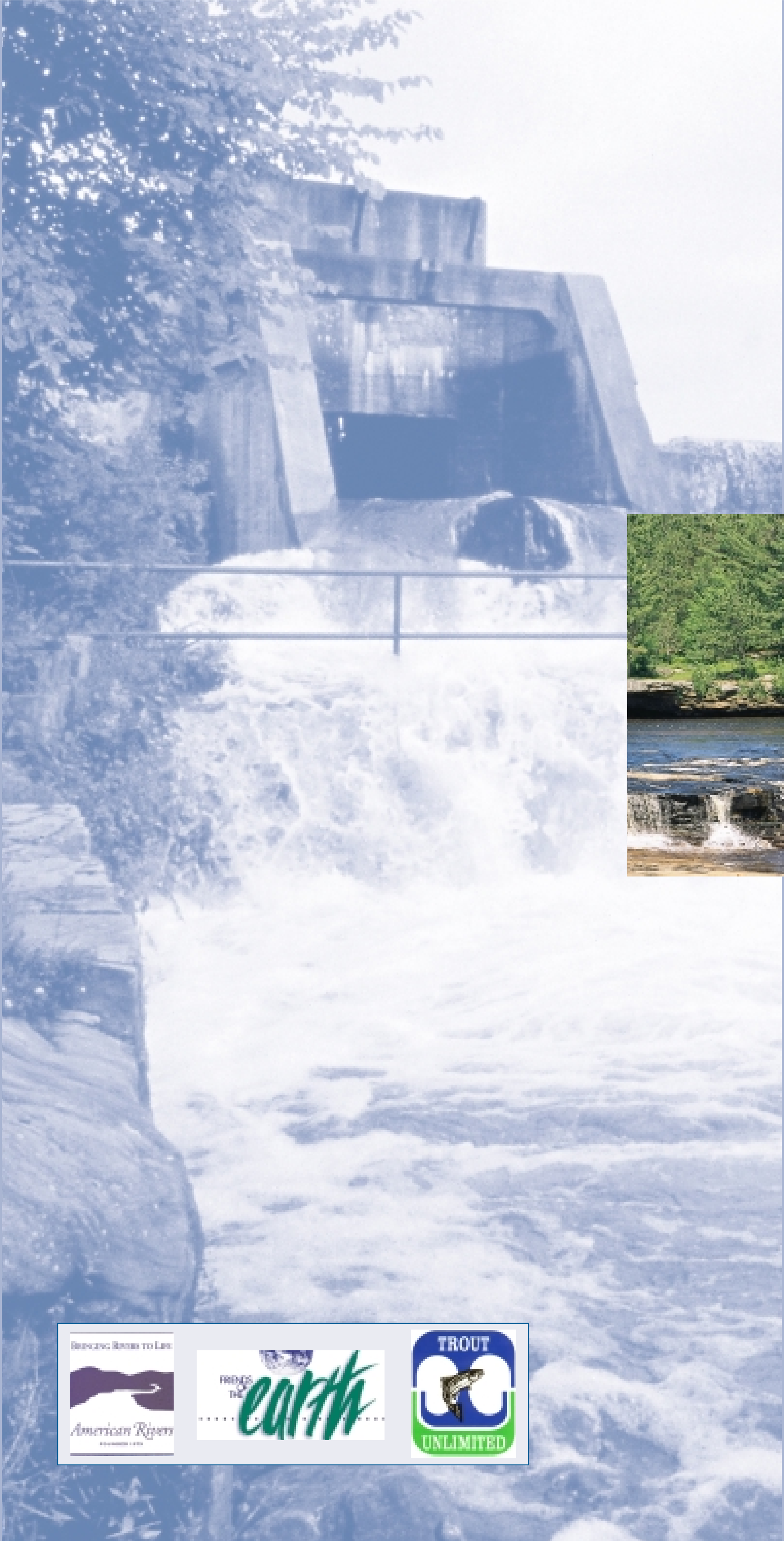


DAM REMOVAL SUCCESS STORIES

RESTORING RIVERS THROUGH SELECTIVE REMOVAL OF DAMS THAT DON'T MAKE SENSE

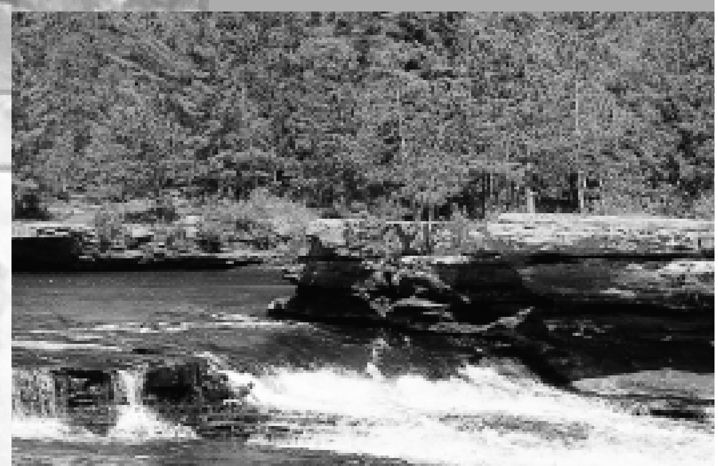
BRINGING RIVERS TO LIFE
American Rivers

FRIENDS OF THE earth

TROUT UNLIMITED

DECEMBER 1999

DAM REMOVAL SUCCESS STORIES



Restoring Rivers through Selective Removal of Dams that Don't Make Sense

DECEMBER 1999

This report was prepared by
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DAM REMOVAL SUCCESS STORIES:
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Introduction

Over the past 100 years, the United States led the world in dam building—blocking and harnessing rivers for a variety of purposes, including hydropower, irrigation, flood control, and water storage. The US Army Corps of Engineers (Army Corps) has catalogued approximately 75,000 dams greater than six feet tall along the waterways of the United States[1]—and at least tens of thousands of smaller dams plug our rivers across the country. (The National Research Council estimates that the number of US dams is over 2.5 million.[2]) US Secretary of the Interior Bruce Babbitt recently observed, "that means we have been building, on average, one large dam a day, every single day, since the Declaration of Independence."[3]

Few human actions have more significant impacts on a river system than the presence of a dam. As a result, dams occupy a central role in the debate about protecting and restoring our river resources. Many of the major environmental campaigns in the United States, and around the world, have revolved around efforts to fight construction of large dams. Hetch Hetchy, Marble Gorge, Bridge Canyon, Tellico, and Three Gorges are all examples of pivotal campaigns focused on the environmental, economic, and societal costs and benefits associated with building a new dam.

A less known page in the history of rivers is the large number of dams that have been removed. Relatively little attention has been paid to the hundreds of smaller dams that have been torn down and the thousands of miles of free flowing rivers that have been restored. For decades dam removal has been an accepted approach for dam owners to deal with unsafe, unwanted, or obsolete dams. The decision to remove a dam is not as radical an idea as some today may suggest; dams are removed all the time, by a variety of entities, for a variety of reasons. Just as for any building or other human construction, dams have finite lifetimes and are often removed when they become obsolete or dangerous.

Although dams can provide important societal benefits, dams also cause negative impacts to rivers, wildlife, and sometimes local communities. Some dams no longer provide any benefits, while continuing to harm the river. Others have significant negative impacts that outweigh the dam's benefits. Still others simply are so old and/or unsafe that they cost too much money to maintain. In these situations, dam removal has been demonstrated to be a reasonable option to eliminate negative impacts and safety concerns.

[1] The Army Corps criteria for including a dam in the National Inventory of Dams (NID) is as follows: (1) high hazard (failure would likely cause loss of life and significant property damage); (2) (6 ft in height and impoundment (50 acre-feet; or (3) (25 ft and impoundment >15 acre-feet.

[2] NRC. *Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy*. Committee on Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy. National Academy Press: Washington, DC. p. 26. 1992.

[3] Babbitt, Bruce. "Dams are not Forever." *Ecological Society of America*. Remarks of Interior Secretary. Baltimore, Maryland. August 4, 1998

I. Dam Removal - Not a New Concept

In recent years, the public debate regarding whether or not to remove certain dams blocking key river stretches has become increasingly visible. National and local media have produced numerous news reports and articles on proposed dam removals in nearly every region of the country. Yet despite this growing national policy debate regarding proposed dam removals, surprisingly little attention has been paid to the hundreds of smaller dams that have already been removed in the United States.

For those interested in the issue, learning about previous dam removals has been a difficult endeavor. While volumes have been written on the construction of dams—and to a lesser extent on campaigns opposing construction of dams—little information is available on the history of taking down dams. Citizens and policy makers considering the future of a dam have a limited ability to review similar situations from the past. No comprehensive review of dam removal experiences exists nor is there a complete compilation of lessons learned.

To help compensate for this lack of information, *American Rivers*, *Friends of the Earth*, and *Trout Unlimited* have prepared this report providing information on some of the dams that have been removed—and the ecological, safety, and economic benefits that accompanied these removals. Our research identified more than 465 dams that have been removed in the United States since 1912.[4] We have documented removals in all regions of the country, from Washington State to Florida, from Maine to California, Texas to North Dakota.

In addition to the list of over 465 dams that have been removed around the country, we have also compiled 26 case studies on various dam removals—25 of which are dams that were successfully removed, providing cost-effective opportunities to restore river system health, alleviate dam safety concerns, and, in some circumstances, revitalize local communities. The final case study (which is included as an appendix), while not a success story, is an equally important aspect of this report and of dam removal history and provides lessons about some mistakes to avoid when removing a dam.

The case studies in this report were selected for their regional representation, as well as their distinct successes in one or more of the following areas: ecological restoration; public safety hazard elimination; cost-effective decision-making; and community revitalization. The case studies are not necessarily a representative sample of the 465 dams that have been removed across the country, but rather were chosen to highlight their successfulness. By both recognizing and honoring their successes, we hope that these dam removal case studies will encourage more dam owners, natural resource managers, conservationists, and others concerned with the future of our nation's rivers to consider dam removal as an option at appropriate decision points in a dam's life.

In researching past dam removals, we utilized a variety of sources for information. We were faced with the fact that there is no single, centralized repository of records and data on dam removals at either the federal or state level. While the Army Corps maintains the National Inventory of Dams (NID) for existing "large" dams, there is no comparable database on either small dams or removed dams. Individual federal agencies such as the National Park Service and US Forest Service, as well as the Army Corps, have information on selected dam removals, but these include just those projects in which the agency was involved, and may not be inclusive. Most state governments maintain records

[4] We do not believe that this is a thorough listing of all dams removed, and expect the number is higher. Many states and federal agencies have not kept thorough records of dams under their jurisdiction that have been removed.

on dams under their jurisdiction, including information on dams breached, removed, or never built. But the majority of the state-maintained documentation on past removals is incomplete at best. Very little of the data is computerized or otherwise organized in an easily accessible format. It is often scattered among a myriad of locations or agencies, and in some instances has been completely lost or destroyed. Many smaller dam removals (e.g. less than six feet high) often are not documented at all.

As a result, the list of removed dams that we have compiled should not be considered comprehensive. It is based upon data collected from state dam safety offices, federal agencies, river conservation and fishing organizations, dam owners, media reports, and academic institutions. Our report represents an attempt to bring together existing information on past dam removals. It relies on information from these various sources, much of which is hard to confirm and is of variable accuracy. We are sure that others will be able to add to and revise the list, and we encourage interested parties to help expand and move the discussion forward by contacting one of our organizations (see page xviii for contact information).

II. General Information about Dams in the United States

A. Uses and Ownership of Dams

As mentioned above, there are approximately 75,000 dams over six feet tall on rivers across the United States, and tens of thousands more smaller dams. Dams have been built for a variety of reasons: to harness water to generate electricity, irrigate crop lands, protect from flooding, assist navigation and transportation, supply municipal water systems, and provide flat-water recreation opportunities (see Table 1).

Table 1. Listed purposes of dams in the US Army Corps of Engineers National Inventory of Dams.

Purpose	*Percentage*	*Number*
Recreation	31.3	23,185
Fire & farm ponds	17.0	12,557
Flood control	14.6	10,801
Irrigation	13.7	10,176
Water supply	9.8	7,226
Tailings & other	8.1	5,967
Hydroelectric	2.9	2,166
Undetermined	2.3	1,732
Navigation	0.3	243

The federal government is the largest single owner and operator of large dams in the country. Yet while the federal government owns more dams than anyone else, it still accounts for only three percent of all the dams in the United States. The majority of dams nationwide are privately owned, with local and state governments, including public utility districts, also owning a sizeable number (see Table 2).

Table 2. Ownership of dams in the US Army Corps of Engineers National Inventory of Dams

Owner	*Percentage*
Private	58
Local government	17
Undetermined	15
State government	5
Federal government	3
Public utility	2

B. Regulation/Public Oversight of Dams

There are numerous federal, state, and local government agencies with overlapping layers of authority and responsibility for regulating and overseeing dams on our public waterways. Most federal dams are built and operated by the Army Corps or the Bureau of Reclamation. Management decisions for these projects are guided by numerous statutes and specific project authorizations enacted by Congress, including the Reclamation Act, Flood Control Act, Water Supply Act, Endangered Species Act, Clean Water Act, and Pacific Northwest

Electric Power Planning and Conservation Act. The Army Corps and Bureau of Reclamation work in consultation with other federal agencies, such as the Department of Energy's power marketing division, to control how the dams and associated water and power facilities are operated.

The Federal Energy Regulatory Commission (FERC) is the agency responsible for determining if and how most non-federal hydroelectric dams are built and operated. FERC determines under what conditions new and existing projects can operate for a license period of up to 50 years. FERC licensing decisions must comply with numerous federal laws including the Federal Power Act, Electric Consumers Protection Act, Endangered Species Act, and National Environmental Policy Act. When a dam's license expires, the project owner must apply for a new FERC license if they want to continue to operate the dam. Due to the length of the license period, the relicensing process provides a once in a generation opportunity to re-evaluate the appropriate use of a river's resources and the future operations of a dam project.

In 1994, FERC determined that it has the authority to require the decommissioning (including removal) of dams at licensee expense at the end of their license term.[5] FERC utilized this authority in the case of the Edwards Dam, on the Kennebec River in Maine. In November 1998, FERC denied the dam owner's application for a new operating license and ordered that the dam be removed and paid for by the owner. Pursuant to a settlement agreement between all active parties to the relicensing, the dam was removed in the summer and fall of 1999. The costs of dam removal were financed by upriver dam owners in exchange for a delay in their fish passage obligations and by a shipbuilder downstream as mitigation for expanding its operations. (See the Kennebec River Success Story on page 59 for more information about this removal.)

Increasingly, intervening groups and the licensee are choosing to negotiate directly to develop a mutually agreeable settlement of the licensing proceeding. These settlements, attained outside the FERC process, have sometimes yielded faster and more creative improvements for rivers than those achieved in traditional relicensing and, in some cases, have the potential to save the dam owner millions of dollars over traditional processes. These negotiations are free to explore decommissioning and removal options. For instance, the relicensing proceeding for 11 hydroelectric projects in Michigan owned by Consumers Power Company included an agreement for the removal of Stronach Dam on the Pine River. In Washington State, conservation groups, state and federal resource agencies, and Native American tribes recently signed a settlement agreement with PacifiCorp whereby the utility will remove Condit Dam on the White Salmon River in order to re-establish salmon runs in this federally-designated Wild and Scenic River. A collaborative agreement with Wisconsin Electric (WE), which affects 11 dams on the Menominee River System, includes the removal of three uneconomical dams. WE reduced its relicensing costs considerably, and maintained future operational flexibility for eight dams (which helps ensure these projects remain economically viable), while providing environmental, recreational, and socio-economic benefits in the basin for the 40-year life of the license.

In addition to FERC's direct federal regulatory authority over hydroelectric dams, numerous other government agencies have varying levels of responsibility for how hydro and non-hydro dams can and must operate. The National Marine Fisheries Service, US Fish and Wildlife Service, Environmental Protection Agency, US Forest Service, Bureau of Land Management, National Park Service, and Bureau of Indian Affairs are all federal agencies with influence over how dams are operated. These

[5] FERC. "Project Decommissioning at Relicensing; Policy Statement." RM93-23-000. 60 Fed. Reg. 339 (January 4, 1995). III FERC Stats. & Regs. 31,011 at p. 31,234. December 14, 1994.

agencies' authority over dam operations, however, is limited, with no agency providing comprehensive federal oversight for dams (other than FERC's oversight for non-federal hydropower dams).

State governments also have significant responsibilities in the oversight of dams, although it is not uncommon for state review to be limited largely to public safety concerns. Most states maintain a dam safety office, agency, or department. These state agencies are generally responsible for ensuring the safety of non-federal dams in their state, overseeing the design, construction, operation, and maintenance of dams. Dam safety offices are most involved in issues such as on-site inspections, providing technical assistance, and requiring remedial actions to correct safety deficiencies, and often are woefully understaffed and underfunded. In Wisconsin for example, state-regulated dams are to be inspected every ten years; in practice they are inspected every 17 years. Other state and local government agencies dealing with water rights, fish and wildlife protection, water quality, and utility regulation also can play a significant role in overseeing dams within their jurisdiction, though in many states no such oversight role is exercised.

A large but unknown number of smaller dams are not inventoried, regulated, or inspected by any federal or state agency. For example, in the state of Washington, the Department of Ecology Dam Safety Section has jurisdiction only over projects that impound a minimum of 10 acre-feet (3.3 million gallons) of water.[6] Dams smaller than this are not subject to direct agency regulation. Similarly, dams in Virginia that are less than 25 feet in height, have a capacity less than 50 acre-feet, or are operated for mining purposes are exempt from regulation under the state's dam safety act.[7] And of the more than 50,000 dams identified in Ohio, only 2,700 fall under the jurisdiction of the state's dam safety laws. The remainder are unregulated due to their small size, which means that just over 5 percent of all dams in the state are regulated.[8]

III. Why Remove Dams?

In many cases where a dam's negative impacts on a river and riverside community outweigh the dam's benefits, dam removal can be a reasonable approach to restore rivers and riverside communities. Dam owners have already chosen removal as the preferred alternative for hundreds of deteriorating, unsafe, or abandoned dams—and removal may be the best alternative for many more. Even for some functioning dams, removal may be a sound solution when a dam's benefits are outweighed by the significant environmental damage it causes.

Many of these older dams have outlived their intended purpose and now serve no official use. Thousands of dams in the United States were built generations ago, powering mills that fueled this country's leap into the industrial age. Although these dams served an important purpose in their day, today many of them have outlived that purpose. The mills have gone, but the dams remain as a memory of an age gone by. These dams often are abandoned by the original owner, which requires the state to take over the obligation of safety repairs and other maintenance, thus placing large economic burdens on taxpayers.

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[6] "Status of Dams in Washington State and Notable Dam Failures." *Washington State Department of Ecology, Dam Safety Office*. URL: www.wa.gov/ecology/wr/dams/failure.html. 1999.
[7] "Virginia Dam Safety Program." *Virginia Department of Conservation & Recreation*. URL: www.state.va.us/~dcr/sw/damsafty.htm. 1999.
[8] Ohio Department of Natural Resources. *Division of Water Programs and Service, Dam Safety Engineering Programs*. URL: www.dnr.state.oh.us/odnr/water/dsafety/whatdam.html. 1999.

Hydrowire, the newsletter of the hydroelectric industry, noted in the August 18, 1997 edition that the American Society of Civil Engineers was developing guidelines for the retirement of hydropower projects "in response to concern that no guidelines existed and that thousands of US dams built in the 1930s and 1940s were nearing the end of their design life." And in recent years, changing public sentiment has begun to challenge the wisdom of keeping dams despite the costs. As *Newsweek* noted in a November 17, 1997 article entitled "Dams Are Not Forever," "[J]ust because politicians in the 1930s cut deals to build dams, it doesn't mean that people in the 1990s have to live with them."

Clearly dam removal is not appropriate for all—or even most—of the nation's 75,000 large dams. Many dams continue to serve public or private functions such as flood control, irrigation, and hydropower generation. This does not mean, however, that rivers should continue to be heavily impacted by these dams. Most dams across the country could be operated in a fashion that reduces their current negative impacts on the river. In hundreds of cases nationally, our organizations work to improve the operations of functional and economically viable hydropower dams through active participation in the federal licensing process. However, some dams cause such significant environmental damage that no amount of reoperation will alleviate the environmental harm. For these dams, where the environmental impacts of the dam outweigh its benefits, dam removal is a reasonable and viable solution for restoring river functions.

Dams all across the country have been and are in the process of being removed for three primary reasons: environmental, safety, and economic. Most removal decisions involve a combination of all three of these reasons.

A. Environmental Reasons for Removal

While dams can benefit society, today science shows they also cause considerable harm to rivers. Dams change the chemical, physical, and biological processes of rivers and related fish and wildlife, and reduce or eliminate economically profitable recreational opportunities. Dams block free-flowing river systems, hindering the flow of nutrients and sediments and impeding fish and wildlife migration. Upstream of dams, stagnant reservoir pools and altered flow timing confound the reproductive cues and behaviors of many fish species. Dams also alter water temperatures and oxygen levels critical to species survival and to good water quality. Because dam owners often own large parcels of land above and below dams, significant portions of publicly owned rivers are effectively inaccessible to members of the public.

