Canyon Dam is to be operated in a manner that protects resources within Grand Canyon, and that long-term scientific studies be conducted to monitor the downstream effects of the dam.

With increasing frequency, scientists have called for “beach-building” or “habitat-maintenance” flows. To this end, in March 1996 Glen Canyon spilled 45,000 cubic feet per second for eight days—the first intentional flood ever released for environmental purposes. When the flood receded, a great deal of clean new sand had been deposited well above the normal high-water line.

Periodic beach-building flows are an exciting new tool in dam management. But much needs to be learned about the ideal volume and length of such releases, about their impact on native fish and riparian vegetation, and about the amount of revenue lost because of bypassed electrical generation.

RESOURCE PRESSURES: MINING

In the lower 48 states, the upper reaches of most rivers are quickly affected by human activities. Mining, logging, residential development, and other factors all put pressures on headwater areas. Water quality in headwaters areas also can be altered by natural factors (Box 3.2).

Mining and resource extraction activities can present difficult conflicts between development and environmental objectives. In many cases, resource extraction has severe environmental impacts that can affect wildlife habitat, aquatic life and the safety of drinking water supplies.

Many current environmental insults are the result of past mining operations. In the upper Colorado river basin today, gold and silver mines operated in the late nineteenth century are a major source of water quality degradation. Trace metals are stored in stream bed sediments and interact with stream biota. Some of the affected streams are used for municipal supplies, or have recreation potential. In the Appalachian states, as discussed later in this chapter, abandoned coal mines are a frequent source of acid mine drainage.

Present activities also pose significant environmental problems. In northeastern Washington, for example, mining and smelting operations have contributed millions of tons of metal-rich sediment to the lakes and rivers in the area, causing ecological disruption, contamination of fish tissue, and possible human health risks. Examples include Lake Coeur D’Alene, which is nearly devoid of bottom-dwelling organisms, and Lake Roosevelt, which receives 300 tons of slag daily from a Canadian lead/zinc smelter.

On the Humboldt River in north-central Nevada, dewatering aquifers to allow continued deepening of open-pit gold mines has lowered water levels more than 500 feet. The volumes of water moved in dewatering are approaching the total urban water use in Las Vegas. Discharge of the mine waters to adjacent surface and groundwater basins has resulted in significant interbasin transfers.

Future mineral development also can be controversial. In northeastern Wiscon-

Box 3.2
The Impact of Natural Factors on Water Quality

In the absence of human activities, the chemical composition of streams and lakes is controlled by the release of minerals from rocks and soils, which in turn is affected by factors such as rainfall, temperature, evaporation, and by the life cycles of plants. Concentrations of calcium, magnesium, sodium, and potassium are generally correlated with the chemical composition of rocks and soils in a given drainage basin. In some relatively unusual cases, unmined mineral deposits can affect stream water quality.

The U.S. Geological Survey recently found significant leaching from undisturbed silver, lead, and zinc deposits in the northwestern Brooks Range in Alaska. Prior to mining, water quality in streams draining the Red Dog deposit were acidic and contained highly toxic levels of cadmium, lead, and zinc that exceeded the drinking water standards recommended by the state of Alaska. These contaminated waters were toxic to most aquatic life; streams immediately draining the deposit did not support any significant fish populations. Streams draining the undisturbed Drenchwater deposit had low pH values and high concentrations of dissolved solids (Box Figure 3.2). The most acidic water in the region (pH 2.8 to 3.1) is in False Wager Creek, which partly drains the deposit on the east side. These streams also contain high concentrations of dissolved aluminum, arsenic, iron, cadmium, copper, lead, manganese, nickel, and zinc. In most cases, concentrations exceed state safe drinking water standards. At the nearby Lik deposit, stream waters are in the neutral range for acidity and contain only zinc in consistently high concentrations. Carbonate rocks in the area neutralize acid in the water and lower its ability to carry most metals in solution.

A 1971 study on sources of sulfate in streams estimated that for North America about 40 percent was from natural sources and up to 60 percent was related to human activities. But scientists now realize that there is considerable variation in sources around the country.

For example, when the U.S. Geological Survey sampled the chemical composition of the St. Lawrence River at the entrance to Lake Ontario in 1906-7, sulfate (SO_4) concentrations were estimated at 9.7 tons per square mile. In 1969, some 60 years later, concentrations were estimated at 25.2 tons per square mile.

Although some of the sulfate in 1906 could have been the result of atmospheric deposition, scientists believe they largely represent the natural stream condition dating back into the 19th Century. The increase in sulfate is thought to be due largely to an increase in atmospheric sulfur contributions to the Great Lakes drainage basin.

Similar estimates of sulfate for the Columbia River at Northport, Washington, in 1910 found concentrations of 22 tons per square mile; in 1954, concentrations had increased only slightly to 25.8 tons per square mile. Natural sources of sulfate in the Columbia include mineral and thermal springs in the Canadian part of the river's drainage basin. The human contribution to sulfate concentrations seems to be a relatively minor part of the total.

In short, even without considering affects from human activities, stream water quality is affected by a complex interaction of chemical, geological,and hydrological factors. No two river systems are exactly alike; each has unique characteristics that are not exactly duplicated in any other system. For a detailed discussion, see the multi-volume series by Ruth Patrick entitled *Rivers of the United States*.

sin, the Wolf River is one of the last wild riverways in the Midwest and a component of the National Wild and Scenic Rivers system. It is one of the premier fishing and whitewater recreation rivers in the region, and has been recognized by the state for its excellent water quality.