The process of blocking a moving river inherently changes the ecosystem, destroying the natural processes dependent on that system—and hindering recreational activities. The impacts can include:

- Inundating wildlife habitat
- Reducing river levels
- Blocking or slowing river flows
- Altering timing of flows
- Fluctuating reservoir levels
- Altering water temperatures
- Decreasing water oxygen levels
- Obstructing the movement of gravel, woody debris, and nutrients
- Blocking or inhibiting upstream and downstream fish passage
- Altering public river access
- Impacting negatively the aesthetics and character of a natural setting

Hydropower is a clean and, sometimes, renewable energy source relative to energy from fossil fuels, but in many cases it should not be considered a sustainable energy source. Because of the way they are operated for power generation, hydropower dams are especially damaging to rivers, and the damage is magnified over time. Through diversion for power production, hydropower dams remove water needed for healthy instream ecosystems. Stretches below dams are often completely de-watered. By withholding and then releasing water to generate power for peak demand periods, hydropower dams can cause downstream stretches to alternate between no water and powerful surges that erode soil and vegetation, and flood or strand wildlife. Following currents downstream, fish are drawn into and maimed or killed by power turbines.

Studies show that fish populations in rivers have declined drastically from historic levels due in large part to dams and water diversion projects. Dams have particularly harmed migratory fish such as salmon, steelhead, American shad, striped bass, sturgeon, alewife, herring, and American eel.[9] Dams can significantly delay the time that it takes for juvenile migratory fish to be flushed to the ocean by turning fast-flowing rivers into slow-moving reservoirs. This delay is very harmful to the fish as their bodies undergo physiological changes that prepare them to survive in salt water. This evolutionary biological process cannot be delayed to accommodate delays in reservoirs. The stagnant reservoirs also expose young fish to predators and disease and often lethally high water temperatures. Further, many fish die when forced through the power turbines associated with hydropower dams.

Dams also take a heavy toll on adult fish returning from the ocean to spawn upstream. Many dams provide no mechanism to allow fish to pass above the dam, thus blocking off thousands of miles of spawning habitat nationwide. When fish passage does exist, many migratory fish have trouble finding the fish ladders on dams or die when exposed to high water temperatures in the ladders. Scientists believe that many of the adult fish that eventually reach their spawning grounds are often too exhausted from the journey over the dams and through the unnaturally warm reservoirs to spawn successfully. As a result, the number of adults returning to spawn is often far below the number needed to ensure the survival of many migratory species.

In the Pacific Northwest, chinook, sockeye, pink, chum, and coho salmon, along with steelhead and cutthroat trout have all experienced dramatic declines on dammed rivers. Salmon runs that numbered in the millions before the era of dam building have now dwindled to only hundreds, and in many instances have been completely wiped out. A startling 80 to 95 percent of Snake River salmon are killed by the series of eight federal dams and reservoirs that these migrating fish must pass on their trip to and from the ocean.[10] This type of destruction is by no means a Northwest phenomenon. The US Fish and Wildlife Service estimates that 91 percent of migratory fish habitat in northern New England is blocked by dams. These dams have contributed to the reduction of Atlantic salmon populations to less than one percent of historic levels, with the native salmon fully extirpated from many of New England's rivers.[11] And American shad, which was once a cultural icon for the Mid-Atlantic, has been decimated to the point that people no longer realize its historical significance.

Reversing these negative impacts and restoring damaged ecosystems, including rebuilding depleted fish

[9] These fish are born in rivers, migrate to the ocean to live most of their lives, and then migrate back up the same river to spawn and often die. The American eel migrates in the opposite direction.

[10] "Dams, Energy, and Salmon." *NW Energy Coalition and the Columbia & Snake Rivers Campaign*. 1998.

[11] Anderson, Ross. "Salmon in Maine worse off than here; to aid ailing runs, dams are breached - even demolished." *Seattle Times*. Sunday, October 24, 1999.

and wildlife populations, has often been a significant reason in decisions to remove dams. For example, numerous dams in the case studies section of this report—Sunbeam Dam on the Salmon River in Idaho, Quaker Neck Dam on the Neuse River in North Carolina, 4 dams on Butte Creek in California, and Marie Dorian Dam on the Walla Walla River in Oregon—were all taken out in order to reestablish free-flowing rivers and the fish and wildlife that depend on a natural river system, as were numerous other dams around the country.

Table 3. Causes of Dam Failures Nationwide.*

Percentage	*Causes of Failure*
34	OVERTOPPING
	¥ Inadequate spillway design
	¥ Debris blockage of spillway
	¥ Settlement of dam crest
30	FOUNDATION DEFECTS
	¥ Differential settlement
	¥ Sliding and slope instability
	¥ High uplift pressures
	¥ Uncontrolled foundation seepage
20	PIPING AND SEEPAGE
	¥ Internal erosion through dam caused by seepage -- piping
	¥ Seepage and erosion along hydraulic structures such as outlet conduits or spillways, or leakage through animal burrows
	¥ Cracks in dam
10	CONDUITS AND VALVES
	¥ Piping of embankment material into counduit through joints or cracks
6	OTHER

* Source: Washington State Department of Ecology, Dam Safety Section

<u>B. Safety Reasons for Removal</u>

Dams are built to block or divert millions of gallons of moving water daily. Such stress causes deterioration and limits the lifetime of a dam. If the structural integrity of a dam is compromised, the danger of failure becomes a serious concern. Just like any building, dams must be properly maintained to remain viable and structurally sound. In many cases, the failure of a dam could seriously damage property and threaten lives downstream of the dam, which in some cases makes their maintenance much more important than that of a typical building.

For instance, four tragic dam failures in the 1970s—Buffalo Creek Dam in West Virginia, Canyon Lake Dam in South Dakota, Teton Dam in Idaho, and Kelly Barnes Dam in Georgia—cost more than 300 lives and hundreds of millions of dollars in property damages.[12] More recently, more than 100 separate dams in Georgia failed during Tropical Storm Alberto in 1994, exacerbating downstream property damages.[13] In 1999, Hurricane Floyd also caused numerous dams along the East Coast to fail, although no associated injuries or deaths were reported.

Many dams across the country have aged beyond their planned life expectancy, causing safety risks for communities downstream. The American Society of Civil Engineers (ASCE) emphasized this concern

[12] "Why is Dam Safety Important?" *Ohio Department of Natural Resources, Division of Water Programs and Service, Dam Safety Engineering Programs*. URL: www.dnr.state.oh.us/odnr/water/dsafety/safeownr.html. 1999.
[13] "National Dam Safety." *Federal Emergency Management Agency*. URL: www.fema.gov/home/mit/damsafe.htm. January 1996.

by giving dams a grade of D in their "1998 Report Card for America's Infrastructure"—citing age, downstream development, dam abandonment, and lack of funding for dam safety programs. According to the Association of State Dam Safety Officials, the average life expectancy of a dam is 50 years.[14] A full one-quarter of all United States dams identified on the NID are now more than 50 years old, and ASCE estimates that by the year 2020 that figure will reach 85 percent.[15]

Remedying safety deficiencies of aging and deteriorating dams is often a main criterion in the decision to remove a dam. For example, Salling Dam on the Au Sable River in Michigan, Mussers Dam on Middle Creek in Pennsylvania, and McMillan Dam on the Pecos River in New Mexico were all taken out in order to address significant public safety hazards posed by these dams—as were numerous dams in the case studies section of this report (see Appendix D: Index).

C. Economic Reasons for Removal

Financial issues are often a significant factor in the decision to remove a dam. As a dam ages, a number of factors can often make it less efficient, to the point where continued operation may no longer be cost-effective. For instance, as a dam traps river sediments traveling downstream, the reservoir impounds less water and therefore decreases the effectiveness of the dam. For hydropower dams, the sediment may eventually block the penstocks that draw the water to the turbines, and if dredging is not done, the facility may lose its ability to draw water for power. Similarly, when flood control dams fill with sediment, their effectiveness in trapping floodwater is reduced and can be fully eliminated.

Likewise, regular dam operation and maintenance costs tend to increase as a dam gets older. A dam owner is often faced with the need for significant, on-going operation and maintenance investments, as well as required structural upgrades and operational modifications in order to comply with current regulatory requirements. These increased costs, combined with potentially lower revenues generated by the dam, can make removal the most cost-effective alternative for a dam owner. In addition, potential financial liability from current or future impacts of a dam (such as dam failure) can influence the decision of whether or not to remove a dam.

In many cases, dam removal costs less than repairing an unsafe dam, especially where the benefits of the dam are marginal or non-existent. Even if these costs are comparable, dam removal eliminates the need (and cost) for continued maintenance and repairs in the future. In Wisconsin, an examination of small dam removals showed that removal typically cost two to five times less than the estimated safety repair costs.[16] For example, Simpson's Pond Dam on Wharton Brook in Connecticut, Stone Gate Dam on Waubonsie Creek in Illinois, and Bennet Dam on Lodgepole Creek in Nebraska were all removed because removal was less expensive than to repair and continue operating them. Numerous dams in the case studies of this report were also removed for economic reasons (see Appendix D: Index).

[14] "Regulatory Facts." *The Association of State Dam Safety Officials*. URL: www.members.aol.com/damsafety/asdso.htm. 1999.
[15] "1998 Report Card for America's Infrastructure." *American Society of Civil Engineers*. Issue Brief - Dams March 5, 1998.
[16] Trout Unlimited. *Dams and Instream Flows*. URL: www.tu.org/watch/wisrivers.html. September 1999.

IV. What Have We Learned?

A. Research Findings

We found specific information on past dam removals in 43 states. States with the most recorded removals include Wisconsin (73 dams), California (47 dams), Ohio (39 dams), Pennsylvania (38 dams), and Tennessee (25 dams). Wisconsin and Pennsylvania are the two states that have removed the most dams since 1990, with 37 and 29 dam removals respectively. All types of dams have been removed, from water supply to hydroelectric, flood control to recreation. Earthfill dams, concrete arch dams, gravity dams, masonry dams, and timber crib dams have all been taken out. Removed dams have been publicly owned, privately owned, and abandoned dams.

Of the dam removals for which we were able to determine the height of the dam,[17] the average height was approximately 21 feet and the median height was 15 feet. Not all removed dams have been small however; there are more than 40 dams that were 40 feet or taller that have been taken out, including 4 dams that were 120 feet or taller. The tallest known dam that was removed was 160 feet tall (Occidental Chem Pond Dam D on Duck Creek in Tennessee) and the smallest was 2 feet tall (Hampden Recreation Area Dam on Souadabscook Stream in Maine). Of the removals for which we were able to determine the length of the dam,[18] the average length was approximately 224 feet and the median length was 170 feet. The longest length for the removed dams was 1060 feet (Lewiston Dam on the Clearwater River in Idaho) and the shortest length was 10 feet (two dams on Lititz Run in Pennsylvania).

The majority of dam removals identified occurred in the 1980s (92 dams) and 1990s (177 dams). The year in which there were the most removals was 1998, with 29 structures taken out. It is difficult to determine, however, if this is a reflection of better record keeping on the topic in recent years and greater public interest and awareness of the issue, or if there is in fact a significant increase in removals in recent years. Among the earliest removals for which we have records were Marquette Dam on the Dead River (Michigan) in 1912, Russel Dam on Hayfork Creek (California) in 1922, Sunbeam Dam on the Salmon River (Idaho) in 1934, and Baltic Mills Dam on the Shetucket River (Connecticut) in 1938.

The cost to remove a dam varies as drastically as the characteristics of the rivers on which dams are located. Although we have found only limited information on the cost of removals, where we have information, removal of the structure itself has cost as little as $1,500 (an Amish dam on Muddy Creek in Pennsylvania) and as much as $3.2 million (Two-Mile Dam on the Santa Fe River in New Mexico). Who has paid for the dam removals is equally varied, ranging from federal, state, and local government entities to the dam owners themselves, including private citizens and corporations. Some of the most creative funding sources for dam removals have been from license plate programs (Jacoby Road Dam on the Little Miami River in Ohio), environmental mitigation funds (4 dam removals on the Naugatuck River in Connecticut), and mitigation for continued operation of other dams on the river system (Stronach Dam on the Pine River in Michigan).

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[17] 394 of the 467 dam removals have known heights.
[18] 89 of the 467 dam removals have known lengths.

B. Lessons from Past Removals

There is an enormous amount to learn from past dam removals for river restoration advocates, local communities, dam owners, and federal, state and local resource agencies. Removal is often the most environmentally-sound, cost-effective way to address the various safety, economic, and ecological issues surrounding an aging and/or obsolete dam. Dam removal has been shown to provide significant benefits to a river, river system, and riverside communities, including:

- Restoring river habitat
- Improving water quality
- Reestablishing fish passage upstream and downstream
- Restoring threatened and endangered species
- Removing dam safety risks and associated liability costs
- Saving taxpayer dollars
- Improving aesthetics of the river
- Improving fishing opportunities
- Improving recreational boating opportunities
- Improving public access to the river, both up and downstream
- Recreating “new” land for parks or landowners
- Improving riverside recreation
- Increasing tourism

It is critical to note, however, that while removal has been and continues to be a viable option for alleviating impacts and risks of dams, river restoration advocates are not calling for the removal of all, or even most, dams. Far less than one percent of all documented dams in the United States are even under consideration for removal, and the percentage of power generation and water storage capacity associated with these is equally miniscule. The lesson learned from this is that river restoration and community revitalization can be obtained without losing any significant amount of the benefits that the nation’s tens of thousands of dams provide.

It is equally important to note that not all dam removals are success stories, and dams can be removed incorrectly. In Appendix A to this report, we have included a case study on the Fort Edward Dam on the Hudson River in New York. This dam was removed in 1973 without adequate testing and analysis of the sediments behind the dam. As a result, tons of PCB-laden sediments were released downstream, hurting wildlife and jeapordizing public health. This is clearly not an example of how to remove a dam, but it provides a valuable lesson on the steps to take in order to ensure that the same mistakes are not repeated. The case studies in this report demonstrate the value of removing dams in an informed and responsible manner to minimize or eliminate negative impacts from the removals.

Now that dam removal is no longer considered a fringe, radical approach to river restoration, there will be significantly more opportunities to use dam removal as a river restoration tool where appropriate. By continuing the trend to selectively remove those dams that do not make sense—those dams where costs outweigh benefits, that pose a public safety hazard, or both—we can begin to restore the ecological, safety, and economic benefits associated with free-flowing rivers.

This report was prepared by *American Rivers*, *Friends of the Earth*, and *Trout Unlimited*. For more information about these success stories or for information about dam removal in general, please contact the staff listed below, or view our web pages at www.amrivers.org, www.foe.org, and www.tu.org.

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American Rivers, celebrating 26 years of bringing rivers to life, is North America's leading national river-conservation organization. *American Rivers*' mission is to protect and restore America's river systems and to foster a river stewardship ethic.

Friends of the Earth is an international environmental advocacy organization dedicated to protecting the planet from environmental degradation and empowering citizens to have an influential voice in decisions affecting the quality of their environment and their lives. *Friends of the Earth* has been deeply involved in river protection and restoration efforts for more than 25 years.

Trout Unlimited, celebrating its 40th Anniversary this year, is the nation's largest trout and salmon conservation organization. *Trout Unlimited's* volunteers and members, more than 100,000 strong, are committed to conserving, protecting, and restoring North America's coldwater trout and salmon fisheries and their watersheds.

DAM REMOVAL SUCCESS STORIES:
Restoring Rivers through Selective Removal of Dams that Don't Make Sense

LIST OF COMPLETED DAM REMOVALS

Total Number Removed: 467

State	River	Project Name	Removed	H(ft)	L(ft)	Reason
AK	Switzer Creek (trib.)	Switzer One Dam	1988	15		S
AK	Switzer Creek (trib.)	Switzer Two Dam	1988	15		S
AR		Hot Springs Park Ricks Lower #1 Dam	1986	11		NPS
AR		Winton Spring Dam		4		NPS
AR	Coop Creek	Mansfield Dam		19		
AR	Crow Creek	Lake St. Francis Dam	1989	45		U
AZ	Canada del Oro	Golder Dam	1980			S
AZ	Walsh Canyon	Concrete Dam	1982	39		S
AZ	Walsh Canyon	Perrin Dam	1980	32		S
CA		Arco Pond Dam		10		NPS
CA		Bear Valley Dam	1982	15		NPS
CA		C-Line Dam #1	1993	56		NPS
CA		Hagmmaier North Dam		30		NPS
CA		Happy Isles Dam	1987	8		NPS
CA		John Muir #1 Dam				NPS
CA		Lower Murphy Dam		6		NPS
CA		Rogers Dam	1983	40		NPS
CA		Upper Murpy Dam		25		NPS
CA	Beaver Creek	Three C. Picket Dam	1949			
CA	Big Creek	Big Creek Mfg. Dam		14		
CA	Butte Creek	McGowan Dam	1998	6		E
CA	Butte Creek	McPherrin Dam	1998	12		E
CA	Butte Creek	Point Four Dam	1993	6		
CA	Butte Creek	Western Canal East Channel Dam	1998	10		E
CA	Butte Creek	Western Canal Main Dam	1998	10		E
CA	Canyon Creek	Henry Danninbrink Dam	1927			
CA	Canyon Creek	Red Hill Mining Co. Dam	1951	30		
CA	Cold Creek	Lake Christopher Dam	1994	10	400	
CA	Guadalupe River	unnamed small dam #1	1998			
CA	Guadalupe River	unnamed small dam #2	1998			
CA	Hayfork Creek	Hessellwood Dam	1925	10		E
CA	Hayfork Creek	Russell (Hinkley) Dam	1922	11		E
CA	Horse Creek	Big Nugget Mine Dam	1949	12	40	
CA	Indian Creek	D.B. Fields Dam	1947	6		
CA	Indian Creek	D.B. Fields/Johnson Dam	1946			
CA	Indian Creek	Minnie Reeves Dam		20		
CA	Kidder Creek	Altoona Dam	1947	12	60	
CA	Lost Man Creek	Upper Dam	1989	7	57	
CA	Mad River	Sweasey Dam	1970	55		
CA	Monkey Creek	Trout Haven Dam				E
CA	Redding Creek	Clarissa V. Mining Dam	1950	20		

KEY:

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State	River	Project Name	Removed	H(ft)	L(ft)	Reason
CA	Rock Creek	Rock Creek Dam	1985	12	63	
CA	Rush Creek	Anderline Dam	1936	20		
CA	Salmon River	Bennett-Smith Dam	1950	10		
CA	Salmon River	Bonally Mining Co. Dam	1946	11	177	
CA	Salt Creek	Salt Creek Dam		10		
CA	Scott River	Barton Dam	1950	12	25	
CA	Swillup Creek	Moser Dam	1949			
CA	Trinity River	Lone Jack Dam		24		
CA	Trinity River	North Fork Placers Dam	1950	15		
CA	Trinity River	Quinn Dam	1951	14		
CA	Trinity River	Todd Dam	1949	14		
CA	Trinity River	Trinity Cty. Water & Power Co. Dam	1946	10		
CA	White s Gulch	Smith Dam	1949	8	25	
CA	Wildcat Creek	unnamed dam #1	1992	6		E
CA	Wildcat Creek	unnamed dam #2	1992	6		E
CO		Glacier #1 Dam	1985	11		NPS
CO		No Name #8 Dam	1990	12		NPS
CO		No Name #15 Dam		15		NPS
CO		No Name #17 Dam		15		NPS
CO		No Name #21 Dam	1990			NPS
CO		No Name #22 Dam		15		NPS
CO	Cony Creek	Pear Lake Dam	1988	28		NPS
CO	Ouzel Creek	Bluebird Dam	1990	56	200	NPS; S
CO	Sand Beach Creek	Sand Beach Dam	1988	25		NPS
CT	Bigelow Creek (trib.)	Little Pond Dam	1994	10		U
CT	Blackwell Brook (trib.)	Paradise Lake Dam	1991	6		$
CT	Bradley Brook	unnamed dam	1993	11		S
CT	Cedar Swamp Brook	Lower Pond Dam	1991	12		$
CT	Indian River	Indian Lake Dam	1994	12		$
CT	Mad River	John Dee s Dam		17	45	
CT	Mad River (trib.)	Frost Road Pond Dam	1983	7		S
CT	Mill Brook	Sprucedale Water Dam	1980	10		
CT	Muddy Brook	Muddy Pond Dam	1992	8		S
CT	Naugatuck River	Anaconda Dam	1999	11	330	E
CT	Naugatuck River	Freight Street Dam	1999	2	158	E
CT	Naugatuck River	Platts Mill Dam	1999	10	231	E
CT	Naugatuck River	Union City Dam	1999	16	200	E
CT	Quinnipiac River (trib.)	Woodings Pond Dam	1971	15		
CT	Shetucket River	Baltic Mills Dam	1938	26		F
CT	Wharton Brook	Simpson s Pond Dam	1995	8		$
DC	Rock Creek	Ford Dam #3	1991			
DC	Rock Creek	Millrace Dam		18		NPS
FL		Pace s Dike Dam	1991	6		NPS
FL	Chipola River	Dead Lakes Dam	1987	18	787	E
FL	Withlacoochee River	Wysong Dam	1988	3		$
GA	Wahoo Creek	Hamilton Mill Lake Dam				
ID	Clearwater River	Grangeville Dam	1963	56	440	E
ID	Clearwater River	Lewiston Dam	1973	45	1060	E
ID	Colburn Creek	Colburn Mill Pond Dam	1999	12	35	E

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State	River	Project Name	Removed	H(ft)	L(ft)	Reason
ID	Dip Creek	Dip Creek Dam				
ID	Elkhorn Gulch	Lane Dam				
ID	Garden Creek	Buster Lake Dam				
ID	John Day Creek (trib.)	Kshmitter Dam	1988			U
ID	Lake Fork Creek	Malony Lake Dam	1986			E
ID	Lake Timber Creek	Timber Creek Dam	1970			
ID	Packsaddle Creek	Packsaddle Dam				
ID	Salmon River	Sunbeam Dam	1931			E
ID	Skein Lake	Skein Lake Dam	1980			
ID	Soldier Creek	Kunkel Dam	1994			
IL		Woodhaven North Impoundment Dam		12		
IL		Woodhaven South Impoundment Dam		11		
IL	Brush Creek (trib.)	Amax Delta Basin 31 Dam		11		
IL	Cypress Ditch (trib.)	Peabody #1A Dam		24		
IL	Cypress Ditch (trib.)	Peabody #5 Dam		42		
IL	Delta Creek	Lake Marion Dam				
IL	Ewing Creek (trib.)	Old Ben Dam		29		
IL	Little Muddy River (trib.)	Consol/Burning Star 5/20 Dam		18		
IL	Mississippi River	Mississippi River Lock & Dam #26		98		
IL	Mississippi River (trib.)	Turkey Bluff Dam		43		
IL	Negro Creek (trib.)	Lake Adelpha Dam		15		
IL	Sangamon River (trib.)	Faries Park Dredge Disposal Dam		29		
IL	Sevenmile Branch	Olsens Lake Dam		17		
IL	Tributary to Sugar Creek	Springfield Dam		25		
IL	Waubonsie Creek	Stone Gate Dam	1999	4	100	E; $; F
IL	Wolf Branch (trib.)	Garden Forest Pond Dam				
IL	Wood River (trib.)	Paradise Lake Dam		20		
IN		Pinhook Dam		15		NPS
KS		Chapman Lake Dam		38		
KS		City of Wellington Dam		36		
KS		Edwin K. Simpson Dam		25		
KS		Kansas Gas & Electric Dam				
KS		Lake Bluestem Dam		68		
KS		Moline Middle City Lake Dam		21		
KS		Mott Dam		21		
KS		Robert Yonally Dam				
KS		Soldier Lake Dam		14		
KS		Wyandotte County Dam		139		
KY	Great Onyx Pond	No Name #1 Dam	1982	5		NPS
KY	Great Onyx Pond	No Name #2 Dam	1982	5		NPS
KY	Little Flat Creek	Sharpsburgh Reservoir Dam	1985	35		
KY	Pond Creek (trib.)	Ebenezer Lake Dam	1985	15		
KY	Pond River	West Fork Pond River #2 Dam		16		
LA	Bayou Dorcheat	Shirley Willis Pond Dam		10		
LA	Bayou Dupont (trib.)	Bayou Dupont #13 Dam		23		
LA	Dry Pong Creek	Kisathie Lake Dam		25		
LA	Pond Branch	Castor Lake Dam		10		
MD	Bacon Ridge Branch	Bacon Ridge Branch Weir	1991			
MD	Deep Run	Deep Run Dam	1989			

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State	River	Project Name	Removed	H(ft)	L(ft)	Reason
MD	Dorsey Run	Railroad Trestle Dam	1994			
MD	Horsepen Branch	Horsepen Branch Dam	1995			
MD	Little Elk Creek	Railroad Bridge at Elkton Dam	1992			
MD	Stony Run	Stony Run Dam	1990			
MD	Western Branch	Route 214 Dam	1998			
ME	Kennebec River	Edwards Dam	1999	24	917	E
ME	Machias River	Canaan Lake Outlet Dam	1999			
ME	Penobscot River	Bangor Dam	1995			
ME	Pleasant River	Brownville Dam	1999	12	300	
ME	Pleasant River	Columbia Falls Dam	1998	9	350	$
ME	Souadabscook Stream	Grist Mill Dam	1998	14	75	E
ME	Souadabscook Stream	Hampden Recreation Area Dam	1999	2		
ME	Souadabscook Stream	Souadabscook Falls Dam	1999		150	
ME	Stetson Stream	Archer s Mill Dam	1999	12	50	
MI		Foster Trout Pond Dam	1983	3		NPS
MI		Three River City Dam	1992	13		
MI	Au Sable River	Salling Dam	1991	17	250	E; R
MI	Dead River	Marquette Dam	1912			
MI	Grand River	Wager Dam	1985	10		E
MI	Looking Glass River	Wacousta Dam	1966	4		
MI	Muskegon River	Newago Dam	1969	18		
MI	Pine River	Stronach Dam	*	18	350	
MI	Silver Lead Creek	Air Force Dam	1998			
MN		Stockton Dam	1994	30		F
MN	Cannon River	Welch Dam	1994	9	120	E;S
MN	Cottonwood River	Flandrau Dam	1995	12		E
MN	Crow River	Berning Mill Dam	1986	10		F
MN	Crow River	Hanover Dam	1984	12		F
MN	Garvin Brook	Stockton Dam				
MN	Kettle River	Sandstone Dam	1995	20	150	E; R
MN	Pomme de Terre River	Pomme de Terre River Dam				
MN	Root River	Lake Florence Dam		12		
MO		Alkire Lake Dam	1990	30		
MO		Goose Creek Lake Dam	1987	52		
MO		Indian Rock Lake Dam	1986	57		S
MT		Three Bears Lake-East Dam		10		NPS
MT	Bear Creek	Three Bears Lake-West Dam		20		NPS
MT	Lone Tree Creek	Vaux #1 Dam	1995	34		S
MT	Lone Tree Creek	Vaux #2 Dam	1995	56		S
MT	Peet Creek	Peet Creek Dam	1994	43		S
MT	Rock Creek	small dam				
MT	Wallace Creek	Wallace Creek Dam	1997	29	720	
NC		Ash Bear Pen Dam	1990	10		NPS; $
NC		Forny Ridge Dam	1988	4		NPS
NC	Little River	Cherry Hospital Dam	1998	7	135	E
NC	Neuse River	Quaker Neck Dam	1998	7	260	E
ND	Knife River	Antelope Creek Dam	1979	22		S

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State	River	Project Name	Removed	H(ft)	L(ft)	Reason
ND	Little Missouri River	Kunick Dam		24		U
ND	Stony Creek	Epping Dam	1979	47		
NE		Golf Course Dam				NPS
NE	Bozle Creek	Lake Crawford Dam	1987	25		S
NE	Camp Creek	Diehl Dam	1981	34		$
NE	Cedar River	Fullerton Power Plant Dam		15		F
NE	Lodgepole Creek	Bennet Dam	1982	21		$
NE	Timber Creek (trib.)	Helen Fehrs Trust Dam	1995	35		U
NJ		Pool Colony Dam		8		NPS
NJ	Cold Brook	Pottersville Dam	1985	20	180	S
NJ	Crooked Brook	Patex Pond Dam	1990	20	340	S
NJ	Delaware River (trib.)	Lake Success Dam	1995	20	300	S
NJ	Raritan River	Fieldsville Dam	1990	10	400	E
NJ	S.B. Timber Creek	Glenside Dam	1997	12	130	S
NJ	Van Camptens Brook	Upper Blue Mountain Dam	1995	26	210	NPS; S
NJ	Whippany River (trib.)	Knox Hill Dam	1996	18	150	S
NM	Pecos River	McMillan Dam	1989	65		S
NM	Sante Fe River	Two Mile Dam	1994	85	720	S
NV		Katherine Borrow Pit Embankment	1992	15		NPS
NY		Curry Pond Dam		3		NPS
NY		Luxton Lake Dam				NPS
NY	Hudson River	Fort Edward Dam	1973	31	586	S
OH		Armington Dam #2	1991	15		NPS
OH		Foxtail Dam		30		NPS
OH		Slippery Run (Stahl) Dam	1990	14		NPS
OH	Black Fork (trib.)	Altier Pond Dam	1989	33		
OH	Brannon Fork	Ohio Power Company Pond Dam	1987	17		
OH	Brush Creek (trib.)	Williams Dam		40		
OH	Collins Fork	Ohio Power Company Pond Dam		13		
OH	East Reservoir (trib.)	Wonder Lake Dam	1986	15		
OH	Hamley Run (trib.)	Poston Fresh Water Pond Dam	1988	42		
OH	Hocking River (trib.)	Cottingham Lake Dam	1991	17		
OH	Ice Creek (trib.)	Fair Haven Lake Dam	1980	30		
OH	Jackson Run (trib.)	Howard s Lake Dam				
OH	Johnny Woods River (trib.)	Carr Lake Dam	1985	10		
OH	Licking River (trib.)	Dutiel Pond Dam	1986	14		
OH	Little Auglaize River (trib.)	Burt Lake Dam	1992	18		
OH	Little Darby Creek	Little Darby Dam	1989	20		
OH	Little Darby Creek	Okie Rice Dam	1990	12		S
OH	Little Miami River	Foster Dam	1984			
OH	Little Miami River	Jacoby Road Dam	1997	8	100	E
OH	Little Pine Creek (trib.)	Mastrine Pond Dam	1978	15		
OH	Little Yellow Creek (trib.)	Old Jenkins Lake Dam		22		
OH	McLuney Creek (trib.)	Strip Mine Pond Dam		25		
OH	Modoc Run	Modoc Reservoir Dam	1981	24		
OH	Ogg Creek	Jones Lake Dam		20		
OH	Porter Creek	Marshfield Lake Dam	1973	15		
OH	Robinson Run (trib.)	Lake Hill #2 Dam		30		
OH	Robinson Run (trib.)	Lake Hill Dam #1		30		

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State	River	Project Name	Removed	H(ft)	L(ft)	Reason
OH	Rocky Fork (trib.)	Village at Rocky Fork Lake Dam		7		rebuilt
OH	Seven Mile Creek (trib.)	Ashworth Lake Dam		25		
OH	Silver Creek	Silver Creek Dam				
OH	Silver Creek (trib.)	Chapel Church Lake Dam	1989			
OH	South Fork (trib.)	Georgetoen Freshwater Dam	1988	13		
OH	Spencer Creek (trib.)	State Route 800 Dam	1989	25		
OH	Stillwater Creek	Consol Pond Dam		12		
OH	Sugartree Creek (trib.)	Brashear Lake Dam	1991	16		
OH	Timber Run (trib.)	Derby Petroleum Lake Dam	1984	30		
OH	Town Fork	Toronto Band Father s Lake Dam	1991	15		
OH	Wills Creek (trib.)	Killiany Lake Dam		8		rebuilt
OH	Yankee Run	Yankee Lake Dam	1980	26		
OR	Bear Creek	Jackson Street Dam	1998	11	120	E
OR	Evans Creek	Alphonso Dam	1999	10	56	E
OR	Walla Walla River	Marie Dorian Dam	1997	8	100	E
OR	Willamette River	Catching Dam	1994	28	225	
OR	Yamhill Basin	Lafayette Locks Dam	1963			
PA		Butterfield Pond Dam	1992	13		NPS
PA		Carpenters Pond Dam		17		NPS
PA		Fire Pond at Incline #10		16		NPS
PA		Lake Lettini Dam		7		NPS
PA		Lemon House Pond Dam	1984	15		NPS
PA		Lower Friendship Dam	1982	30		NPS
PA		unnamed dam, Peace Light Inn	1991	7		NPS
PA		Upper Friendship Dam	1982	12		NPS
PA		Van Horn Dam #1	1991	8		NPS
PA		Van Horn Dam #2		10		NPS
PA		Van Horn Dam #5	1991	12		NPS
PA	Clear Shade Creek	Clear Shade Creek Reservoir Dam	1998	14	190	
PA	Coal Creek	Coal Creek Dam #2	1995	23	116	
PA	Coal Creek	Coal Creek Dam #3	1995	24		
PA	Coal Creek	Coal Creek Dam #4	1995	14	356	
PA	Coal Creek	Diverting Dam		8	55	
PA	Codorus River (trib.)	Yorkane Dam	1997			
PA	Conestoga River	American Paper Products Dam	1998	4	130	E
PA	Conestoga River	Rock Hill Dam	1997	13	300	E
PA	Fishing Creek	Snavely s Mill Dam	1997	3	106	
PA	Gillians Run	Maple Hollow Reservoir Dam	1995	22	192	
PA	Juniata River	Williamsburg Station Dam	1996	13	260	E
PA	Kettle Creek	Rose Hill Intake Dam	1998	12	150	
PA	Kishacoquillas Creek	unnamed dam	1998	9	175	
PA	Laural Run	unnamed dam	1998	5	50	
PA	Lititz Run	Mill Port Conservancy Dam	1998	10	10	E
PA	Lititz Run	unnamed dam	1998	4	10	E
PA	Little Conestoga River	East Petersburg Authority Dam	1998	4	20	E
PA	Little Conestoga River	Maple Grove Dam	1997	6	60	E
PA	Middle Creek	Mussers Dam	1992	31	384	
PA	Mill Creek	Niederriter Farm Pond Dam	1995	21	350	
PA	Mill Creek	Yorktowne Paper Dam	1997	5	60	

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State	River	Project Name	Removed	H(ft)	L(ft)	Reason
PA	Muddy Creek	Amish Dam		3	40	E
PA	Muddy Creek	Castle Fin Dam	1997	5	383	
PA	Red Run	Red Run Dam	1996	7	40	
PA	Spring Creek	Cabin Hill Dam	1998			
PA	Sugar Creek	Pomeroy Memorial Dam	1996	24	442	
PA	Tinicum Creek (trib.)	unnamed dam	1998	6	40	
RI	Pawtuxet River	Jackson Pond Dam	1979	20		$
SC	Burgess Creek	Gallagher Pond Dam	1989	42		S
SC	Cowpens National Battlefield	unnamed dam, State Road 11-58	1979	7		NPS
SC	Pole Branch River	Pole Branch Dam	1990	26		F
SC	Tools Fork (trib.)	Miller Trust Pond Dam	1993	38		S
SC	Turkey Quarter Creek	Old City Reservoir Dam	1988	25		S
SD		Arikara Dam	1978	39		
SD		Farmingdale Dam	1986	24		
SD		Lake Farley Dam	1980	25		rebuilt
SD		Menno Lake Dam	1984	38		
SD		Mission Dam	1987	25		
SD		Norbeck Dam & SD Highway 87		40		NPS
SD		P6L-Lower Bigger Dam		10		NPS
SD		unnamed dam #26	1987	10		NPS
SD		unnamed dam #30	1987	10		NPS
SD		unnamed dam #32		10		NPS
SD		unnamed dam #35	1987	10		NPS
TN		L. Thompson Dam #1	1990	10		NPS; $
TN		L.C. Hancock #1	1990	8		NPS
TN		L.C. Hancock #3		8		NPS
TN	Adkinson Creek	Gin House Lake Dam	1994	32		$
TN	Burra-Burra Creek	Cities Service Company Dam	1995	30		
TN	Decant Pipes	Monsanto Dam #3	1988	39		
TN	Duck Creek	Occidental Chem Pond Dam A	1995	120		
TN	Duck Creek	Occidental Chem Pond Dam D	1995	160		
TN	Duck River	Monsanto Dam #7	1990	78		
TN	Flat Creek	Sandy Stand Dam	1987	38		$
TN	Flat Creek	Shangri-la Lake Dam	1985	32		S
TN	Fork Creek (trib.)	Ballard Mill Mine Dam	1992	30		
TN	Greenlick Creek	Monsanto Dam #4	1990	53		
TN	Greenlick Creek	Monsanto Dam #5A	1990	52		
TN	Helms Branch	Monsanto Dam #9	1990	33		
TN	Hurricane Creek	Cumberland Springs Dam	1989	30		$
TN	Johnson Creek	Lake Deforest Dam	1991	36		$
TN	Ollis Creek	Eblen-Powell Dam #1		32		$
TN	Quality Creek	Rhone Poulenc Dam #17	1995	34		
TN	Quality Creek	Rhone Poulenc Dam #19	1995	60		
TN	Quality Creek	Rhone Poulenc Dam #20	1995	33		
TN	Rocky Branch	Monsanto Dam #12	1990	125		
TN	Rutherford Creek (trib.)	Occidental Chem Dam #6	1991	53		
TN	Snake Creek (trib.)	Spence Farm Pond Dam #5	1983	35		S
TN	Tipton Branch	Laurel Lake Dam	1990	43		S
TN	Walker Stream	Walkers Dam	1992	32		

KEY:

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State	River	Project Name	Removed	H(ft)	L(ft)	Reason
TX		Alamo Arroyo Dam	1979	48		
TX		Boot Spring Dam		15		NPS
TX		Duke Dam		8		NPS
TX		H and H Feedlot Dam	1980	35		
TX		Harris Back Lake Dam		15		
TX	Big Sandy Creek (trib.)	Lake Downs Dam		26		
TX	Daves White Branch	Millsap Reservoir Dam		25		
TX	Mill Creek	Barefoot Lake Dam		27		
TX	Mustang Creek (trib.)	Bland Lake Dam	1989	21		
TX	Pecan River (trib.)	Hilsboro Lake Park Dam		20		
TX	Tributary to Willis Creek	Railroad Reservoir Dam		10		
TX	Wasson Branch	Nix Lake Dam		23		
UT		Atlas Mineral Dam	1994	93		
UT		Bell Canyon Dam	1979	30		$
UT	Box Elder Creek	Box Elder Creek Dam	1995	50		S
UT	Muddy Creek	Brush Dam	1983	49		$
VA		Adney Gap Pond Dam	1984	12		NPS
VA		Berryville Reservoir		15		NPS
VA		Fredricksburgh & Spotsylvania Dam #2		5		NPS
VA		Fredricksburgh & Spotsylvania Dam #3		5		NPS
VA		Fredricksburgh & Spotsylvania Dam #5		5		NPS
VA		Fredricksburgh & Spotsylvania Dam #6		4		NPS
VA		Osborne Dam		12		NPS
VA		Sykes Dam	1992	22		NPS
VA	Manassas NP Battlefield	Picnic Area Dam	1984	5		NPS
VT	Batten Kill River	Red Mill Dam				
VT	Charles Brown Brook	Norwich Reservoir Dam		20		S
VT	Clyde River	Newport No. 11 Dam	1996	19	90	E
VT	Mussey Brook	Lower Eddy Pond Dam	1981	20		S
VT	Passumpsic River (trib.)	Lyndon State College Lower Dam				
VT	Wells River	Groton Dam	1998	5		
VT	Winooski River (trib.)	Winooski Water Supply Upper Dam	1983	19		S
VT	Youngs Brook	Youngs Brook Dam	1995	46		S
WA		Black Mud Waste Pond A Dam		15		
WA		Black Mud Waste Pond B Dam		15		
WA		Black Mud Waste Pond C Dam		15		
WA		Bow Lake Reservoir		7		
WA		City Lakes Dam		15		
WA		North End Reservoir		28		
WA		Pomeroy Gulch Dam		38		
WA	Boise Creek	White River Mill Pond Dam		3		
WA	Coffee Creek	Coffee Creek Dam		10		
WA	Columbia River (trib.)	Stromer Lake Dam		5		
WA	Hanford Creek (trib.)	PEO Dam #32A		14		
WA	Hanford Creek (trib.)	PEO Dam #48		3		
WA	Hunters Creek	Hunters Dam		65		
WA	Mill Creek	Mill Creek Settling Basin Dam		15		
WA	Sauk River (trib.)	Darrington Water Works Dam		19		
WA	Touchet River	Maiden Dam	1998			

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State	River	Project Name	Removed	H(ft)	L(ft)	Reason
WA	Wagleys Creek	Sultan Mill Pond Dam		18		
WA	Whitestone Creek	Rat Lake Dam	1989	32	240	S
WA	Wind River	Wind River Dam		20		
WI		McNally Trout Pond Dam	1983	5		NPS
WI		Poppe Dam	1982	2		NPS
WI		Rassussen #1 Dam				NPS
WI		Rassussen #2 Dam	1982	3		NPS
WI		Rassussen #3 Dam	1982	3		NPS
WI		Schaaf #1 Dam	1982	2		NPS
WI		Schaaf #2 Dam	1982	2		NPS
WI		unnamed dam #1 (Larrabee Tract)	1990			NPS
WI		Weingarten Dam	1982	2		NPS
WI	Apple River	Huntington Dam	1968			
WI	Apple River	McClure Dam	1968			E
WI	Apple River	Somerset Dam	1965			
WI	Bad River	Mellen Dam	1967			E
WI	Baraboo River	Island Woolen Co. Dam	1972			
WI	Baraboo River	Oak Street Dam	*	12	208	
WI	Baraboo River	Reedsburg Dam	1973	9		
WI	Baraboo River	Waterworks Dam	1998	9	220	$
WI	Baraboo River	Wonewoc Dam	1996	28		
WI	Bark River	Hebron Dam	1996	17	170	
WI	Bark River	Slabtown Dam	1992	10	60	
WI	Beaver Creek	Ettrick Dam	1976			
WI	Black Earth Creek	Black Earth Dam	1957	9		
WI	Black Earth Creek	Cross Plains Dam	1955	11		
WI	Black River	Greenwood Dam	1994	16		
WI	Carpenter Creek	Carpenter Creek Dam	1995			
WI	Cedar Creek	Hamilton Mill Dam	1996	8	100	
WI	Centerville Creek	Centerville Dam	1996	12		
WI	City Creek	Mellen Waterworks Dam	1995	12		
WI	Dunlop Creek	Dunlop Creek Dam	1955			
WI	Eau Galle River	Spring Valley Dam	1997	3		
WI	Eighteen Mile Creek	Colfax Dam	1998	20	350	
WI	Embarrass River	Hayman Falls Dam	1995	17	200	
WI	Embarrass River	Upper Tigerton Dam	1997	9		
WI	Flambeau River	Port Arthur Dam	1968			E
WI	Flume Creek	Northland Dam	1992	10		
WI	Fox River	Wilmot Dam	1992	6	200	
WI	Handsaw Creek	Huigen Dam	1970	6		
WI	Handsaw Creek	Schiek Dam	1970	6		
WI	Iron River	Orienta Falls Dam	*	44		
WI	Kickapoo River	Ontario Dam	1992			E
WI	Kickapoo River	Readstown Dam	1985			
WI	Lemonweir River	Lemonweir Dam	1992	14		
WI	Lowe Creek	Lowe Creek 1 Dam				
WI	Lowe Creek	Lowe Creek 2 Dam				
WI	Madden Branch (trib.)	Beardsley Dam	1990	12		
WI	Manitowoc River	Manitowoc Rapids Dam	1984	16	400	E

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State	River	Project Name	Removed	H(ft)	L(ft)	Reason
WI	Manitowoc River	Oslo Dam	1991	8		E
WI	Marengo River	Marengo Dam	1993	17		E
WI	Maunesha River	Upper Waterloo Dam	1995	17	115	
WI	Milwaukee River	North Avenue Dam	1997	19	432	
WI	Milwaukee River	Woolen Mills Dam	1988	18		$
WI	Milwaukee River	Young America Dam	1994	11		
WI	Oconomowoc River	Funks Dam	1993	7		
WI	Oconto River	Pulcifer Dam	1994	5		
WI	Otter Creek	Klondike Dam	1978	30		
WI	Peshtigo River	Crivitz Dam	1993			
WI	Pine River	Bowen Mill Dam	1996	12		
WI	Pine River	Parfrey Dam	1996	19	450	
WI	Prairie River	Prairie Dells Dam	1991	60		
WI	Prairie River	Prairie Dells Dam	1991	60		E
WI	Prairie River	Ward Paper Mill Dam	1999	18	80	
WI	Rathbone Creek	Evans Pond Dam	1998	10		
WI	Red Cedar River	Colfax Light Power Dam	1969	21		
WI	Sheboygan River	FranklinDam	*	13	136	
WI	Shell Creek	Cartwright Dam	1995	7		
WI	Sugar River	Mount Vernon Dam	1950	11		
WI	Token Creek	Token Creek Dam	*	13		
WI	Tomorrow/Waupaca River	Nelsonville Dam	1988			
WI	Trempealeau River	Whitehall Dam	1988			
WI	Turtle Creek	Shopiere Dam	*	13	138	
WI	Willow River	Mounds Dam	1998	58	430	$
WI	Willow River	Willow Falls Dam	1992	60	160	$
WI	Yahara River	Fulton Dam	1993	16		E
WV		Ladoucer Pond Dam	1993			NPS
WY		East Dam		7		NPS
WY		No Name Dam #1		7		NPS
WY		North Dam		15		NPS
WY		South Dam		7		NPS
WY		West Dam		7		NPS
WY		White Grass Dude Ranch Dam	1988			NPS
WY	City of Sheridan (trib.)	Sheridan Heights Reservoir				$
WY	Laramie River	unnamed dam	1997			

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When we had information about the reason for a dam's removal, we tried to fit that reason into one of six very broad categories. It should be noted that many of these categories overlap and that few dams are in fact removed for only one reason. Following are examples of specific reasons for removal that are encompassed by each category.