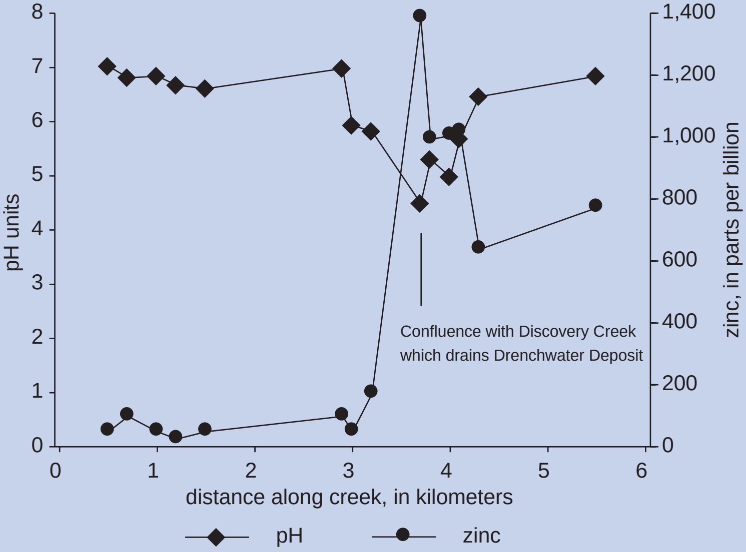
Crandon Mining Company is proposing to develop an immense zinc/copper sulfide deposit at the Mole Lake Reservation near Crandon, Wisconsin. The company plans to put part of the mine's waste in a dump at the headwaters of the Wolf River. The estimated 44 million tons of mine waste—including mercury, lead, zinc, arsenic, and sulfuric acid—has prompted American Rivers, Inc., an environmental organization, to list the Wolf as one of the nation's 20 most endangered rivers.

In February 1998, the Wisconsin legislature approved the Mining Moratorium bill, which would require the Wisconsin Department of Natural Resources to refrain from issuing a permit for a new sulfide mine until a similar mine has been operated elsewhere for at least 10 years and has been closed for at least 10 years without polluting groundwater or surface water. Governor Thompson is expected to sign the measure into law.

Case Study: Blackbird Mine, Idaho

The Blackbird mine site in the Salmon National Forest east of Salmon,

Box Figure 3.2 pH and Dissolved Zinc in Drenchwater Creek, Brooks Range, Alaska, July 1994



Source: U.S. Department of the Interior, U.S. Geological Survey, *Natural Environmental Effects of Silver-Lead-Zinc Deposits in the Brooks Range, Alaska*, USGS Fact Sheet 092-95 (USGS, Reston, VA, 1995).

Idaho, is one of the largest cobalt deposits in North America. Several companies have mined cobalt at the site since the late 1800s. Shaft methods were used through the late 1950s. Open-pit mining began in the late 1950s. Noranda Mining Company, which currently owns the site, ceased operations in 1982. At that point, the site included numerous waste rock piles, a 5-hectare open pit, about 24 kilometers of underground shafts and about 34 hectares of exposed contaminated mine wastes.

Mining tunnels, waste rock piles, tailing piles, and the open pit are located at the headwaters of Meadow and Bucktail Creeks, which drain into Big Deer and Blackbird Creeks. These creeks are part of the Middle Salmon River-Panther Creek drainage basin, which in turn is part of the Salmon River.

The site, which is on EPA's Superfund National Priorities List, has a variety of pollution problems, including acid drainage and leachate from the tunnels, waste piles, and tailings, plus high levels of heavy metals such as arsenic, copper, cobalt, and nickel. In 1983, the Idaho Attorney General filed a natural resources damage complaint against the current owner and two previous owners for alleged damages to the state's surface water and groundwater. The suit was settled in 1995.

In 1993, the potentially responsible parties initiated early actions to prevent further migration of the tailings, followed in 1995 by efforts to address the waste rock problem—including relocating some of the waste rock piles, intercepting groundwater and surface water for treatment, and capping an area and interecepting its groundwater for treatment. In late 1994, the potentially responsible parties, under EPA supervision, began to investigate the nature and extent of site contamination, which will be used to determine the most effective remedy for final site cleanup.

Panther Creek historically supported large runs of chinook salmon and steelhead trout, but these runs gradually declined during the 1940s when extensive mining activities began near Blackbird Creek. Since the early 1960s, the watershed has been largely uninhabitated by these species. Water quality degradation in Panther Creek from the Blackbird Mine seems to have been a significant factor in the decline of the chinook species, contributing to the now threatened status of the spring/summer chinook. Most of the salmon stock must pass through contaminated areas to reach suitable spawning grounds, and juveniles must migrate back through contaminated areas for summer rearing.

NOAA joined the state of Idaho and the Forest Service in a Natural Resource Damage Assessment in 1993, conducting extensive studies to determine the scope and scale of the damage and developing a restoration program. Major biological components of the restoration plan include:

- Restoration of spring/summer chinook salmon to Panther Creek. To accelerate run restoration, a fish barrier/trap and acclimation ponds will be maintained on Panther Creek for a period of time to capture returning adults and imprint juveniles.

- Realignment of 1.2 miles of a straightened and channelized section of Panther Creek to conform to its natural meander pattern to improve and create salmon and steelhead spawning and rearing habitat.
- Creation of off-channel habitat in Panther Creek to improve juvenile salmon rearing conditions.
- Fencing of 2 miles of heavily grazed private land along Panther Creek, and 5 to 8 miles of heavily grazed private land along other Salmon River Basin tributaries to allow regeneration of riparian vegetation and improve spawning and rearing conditions for salmon and steelhead.

All decisions regarding implementation will be made by a Trustee Council, comprised of representatives from NOAA, the Forest Service, and the state of Idaho. The trustees are working closely with EPA to ensure a coordinated, cost-effective remediation and restoration strategy. The consent decree settling the case requires the responsible parties to restore water quality in Panther Creek by 2002. The parties are also required to fund a program to reintroduce chinook salmon to Panther Creek; implement a Biological Restoration and Compensation Plan (BCRP) to restore and enhance salmon habitat in site-impacted and out-of-basin streams; fund trustee oversight of BCRP implementation; and reimburse trustees' past damage assessment costs.

Case Study: The New World Mine

In some especially sensitive headwaters areas, the prospect of even a single new mining project may bring unacceptably severe environmental risks. Such is the case with a recent proposal by Crown Butte Mines to develop a gold, copper, and silver mining complex less than three miles from the northeast border of Yellowstone National Park. The rights to the minerals at New World Mine had been obtained under the 1872 Mining Act.

The complex was to be located partially on private property and partially on public lands managed by the Forest Service. Most of the private lands at issue are held by Crown Butte or Ms. Margaret Reeb, a Montana resident who leased her lands to Crown Butte.

Crown Butte submitted a plan that called for 15 years of operation, with six major facilities, plus a 70-100 acre tailings impoundment behind a 90-foot-tall dam. The tailings impoundment was planned to contain the highly acidic waste rock and metals in perpetuity.

The New World proposal required preparation of an environmental impact statement under the National Environmental Policy Act. The EIS process began in April 1993.

A preliminary draft of the EIS showed that there could be major adverse impacts on the Clark's Fork of the Yellowstone River (a federally designated wild and scenic river), on grizzly bear habitat, and on Yellowstone National Park itself. Interagency review of preliminary drafts also showed a need for additional studies to characterize groundwater conditions at the mine site and for a risk assessment of the proposed tailings impoundment. As a result of these findings, work on the draft EIS was extended.

The preliminary draft EIS was widely reviewed. Many analysists, including mining engineers, were critical of the submerged tailings system. Questions also were raised about: seismological risks in an area that had experienced more than 4,000 earthquakes within a 180-mile radius; the need for more analysis concerning containment of the 5.5 million tons of highly acidic waste rock that would be generated by the mine; the risks associated with the tailings impoundment; and the lack of information about the potential impact of the mine on groundwater.

In March 1995, Wyoming Governor Jim Geringer wrote Montana Governor Marc Racicot to say that the alternative preferred by the company could have a significant impact on Wyoming water resources and suggested that the tailings impoundment should be the subject of a separate review. Because of the highly acidic nature of the ore body at the New World mine, Governor Geringer suggested a bonding level of $75 million to $100 million. The company's plan of operations called for "dewatering" a portion of Henderson Mountain, and the Yellowstone Water Compact governing water flows into the park could have required Crown Butte to replace the diverted water. It was also abundantly clear that there would be years of contentious litigation over the mine, regardless of whether the federal government approved or denied the company's application.

In the face of this apparent stalemate, environmental groups and the company began discussing creative ways to resolve the conflicts. In February 1996, Crown Butte, Hemlo Gold (the Crown Butte parent company) and the Greater Yellowstone Coalition asked the Clinton Administration to consider transferring federal assets to Crown Butte in exchange for the company's agreement to drop any further pursuit of the mine proposal. After studying the proposal, the Administration agreed to further discussions. The discussions focused primarily on the value of the mine, cleanup and restoration of the environmental impacts associated with past mining, resolving a protracted lawsuit brought by environmental groups, and resolving potential federal enforcement actions.

On August 12, 1996, President Clinton and the parties announced an agreement. The essential details were that Crown Butte would agree to drop plans to develop the site, that the federal government would agree to transfer to Crown Butte $65 million in federal assets in exchange for title to all the lands essential to development of the mine, that the company would place $22.5 million in a trust fund to remediate historic environmental contamination in the area; and that the parties would agree to settle the existing litigation by the environmental groups and potential environmental claims by the federal government. The agreement was contingent on: 1) identification by the United States of $65 million in federal assets that could be transferred to Crown Butte; and 2) Crown Butte's acquisition of the property it leases from Margaret Reeb.

After considering a wide variety of assets to exchange, Congress and the Administration ultimately decided to directly appropriate up to $65 million from the Land and Water Conservation Fund to acquire the Crown Butte/New World Mine property. The acquisition will be accompanied by an additional $12 million federal expenditure to improve and maintain the Beartooth Highway.

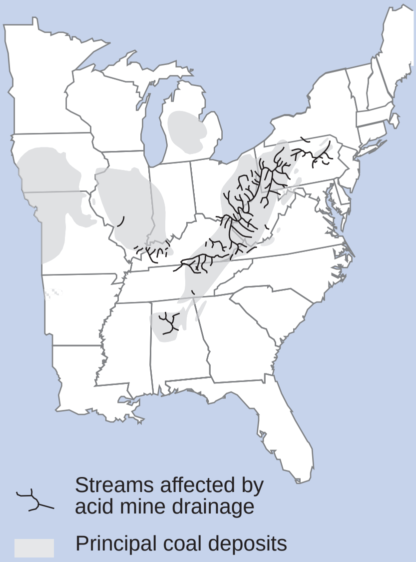
Acid Mine Drainage

Through the World War II era, coal was mined in Appalachia with little or no environmental control. Advances in technology gave the mining industry the capacity not only to mine coal more efficiently but also to disturb vast areas without reclamation at an alarming rate, both underground and on the surface, as mining became widespread. These new mining methods had two major impacts. First, fewer people were needed to mine greater quantities of coal. Declines in employment contributed to intense poverty and hardship. Second, the very lifeblood of thousands of communities, the streams and rivers, became so heavily polluted by acid and heavy metal contamination that they supported little or no life and were of limited use for drinking, agriculture, recreation, or aesthetic enjoyment.