Ecology: dam was removed to restore fish and wildlife habitat; to provide fish passage; to improve water quality
Economics: maintenance of dam was too costly; removal was cheaper than repair; dam was no longer used; dam was in deteriorating condition
Failure: dam failed; dam was damaged in flooding
Recreation: dam was removed to increase recreational opportunities
Safety: dam was deemed unsafe; owner no longer wanted liability
Unauthorized dam: dam was built without a needed permit; dam was built improperly

In addition, **NPS** sometimes appears in the "Reasons for Removal" column of the list. The information for dams with this designation was provided by the National Park Service, which documents deactivation of dams on or having an impact on National Park Service lands. These dams were removed for many of the same reasons that other dams on the list were removed, but we thought it would be valuable to retain the distinction that these dams were on or affected National Park Service lands.

DAM REMOVAL SUCCESS STORIES:
Restoring Rivers through Selective Removal of Dams that Don't Make Sense

CASE STUDIES

Baraboo River, Wisconsin
Bear Creek, Oregon
Butte Creek, California
Cannon River, Minnesota
Chipola River, Florida
Clearwater River, Idaho
Clyde River, Vermont
Colburn Creek, Idaho
Cold Creek, California
Conestoga River, Pennsylvania
Evans Creek, Oregon
Juniata River, Pennsylvania
Kennebec River, Maine
Kettle River, Minnesota
Little Miami River, Ohio
Milwaukee River, Wisconsin
Naugatuck River, Connecticut
Neuse River, North Carolina
Ouzel Creek, Colorado
Pleasant River, Maine
Santa Fe River, New Mexico
Souadabscook Stream, Maine
Walla Walla River, Oregon
Whitestone Creek, Washington
Willow River, Wisconsin

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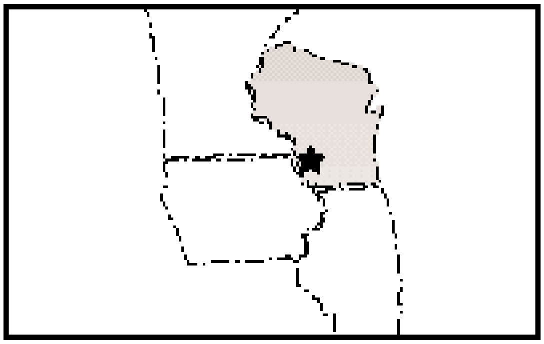

BARABOO RIVER

REMOVAL OF THE WATERWORKS DAM IN WISCONSIN

DAM REMOVAL BENEFITS: IMPROVED MIGRATORY AND RESIDENT FISH HABITAT, REVITALIZED RIVERFRONT, IMPROVED THREATENED SPECIES HABITAT, IMROVED WATER QUALITY, TAXPAYER SAVINGS

SUMMARY

A stretch of the Baraboo River runs free for the first time in 140 years, following the 1997 removal of the defunct Waterworks Dam in downtown Baraboo, Wisconsin. Two other small dams within a five-mile stretch historically known as the "Baraboo Rapids" will come down within three years as part of the same fish passage project. Removal of the series of dams, all between 9 and 20 feet high, is expected to dramatically improve the sport fishery, and will allow state threatened and federal species of concern, including the lake sturgeon and prehistoric paddlefish, to return to waters they once inhabited for spawning. Recently published studies document dramatic improvements already in the water quality and fisheries at this site, including the smallmouth bass sport fishery. Local paddlers are increasing their use of the river for recreational purposes, and revitalization of the waterfront is underway, including plans for a new Riverwalk, which promises to literally reconnect the city's downtown to the river.

THE RIVER

The Baraboo flows over 100 miles from its headwaters near Hillsboro to its confluence with the Wisconsin River. Its watershed encompasses 650 square miles, or about 415,000 acres. Through its course, the river drops over 150 feet in elevation; 45 feet of that gradient occurs in a four- to five-mile stretch through the City of Baraboo. Historically known as the "Baraboo Rapids," such a concentration of steep gradient is rare in southern Wisconsin. The Baraboo served as an important "nursery" for fish from the larger Wisconsin River, a major tributary to the Mississippi River. Early white settlers recognized the river's drop for its potential to generate mechanical power. From the middle to late 19th century, dams were the life and economic engine that drove the local economy, powering grist, lumber, and other essential milling enterprises.

THE IMPACT PRIOR TO REMOVAL

The name Baraboo comes from the French "Riviere a la Barbeau," meaning "Sturgeon River" and the Native American name, "Ocoochery," meaning "plenty of fishes." But this abundance of fish and fish species began to disappear after the dams were built. Together, the Waterworks, Oak Street, and Linen Mills Dams transformed the "Baraboo Rapids" from a fast-moving stream with riffles and diverse and healthy fish populations into a series of sluggish impoundments supporting primarily carp and black crappie. Prior to removal of the Waterworks Dam, studies conducted by the Wisconsin Department of Natural Resources (DNR) showed ten species of fish below the lowermost dam that were not present above the others, indicating that the dams were blocking fish passage. Unobstructed movement is important to many fish species, including smallmouth bass, walleye, catfish, lake sturgeon, and paddlefish, and to other forms of aquatic life, including mussels, which depend on fish to move around. In addition, the dams served no flood control function; in fact, in high-water situations, the already-elevated water levels of the impoundment led to flooding on adjacent properties.

THE REMOVAL DECISION & PROCESS

For the Waterworks Dam, the question of removal was triggered by public safety concerns. The old structure failed a 1994 safety inspection due to major deterioration and inadequate spillway capacity. The City of Baraboo, ordered to repair or remove it, began to explore its options.

DAM REMOVAL FACTS:

- **Height: 9 ft; Length: 220 ft**
- **Impoundment: 47 acres**
- **Built: 1848**
- **Historic purpose: power for mills**
- **Owner: City of Baraboo**
- **Regulatory jurisdiction: state DNR**
- **Estimated cost of repair: $694,600 - $1,091,500 range of options**
- **Cost of removal: $213,770**
- **Removed: 1998**
- **Removal method: heavy equipment and explosives**

Initially, there was much resistance to the idea of removal. As in most small communities that grew up around a dam, emotional attachments to the impoundment and the dam ran high. But repair cost estimates ranged from three to five times more than removal estimates. By removing the dam, the city could permanently eliminate its current and future liability for less than one-third the cost of repairing the dam. City officials determined it was not fiscally prudent to repair the structure and voted to remove it. While economics were the key determining factor, the restoration would not have been possible without the support of Mayor Dean Steinhorst and other community leaders who had the foresight to recognize environmental and other community benefits potentially associated with dam removal.

The most vocal opponent to removal was a non-profit business located on the impoundment that effectively delayed the removal process on several occasions and increased costs for the city, but eventually dropped their opposition. Historical assessments determined that adverse impacts from the removal would be minimal, and mitigation measures were worked out that included historical interpretation of the role of the three dams in the growth of the community.

Meanwhile, the Oak Street and Linen Mill Dams were each producing a small amount of hydropower, and both were in need of repairs. The Federal Energy Regulatory Commission (FERC) claimed jurisdiction over the dams. While the state's scrutiny had been limited to public safety, the federal agency's review of dams addresses a wide array of public interest criteria, including environmental considerations. As part of the FERC licensing process, expensive studies could be requested on the dams' impacts on fish and wildlife, recreation and water quality, and to this expense would be added any needed repairs and upgrades for the two dams. The dams, which produced only a miniscule amount of hydropower and were already marginally economical, were becoming an economic burden on the owner, who became increasingly amenable to the idea of removal. City officials were interested in removal of the Oak Street Dam in particular. With it gone, the city will save an estimated $300,000 when making much-needed road repairs to Water Street, gateway to the main tourist attraction in Baraboo—Circus World Museum, the former winter quarters of the Ringling Brothers Circus.

The River Alliance of Wisconsin, a statewide citizen advocacy organization for rivers, served as a catalyst for the Baraboo River restoration project. Because of the potential high quality and scale of the river restoration, the non-governmental organization raised funds from a variety of sources to begin a fish passage demonstration project. The effort evolved into a collaborative project involving the private owner of the two hydro dams, the City of Baraboo, the state, and non-governmental groups, including the River Alliance and the Baraboo River Canoe Club.

Public education played an important role in gaining support for removal of Waterworks and the other dams. Lack of funding precluded a comprehensive, pro-active education effort. Nonetheless, project collaborators identified public education needs on a continuing basis and provided information designed to help improve the decision-making process for the public officials, local community leaders, and federal and state agencies involved, as well as concerned citizens.

REMOVAL BENEFITS:
- **¥ Dramatic improvements to sport fishery**
- **¥ Rare riffle habitat restoration**
- **¥ Community revitalization & expected urban riverfront restoration**
- **¥ Public safety hazard elimination**
- **¥ Taxpayer savings**

Flooding and sediment transport issues were considered in timing the removal of the Waterworks Dam, and an effort was made to avoid interference with fish spawning. The dam was breached in December 1997 and the impoundment was drawn down. The Baraboo River Canoe Club sponsored several river cleanups to remove debris from the newly exposed mudflats; the first cleanup immediately followed the drawdown. The bulk of the dam was removed with a backhoe-mounted jackhammer. Due to use of heavy reinforced steel in the dam below the riverbed, explosives experts helped complete removal of the structure. Dam rubble (and timber and rock from earlier versions of the dam at that site) were used to stabilize the banks. The dam was completely removed by late April. The mudflats were extremely fertile and contained ample seed. Without benefit of artificial seeding, the former impounded area began to "green up" within two weeks, and within six weeks the banks were fully vegetated.

RESTORATION OF THE RIVER

Positive changes in river habitat were evident very soon after the removal of the Waterworks Dam. When spring floods completely submerged the lowermost dam (allowing fish to pass over it), fisheries biologists identified sturgeon at the former Waterworks Dam site. Eighteen months after the removal, the number of fish species above the former dam site had more than doubled from 11 to 24 species, according to a Wisconsin DNR survey. The survey also indicated that water quality had improved — numbers of smallmouth bass, a species that cannot tolerate poor water quality, had increased from only 3 to 87 in the former impoundment. Three-quarters of a mile of high-quality riffle habitat, rare in southern Wisconsin rivers, has been restored to its free-flowing condition. Some other communities in Wisconsin that have removed small dams have enjoyed an increase in recreational opportunities, especially canoeing, that have attracted visitors and resulted in important economic development opportunities. These and other improvements promise to serve as an economic boost to this small town, and once again make the river an integral part of the community.

FUTURE EFFORTS TO RESTORE THE RIVER

By 2003, both the Oak Street and the Linen Mill Dams will be removed. The Oak Street Dam removal, originally scheduled for 1998, was delayed due to contaminated sediment found upstream. The contaminant was identified as coal tar, a byproduct of the coal gasification process used across the Midwest in the late 1800s. Alliant Energy (formerly Wisconsin Power & Light), which purchased the site in 1913, is assuming financial responsibility for the cleanup, which is expected to be completed shortly. Removal of the Oak Street Dam is scheduled for this winter (1999-2000).

Linen Mill is the lowermost and will be the last of the three dams to be removed. Sediment flushed downstream from the removal of the two upper dams, on top of a century's worth of sediment already trapped behind the dam, may present a challenge. Resource managers are already discussing alternatives for handling the sediment.

LaValle Dam, approximately 30 miles up river from the City of Baraboo, has recently been purchased by a private non-governmental organization. The new owner is planning to remove the dam in 2001. With the removal of the four dams, the entire main stem of the Baraboo River will flow freely for the first time in more than a century.

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The River Alliance recently initiated the Baraboo Riverfront Sustainability Project, a partnership between city, state, and private organizations to coordinate the restoration and revitalization of the river corridor. The organizations plan to work with the local community to plan river-related development, including wayside public parks, an area dedicated to the history of the dams and the river, and the revitalization of the riverside historic district.

THE SIGNIFICANCE OF THIS REMOVAL

The Baraboo River restoration has been called a model for both its natural resource benefits and its collaborative process. The public-private partnership involves many stakeholders, including the private owner of the two hydropower dams, city and state officials, and non-governmental organizations. When all four dams—the three blocking the Baraboo Rapids and the LaValle Dam upstream—are finally removed, 120 miles of the Baraboo will be restored to free-flowing conditions. Research indicates that this may be the longest main stem stretch of river ever restored in the United States through dam removal.

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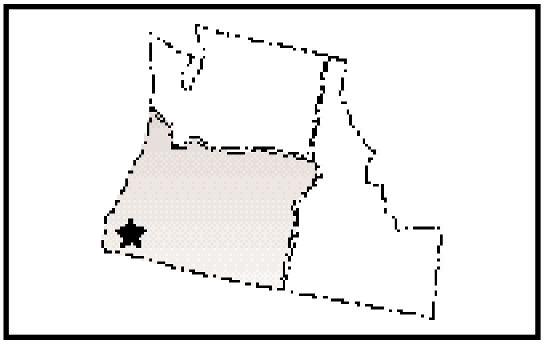


BEAR CREEK

REMOVAL OF THE JACKSON STREET DAM IN OREGON

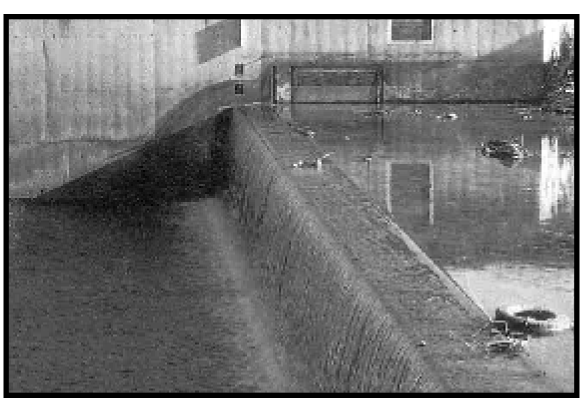
DAM REMOVAL BENEFITS: IMPROVED MIGRATORY FISH HABITAT, IMPROVED WATER QUALITY, REVITALIZED DOWNTOWN RIVERFRONT

SUMMARY

The Jackson Street Dam was built in 1960 on Bear Creek in Medford, Oregon to divert water from Bear Creek into the irrigation canals of the Rogue River Valley Irrigation District (RRVID). The construction of the dam resulted in a partial barrier to migratory fish, loss of stream habitat, and an algae-filled impoundment located in Medford's largest city park. In the early 1980s, the City of Medford, state and local government agencies, environmental groups, and the RRVID reached consensus that removing Jackson Street Dam was the most cost-effective solution to fixing the problems caused by the dam. However, the solution had to devise an equally feasible and cost-efficient diversion alternative for the RRVID. Funding, planning, and implementing the Jackson Street Dam removal required a multi-stakeholder collaborative effort that was by no means a simple task. But in the end, the decision to remove Jackson Street Dam benefited all of the involved parties—as well as Bear Creek and the migratory fish species that reside there.

THE RIVER

Bear Creek is a major tributary of the Rogue River flowing through the City of Medford in southern Oregon. Approximately 100,000 people reside in the lower part of the Bear Creek watershed and the land use in this area is largely agricultural and urban. The former dam was located within a Medford City park, which is part of the larger Bear Creek Greenway that extends for 21 miles along the river through five urban areas. Bear Creek and its tributaries provide habitat for migratory fish species, such as coho salmon, chinook salmon, and steelhead, as well as resident fish species. Of these species, steelhead are the most abundant migratory fish in Bear Creek, with several hundred adults returning annually to spawn. Of the migratory fish historically found in Bear Creek, coho salmon are the species that have been most negatively affected by blockage and habitat degradation. Because of these impacts, coho are rarely found in Bear Creek



and its tributaries and are now listed under the Endangered Species Act as a threatened species.

THE IMPACT PRIOR TO REMOVAL

The Jackson Street Dam, which was 11 feet tall and 120 feet long, was located at river mile 11 of Bear Creek and was the first major barrier to fish passage encountered by migratory fish as they moved upstream from the main stem Rogue River. Jackson Street Dam created an impediment to fish migration due to poorly designed fish passage facilities. This was further complicated by irrigation withdrawals from the impoundment and low flows during migration periods. The dam did have a fish ladder that was designed for upstream fish passage, but due to construction flaws it either blocked or delayed fish. Downstream fish passage was also a significant problem at the dam because the fish screen and bypass system constructed to keep fish out of the RRVID's irrigation canal were outdated and did not meet criteria established by the National Marine Fisheries Service (NMFS). Further, the dam and slow-moving reservoir were thought to hinder fish movement and to increase their exposure to predators.

In addition to hindering fish passage, Jackson Street Dam created water quality and aesthetic problems. Bear Creek has among the worst water quality of streams its size in Oregon and has not met water quality standards of the federal Clean Water Act since the State of Oregon began monitoring the stream in 1977. Dams, land use, irrigation withdrawals, stream channel modifications, drought, and water treatment plants all contribute to the degradation of Bear Creek. However, since 1978 local government agencies have been successful in reducing fecal bacteria and sediment loads in Bear Creek. Before Jackson Street Dam was breached in 1998, these water quality improvements were negated by the sedimentation, increased water temperatures, and algae growth caused by the Jackson Street Dam's reservoir. In addition, the silt- and debris-filled reservoir was also an eyesore—and source of stench—in downtown Medford.

THE REMOVAL DECISION & PROCESS

Because the Jackson Street Dam provided the RRVID with a cost-effective and mechanically functional irrigation diversion system, any plans to remove the dam had to provide the irrigation district with an equally beneficial method of water diversion. After 13 years of using a consensus-based approach, a solution was found that satisfied all of the involved parties—before the Jackson Street Dam could be removed, a new less damaging diversion structure had to be built to replace it. The new diversion device was approximately one-fourth the height of the old one (about 3 feet), located 1,200 feet upstream of the old dam site, and would be removed at the end of each irrigation season when most upstream migration occurs. When it was in place, the new diversion was designed to allow steelhead, chinook, and coho to move up and downstream much more easily—and designed so that little water would back up behind it. The new diversion system was also equipped with fish screens designed to keep fish out of the irrigation canal.

DAM REMOVAL FACTS:

- **Height: 11 ft; Length: 120 ft**
- **Built: 1960**
- **Purpose: irrigation diversion**
- **Owner: Rogue River Valley Irrigation District**
- **Regulatory jurisdiction: state**
- **Estimated cost of repair: not examined**
- **Cost of removal: $1.2 million**
- **Removed: July - September 1998**
- **Removal method: breaching**

The total cost of removing the Jackson Street Dam was $1.2 million. Primary funding for the project was provided by the State of Oregon, which used state lottery proceeds from its watershed enhancement program, and by the City of Medford, which used funds from its urban renewal program. Oregon Trout, a state non-profit organization, and the US Bureau of Reclamation provided additional funding for the removal. Removing the Jackson Street Dam was the lowest cost alternative for achieving the project's objectives.