Acid mine drainage (AMD)—water containing high concentrations of acidity, iron, manganese, aluminum, and other materials—is the number-one water pollution problem in the Appalachian region and has damaged more than 8,000 miles of streams and rivers in the eastern United States (Figure 3.11). Most acid drainage originates in abandoned underground coal mines and is carried by surface or groundwater into nearby streams. Affected streams are typically devoid of fish and other aquatic life due to low pH levels and the smothering effects of iron and other metals deposited on the stream beds. Acid mine drainage also can impair drinking water supplies, interfere with river recreation, and harm communities' economic development.

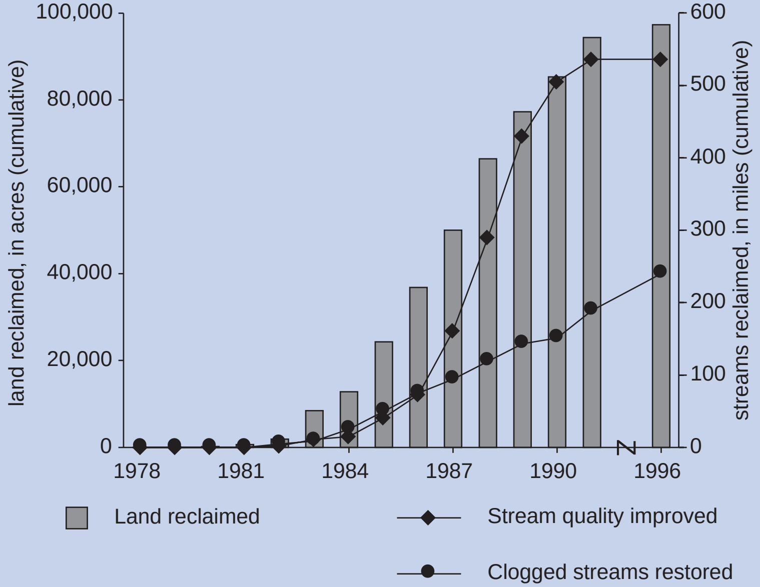
In the Allegheny River subbasin, a chain of industrial river valleys and min-

Figure 3.11 Streams Affected by Acid Mine Drainage



Source: Executive Office of the President, Council on Environmental Quality, *Environmental Trends* (GPO, Washington, DC, 1986).

Figure 3.12 Abandoned Coal Mine Land and Stream Reclamation, 1978-1996



Source: U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement, *Surface Coal Mining Reclamation: 20 Years of Progress, 1977-1997,* Part 2, Statistical Information (DOI, OSMRE, Washington, DC, forthcoming) and earlier reports.

ing towns east of Pittsburgh, 775 miles of streams are impacted by acid mine drainage. In the 130 miles of impaired streams in the Upper Allegheny Subbasin, resource extraction is a source of pollution in nearly 60 percent of the affected stream miles.

The problem is caused when surface or underground mining operations expose coal and bedrock high in pyrite (iron sulfide) to oxygen and moisture. If produced in sufficient quantity, the iron hydroxide and sulfuric acid that result from chemical and biological reactions eventually contaminate surface water and groundwater.

Filling or sealing old shafts to eliminate acid production is expensive, and the results have been inconsistent. Water treatment, the other main option, involves two types. “Active” treatment usually involves neutralizing acid-polluted water with hydrated lime or crushed limestone. This treatment reduces acidity and significantly decreases iron and other metals, but is expensive to construct and operate, requires constant maintenance, and does not permanently eliminate the problem.

Biological, or “passive,” control involves the construction of a treatment system that is more permanent and requires little or no maintenance. Passive control measures include the use of anoxic drains, limestone rock channels, alkaline recharge of groundwater, and diversion of drainage through man-made wetlands or other settling structures. Passive systems are relatively inexpensive to build and have been very successful in controlling some small discharges of acid drainage, but these technologies are still relatively new and their long-term effectiveness has not been proven.

The federal government has been actively engaged in dealing with acid mine drainage for several decades. The 1977 Surface Mining Control and Reclamation Act created a fund for abandoned mine land (AML), which is supported by tonnage-based fees collected from coal producers. Each year Congress appropriates money from the fund for reclamation projects. Coal companies paid in $266 million in FY 1997 to the fund and Congress appropriated $174 million in FY 1997. As of September 1997, there was $1.2 billion in the fund's unappropriated balance.

Historically, abandoned-mine-related water quality problems were not considered a top priority, making it difficult for states and tribes to fund a significant number of reclamation projects. (The law requires that one half of the funds collected within a state or Indian tribal boundaries be reserved for use by that state or Indian tribe. To receive a grant, a state or Indian tribe must have a reclamation plan that has been approved by the Secretary of Interior.)

In 1990 the law was amended to include adverse economic impacts on a community as a reason for giving priority to the reclamation of certain sites. Beginning in 1995, Interior's Office of Surface Mining (OSM) encouraged states and tribes to consider whether acid mine drainage pollution sites could be considered "general welfare" problems that had an adverse economic impact on a community. Such an interpretation gives these water problems a higher priority and allows them to compete more easily for limited AML dollars. The law also provides that up to 10 percent of the annual grants to states and tribes may be set aside in state-managed accounts for use in cleaning up mine drainage problems. OSM also has determined that funds in these accounts can be used to match other federal grants for stream cleanup projects. In the FY 1997 appropriation, Congress authorized states and tribes to use any of the AML grant funds to match other federal dollars, as long as the purpose is environmental restoration related to treatment or abatement of acid mine drainage from eligible abandoned mines and if the project is consistent with the law's purposes and priorities. Progress to date is shown in Figure 3.12.

The Appalachian Clean Steams Initiative. In the 1960s and 1970s, dozens of federal agencies and all states had some jurisdiction over mine drainage, but communication among these groups was practically nonexistent.

To help break down these barriers, OSM in 1995 started a new program called the Appalachian Clean Streams Initiative. The Clean Streams Initiative has a simple, but challenging mission: unite all parties to clean up streams polluted by mine drainage. The initiative encourages increased information exchange, multiagency coordination, and the formation of partnerships among government, citizens, and corporations to bring innovative solutions to this national problem. The initiative is a watershed-based, grassroots partnership and alliance with over 40 state, federal and local organizations dedicated to stream cleanup.

In FY 1996, the Clean Streams Initiative team established a clearinghouse for information and technology on acid mine drainage and a World Wide Web site. A working group with the states and the International Association of Fish and Wildlife Agencies identified and ranked candidate projects, and proposed a pilot program to clean up 236 miles of streams in nine states at a cost of about $22 million. The group estimated that the projects would generate $6 million in economic benefits yearly in increased recreation and fishing. Congress authorized $4 million for an initial grants program covering 14 projects in nine states. For most of these projects, these grants provide only “seed” money; additional funding must be arranged through cooperating government agencies and private sector groups.

All told, these projects will clean up almost 200 miles of streams. For example:

- Restoration of Cane Creek, which is within the Wolf Creek Wildlife Management Area in Alabama. Phase I of the Cane Creek project, which is completed, helped restore a 20-mile multi-species fishery on public land and eliminated a hazardous sinkhole. This project was strongly supported by the citizens of the region, several state agencies and the U.S. Fish and Wildlife Service.
- The first phase of the Quemahoning Creek project is completed. This project will restore about 15 miles of fishery and improve a public water supply to Farrellton, Pennsylvania. This project has strong support from several federal agencies, as well as state, county, local and private groups.
- Little Toby Creek in Pennsylvania is a wadable, fast-flowing cold water stream in an area of historic and widespread mining impacts. A proposed restoration would support the area’s inclusion into the Wild and Scenic River System, create a trout fishery and other recreational benefits, and generate economic benefits to the nearby communities.

An additional Clean Streams Initiative achievement is the accelerated development of low cost, reliable technologies for acid mine drainage treatment and prevention, such as constructed wetlands and other passive systems. Project partners, including the mining industry, started an Acid Drainage Technology Initiative to identify best science and technology for AMD prediction, avoidance, and abatement.

Clean streams return benefits to the local area many times greater than the initial investment. Clean drinking water improves the general health of the population by reducing sulfates and heavy metal contamination that are common results of acid mine drainage. Clean rivers and streams benefit agriculture, recreation, tourism, and navigation.

Industries that depend on clean water often bypass Appalachian towns in part because their streams are polluted by acid mine drainage. The dirty waters reflect poorly on the community and diminish the pride people take in their hometowns. Cleaning up these eyesores could make the difference in attracting new businesses and laying the foundation for sustainable economies.

Because of the clean streams initiative, several new citizen watershed groups have formed to clean up and protect streams and rivers and many other citizen groups with an environmental or clean water agenda have become more active. These groups are taking an active role and helping to set the the Initiative's agenda and priorities. The Clean Streams Initiative team has received Vice President Gore's Hammer Award for its innovative approach to government reinvention.

RESOURCE PRESSURES: TIMBER

Timber harvesting can have a wide variety of impacts on stream water quality and aquatic resources. The range and extent of impacts are influenced by factors such as climate, topography, soils, and proximity to water bodies.

One of the most significant impacts is the road-building infrastructure created to carry out timber operations. In the Pacific Northwest, which has been intensively studied in recent years and is the primary focus of this discussion, road networks in many upland areas are the most important source of sediment delivery to streams and rivers. The contribution of roads to stream sedimentation is often much greater than all other land management activities combined. Road-related landslides, surface erosion and stream channel diversions frequently deliver large quantities of sediments to streams, both chronically and catastrophically during large storms. No matter how well they are located, designed, or maintained, roads may have unavoidable impacts on streams. Many older roads with poor locations and inadequate drainage control and maintenance pose high risks of erosion and stream sedimentation.

Stream crossings are especially vulnerable elements of road networks. Within the range of the northern spotted owl in the Pacific Northwest, there are approximately 110,000 miles of roads on federal lands and about 250,000 stream crossings (culverts). The majority of these crossings cannot tolerate more than a 25-year flow event without failing. Over a 30-year period, there is a 70 percent chance that such an event will occur. When stream crossings fail, a local flood usually occurs, resulting in severe impacts on water quality and habitat.

Roads modify natural hillslope drainage networks and accelerate erosion processes. Where roads slope to a ditch, the ditch extends the drainage network, collects surface water from the road surface, and transports this water quickly to streams. In watersheds of 20-200 square miles in the Pacific Northwest, increased peak flows have been detected after road construction and clearcutting occurred,

A stream in central New Hampshire.

Photo Credit:
S.C. Delaney/EPA

though there is considerable variability among sites. Removing forest vegetation alters hydrological processes such as rain or snow interception and snow accumulation and melt, which tends to increase the amount of water flowing from a logged watershed.

In many watersheds, peak flows appear to rise in a nonlinear fashion with increased timber harvest. Hydrologic impacts may appear when less than 20 percent of a watershed is clearcut. For example, peak winter storm flows increased 13 percent after 19 percent of a coastal British Columbia watershed was clearcut. In the rain-dominated systems of the Coast Range, clearcutting two thirds or more of a watershed may increase fall peak flows by about 50 percent and winter peak flows by 20-30 percent.

These alterations tend to be most severe immediately after timber harvesting and gradually diminish over time, but the alteration of hydrological processes can continue for three to four decades. The long-term impacts of logging also depend on the types of trees that dominate the landscape before and after harvest. One study of a stream in Oregon's Cascade Range found that August flows increased for 8 years following logging, but decreased for 18 of the next 19 years. The authors attributed the reduction in streamflow to the replacement of coniferous vegetation with more water-consumptive hardwood species.