REMOVAL BENEFITS:
- ¥ **Restored 1/4 mile of aquatic habitat**
- ¥ **Improved up & downstream fish passage**
- ¥ **Improved water quality**
- ¥ **Enhanced aesthetics at site**
- ¥ **Diminished debris and stench associated with reservoir**
- ¥ **Aided with urban riverfront revitalization**
- ¥ **Allowed an irrigation district to upgrade its fish passage facilities**

The removal of Jackson Street Dam took place from July to September 1998. The initial step in the removal process was to provide a dry workplace by using concrete dividers to channel Bear Creek around the dam. Because a fiber optic cable ran underneath the reservoir, the Jackson Street Dam could not be completely removed. In order to ensure that migratory fish could pass the remaining three-foot structure, two V-shaped concrete weirs were built at intervals below the dam to provide a gradual height increase. Once this was completed, the sediment trapped behind the dam was removed and disposed in a landfill. The old fish screen was also removed and the obsolete section of the irrigation pipeline was abandoned. For the two years following removal, volunteer community groups will restore the newly exposed stream banks through landscaping and planting native trees.

RESTORATION OF THE RIVER

The breaching of Jackson Street Dam restored the 1/4 mile of streambed formerly inundated by the reservoir and improved both upstream and downstream fish passage for migratory fish. The upstream fish passage was improved by replacing a poorly designed fish ladder with an easily passable series of one-foot drops. The same one-foot drops also provide restored downstream passage as the fish no longer have to negotiate the reservoir, fish screen, and bypass system. Already, coho salmon—the fish species in Bear Creek most impacted by dams—and other species have been found upstream of the former dam site.

During the irrigation season, the new diversion structure that was constructed upstream of the original dam site has a short, well-designed fish ladder that provides effective upstream passage for adult fish and well-designed fish screens that provide effective downstream passage for juvenile fish. From October through April when water is not needed for irrigation, the new diversion structure is removed and Bear Creek flows freely. This is especially beneficial to juvenile chinook salmon, which move downstream primarily in April before the start of the irrigation season.

When the new diversion structure is in place, the new reservoir is five to ten percent the surface area of the old reservoir. The new stream channel creates much better downstream passage conditions for migratory fish than the old reservoir—and it may also provide some rearing habitat as the stream banks and riparian vegetation are restored. Upstream passage is also improved due to the cooler water and reduced poaching opportunities created by the new stream channel.

In addition to fish passage and habitat restoration, the City of Medford now enjoys a revitalized stretch of river devoid of the sediment, trash, and stench associated with the Jackson Street reservoir. This restoration of a river in a downtown city park comes at a particularly exciting time for Medford, whose economy is currently booming as it transitions away from agriculture and forestry to more diversified industries. The Jackson Street Dam removal project provides an excellent model for urban stream restoration—and how riverfront restoration can revitalize our nation's cities and towns.

FUTURE EFFORTS TO RESTORE THE RIVER

Bear Creek is also undergoing other restoration projects that will help restore the historic migratory fish habitat of this river. The Phoenix Dam located upstream of the former Jackson Street Dam site at river mile 15 and the Oak Street Dam located further upstream at river mile 23 are also irrigation diversions on Bear Creek that cause major impediments to migratory fish passage. Through the Bureau of Reclamation's Rogue River Basin Fish Passage Improvement Program, these two dams are being retrofitted with fish ladders and screens in order to meet NFMS standards. This will result in greatly improved passage at these two dams that will give migratory fish more access to their historic habitat.

Another dam on Bear Creek that entirely blocks fish passage is the Emigrant Dam (further upstream at river mile 26), which is a large water storage and flood control reservoir. Emigrant Dam blocks 20 to 40 percent of historic steelhead habitat and a smaller percentage of coho and chinook habitat on Bear Creek. Unfortunately, no fish passage is currently planned for this site.

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THE SIGNIFICANCE OF THIS REMOVAL

The removal of Jackson Street Dam is an important step in restoring fish passage not only in the Bear Creek watershed, but the entire state of Oregon. It was the first concrete irrigation dam removed in the Rogue River Basin—and the first Oregon dam ever removed in order to restore coho salmon, a threatened species under the federal Endangered Species Act.

Perhaps more important is this dam removal's significance as a model for future removals. The cooperative spirit that the various community groups brought to the negotiation table—and their willingness to overcome long-standing differences—is the reason that this dam was removed. The Jackson Street Dam removal not only restored migratory fish habitat and improved water quality, but it created an equally effective and efficient irrigation diversion replacement and contributed to the urban revitalization of downtown Medford. The diligence and persistence of the groups involved in the effort to remove the Jackson Street Dam paid off for all when this dam was removed in July of 1998. US Secretary of the Interior, Bruce Babbitt, was right when he said "It's a little dam, but it's a big win for this community"—further, it's a big win for this country.

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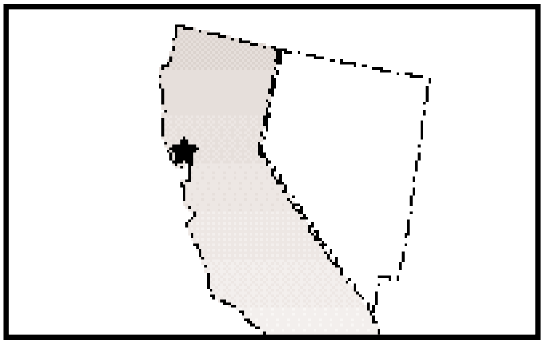


BUTTE CREEK

REMOVAL OF THE WESTERN CANAL MAIN, WESTERN CANAL EAST CHANNEL, McGOWAN, AND McPHERRIN DAMS IN CALIFORNIA

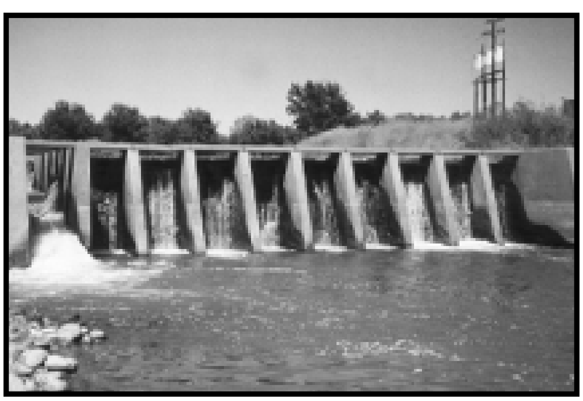
DAM REMOVAL BENEFITS: IMPROVED MIGRATORY FISH HABITAT, IMPROVED WILDLIFE HABITAT, IMPROVED ENDANGERED SPECIES HABITAT

SUMMARY

Removal of four water diversion dams and 12 unscreened water diversions are resulting in dramatic improvements to 25 miles of chinook salmon habitat in the Sacramento Valley's Butte Creek. The collaborative effort includes one of northern California's largest irrigation districts, rice growers and other agricultural interests, government resource agencies, and other stakeholders. The group worked together to solve individual and mutual problems, with a primary goal of restoring the fisheries. The project is making important progress toward protecting chinook salmon, which are listed as threatened under California's Endangered Species Act. In 1987, only 14 spring-run chinook salmon were found spawning in Butte Creek. The removal of four small dams and other river restoration efforts contributed to a record spring 1998 run of more than 20,000 adult chinooks.

THE RIVER

Butte Creek is considered a keystone for preserving and recovering the spring run of chinook salmon, which once numbered in the hundreds of thousands in the Sacramento River system, but had dwindled to less than 10,000 returning adults in an average year. Before dams were constructed, the spring-run chinook was California's most abundant salmon species, and the stock that sustained a now-extinct inland fishery. Some 700,000 salmon used to spawn in 40-odd streams, and 21 turn-of-the-century canneries processed the fish. The recent restoration efforts took place along the middle reach of Butte Creek, which is one of only four Sacramento River tributaries with remaining populations of spring-run chinook salmon. Along Butte Creek's valley reach, several irrigation diversion dams have been built. Upstream of these diversions is a gorgeous, deeply incised volcanic canyon that provides prime spawning habitat.



THE IMPACT PRIOR TO REMOVAL

Spring-run chinook was once California's most abundant salmon species, but with the extensive construction of dams and diversions following World War I, the chinook population began to decline. The undoing of the state's natural hydrologic regime through dams and water withdrawals led to an inexorable decline of these fish.

During the 1987 to 1992 drought, the total state population of spring-run chinook was estimated at fewer than 500 fish. Pure spring-run chinook stock spawned in only three or four small Sacramento River tributaries, one of which was Butte Creek. The creek's spring-run chinook are listed as threatened under California's Endangered Species Act, and are candidates for the federal Endangered Species List.

DAM REMOVAL FACTS:

- ¥ **Height: 6 to 12 ft**
- ¥ **Length: 10 to 100 ft**
- ¥ **Built: early 1900s**
- ¥ **Historic purpose: irrigation diversion dams**
- ¥ **Owner: water districts and private landowners**
- ¥ **Regulatory jurisdiction: state**
- ¥ **Estimated cost of repair: not examined**
- ¥ **Estimated cost of removal & associated work: $9.5 million**
- ¥ **Actual cost of removal & associated work: $9.13 million**
- ¥ **Removed: 1998**

In 1993, the rains came again. Two years later, many spring-run chinook were returning to Butte Creek. At the end of the run, state biologists had counted at least 7,500 outmigrating juvenile fish—the most since World War II, and more than twice the number in all other streams combined. These outmigrants were the source for the record 1998 runs.

An interesting agricultural dilemma served as a catalyst for restoration efforts on Butte Creek. Rice farmers need to remove rice stalks from the previous year's crop before they can plant the next one. Rice stalks are especially tough and do not readily decompose, so many of California's rice growers were burning them. In 1991, air pollution problems resulted in a decision to phase-out rice-straw burning over the next 10 years. Growers turned to another alternative for straw removal—flooding fields after harvesting the rice. By flooding the fields in the fall when temperatures are still warm, the decomposition of the rice stalks is accelerated, and winter and spring rains finish the job. Another benefit of this approach is that ducks, geese, and shorebirds on the Pacific Flyway's migration route stop to eat and drink in the flooded fields.

Although the state's waterfowl division was enthusiastic about flooding the fields, the state's fisheries division was clearly concerned. The flooding of the fields resulted in impacts to the salmon population, including outmigrating juvenile salmon being drawn into the unscreened water diversions.

THE REMOVAL DECISION & PROCESS

The potential federal listing of spring-run chinook salmon as a threatened or endangered species, coupled with the amazing turn-around at Butte Creek, got the attention of many water users. If the spring-run chinook were listed, commercial fishermen would not be able to fish because the spring-run chinook feed off the coast with the fall-run chinook, and are impossible to differentiate from each other until it's too late. A spring-run chinook listing might also shut down pumps for Southern California's water supply, half of which comes from Northern California. San Joaquin Valley agriculture interests had similar fears of a listing.

The Western Canal Water District, which had had a positive experience with the removal of the six-foot high Point Four Dam from Butte Creek in 1993, stepped forward and offered to help ease the problem. The District proposed to remove two small diversion dams—the Western Canal Main and Western Canal East Channel Dams. These two dams blocked Butte Creek and had antiquated fish passage structures. The District's dams were designed to keep an introduced source of water from going downstream, and to allow gravity flow of water out of the other side of the creek to the District's 30,000 acres. The District's plan was to create an alternative water diversion system using relatively inexpensive piping. The District proposed to run its additional source of water in pipes under Butte Creek instead of damming the creek to pump the water across. The project would be fish friendly, and would result in increased and more reliable flows for rice farmers and associated managed wetlands.

California Fish and Game biologists sensed a larger opportunity in the Western Canal Water District's proposal to remove its two dams. The state agency concluded that by joining some lateral canals and working out some water exchanges, more dams could be removed from Butte Creek.

REMOVAL BENEFITS:

- **Restored fish passage for imperiled chinook salmon**
- **Eliminated impact of water diversions on outmigrating juvenile fish**
- **Increased reliability and amount of water available for agriculture and waterfowl management**

Seeking to avoid a spring-run chinook listing, the US Department of Interior (DOI) funded a feasibility study of the Butte Creek restoration efforts, even though none of the facilities were in its immediate service area. The study concluded that the proposals of the California Fish and Game and the Western Canal Water District made sense, and expanded the project to include other restoration efforts.

The final Butte Creek restoration effort—implemented in 1998—included removal of four dams—the two dams owned by the Western Canal Water District, McGowan Dam, and McPherrin Dam. It also involved other alterations to the system, including elimination of at least 12 unscreened water diversions. The final cost for implementing the full project was $9.13 million, including all stages of design, permitting, environmental documentation, construction, construction management, and environmental impact mitigation. The Western Canal Water District, DOI (through the Central Valley Project Improvement Act), and California Urban Water Agencies each provided one third of the funding for the effort.

One of the most challenging aspects of the project was working within the allowable construction windows related to threatened and endangered species, and continuing full water deliveries to agricultural users during construction. From a construction perspective, the two most significant challenges were the dewatering of construction sites and the dispersed nature of the facilities and construction sites over an area of 60 square miles. These and other factors resulted in a complex design, a challenging construction schedule, and the need for constant coordination among all parties.

RESTORATION OF THE RIVER

The Butte Creek salmon populations have already made an impressive recovery from the 14 spring-run chinook that were found spawning in Butte Creek in 1987. The 1998 restoration efforts restored approximately 25 miles of Butte Creek to free, unimpeded flow for the first time since the 1920s. The imperiled chinook salmon have already returned to the unimpeded river and benefited from the restoration efforts. Because of the three year salmon lifecycle, it is too early to determine definitively the results of this restoration effort, but early results are promising—the spring run of 1998 consisted of more than 20,000 adult chinooks.

Recent improvements in ocean conditions hold even more promise for the migratory chinook. Ocean productivity occurs in cycles—roughly every 20 to 40 years, ocean upwellings cause an increased abundance of food to be available for fish. Fisheries biologists have seen an upwelling in 1999 along the entire Pacific Coast, as evidenced in part by sport and commercial fish catches being higher in size and higher in number. These ocean condition improvements are expected to result in more and bigger chinook returning to Butte Creek to spawn. Coupled with the improved spawning habitat from the dam removals, the future looks even more promising for the threatened spring-run chinook.

FUTURE EFFORTS TO RESTORE THE RIVER

Researchers are assessing the possibility of removing, or at least modifying, two hydropower dams owned by Pacific Gas and Electric Company that block salmon access to the pristine upper canyon reach of Butte Creek above this restoration project.

THE SIGNIFICANCE OF THIS REMOVAL

The Butte Creek restoration project is significant both because of its river basin-wide scale and because of its collaborative nature and innovative cost-sharing partnership. Consensus building and cooperation among the agricultural, urban and environmental communities, as well as creative funding partnerships, were essential to the success of the project. This project may mark the first time in the American West that dam removals were inspired for combined agricultural and environmental reasons.

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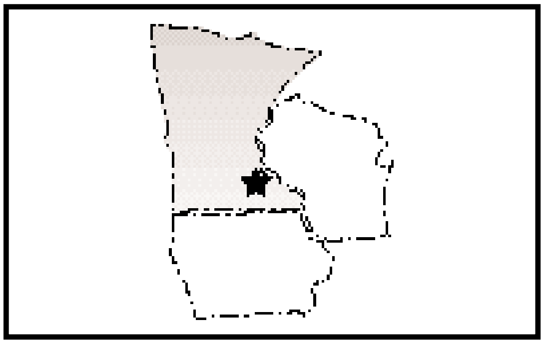


CANNON RIVER

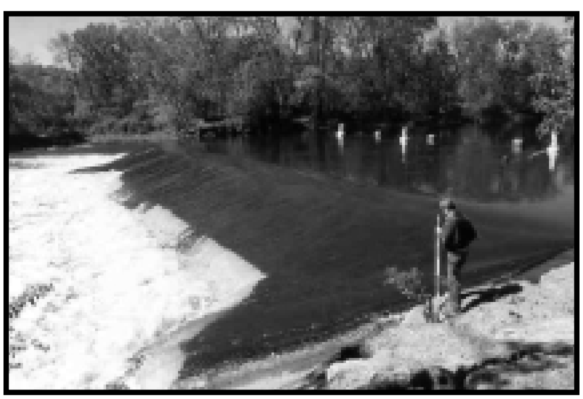
REMOVAL OF THE WELCH DAM IN MINNESOTA

DAM REMOVAL BENEFITS: IMPROVED WARM WATER FISH HABITAT, ENHANCED RECREATIONAL OPPORTUNITIES, ELIMINATED PUBLIC SAFETY HAZARD, COST SAVINGS

SUMMARY

The Welch Dam, originally constructed to power an adjacent mill, blocked the Cannon River—a Minnesota Wild and Scenic River—for over a century. The dam, which had been obsolete for approximately 30 years when it was removed, blocked fish migration, created water quality and sedimentation problems, and posed a safety hazard for canoeists. In 1994, the Minnesota Department of Natural Resources (DNR) removed the Welch Dam for $46,000—almost $75,000 less than the estimated cost of removal. Numerous species of fish are now found upstream of the former dam site, where they had not been seen in decades—and the canoeing opportunities and safety conditions at the site have been greatly enhanced.

THE RIVER



The Cannon River, which flows northeastward to its confluence with the Mississippi River, is one of six rivers that make up Minnesota's Wild and Scenic River System. The Cannon, which was named a state Wild and Scenic River in 1980, is one of the most popular canoeing rivers in Minnesota and is often described for its outstanding scenic qualities. Because of the Cannon's close proximity to Minneapolis-St. Paul, it is a favorite destination for canoeists trying to escape from the Twin Cities on weekends. Additionally, running along side of the Cannon River is one of the ten most beautiful rails-to-trails projects in the country, providing 20 miles of trail for hiking, biking, skating, and cross-country skiing. The Cannon River, which varies in width from 50 to 200 feet as it flows to the Mississippi, also provides significant warm water fishery habitat. The Cannon River watershed is approximately 1,460 square miles and has high fish diversity, with 47 species of fish found between the first dam, Lake Byllesby, and the Mississippi

River. The watershed is largely agricultural with approximately 90 percent of the land devoted to farming. Soybeans and corn are the predominant crop. Despite the fact that less than five percent of the watershed land remains in its natural state, the Cannon River stream corridor harbors ecosystems that are home to rare species of flora and fauna.

THE IMPACT PRIOR TO REMOVAL

The history of the Welch Dam is incomplete, but at some point in the 1890s a dam was built on the Cannon River in southeastern Minnesota approximately 13 miles from the confluence of the Mississippi River. The dam that was removed in 1994, a 9-foot tall and 120-foot wide structure, was built in the 1920s or 1930s. Although the purpose of the original dam is unclear, the latter dam was built to provide power at an adjacent mill in order to grind grain. The Welch Dam, which was privately owned throughout most of its existence, generated hydropower for the mill and provided some electricity to residents of Welch until the early 1960s when the facility ceased to operate. Because it no longer generated the income necessary to cover maintenance costs, the Welch Dam eventually fell into disrepair and posed a safety hazard to downstream interests.

The Welch Dam was the first dam on the Cannon River and blocked numerous fish species from the Mississippi River from reaching their historic habitat. The Minnesota DNR reported that the dam posed problems for upstream habitat as well, by degrading water quality and causing sedimentation to back up behind the dam. The Welch Dam presented a significant safety hazard not only to downstream interests due to its lack of structural integrity, but also to canoeists who had to portage around the structure. In the 25 years prior to the removal of the Welch Dam, at least six people drowned at the site.

THE REMOVAL DECISION & PROCESS

Prior to the removal of any dam, the Minnesota DNR involves the general public in the decision-making process. The agency's goal is to reach a consensus on which action—repair or removal—is the most appropriate not only for the river ecosystem, but also for the surrounding community. The Minnesota DNR feels that it is important to have local buy-in and support before removing a structure from the river. While there was some local concern about the impacts of removing the Welch Dam, there was little opposition to the proposed removal. Many of the local citizens felt that the Welch Dam should be removed because it was obsolete, structurally unsafe, a hazard to canoeists, and because it was vastly more expensive to repair the dam than to remove it. In 1992, the Minnesota State Legislature approved the Minnesota DNR's plan to remove the dam and appropriated $80,000 for the removal of the Welch Dam. The removal was expected to cost approximately $120,000, but only cost $46,000—well under the $80,000 appropriated by the state legislature.

DAM REMOVAL FACTS:

- **Height: 9 ft; Length: 120 ft**
- **Impoundment: 10 acre-ft**
- **Built: 1890s**
- **Purpose: hydropower (inactive)**
- **Owner: private citizen**
- **Regulatory jurisdiction: state**
- **Estimated cost of repair: not available**
- **Estimated cost of removal: $120,000**
- **Actual cost of removal: $46,000**
- **Removed: 1994**
- **Removal method: wrecking ball & backhoe with heavy machinery**

Prior to the removal of the Welch Dam, the ownership of the dam was transferred from the private citizen to the Minnesota DNR. The funding, engineering, and removal were accomplished through the

Dam Safety Program at the Minnesota DNR Division of Waters. A private company was employed to conduct the actual demolition of the Welch Dam, which took approximately three days to complete. The dam was removed using both a wrecking ball and a jackhammer attached to a backhoe. All of the debris from the removal was used to stabilize the adjacent riverbanks and to fill in the scour hole below the former dam. Other than removing the dam and stabilizing the shoreline, no restoration work was done in conjunction with the removal of the Welch Dam. According to the Minnesota DNR, allowing the site to restore itself naturally was the best option for this particular dam removal.

REMOVAL BENEFITS:

- **Opened 12 miles for fish migration**
- **Removed a safety hazard to downstream interests**
- **Enhanced recreation opportunities & improved safety conditions for canoeists**
- **Expected to provide economic benefits as result of improved recreation**

The reservoir of the Welch Dam, although only ten acre-feet in size, was extremely silted-in. Prior to the removal, some local citizens were concerned that the sediments could contain toxic substances, which if true, would have required that the Minnesota DNR dredge the sediment and dispose of it in an approved disposal site. Such an action would have significantly increased the cost of the Welch Dam removal. In the end toxic substances were not present and the sediment was allowed to wash downstream.

RESTORATION OF THE RIVER

The removal of the Welch Dam provided benefits on many levels—to fish and wildlife, river recreationists, downstream interests, and the general scenic qualities of the Cannon River. In addition to restoring a section of this Minnesota Wild and Scenic River to its natural free flowing conditions, it also provided aesthetic benefits and a look into the past. After the impoundment created by the former Welch Dam was drained, a riffle was exposed that had been inundated for over a century, giving residents of Welch a chance to see the river as their ancestors did. Sedimentation and water quality problems long associated with the dam site were also eliminated with the removal of the Welch Dam—improving the river habitat for numerous species of fish and wildlife.

Since the removal of the Welch Dam, muskellunge, flathead catfish, bowfin, longnose gar, mooneye, and gizzard shad have been reported in the 12-mile stretch of the Cannon upstream of the former dam—where the fish had not been seen in numerous decades. A fisheries biologist for the Minnesota DNR stated that most of these species were native to the Mississippi River and that it was very likely that they inhabited that section of the Cannon prior to the construction of the Welch Dam in 1890s. “The removal of the Welch Dam is a perfect example of what can happen to fish. It creates all-new fishing opportunities,” said Al Schmidt, a fisheries biologist for the Minnesota DNR.

The removal of the Welch Dam also greatly enhanced canoeing opportunities along this stretch of the Cannon River. Prior to the removal, after paddling through the slack water created by the reservoir, canoeists had to portage around the dam—which not only degraded the quality of the canoe trips, but also increased the risk of injury or death. Because the Cannon River is one of the most popular canoeing routes in Minnesota, removing this safety hazard was an enormous benefit to canoeists and canoe outfitters. Because of the river’s close proximity to the Twin Cities, the local area is expected to receive enhanced economic benefits as a result of the recreational improvements created by the removal of the Welch Dam.

FUTURE EFFORTS TO RESTORE THE RIVER

Although, at least six other dams exist on the Cannon River, there are no current plans to remove these structures. The next dam upstream from the former Welch Dam is Lake Byllesby Dam, which is licensed by the Federal Energy Regulatory Commission and owned and operated by Dakota and Goodhue Counties to produce hydropower. Lake Byllesby Dam, which was completed in 1911, is a large structure that stands 60 feet tall and 2,870 feet wide. Following the construction of the dam, S.S. Lewis wrote the following about the falls that the dam had inundated, "The cascade and all adjacent scenery were obliterated when the great dam was built across the river's channel, about half a mile below the cascade, during the summer of 1910." For now, these falls will remain covered by the Lake Byllesby Dam.

Despite the fact that there are no future dam removals planned for the Cannon River, there is an active grass-roots group, the Cannon River Watershed Partnership, that is working to protect and restore the river. The Partnership coordinates existing local and state government and citizen resources in implementing local water plans; instills a sense of watershed pride through education, information and special events; and provides cooperative management and protection for the watershed.

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THE SIGNIFICANCE OF THIS REMOVAL

The removal of the Welch Dam was significant for a number of reasons—an obsolete structure was removed from the Cannon River eliminating a safety hazard, improving canoeing opportunities for one of the most popular canoeing rivers in the state, and restoring a significant warmwater fishery. All of these benefits were recognized for only $46,000—and for almost $75,000 less than the Minnesota DNR estimated. This was an small cost considering the benefits received by the City of Welch, not to mention the Minneapolis-St. Paul metropolitan area, which now has a significantly improved natural resource—and just 45 minutes away.

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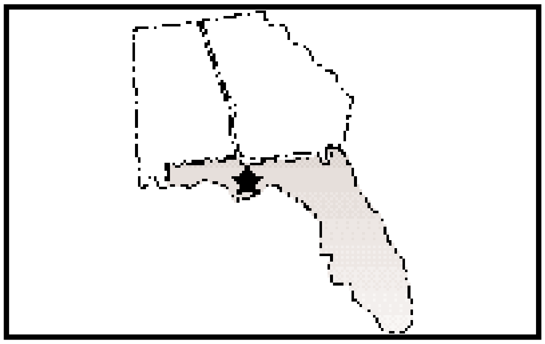

CHIPOLA RIVER

REMOVAL OF THE DEAD LAKES DAM IN FLORIDA

DAM REMOVAL BENEFITS: IMPROVED MIGRATORY AND RESIDENT FISH HABITAT, IMPROVED WATER QUALITY, ENHANCED RECREATIONAL OPPORTUNITIES

SUMMARY

Dead Lakes Dam on the Chipola River in the Florida Panhandle was removed in 1987 in an attempt to restore to life this section of the river. The sheetpile dam was built in 1960 to corral the water and fish in Dead Lakes. Dead Lakes Dam did achieve the desired goal of preventing low water conditions, but it also resulted in a serious decline in fish populations. Without the natural flood and drought cycles, certain species of aquatic plants began to take over the lake and choke out other species of both flora and fauna. By the 1970s, the lake was filling with organic matter and experiencing a decrease in diversity and abundance of aquatic life forms. It is likely that without the removal of the dam in 1987, Dead Lakes would have eventually been devoid of most aquatic life forms. In the 1980s, the local community voted to have Dead Lakes Dam removed in an attempt to restore this section of the Chipola River. Since the removal of the dam, the aquatic plant and fish species diversity and abundance has in fact increased dramatically, along with local angling opportunities.

DAM REMOVAL FACTS:

- ¥ Height: 18 ft; Length: 787 ft
- ¥ Impoundment: 34,800 acre-ft
- ¥ Built: 1960
- ¥ Purpose: recreation
- ¥ Owner: Dead Lakes Water Management District
- ¥ Regulatory jurisdiction: state
- ¥ Estimated cost of repair: not examined
- ¥ Estimated cost of removal: $32,000
- ¥ Cost of removal: $32,000
- ¥ Removed: Oct. - Dec. 1987
- ¥ Removal method: floating barge with crane & reverse pile driver

THE RIVER

The Chipola River, a state Wild and Scenic River and an Outstanding Florida Water, is the largest tributary to the Apalachicola River and drains one-half of the Apalachicola watershed. Natural forces created the 6,700-acre Dead Lakes (which is only one and not multiple lakes as the name suggests), when the Apalachicola River formed sandbars that ultimately blocked the Chipola River. Thousands of cypress trees in the floodplain were logged by a sawmill in the 1800s, which gave the lake its name and the eerie appearance of this ecosystem. Dead Lakes, which is a Florida State Recreation Area, is known for its excellent shellcracker fishing for which the submerged cypress trees make an ideal habitat. The surrounding land area is rather unspoiled and largely undeveloped, with no industry or urban areas. In fact, the last bastion of the ivory-billed woodpecker, now extirpated from North America, was found around Dead Lakes and the Chipola River, demonstrating its pristine qualities.

THE IMPACT PRIOR TO REMOVAL

Dead Lakes Dam was located on the Chipola River at the lower end of a natural lake where a section of the Apalachicola River, called the Cutoff, meets the confluence of the Chipola River. This stretch of the Chipola River, which is naturally wide and shallow, is subject to flow fluctuations especially during periods of drought and is directly affected by the flow conditions in the Apalachicola. The US Army Corps of Engineers (Army Corps) and the Florida State government built Dead Lakes Dam in 1960 in order to stabilize the water fluctuations of the natural lake and prevent low water events from occurring. The structure, which was approximately 18 feet tall and 787 feet long, was an interlocking sheet-pile dam that was reinforced with granite rocks.

Once Dead Lakes Dam was complete, the ownership was transferred to the Dead Lakes Water Management District, which was a governor-appointed board of local citizens charged with managing the dam. While this group was responsible for managing the dam (and became defunct when the dam was removed), the responsibility for the dam ultimately fell into the hands of the Northwest Florida Water Management District and the Florida Game and Fresh Water Fish Commission (GFC) (now the Florida Fish and Wildlife Conservation Commission).

Many felt that Dead Lakes Dam would provide an excellent recreational fishing resource by giving shellcracker more spawning habitat and by creating more waterfront property for fishing camps. In fact, fishing did improve in the years immediately following the dam's construction as the fish became corralled in the lake and thus were easier to catch.

However, by the late 1970s, the health of Dead Lakes had greatly deteriorated and some sections of the lake were largely devoid of life. By eliminating the water level fluctuations, the Dead Lakes Dam allowed certain aquatic vegetation, specifically Brazilian elodea and water hyacinth, to thrive to the point that spawning areas disappeared and fishing access became impaired. This created a lake that was full of silt, mud, and dead plants that could not be restored to its natural state under the static water conditions created by the dam. In an attempt to remedy the situation, four drawdown gates were installed on the dam in the 1970s, so that the lake level could be fluctuated manually. However, the gates were inadequately designed and only allowed the lake level to be drawn down by about four to five feet. Dead Lakes, which once provided a valuable fishing resource, had become a wasteland—and almost literally a dead lake. The shellcracker beds that had once stretched for acres had virtually disappeared, as had the bluegill and largemouth bass populations.

An additional impact of Dead Lakes Dam was its blockage of migrating striped bass from the upper Chipola River system. The Chipola River is a unique Florida waterway because it is fed by a number of spring-fed streams that have water temperatures significantly lower than those of other rivers and lakes in the state. Because of this cold water, the Chipola River provides a refuge for striped bass during the warmer summer months. Prior to the construction of Dead Lakes Dam, these fish were also suspected to spawn upstream of the dam (although there is no existing documentation of this). With no fish passage structure at the dam, migrating striped bass could no longer move upstream.

THE REMOVAL DECISION & PROCESS

By the 1980s, the local community decided that Dead Lakes Dam should be removed in an effort to restore the prosperous native fishery to this section of the Chipola River. A vote was held and—

despite opposition by lakefront property owners—over 70 percent of the local community supported the removal of Dead Lakes Dam. In 1987, the Florida State Legislature appropriated money to the Northwest Water Management District to remove Dead Lakes Dam. Three permits had to be obtained for the removal—one each from the Army Corps, the Florida Department of Environmental Regulation (DER) (now the Florida Department of Environmental Protection), and the Northwest Florida Water Management District. A group of local citizens filed a third party intervention on the Florida DER permit in an attempt to stop the removal. An administrative hearing was held in which it was decided that the removal should continue as planned. To the knowledge of those involved in the Dead Lakes Dam removal, this was the first time that the Army Corps issued a permit for the removal of a dam.

Because of the complicated construction of the dam in which sheetpile had been driven approximately 40 feet into the clay zone below the river bottom, a local salvage contractor, KMT, Inc., was hired to remove Dead Lakes Dam. A burning rod was used to cut slots in the dam, which were then removed a section at a time to allow the water impounded behind the dam to drawdown to the point where no scouring would occur. After the drawdown, a reverse pile driver, located on a barge below the dam, was used to extract the sheetpile. Each sheetpile was pulled halfway out, cut in half, and then the remainder was removed. The entire removal of Dead Lakes Dam took approximately two months to complete and cost a total of $32,000. KMT, Inc., who realized the value of the sheetpiles, largely won the contract bid to remove Dead Lakes Dam because the company bid very low for the job with the understanding that the they would retain the sheetpiles. Because the sheetpiles had not seen air since they had been put in place almost 30 years earlier, they were essentially brand new after they were removed from the river. KMT, Inc. probably made three to four times more money out of the steel than they did from the payment of the dam removal job—and saved the cost of disposing of the material.

REMOVAL BENEFITS:

- **Increased abundance & quality of resident fish**
- **Enhanced recreational fishing opportunities**
- **Improved water quality, specifically dissolved oxygen**
- **Improved migratory fish habitat**

The granite rock that reinforced the sheetpile was left in the river, so that a barrier to migratory fish, river flows, boats, and sediment still existed during low water levels. In February 1989, at the insistence of the local community, the county was able to appropriate enough money to remove some of the granite, which restored free-flowing conditions to the Chipola River. As with the sheetpile, the granite was reused for other purposes, which eliminated any disposal costs.

RESTORATION OF THE RIVER

During normal water flow conditions, Dead Lakes maintains a water level similar to the level created with the dam in place—which was a real surprise to some of the people who opposed the removal. During times of drought and floods, the lake level is either much lower or higher than when the dam existed. The low water levels during droughts are specifically significant for a healthy ecosystem in Dead Lakes because the mud and other material that accumulates on the bottom can be broken down through exposure to the sun and air. This creates spawning habitat for numerous fish species, allows a larger variety of aquatic vegetation to grow in the lake, and improves the dissolved oxygen content levels—all of which contribute positively to the health of Dead Lakes. Dead Lakes was so badly degraded by the time the dam was removed that it will take several hurricane and tropical storm cycles before the lake fully recovers from the muck buildup. However, it now appears that all of these natural processes are again occurring in Dead Lakes—and this section of the Chipola River is well on its way to recovery.

Prior to the construction of Dead Lakes Dam, the shellcracker beds in the lake used to stretch for acres, but declined significantly during the dam's existence. Now that the dam is gone, the shellcracker beds are beginning to return to their previous state—and while the beds may not be acres long yet, fishermen report that the beds are on their way to recovery. Other fish species are also making a recovery. The number of fish species found in the lake prior to the removal of the Dead Lakes Dam was 34. This number increased to 61 after the dam was removed—which is a sign that the ecosystem is recovering. Michael Hill, a fisheries biologist for the Florida GFC remarked, "Any time that you have increased diversity, that shows that your system is healthy." The removal of Dead Lakes Dam was also beneficial for striped bass migration. Striped bass are now found in the Chipola River upstream of the former dam site. This is a significant benefit not only for the river ecosystem, but also for the sport fishing industry in Florida.

A study to determine the effects of removing Dead Lakes Dam was conducted by the Florida GFC over the five years immediately following the removal until the funding ran out. This study, funded by the Federal Aid in Sport Fish Restoration, is one of the few post-dam removal studies to be conducted to date. Although it was terminated earlier than was ideal, it still provides valuable evidence of the restoration of Dead Lakes and helps to demonstrate that the removal of dams can restore natural ecosystems.

FUTURE EFFORTS TO RESTORE THE RIVER

No future restoration efforts are currently planned for the Chipola River. However, according to the Florida GFC, a restoration effort that should occur is to remove the remainder of the granite rocks on the riverbed at the former Dead Lakes Dam site. Roughly 500 feet of rock remain, and while the Chipola River is able to fluctuate more naturally with the removal of the dam, the granite rocks may be obstructing some of the river flow.

THE SIGNIFICANCE OF THIS REMOVAL

The removal of Dead Lakes Dam is significant not only because it so successfully restored the ecological balance to the river and lake, but also because it was the local community that initiated the removal of the structure. The fishery decline of Dead Lakes coincided so precisely with the construction of the Dead Lakes Dam, that it was obvious to the community surrounding Dead Lakes what had to be done to restore the fishery. Unlike in many other dam removal cases, because this area is relatively undeveloped, water pollution, agricultural run-off, or other factors could not be blamed for the decline in the fishery. By voting to remove the Dead Lakes Dam, the local community once again is able to enjoy numerous angling opportunities.

The Dead Lakes Dam removal is also significant from the standpoint that it is one of the few dam removals in this country to have been studied after the dam was removed. The Florida GFC should be applauded for taking the time and effort to provide valuable data for future dam removals and river restoration efforts.

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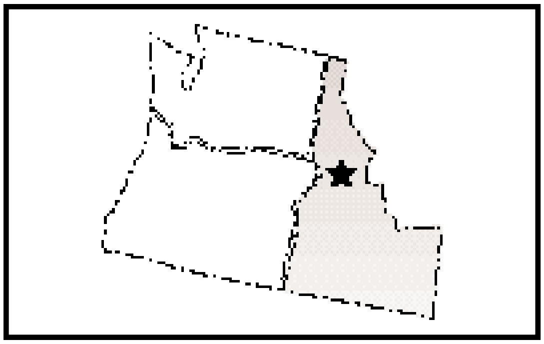


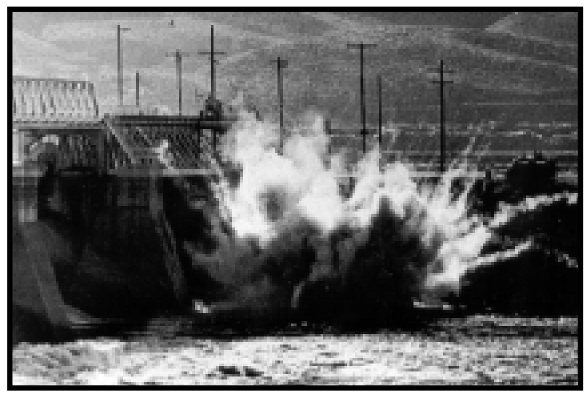
CLEARWATER RIVER

REMOVAL OF THE GRANGEVILLE & LEWISTON DAMS IN IDAHO

DAM REMOVAL BENEFITS: IMPROVED MIGRATORY FISH HABITAT, RESTORED TRIBAL FISHERY

SUMMARY

The Grangeville Dam was a functioning, yet inefficient, hydropower dam located in north central Idaho on the South Fork of the Clearwater River. After the dam's fish ladder failed in 1949, the steelhead runs were extirpated on this tributary of the Clearwater River. The dam's owner, Washington Water Power Company (WWP), decided to remove the dam in 1963 because the reservoir was filled with silt and because of the dam's negative impacts to migratory fish. After removal of the Grangeville Dam, salmon and steelhead returned to the South Fork of the Clearwater upstream of the former dam site.



Salmon returns to the Clearwater were lost in 1927 due to the construction of the Lewiston Dam near Lewiston, Idaho at the mouth of the main stem Clearwater River. The dam was still a functional 10 MW hydroelectric facility at the time of its removal in 1973, but WWP agreed to the removal of the project because the reservoir of the newly built Lower Granite Dam on the Lower Snake River would interfere with the operation of the Lewiston Dam. This dam removal opened access to hundreds of miles of the Clearwater and its tributaries and increased the number of salmon and steelhead returning to the Clearwater to spawn.

THE RIVER

The Clearwater River watershed, which comprises 9,645 square miles, is located in north central Idaho. The Clearwater River is a major tributary to—and provides approximately one-third of the flow into—the Snake River. The South Fork of the Clearwater River flows from the Bitterroot Mountains to meet the main stem of the Clearwater River at Kooskia, Idaho. The Nez Perce Tribe has fished the Clearwater River since time immemorial and reserved its rights to take fish at all usual and accustomed places in its 1855 Treaty with the United States. The federal government manages the majority of land in the Clearwater watershed and the predominant land uses are forestry, agriculture, and grazing. The drainage supports a large wilderness area within the Selway-Bitteroots Mountain range as well as 185 miles of designated wild and scenic river. Since the turn of the century, the Clearwater River and its tributaries have been critically altered by the presence of dams. Construction of the Lewiston Dam near the river's mouth in 1927 caused the near extirpation of a thriving salmon population because of an inadequate fish ladder. Only steelhead were able to negotiate the ladder. In addition, the migratory fish habitat in the North Fork of the Clearwater, approximately 150 main stem miles, is entirely blocked by the Dworshak Dam. The North Fork of the Clearwater had a reputation for supporting the largest natural spawning steelhead run found in the Columbia River basin—individual fish ranged to 30 pounds in weight. In addition to the fish passage problems created by dams, mining, logging, road building, sedimentation, and a lack of woody debris in the tributaries have contributed to the degradation of habitat for migratory fish. However, because of the abundant meadow habitat in the South Fork watershed, this highly productive Clearwater tributary is thought to have historically provided the best habitat for chinook salmon in the basin.

THE IMPACT PRIOR TO REMOVAL

The Grangeville Dam was built in 1903 as a timber crib/rock structure to provide power to the City of Grangeville. The original dam washed out several times between 1903 and 1910 and was eventually replaced with concrete in 1918. The reservoir created by the 56-foot tall and 440-foot wide arched concrete structure was silted-in—and thus obsolete—by the time of its removal. Although a fish ladder had been constructed at the site in 1935, it collapsed in 1949 causing the final extirpation of migratory steelhead in the South Fork of the Clearwater River above the dam. Salmon returns to the Clearwater were lost in 1927 due to the construction of the Lewiston Dam near Lewiston Idaho at the mouth of the main stem Clearwater River.

GRANGEVILLE & LEWISTON DAM REMOVAL FACTS:

- **Height: 56 ft & 45 ft**
- **Length: 440 ft & 1060 ft**
- **Built: 1903 & 1927**
- **Purpose: hydropower (both)**
- **Generating capacity: 1 MW & 10 MW**
- **Owner: Washington Water Power (both)**
- **Regulatory jurisdiction: FERC (both)**
- **Estimated cost of repair: not examined (both)**
- **Cost of removal: unknown & $633,428**
- **Removed: 1963 & 1973**
- **Removal method: explosives & dismantling**

The Lewiston Dam, which consisted of a concrete spillway 45 feet tall and 1060 feet long and two earthen dams 4800 feet and 2400 feet long, was built in 1927 approximately four and a half river miles upstream from the confluence of the Clearwater and Snake Rivers. The dam was originally built to create a millpond and generate electricity for Potlatch Forests, Inc. (Potlatch). At the time of removal, it was a functioning 10 MW, federally-licensed hydropower facility owned by WWP (now Avista Corporation). Despite three fish ladders, the Lewiston Dam severely impacted fish passage, and it is thought that the dam virtually eliminated all runs of wild chinook on the Clearwater River.

The extirpation of the salmon and steelhead runs on the Clearwater severely impacted the subsistence fishing and treaty rights of the Nez Perce Tribe. In 1991, the Nez Perce Tribe filed a law suit against WWP for damages the Tribe incurred as a result of the depletion of the salmon and steelhead runs caused by the Grangeville and Lewiston Dams. The Nez Perce claimed that inadequate fish passage at the two dams violated the treaty rights guaranteed to them in their 1855 Treaty with the United States. Damages to the Nez Perce were estimated to be as high as $650 million. A final settlement of the litigation was reached in January 1999 in which WWP agreed to pay the Nez Perce Tribe $39.2 million over the next 44 years to compensate the Tribe for lost fishing opportunities.