These changes can have significant biological consequences that affect virtually all components of stream ecosystems. Increased levels of sedimentation can reduce the survival rates of fish eggs in spawning gravels, reduce the availability of food for fish, and disrupt social and feeding behavior.

Timber harvesting can also reduce the complexity of aquatic habitats, which is an important indicator of the quality of aquatic ecosystems. Trees in streams are an important factor in creating large pools, which are preferred habitat for fish species such as salmon. Reducing wood in the channel generally reduces the quantity and quality of such pools. Within the range of the northern spotted owl in eastern and western Washington, it is estimated that in the past 50 years there has been a 58 percent reduction in the number of large, deep pools in resurveyed streams on National Forests. On private lands in coastal Oregon, it is estimated that large pools have decreased by 80 percent.

Bridge approaches and streamside roads tend to reduce stream meandering and decrease pools formed by stream meanders. Road failures on steep slopes can cause severe sedimentation that can result in the loss of pools.

Logging in riparian areas has a variety of environmental impacts. Loss of streamside vegetation reduces shade and tends to increase stream temperatures, with subsequent adverse impacts on fish and other aquatic life. The roots of trees and shrubs play an important role in stabilizing streambanks. Timber harvesting and the subsequent loss of root strength may lead to increased incidence of debris slides and flows.

For coniferous forests of the Coast Range and western Cascades, increases in average summer maximum temperatures because of clear-cutting have ranged from about 3 to 8 degrees Centigrade. Increases up to 10 degrees Centigrade have been observed when clear-cutting has been followed by slash burning. The cumulative effects of temperature increases are less well understood. One study of the Needle Branch in Oregon's Coast Range found that stream temperatures returned to near normal conditions after years, with alders replacing conifers as the dominant riparian vegetation. Other studies suggest that elevated temperatures may persist for two decades or more. In the higher elevation fir zone of the Cascades, shading may not return to prelogging levels for 40 years or more. For more on the impacts of riparian vegetation loss, see Chapter Four.

Case Study: Bitterroot National Forest

Applying ecosystem-based management approaches to real-life situations is an extraordinarily complex challenge. One effort is currently underway in the Bitterroot National Forest in western Montana and northeastern Idaho. This national forest, which includes grassland, forest, and alpine ecosystems, surrounds a valley that is both agricultural and urban and is experiencing rapid development. As with most national forests, forest managers must protect species and structural diversity in this landscape and also provide commodities and other benefits to the public.

The Bitterroot Ecosystem Management/Research Project addresses these challenges through a science-management partnership. The project brings together people and resources from the Rocky Mountain Research Station, the University of Montana, several management levels in the National Forest System, and the public. Cooperators have matched the value of the project's original grant.

Four teams of specialists investigate questions relating to social aspects of ecosystems, landscape analysis, vegetation, and fauna. For example, the Human Dimensions Research Group is attempting to integrate the needs of local residents and forest owners with other aspects of management. In one unit, the Stevensville West Central area, more than 20 meetings were held to determine public perceptions, needs, and desires in relation to management. Followup research showed diverse ways of viewing the success of the public involvement effort; many viewed mutual learning as an important aspect of success. An evaluation of the use of collaborative methods in the Bitterroot Valley and other areas in western Montana identified 10 characteristics of successful programs, including participation by the agency representatives with decision-making authority.

The Vegetation Research Group describes current conditions and processes in Bitterroot forest and grassland communities. Demonstration projects have been initiated to regenerate whitebark pine, restore ponderosa pine and western larch, and reduce fire hazard in the wildlands near communities. The Fauna Research Group has investigated the status of several mammal species, aquatic insects, and migrant birds in Bitterroot ecosystems.

The Landscape Analysis Research Group has developed a geographic information system and models that analyze change in forest ecosystems and management options on a landscape scale. Managers have used results from these models to develop alternative treatment strategies for one planning area. Subsequent model runs designed to optimize various benefits produced results that managers incorporated into final alternatives. Scientists report results after completing each major phase of the research. Subsequent research is sometimes modified to answer questions from managers or the public. Dialogue with the public has been an important part of the effort. Education and communication efforts have included formal workshops to present results and address questions; displays and informational materials; progress reports for the public; several public field trips to demonstration sites; and educational materials for students. An Internet site (www.forestry.umt.edu/bemrp) describes the project and individual studies.

THE POWER OF PARTNERSHIPS

While in some cases, such as New World Mine, a single source can threaten a headwaters ecosystem, it is often the case that threats are multiple in nature and principally attributable to general development pressures. Many examples now point to the value of collaborative partnerships in working through these complex situations. Two examples are cited here: Lake Tahoe and the Upper Clark Fork River Basin in western Montana.

Case Study: Lake Tahoe

Lake Tahoe, which is renowned for the clarity of its water and the scenic beauty of its surrounding forests, lies on the California-Nevada border between the Carson Range to the east and the Sierra Nevada Range to the west. The lake is 22 miles long and 12 miles wide, with a surface elevation of 6,223 feet above sea level and a maximum depth of 1,645 feet, making Lake Tahoe the tenth deepest lake in the world. A short growing season, together with highly erodible soils and steep slopes, makes the lake and basin particularly susceptible to erosion, surface runoff, and water quality degradation.

Lake Tahoe is a popular destination for tourists seeking water sports, skiing, gaming, and other entertainment. Propelled by the Squaw Valley Winter Olympics in 1960, the population increased over five times. The current year-round population is estimated at 52,000, and the summertime population can swell to 300,000.