THE REMOVAL DECISION & PROCESS

In 1963, after realizing both that the Grangeville Dam was becoming obsolete due to its silt-filled reservoir and that the dam severely impacted migratory fish populations, WWP decided to retire and remove the hydropower facility. In order to facilitate the removal process, WWP submitted an Application for Surrender of License to the Federal Power Commission (the predecessor to the Federal Energy Regulatory Commission). Through the license surrender, WWP voluntarily agreed to remove the obsolete Grangeville Dam. In August 1963, five tons of dynamite were used to remove the entire structure of the dam. The removal had to be accomplished with one blast because once the river began flowing again, it would be impossible to set another charge of dynamite. As soon as the Grangeville Dam was removed, the silt trapped behind the dam began flowing downstream, and 24 hours after the removal the Clearwater was still flowing with a large amount of silt. However, by the spring of the following year, the South Fork of the Clearwater had flushed nearly all of the sediment downstream. There was no indication that the large amount of silt that washed down the river adversely affected the habitat or fish below the former dam site.

The effort to remove the Lewiston Dam began in 1967 because the construction of Lower Granite Dam, scheduled for completion in 1975, was going to interfere with the Lewiston Dam impoundment and vice versa. An agreement was reached between the US Army Corps of Engineers (Army Corps), WWP, and Potlatch (Potlatch property was also threatened by the Lower Granite Dam) that included removing the Lewiston Dam, protecting Potlatch's property, and constructing an Army Corps levee. Several studies were done to compare the various removal options and costs. The agreed upon removal option was contracted out to Peter Kiewit Sons' Co. for $633,428. In addition, WWP was paid $2.7 million for the project—of which the Army Corps paid $1.5 million and Potlatch paid $1.2 million.

REMOVAL BENEFITS:

- **Opened 42 miles of main stem habitat & over 100 miles of tributary habitat (Grangeville Dam)**
- **Opened 450 miles of habitat (Lewiston Dam)**
- **Returned salmon & steelhead runs**
- **Restored treaty rights to Nez Perce Tribe**

The Lewiston Dam removal began by opening the spillway gates to lower the reservoir level and then removing the gates and bridge, which became property of the contractor. Next, the spillway was cracked with dynamite and dug out in chunks. All debris, minus the salvageable steel, was placed along the north side of the river and covered with soil and vegetation to minimize aesthetic impacts. One negative, yet negligible, aspect of the removal was the flow of sediments downstream and the transfer of an ice drift problem from the Lewiston to the Lower Granite Dam. In order to avoid problems caused by the increased sediment and to limit the impact on migratory fish, the dam removal was scheduled during Lewiston's low water use period. The unavoidable sediment and associated turbidity increases were the only time the contractor was not in compliance with federal, state, and local pollution control laws. The removal was finished by April 1973, with follow up work done in October 1973. It was the first known time that the Army Corps had removed a federally-licensed dam to restore a stretch of free-flowing water.

RESTORATION OF THE RIVER

Forty-two miles of main stem habitat and hundreds of miles of tributaries were opened to migratory fish with the removal of the Grangeville Dam. After the dam was removed, the Idaho Department of Fish and Game began an intensive reintroduction program for salmon and steelhead. This stocking effort, coupled with the dam removal and natural colonization, revitalized chinook salmon runs and steelhead runs on the South Fork of the Clearwater upstream of the former dam site. Actual long-term restoration of the migratory fish runs into the South Fork will depend on significant improvements in migration survival through the four lower Snake River dams located just below the main stem Clearwater River.

Numerous benefits were also immediately gained by removing the Lewiston Dam, including the termination of operation and maintenance costs of a soon-to-be useless structure, deletion of an obstruction to recreational boaters, and restoration of four miles of free-flowing stream. More importantly, the removal of the Lewiston Dam allowed easier upstream and downstream passage for migrating salmon and steelhead in 450 miles of main stem river and hundreds of miles of tributaries.

In addition to the Grangeville Dam and Lewiston Dam restoration efforts, an earlier dam removal in 1934 substantially restored salmon runs on the upper Salmon River, also part of the larger Snake River watershed. The Sunbeam Dam was built in 1910 to provide power for a mining endeavor. Although a fish ladder was provided at the dam, it did not work properly and sockeye salmon were immediately eliminated upstream of the dam. The Idaho Department of Fish and Game paid to have the south abutment of the Sunbeam Dam blown out in 1934. Twenty years later, the sockeye population on the Salmon River had returned to over 4,000 fish. However, by the mid-1950s the dams on the main stem of the Columbia and Snake Rivers were being constructed and upon their completion in 1975, Salmon River sockeye were moving toward extinction.

Unfortunately, the benefits of these three dam removals have been reversed in the last several decades. In the early 1970s, 150 miles of habitat on the Clearwater were again blocked when the Dworshak Dam was built on the North Fork of the Clearwater. Further, four federally-owned dams constructed on the Lower Snake River have significantly harmed salmon and steelhead populations in the Snake and its tributaries—including the Clearwater. Wild salmon stocks that averaged more than 100,000 adults in the 1950s fell to barely 1,500 fish in 1995. All four remaining Snake River salmon populations are listed as threatened or endangered and Snake River steelhead are listed as threatened.

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FUTURE EFFORTS TO RESTORE THE RIVER

A national campaign is currently underway to restore the threatened and endangered salmon and steelhead runs in the Snake River basin to which the Clearwater is a tributary. The Army Corps and the National Marine Fisheries Service are studying the possibility of partially removing four federally-owned dams to improve conditions for salmon migration and bring the Snake River's endangered salmon populations back from the brink of extinction. Partial removal involves removing the earthen portion of the dam and retiring the concrete structure, allowing the river's path to bypass the concrete. Natural flows would be restored, healthy river habitat returned, and fish would be able to swim safely around the dam in their migration to and from the sea. The *Idaho Statesman* estimates that partial removal of the four Lower Snake River dams will result in a net benefit to taxpayers of $183 million annually. Partial removal of these four dams would reverse the mounting losses to the Nez Perce Tribe's culture, health, way of life, and spiritual beliefs resulting from the salmon's decline. A decision on partially removing the dams is expected in early 2000. If this effort is successful, the Clearwater River may again have productive salmon and steelhead runs.

THE SIGNIFICANCE OF THESE REMOVALS

The greatest significance of the Clearwater and Salmon River dam removals is to demonstrate how dam removal can successfully restore both a river system and significant numbers of naturally reproducing migratory fish. These rivers enjoyed restored river segments for numerous years and the increased salmon populations reflected this benefit—until the construction of the Lower Snake River dams. In addition to demonstrating the long-term benefits of dam removal, these removals show that removing dams is not a new untested concept. Dams—even large ones—were being removed a generation ago, and significant benefits resulted. With over 100 dams under consideration for removal across the country—including the four dams on the Lower Snake River—these old and successful dam removals can serve as a model for restoring rivers and migratory fish populations.

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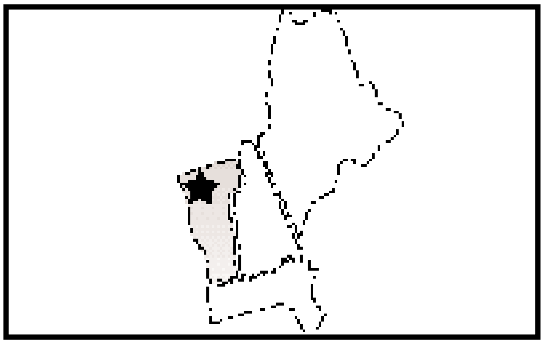


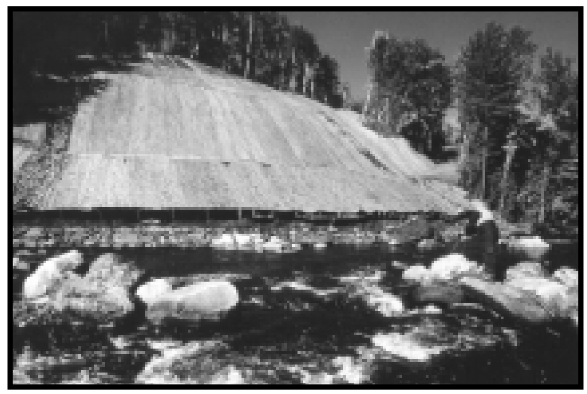
CLYDE RIVER

REMOVAL OF NEWPORT NO. 11 DAM IN VERMONT

DAM REMOVAL BENEFITS: IMPROVED MIGRATORY FISH HABITAT, ENHANCED RECREATIONAL OPPORTUNITIES, IMPROVED WATER QUALITY, COST SAVINGS

SUMMARY

The Newport No. 11 Dam will hold a place in history as the first time that Federal Energy Regulatory Commission (FERC) staff recommended dam removal as the preferred alternative in an environmental impact document against the wishes of the dam owner. The dam was built in 1957 by Citizens Utility to produce electricity. The dam quickly and thoroughly devastated the Clyde River's famed runs of six- to 10-pound landlocked Atlantic salmon. In 1994 the dam breached, rejuvenating longstanding local efforts by Trout Unlimited (TU) and others to remove the dam. Relief came in 1995, when FERC staff, who were considering relicensing the dam, made a landmark recommendation in a draft Environmental Impact Statement (EIS) to require removal of the Newport No. 11 Dam. Following a settlement with the dam owner, in 1996, a controlled explosion shattered the structure, which reconnected the river and allowed fish to move freely for the first time in 40 years.



THE RIVER

The Clyde River rises in the heart of Vermont's Northeast Kingdom, and flows north into Lake Memphremagog—a 30-mile long waterway. Before construction of Newport No. 11, the Clyde's runs of landlocked Atlantic salmon earned the river a place in the annals of fishing. Anglers once traveled from all over the world to witness first-hand the salmon that saturated the Clyde's waters. Images of anglers standing elbow-to-elbow to test their angling skills can be seen only in black-and-white photographs. "Detroit may boast of its autos, Pittsburgh of its steel mills, and Boston of its beans," bragged a 1950 Vermont Life story, "but up Newport way [along the Clyde], it's the fabulous salmon which busts vest buttons and makes local chests puff out."

THE IMPACT PRIOR TO REMOVAL

Unfortunately, the Newport No. 11 Dam, and the others owned and operated by Citizens Utility along the river, proved too much for the fish, putting a rather abrupt end to the Clyde's legendary salmon migratory runs between Lake Memphremagog and the Clyde River. The No. 11 Dam had been a source of controversy since it was constructed hurriedly and with no permits in 1957. The 19-foot high, 90-foot long dam, one of three Citizens Utility dams in one hydropower project, had a capacity of only 1.8 megawatts. It was the most downstream of Citizens Utility's four dams (a fifth upstream dam is owned by the Town of Barton).

The Atlantic salmon fishery had held its own against the other dams until the No. 11 was built, when damages to the river and fisheries were quickly recognized. The banks had been undercut too much during construction, leading to a perennially unstable situation that caused yearly erosion around the end of the dam and at adjoining properties during spring run-off. The prevention of fish passage and inadequate flows—the dam dewatered one-half mile of river—soon caused the fishery to virtually disappear. "The spawning beds went dry and these fish couldn't reproduce," reported a long-time angler of the Clyde River. "There were times the river was so low—and it caused such fish kills—that the county health officer was greatly concerned." The state of Vermont, in a report submitted to FERC, confirmed that the dam and the low flows it caused had killed all hope of maintaining or reestablishing a self-sustaining fishery. "Under present conditions," the state concluded, "the net effective habitat is effectively zero."

THE REMOVAL DECISION & PROCESS

In the late 1980s, the required federal relicensing of Newport No. 11 and the other Citizens Utility dams upstream provided a new opportunity for conservationists to press for removal. Non-governmental organizations, including TU, and federal and state agencies entered as formal parties to the relicensing in order to protect the interests of the Clyde River and ensure an equitable final licensing decision. In 1994, spring rains and snowmelt run-off, coupled with long-term erosion from construction errors, blew out the riverbank at one end of the dam. Following the breach, FERC approved Citizens' plan to repair and reinforce the dam. Conservationists and the state appealed FERC's decision, which was ultimately stopped through action by the US Environmental Protection Agency. The rebuild order eventually became moot due to FERC staff's later recommendation for removal.

DAM REMOVAL FACTS:

- **Height: 19 ft; Length: 90 ft**
- **Built: 1957**
- **Purpose: hydropower**
- **Generating capacity: 1.8 MW**
- **Owner: Citizens Utility**
- **Regulatory jurisdiction: FERC**
- **Estimated cost of repair (with fish passage): $738,200**
- **Cost of removal: $550,000**
- **Removed: August 1996**
- **Removal method: explosives**

In June 1996, FERC issued its final EIS; its "recommended alternative" was the removal of the defunct No. 11 Dam. The EIS found that dam removal would have significant benefits to local resources and the public, including greatly enhanced salmon, steelhead, and walleye habitat, and would dramatically improve fishing opportunities. The report, taking into consideration that there were other dams in the project that could still make a profit, noted that the recommended alternative "would provide the necessary balance between the hydropower use and environmental benefits and enhancements," as required by law.

Following FERC's EIS, all parties involved in the relicensing—including the dam owner—agreed to a settlement that provided for removal of the dam. Under this settlement, all dam removal work requiring activity in the river was to be completed before the salmon's fall spawning migration from Lake Memphremagog up the Clyde. On August 28, 1996, a controlled explosion blew out the concrete of the dam and the remainder of the dam was removed mechanically.

RESTORATION OF THE RIVER

Although unplanned, restoration of the Clyde River actually began when floodwaters breached the dam in 1994. FERC staff followed nature's course in 1996 when they issued the final EIS recommending removal of the structure. In August 1996, the dam was removed from the river. Shortly after flows were restored, an electrofishing survey revealed 17 landlocked Atlantic salmon in a 170-foot section of the Clyde that had been dry since 1957. Landlocked Atlantic salmon continue to be spotted above the former dam site, and fishing opportunities for trout, salmon, and smallmouth bass have been increased.

REMOVAL BENEFITS:

- **Restored fish passage for salmon**
- **Improved instream flows**
- **Improved recreation**
- **Improved water quality**

FUTURE EFFORTS TO RESTORE THE RIVER

The FERC relicensing process for the other dams on the Clyde is currently before the state, which must certify that the dam operations will not violate state water quality standards. Negotiations are continuing around issues including land conservation and potential removal of the next dam upstream (other upstream dams are not under consideration for removal). Because the relicensing is not complete, improved flows in the river are not yet required at other dam sites, and fish passage at dams above the former No. 11 site remains a concern. Instream flows have improved since removal of the No. 11 Dam, but removal of the structure alone is not sufficient to reverse the damage of 40 years of inadequate flows and continuing degradation of the aquatic habitat. Although fishing has improved in the river, local anglers are urging stocking as a temporary measure to help the wild salmon fishery recover. TU and other concerned non-governmental organizations, and state and federal agencies, including the US Fish and Wildlife Service and the US Environmental Protection Agency, continue to work to reverse the damage and restore the river.

In addition, stream banks at the former dam site recently became dangerously unstable and threatened to cover spawning grounds with sediment. This problem was averted and the river's banks have been stabilized.

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THE SIGNIFICANCE OF THIS REMOVAL

The Clyde's historic runs of landlocked Atlantic salmon were of epic proportions until they were devastated by the construction and operation of Newport No. 11 Dam. Importantly, for the first time, the Federal Energy Regulatory Commission conceded that sometimes the best thing—both economically and environmentally—for the public and everyone involved is to remove the dam and restore the river. Newport No. 11 marked the first time in history that FERC staff recommended dam removal against the wishes of the dam owner in an environmental impact document.

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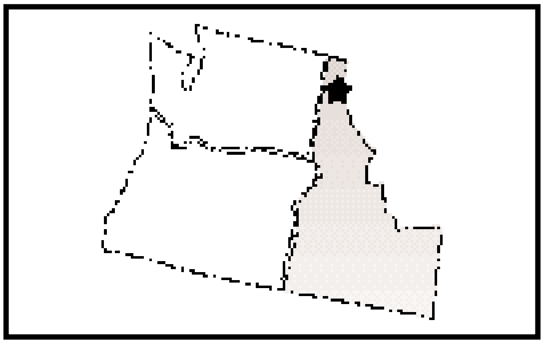

COLBURN CREEK

REMOVAL OF THE COLBURN MILL POND DAM IN IDAHO

DAM REMOVAL BENEFITS: IMPROVED MIGRATORY AND RESIDENT FISH HABITAT, IMPROVED WILDLIFE HABITAT

SUMMARY

In the 1940s, a small milldam was constructed on Colburn Creek in northern Idaho. Located near the creek's confluence with the Pack River, the dam was a complete barrier to fish passage. Over the years, its impoundment became choked with sandy sediment. In early 1999, Crown Pacific closed the aging mill, and at the suggestion of the Idaho Department of Fish and Game, agreed to remove the dam as part of their efforts to improve the site. In September of 1999, the Colburn Mill Pond Dam was breached, allowing fish to travel upstream for the first time in over 50 years. Colburn Creek now provides more than three miles of much needed spawning habitat for several trout species. The dam removal and restoration concluded a truly cooperative effort between Crown Pacific, the Idaho Department of Fish and Game (DFG), and Trout Unlimited (TU) to restore fish passage and improve the mill site.

THE RIVER

Colburn Creek is located in the Lake Pend Oreille watershed in northern Idaho's panhandle. The creek flows about four miles from its headwaters before connecting with the Pack River, which flows into the lake. The mostly rural watershed is home to diverse wildlife species including moose, deer, and waterfowl. As a feeder creek to Lake Pend Oreille, the largest lake in Idaho, Colburn Creek once provided spawning habitat for migratory trout such as the westslope cutthroat. The cutthroat population has been declining for many years in the lake, and petitioners have requested that they be listed as a federally-threatened species. With excellent water quality throughout the Pend Oreille watershed, dam operations are cited as a major cause of the decline. Northern Idaho is also one of the last remaining strongholds of the federally-threatened bull trout, which is known to use the Pack River as a migration corridor. As a tributary to the Pack, Colburn Creek could provide spawning habitat for the native bull trout.

THE IMPACT PRIOR TO REMOVAL

Colburn Mill was built in 1928 and its milldam, which was 12 feet tall and 35 feet long, was constructed on the creek during the 1940s. The dam was a rock and earthen structure, located about half a mile upstream of Colburn Creek's confluence with the Pack River. It was originally used to hold logs until they were processed at the mill. However, because of technology changes, the dam was only used in recent years to store water for fire protection. Over the years, the mill pond had become increasingly filled with sediment. Initially a ten-acre impoundment, by 1999 the water surface covered only about half an acre and required annual dredging. The property adjacent to the dam, where the mill stood, was almost entirely cleared of vegetation, leaving mostly bare, exposed soil.

Historically, Lake Pend Oreille was the largest fishery for resident fish in Idaho. However, since 1952 when the Albeni Falls and Cabinet Gorge Dams were built on the Pend Oreille and Clark Fork Rivers, populations of kokanee salmon, westslope cutthroat trout, and bull trout have declined more than 90 percent in the lake. Colburn Creek was completely blocked by the milldam, preventing fish from reaching upstream spawning and rearing habitat. Reportedly, large kamloops (a subspecies of rainbow trout) seeking spawning ground had been seen bumping against the dam during the spring.

THE REMOVAL DECISION & PROCESS

Crown Pacific, a major forest products company in the western United States, purchased the Colburn Mill and the surrounding 90 acres in 1993. With some of its technology 60 years old, the mill facility was aging and proved to be relatively inefficient. When lumber prices dropped and timber supply dwindled in the late 1990s, Crown Pacific had a difficult decision to make as the mill's profitability declined. In January of 1999, the company closed the 71 year-old mill. Before selling the property, they planned extensive improvements to the site.

When the Idaho DFG suggested removing the dam as part of these improvements, Crown Pacific immediately agreed. The dam was removed during lower summer flows in order to limit the release of sandy sediment trapped in the dam impoundment. The sediment is expected to gradually release and may flush out during high flows early next spring.

Along with removing the dam, Crown Pacific made significant improvements to the riparian areas and wildlife habitat around the site, working closely with the Idaho DFG and TU, which provided technical guidance on all aspects of the project. Crown Pacific removed mill buildings, enhanced two wetland areas, built a fish ladder, planted trees and grasses, and supplied materials for another fish ladder downstream. The first fish ladder was constructed to aid fish passage over a steep drop below the dam. It was completed before breaching the dam and consists of eight descending pools beginning at the former dam location.

DAM REMOVAL FACTS:

- **Height: 12 ft; Length: 35 ft**
- **Impoundment: 10 acres**
- **Built: 1940s**
- **Historic purpose: milldam**
- **Owner: Crown Pacific**
- **Regulatory jurisdiction: none**
- **Estimated cost of repair: not examined**
- **Cost of removal: $15,000 - $30,000**
- **Removed: September 1999**
- **Removal method: track backhoe**

Grass and trees were planted along 1,000 feet of Colburn Creek to create a 20-foot wide buffer zone along the channel. The buffer zone is expected to improve fish habitat by providing shade for cooler water temperatures and cover for fish, and is expected to maintain water quality by filtering runoff into the creek. Just upstream from the dam, Crown Pacific crews flattened a 1,000-foot long berm to connect a marsh with portions of the former mill pond, creating a larger wetland habitat. They also enhanced a small beaver pond on a seasonal creek across the mill site from Colburn Creek. They formally established the banks of the shallow pond and hydroseeded native grasses. Nesting boxes for waterfowl were installed around each wetland area at the site. In all, Crown Pacific spent approximately $50,000 improving the area, transforming the site into better habitat for fish and other wildlife.