Historically and even today, Lake Tahoe is notable among the world's great mountain lakes for the clarity of its waters. Over the last 40 years, however, lake clarity has diminished by about 1 foot per year on average (Figure 3.13). Concurrently, algal growth in the lake is increasing at a rate of about 5 percent per year and contributing to an increase in primary productivity levels (Figure 3.14).

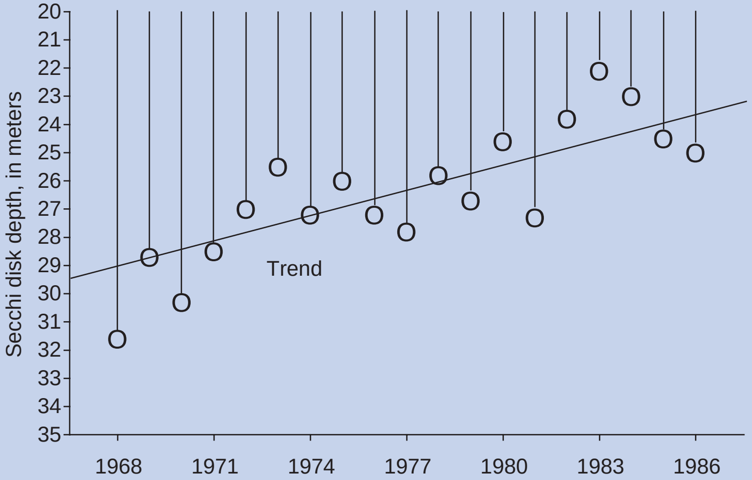
Research has shown that the algae are stimulated by nitrogen, phosphorus, and some micronutrients such as iron. Land development in the basin has increased the rate of sedimentation and fertilization and thus nutrient transport. Other sources, including in-lake nutrient recycling and precipitation, also contribute to the problem.

In-lake nutrient recycling is more dynamic than previously thought. The traditional belief was that nutrients deposited would soon sink well below the surface and not be available to algae. But in 1983, and again in 1993, scientists observed major "turnover" events in the lake. In the 1993 event, it was estimated that nutrients recycled from the deeper zones of the lake exceeded several years of input from all the tributary streams.

Scientists also believe that precipitation brings another significant source of nutrients to the Lake Tahoe basin. The principal source of nitrogen in precipitation is thought to be automobile emissions, but the share of the emissions attributable to local traffic (as opposed to outside sources) is not known. Traffic congestion is clearly getting worse in the region: daily traffic counts on the access routes to the region increased by an average 9.2 percent annually between 1981 and 1990.

Forest health is another significant environmental problem in the Tahoe basin. Lake Tahoe's Ponderosa-pine-dominated forest was leveled in the 19th Century to provide timber for the silver mines of the Comstock Lode in Virginia City. As the young pine and fir trees that replaced the old-growth forest matured, a

Figure 3.13 Annual Average Secchi Disk Depth at the Index Station, Lake Tahoe, 1968-1986



Source: Lahontan Water Quality Control Board, *Water Quality Plan for the Lahontan Region* (1994).
Note: A Secchi disk measures water clarity, an indicator of water quality. The disk is lowered overboard, tethered by a line with graduations, and a measurement is taken when the disk disappears from view.

combination of factors—lack of thinning, exclusion of natural fires, and above-average rainfall—produced the current overcrowded forest of even-aged trees and dense undergrowth. These overstocked forests were hit hard by the prolonged drought from 1986 to 1994, which precipitated a bark beetle infestation that caused widespread tree mortality. The 25-30 percent tree mortality in the basin has created a dangerous fire hazard. Forest fires could threaten the basin's soil, water, and wildlife habitat, as well and human lives and property. Extensive salvage harvests could reduce the fire hazard, but could also create serious water quality problems.

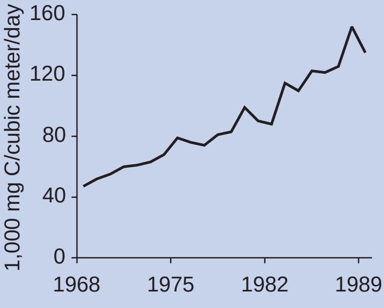
In 1969, at the joint request of the states of California and Nevada, the Tahoe Regional Planning Agency (TRPA) was established by federal law as a bi-state planning and regulatory agency, to better manage growth and to protect the lake and its surrounding environment.

TRPA developed a regional plan intended to control the rate of growth of housing and other development and protect the lake's water quality. Under the plan, new home construction in the basin was limited to 300 units per year, and new construction in "stream environment zones"— generally areas that owe their biological characteristics to the presence of surface water or groundwater—was banned. Transferable development rights were granted to all property owners, including those whose property value might be lost, either in whole or in part, by the ban. These rights could be sold to developers of less environmentally sensitive land. Limits were placed on the "footprint" of buildings, and additions or major remodeling were subject to strict controls to avoid environmental problems.

Under the plan's Individual Parcel Evaluation System (IPES), all undeveloped residential lots were evaluated and scored for their suitability for development based on factors such as relative erosion hazard, runoff potential, ability to revegetate, and proximity to the lake. In 1989, the agency established a minimum score of 725 to qualify for development; properties with lower scores could not be developed. Properties located in stream environment zones received a score of zero, thus precluding development. Owners of property in stream environment zones were given transferable development rights for use on an eligible property in the Lake Tahoe region.

These development controls have proved controversial, particularly among property owners in stream environment zones and other property owners seeking to build new facilities or extensions of older facilities not in compliance with regulatory requirements. Two cases claiming a "taking" of property rights are pending in the federal court system. There have been calls for TRPA to complete permitting actions within 120 days, which would effectively streamline the project review process.

Figure 3.14 Annual Primary Productivity Levels at the Index Station, Lake Tahoe, 1968-1989



Source: Lahontan Water Quality Control Board, *Water Quality Plan for the Lahontan Region* (1994).

As part of its general budget retrenchment in the last few years, California legislators have passed across-the-board cuts in state agencies, including California's two-thirds-share of TRPA's budget. In 1996, a California Assemblyman sympathetic to the criticisms about development restrictions sought to withhold California's entire share of the TRPA budget. The defunding initiative was defeated, but the state required TRPA to use part of its budget to perform a major performance audit. Subsequently, in response to criticisms from Nevada legislators that this required Nevada to pay part of the cost of an audit they considered unnecessary, an alternative source of funds was found.

After 10 years of emphasis on the regulatory approach to controlling the impacts of new development, TRPA is shifting its focus towards facilitating capital investment in environmental improvements.The agency has drafted a proposed 10-year, $900 million environmental initiative that calls for a variety of programs, projects, and regulatory amendments that are primarily intended to reduce erosion and lake sedimentation. The partnership will be supported by $300 million in federal funds, $275 million from the state of California, $85 million from Nevada, and

Tranquil edge of a lake in California.

Photo Credit:
John Rusnak/USGS

the rest from local government and private sources.

In July 1997, President Clinton issued an executive order creating the Tahoe Federal Interagency Partnership, which is intended to facilitate coordination of federal programs and activities within the Lake Tahoe region and promote cooperation with state and local agencies. The president pledged $50 million in assistance (including $26 million in new federal funding) to protect Lake Tahoe and support TRPA's environmental improvement initiative.

Regional officials also are looking at various ways to ameliorate the traffic congestion problem. With the help of a $2.5 million grant from the Environmental Protection Agency and Department of Transportation, the region is supporting a demonstration project called the Coordinated Transit System (CTS). CTS will merge existing public and private transit services into a bi-state, centrally operated, centrally dispatched system that passengers will access via touch-screen kiosks at shopping areas, hotel lobbies, or through a voice-mail telephone system. The system will dispatch a roving fleet vehicle and notify the passengers of the time when they will be picked up.

Case Study: Upper Clark Fork River

The Clark Fork River is a Columbia River tributary that drains most of Montana west of the Continental Divide. The case was described in a recent report by the National Academy of Public Administration, entitled *Resolving the Paradox of Environmental Protection*.

Community-based efforts in this region are particularly challenging because of the sharp conflicts over resources and environment that have characterized the area for nearly a century. In Butte, near the headwaters of the Clark Fork River, lies a massive open pit that once produced millions of dollars of copper ore for the Anaconda Mining Company.

Mine tailings from the Butte pit have traveled as much as 120 miles down the Clark Fork, making it the nation's largest superfund site. ARCO bought Anaconda in the 1970s and later sold the company, but was not able divest itself of Anaconda's superfund liabilities. Cleanup is underway, but the state of Montana has sued ARCO for $730 million to repair damage to the valley's natural resources.

Downstream, the river flows through some of the oldest ranching country in the state. Much of the area is still open ranch land, but residential development is occurring in some parts of the valley.

In 1988, the Northwest Area Foundation awarded a grant to the Northern Lights Institute, a small environmental organization in Missoula that was interested in promoting a civic dialogue on environmental issues. The grant was intended to build a coalition to address environmental issues in the Upper Clark Fork Basin.

As a first project, Northern Lights tackled the always controversial issue of water rights. The specific issue at hand was a pending attempt by the state Department of Fish, Game, and Parks to file legal claims for instream flows in the Upper Clark Fork River. State legislation passed in 1969 and 1973 gave the department the right to "reserve" instream flows sufficient to protect trout populations and to protect other ecosystem services. But the department's initial efforts to reserve water under the statute proved very controversial, pitting lawyers for the department against lawyers from mining companies and rancher-controlled local conservation districts. Ranching, mining, and municipal water supply had always been legally beneficial uses, with individual rights determined by the seniority of the claim.

By 1989, the department had completed an environmental impact statement on how instream flows might benefit fish in the Upper Clark Fork Basin. Agricultural interests were thinking about filing suit, environmentalists were prepared to intervene on the side of the department, and a local conservation district wanted to build a dam on a side creek to store water for use by ranchers in the summer. ARCO also was part of the picture, since it had sold its water rights along with its mining properties and needed water rights to use for the superfund cleanup.

Northern Lights organized a committee of ranchers, environmentalists, businesses, and state and local government officials to study the state of the Upper Clark Fork River. In January 1991, the committee asked the state legislature to suspend the normal processes for allocating water rights until it could write a management plan for the river.

The collaborative effort used a variety of tools to build consensus, including seven public hearings, field trips, publication of articles, briefings on conditions in the basin, and discussions of technical issues. Gerald Mueller, the director of Northern Lights, played an important role as a facilitator. As the process unfolded, mutual trust and loyalty to the process increased.

The steering committee submitted its report to the legislature in 1995. The report recommended that the legislature enable the Department of Fish, Wildlife, and Parks to lease water from ranchers and farmers, and convert those water rights into instream flows. That would allow water being used for irrigation to be left in the river to support fisheries. The report also proposed to use wastewater from the Deer Lodge city treatment plant to irrigate pasture at a National Park Service ranch, which would remove the largest single source of nutrient pollution from the upper river. The legislature adopted virtually all of the management plan.

The story of the Upper Clark Fork Steering Committee adds further credence to the growing conviction that community-based approaches can break through gridlock, avert litigation, and protect the environment while also achieving other community goals.

The authors of the case study concluded that state and federal agencies can provide essential financial and technical assistance, but must refrain from overwhelming community-based efforts. Like other participants, the National Academy of Public Administration found that state and federal officials must be prepared to reconsider the current positions of their agencies, to think creatively for fresh ways to address local issues, and to have authorization from their superiors to actively participate.

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