TU volunteers provided funding and labor to build another fish ladder through a road culvert 80 yards downstream from the dam. The gradient on the culvert was previously too steep for fish at high flows. The ladder consists of a steel frame with rocks placed inside to raise the water level and create eddies to simulate natural stream conditions. TU and Crown Pacific both contributed funds to purchase the materials, and TU volunteers installed the ladder.

The value of close collaboration between the site owner, the state, and TU was significant to the success of the project. Crown Pacific's President & Chief Executive Officer, Peter W. Stott, provided leadership, without which the project would not have been accomplished. "I can't tell you how exciting it is to work together with Trout Unlimited and the Idaho Fish and Game," said former mill manager, David Morrill. "We hope that others in our industry will follow Crown Pacific's example."

RESTORATION OF THE RIVER

When the Colburn Mill Pond Dam was removed, more than three miles of spawning and rearing habitat were opened up for fish migrating from Lake Pend Oreille. Known to be spawning habitat for westslope cutthroat and kamloops rainbow trout, Colburn Creek may also provide much needed habitat for native bull trout. While it is too early to tell if bull trout will make use of the restored waterway, bull trout spawn in small streams such as Colburn Creek, and other Pend Oreille feeder creeks are known rearing sites for the federally-threatened species.

REMOVAL BENEFITS:

- **Opened 3 to 4 miles of migratory trout spawning and rearing habitat**
- **Improved habitat for resident fish**
- **Involved an extremely positive collaboration between industry, government, and a conservation group**

The dam removal converted a sediment-filled impoundment to a free-flowing stretch of creek, improving habitat for resident fish species. As the sandy sediment flushes out of the impoundment, the creek will continue to improve as habitat for the small resident fish that lived for many years above the dam. The newly planted buffer zone along the creek will also serve to improve habitat for fish and other wildlife. The buffer zone, along with the enhanced wetland areas, will filter runoff, trap sediment, and ultimately improve the water quality in the creek.

FUTURE EFFORTS TO RESTORE THE RIVER

Crown Pacific has completely moved out of the Colburn Mill site, and the site has been sold to a new owner. However, prior to making the sale, the riparian areas around the creek and the wetland areas were surveyed out of the plot. These areas will be donated to a conservation organization to help ensure that the improvements to the area will endure.

Since 1996, the Idaho DFG has been implementing the Lake Pend Oreille Fishery Recovery Project, focusing on restoring fish populations in the watershed. The project primarily focuses on restoring kokanee salmon, which were once abundant feeder fish for the larger game fish in the lake. Kokanee spawn along the edge of the lake, but their hatches have dwindled over the years due to dam operations altering the lake level. Because kokanee are a food source for larger fish, restoring them may help restore other species throughout the watershed.

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THE SIGNIFICANCE OF THIS REMOVAL

The removal of the Colburn Mill Pond Dam allows migratory fish to once again travel between spawning habitat in Colburn Creek and downstream to the Pack River and Lake Pend Oreille. The restoration of free-flowing water through the former dam impoundment is expected to also improve habitat for resident fish and possibly for federally-threatened bull trout. Beyond restoring valuable habitat, this project is significant for the high degree of cooperation between the dam owner, a state agency, and local conservationists. The initiative and leadership of the dam owner, Crown Pacific, enabled the dam removal and restoration to occur. In addition, this project demonstrates the large ecological benefits that can be obtained when a relatively small amount of additional funds are expended as part of a larger site closure and restoration project.

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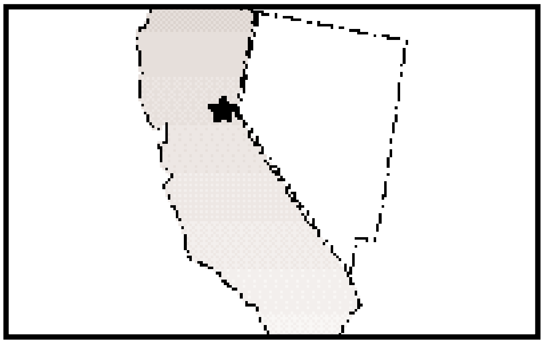

COLD CREEK

REMOVAL OF THE LAKE CHRISTOPHER DAM IN CALIFORNIA

DAM REMOVAL BENEFITS: IMPROVED MIGRATORY AND RESIDENT FISH HABITAT, IMPROVED WATER QUALITY, IMPROVED WILDLIFE HABITAT, ENHANCED AESTHETICS

SUMMARY

Removal of the Lake Christopher Dam was a critical component in the restoration of a mountain meadow ecosystem in California's Lake Tahoe Basin. In the 1950s, the earthen dam was built on Cold Creek, spanning the width of the valley. After discovering that the dam was a flood safety hazard, the City of South Lake Tahoe lowered the level of Lake Christopher. However, resulting sediment, algae, and odor problems led the city to study other alternatives. In 1994, the dam was completely removed as part of the Cold Creek Restoration Project, a collaborative $1.4 million project that reestablished the stream channel and restored the mountain meadow ecosystem. The project strove to re-create a natural system, focusing on the idea that a healthy ecosystem's ability to filter runoff and absorb flood depositions would be the best method for improving water quality and restoring fish habitat.

THE RIVER

Cold Creek's 13 square-mile watershed lies in the Sierra Nevada Mountains in the southern portion of the Lake Tahoe watershed. The creek flows into Trout Creek, the second largest tributary of the lake. The watershed has steep forested slopes in the uplands leading to mountain peaks. The lower portion of the watershed along the creek is naturally a meadow with wetland sedges, shrubs, and deciduous trees. However, much of the land near the creek has been altered by the construction of roads, subdivisions, and the Lake Christopher Dam. Although most of the native fish species no longer live in the watershed, Lake Tahoe supports populations of introduced species, such as Mackinaw lake trout, rainbow trout, and kokanee salmon. As its name suggests, Trout Creek is a migratory run for Lake Tahoe trout, and Cold Creek once provided healthy spawning habitat.

THE IMPACT PRIOR TO REMOVAL

Lake Tahoe is renowned for its deep, crystal clear waters. However, years of development in the Tahoe Basin and the associated loss of vegetation, increased impervious surface, channelization, and filling of wetlands, have led to increased sediment and nutrients flowing into the lake. The sediment, along with algae growth supported by the increased nutrients, has gradually impaired the lake's water quality.

During the 1950s, a rancher dammed the width of the Cold Creek valley to create an agricultural water supply. The dam's impoundment covered much of the valley meadow, forming Lake Christopher. A 3,000-foot long diversion channel routed some of the creek's flow around the east side of the lake. The deep, straightened channel lacked the pools and riffles that normally provide fish habitat and the dam blocked fish access to the natural creek. The channel banks, as well as much of the area around the lake, were sparsely vegetated, resulting in erosion and increased sediment loads in the creek. Without the natural filtering of the mountain meadow, urban runoff and nutrients from lawns flowed directly into the channel, contributing to Lake Tahoe's water quality concerns. Standing water and a lack of shade from trees resulted in relatively warm water temperatures, further impairing fish habitat.

DAM REMOVAL FACTS:

- **Height: 10 ft; Length: 400 ft**
- **Impoundment: 25 acres**
- **Built: 1950s**
- **Purpose: agricultural reservoir**
- **Owner: City of South Lake Tahoe**
- **Regulatory jurisdiction: California Bureau of Dam Safety**
- **Estimated cost of repair: $160,000 to $180,000**
- **Cost of removal: $60,000 to $100,000**
- **Removed: breached in 1989, removed in 1994**
- **Removal method: low-impact construction equipment**

THE REMOVAL DECISION & PROCESS

In 1982, the City of South Lake Tahoe acquired the dam and Lake Christopher for the parks and recreation system. Soon after, the California Bureau of Dam Safety declared the dam a flood safety hazard. The city responded by adjusting the dam's outlet to lower the lake to a safe level. The result was a shallow, stagnant pool and mud flat behind the dam that suffered from algae outbreaks and became an odor nuisance. In 1984, the city developed a remediation plan with several alternatives, including rebuilding the dam and keeping the lake at a lower level; constructing a larger dam and returning the lake to its previous level; or maintaining a flowing creek and developing additional wildlife habitat. The city opted for this last, less expensive alternative.

In 1989, a breach was cut out of the dam, and the old diversion channel was routed into the meadow through two small, shallow ponds, constructed for waterfowl habitat. The project was not successful; the diversion channel was too straight, too erodible, and transported too much sediment. The ponds quickly filled with sediment, and water quality impacts in downstream Lake Tahoe remained a concern.

In 1992, the City requested funding from the California Tahoe Conservancy (CTC), a state agency, to remove the dam and construct a more stable, naturally functioning channel. The CTC funded the project and began a collaborative planning process to restore the creek and meadow. The design team included staff from the CTC, the Natural Resources Conservation Service (NRCS), the City of South Lake Tahoe, and consultant hydrologist, David Rosgen, one of the foremost experts in redesigning streams that have been impaired by human-induced alterations. They designed the new channel by re-creating natural conditions, rather than using artificial channel materials. Instead of a rigidly stable channel, the new channel would be "dynamically stable" with meanders, pools, and vegetated banks. Its channel form would fluctuate over time and would be overtopped by flows that would overtop a natural channel. Although a flooding and fluctuating channel was difficult to accept by some, it carried several benefits. A natural channel would require less maintenance because it would simply adjust to natural flow changes by eroding in some places and depositing sediment in others. During high flood flows, the more natural system would deposit sediment and nutrients onto the floodplain rather than convey them toward Lake Tahoe. It would provide better fish habitat, as fish could reside in pools on the outside of meander bends and under the shade of bank vegetation. It would also be more attractive for nearby residents as a recreational area. This dynamic, meandering channel was designed by studying old aerial photos of the creek and by modeling stable reaches of nearby Trout Creek.

The project faced some early opposition from local residents. The old diversion channel abutted the property line of the Cold Creek subdivision. The new channel would meander down the middle of the valley, and residents were concerned about losing their waterfront amenity. The planners held public workshops and led site walks to show the community how the area would be transformed. These workshops helped dissenters appreciate the improvements the restoration would bring to the area.

In August 1994, the mostly earthen dam was removed by heavy equipment, and the diversion channel was filled in. The former impoundment was re-vegetated with native wetland sod and willows. New streambanks were stabilized with natural materials, such as sod transplants and tree roots.

REMOVAL BENEFITS:

- **Improved water quality of Lake Tahoe feeder stream**
- **Restored migratory and resident fish habitat**
- **Removed a potential flood hazard**
- **Restored a mountain meadow**
- **Enhanced aesthetics**

RESTORATION OF THE RIVER

Cold Creek now provides habitat for both spawning and resident fish, including brown and rainbow trout migrating from Lake Tahoe. The project recreated 6,000 feet of meandering stream channel and restored a mountain meadow at the former impoundment site. The channel now has undercut banks and pools for fish habitat with willows on the banks to provide shade. Observers have noted a visible difference in the fish population, and the restored stretch of the creek now boasts stories of anglers landing five pound trout in recent years.

By approximating a natural system, the project successfully reestablished the hydrologic functions of the ecosystem. As it was designed to do, the creek's flow has been over bank several times since the channel was constructed, and it has responded well. Up to two feet of sediment was deposited on the floodplain during 1995 high flows, instead of flowing into Lake Tahoe. These floods help to restore the health of the surrounding meadow. Rather than flowing downstream and contributing to algal blooms in Lake Tahoe, nutrients from runoff are now utilized by wetland plants. The nutrients help the transplanted sod species and willows to thrive, which in turn provide stability to the stream banks. Runoff from adjacent subdivisions now filters through 3,000 feet of meadow vegetation instead of flowing directly into surface water.

The project has been a resounding success. Even residents initially opposed to losing their channel now feel that the project was worthwhile. One abutting property owner, who had vehemently opposed the project, visited the site on the last day of construction and said to a CTC planner, "I'm really happy with the way this came out, and I'm ashamed that I opposed it." According to local officials, it is hard to imagine that the meadow and meandering stream were once a mud flat and diversion ditch. Residents nearby now use the area for fishing, walking, and birdwatching. The CTC and NRCS also use the area as part of their environmental education programs. Students from area schools visit the stream to learn about the environment and contribute to the stream's maintenance by planting willows. In addition, professional groups are led on tours of the site several times each year.

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FUTURE EFFORTS TO RESTORE THE RIVER

Except for ongoing monitoring, work on the Cold Creek Restoration Project has been completed. The California Water Quality Control Board-Lahontan Region and the US Army Corps of Engineers are in the process of developing other restoration projects in the Upper Truckee River watershed, which includes Cold Creek, to help preserve the clarity of Lake Tahoe. Although none of that work will be specifically focused on Cold Creek, the success of the Cold Creek restoration has influenced a similar, but larger scale restoration effort on Trout Creek. The Trout Creek restoration will be the largest stream restoration to date in the Tahoe Basin, and should be completed in 2001.

THE SIGNIFICANCE OF THIS REMOVAL

The removal of the Lake Christopher Dam and the restoration of Cold Creek transformed a stagnant pond and an artificial diversion channel into what has been called "an absolutely gorgeous setting." The design truly restored the stream channel by recreating a natural channel form and flow pattern. Design engineers re-thought traditional channel design to produce a dynamically stable channel in a self-sustaining system, rather than a constructed artifice. The project increased fish habitat in the Lake Tahoe basin, improved water quality, and created a recreational area for local residents. The dam removal and restoration is significant not only for natural resource benefits, but also for its process, which illustrates the value of public education and participation in the planning process.

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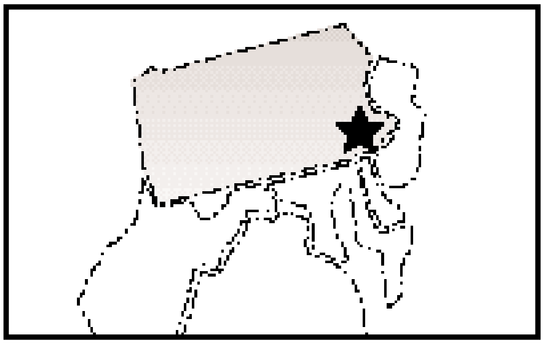

CONESTOGA RIVER

REMOVAL OF SEVEN DAMS IN PENNSYLVANIA

DAM REMOVAL BENEFITS: IMPROVED MIGRATORY AND RESIDENT FISH HABITAT, ENHANCED RECREATIONAL OPPORTUNITIES

SUMMARY

From 1996 to 1999, seven dams were removed from the Conestoga River and its tributaries in southeastern Pennsylvania. All were obsolete run-of-river dams that were originally built to power mills or provide navigation canals with water. The dams blocked American shad—a species historically significant to both the economics and culture of the region—from reaching their historic spawning grounds in the Conestoga. The dams also contributed to the overall degradation of the Conestoga River system by preventing the movement of smaller migratory and resident fish species. The Pennsylvania Fish and Boat Commission, under the auspices of the Environmental Protection Agency's Chesapeake Bay Program for migratory fish passage and stream habitat restoration, removed the dams. There is anecdotal evidence that American shad have returned to the Conestoga River since the removal of the seven dams.

THE RIVER

The Conestoga River, located in Lancaster County in southeastern Pennsylvania, is a large tributary to the Susquehanna River—and is part of the Chesapeake Bay watershed. The Conestoga River and its tributaries (third-order and larger) comprise approximately 114 stream miles. Land use in the Conestoga watershed was historically agriculture. But as the fastest growing area in the state, the Conestoga is becoming heavily urbanized and has many of the land use problems associated with urban sprawl. The current flows of the Conestoga River are relatively shallow—and far below the historical flows of the river. Thirty-one percent of stream banks in the Conestoga watershed have erosion problems. Twenty-eight blockages, such as the City of Lancaster water supply dam, are found on the main stem of the Conestoga River and 45 on its tributaries. Although the Conestoga is a degraded river system, there is a massive federal, state, and local effort underway to restore the river, and Lititz Run, one of the major tributaries to the Conestoga, was selected as a national model for stream restoration projects.

Returning the Conestoga River to a free-flowing state will create numerous recreational opportunities for the heavily populated area, including angling, canoeing, and kayaking.

THE IMPACT PRIOR TO REMOVAL

The Conestoga River has had numerous dams impounding its waters, most of which were built long ago to power mills, feed canals, and generate electricity. Many of these dams no longer serve the purpose for which they were constructed, are in disrepair, or have been abandoned. The legacy of these dams is environmental degradation and conditions hazardous to public safety. Of the seven dams that were removed, all were run-of-river dams that were obsolete. The dams ranged from 3 to 13 feet in height and 10 to 300 feet in length and included: Rock Hill Dam (13 feet tall, 300 feet long), American Paper Products Dam (4 feet tall, 130 feet long), Mill Port Conservancy Dam (10 feet tall, 10 feet wide), unnamed dam (4 feet tall, 10 feet long), East Petersburg Authority Dam (4 feet tall, 20 feet long), Maple Grove Dam (6 feet tall, 60 feet long) and an Amish dam (3 feet tall, 40 feet long). The owners of the dam varied from the Commonwealth of Pennsylvania to townships to private individuals.

DAM REMOVAL FACTS:

- **Height: 3 to 13 ft**
- **Length: 10 to 300 ft**
- **Built: early 1900s**
- **Purpose: varied (all obsolete at removal)**
- **Owner: state, townships, individuals**
- **Regulatory jurisdiction: state**
- **Estimated cost of repair: not examined**
- **Cost of removal: $1,500 to $110,000**
- **Total cost: $218,500**
- **Removed: 1997-1999**
- **Removal method: hydraulic**

The dams that were built on the Conestoga and its tributaries caused many impacts to the aquatic life historically found there. A major impact, from an ecological, cultural, and economic perspective, was the depletion of the spring runs of American shad that historically occurred on the main stem of the Conestoga. These runs were eliminated with the construction of the dams on the Conestoga River—as well as the dams on the Susquehanna River. The dams on the Susquehanna below the confluence of the Conestoga, have since had fish passage installed by the electric company owners, allowing fish to migrate upstream to the Conestoga. Another major impact of the dams was the restricted access to the upstream reaches of the Conestoga's tributaries. These areas provide important habitat for smaller migratory fish species, such as river herring and American eel. The Conestoga dams significantly impacted the year-round fish species such as walleye and trout, which require unimpeded access to optimal habitat in order to ensure their vitality. Additionally, the presence of the dams impacted the aquatic insects that are critical to the Conestoga River's health. Rather than the silt-filled, slow-moving reservoirs, the insects need silt-free, stone-filled streambeds in which to thrive.

Due to the increase in population in the Conestoga watershed, there is a large potential for recreation on this river and its tributaries. The presence of the dams negatively impacted this potential, as the dams hindered both boating and angling on the Conestoga—and created an attractive nuisance for recreationists. The Pennsylvania Fish and Boat Commission predicts that restoration of the shad fishery will generate 5,000 angling trips per year to the Conestoga watershed. Such an increase in fishing trips would provide a significant amount of revenue for local communities—revenue that cannot be realized with the existence of the dams.

THE REMOVAL DECISION & PROCESS

In order to facilitate the removal of unneeded dams across the state, the Pennsylvania Department of Environmental Protection (DEP) adopted procedures that make it easier and less expensive for dam owners to remove unwanted and often unsafe dams. The process, which streamlines complicated permitting procedures, began by soliciting dam owners on all third order or larger streams to see if they were interested in removing their structures. If owners are interested, then all riparian landowners that are affected by the removal are notified and, depending on interest, public meetings are held to discuss the potential effects of the removal. After hearing public comments, an engineering design for the dam removal is created, environmental assessments are conducted, sediment and erosion control plans are established, and approval is sought from the US Army Corps of Engineers. This entire permitting process usually takes 12 to 18 weeks.

The seven dams were removed by using a large hydraulic hammer attached to heavy machinery. Each removal was done incrementally to prevent the sediment built up behind the dam from flowing downstream all at once. Exposed mudflats were allowed to revegetate naturally. The rubble from the dams was used to stabilize the stream banks, unless the dams were made from rebar in which case the ruble was hauled away. Depending on the size of the dam, the removal process took anywhere from one day to one week—and in every case the dam was removed in its entirety.

REMOVAL BENEFITS:

- **Opened over 25 miles to migratory fish**
- **Improved habitat for resident fish species**
- **Increased recreational opportunities for rapidly growing area**
- **Expected to increase local revenue due to new angling & boating opportunities**
- **Removed attractive nuisances**

The funding for the removal of the seven dams on the Conestoga River was provided through the Environmental Protection Agency's Chesapeake Bay Program for migratory fish passage and stream habitat restoration. This program requires a 50 percent cost share from a non-federal funding source. The Pennsylvania Fish and Boat Commission provided most of the matching funds for the dam removals on the Conestoga. Other local government agencies and non-governmental groups provided in-kind services to assist with the removals and contribute to the 50 percent cost share.

RESTORATION OF THE RIVER

The removal of three of the dams on the Conestoga River opened over 25 miles for migratory fish. Although no official sightings of American shad have been documented since the removal of the dams, there are anecdotal reports that the fish have returned to the Conestoga. The other three dam removals also restored numerous additional river miles to natural flowing conditions. Although these removals did not provide access to migratory fish due to downstream blockages, they nonetheless helped restore the ecosystem for resident species. Because the Conestoga River provides optimal spawning and feeding habitat for resident fish, the removal of these dams will improve the quality and quantity of these populations—and, in fact, biological samples have shown this. Resident species typically found in the Susquehanna River, such as large walleye and gizzard shad, were not abundant on the Conestoga prior to the removal of the dams. Since the dam removals, the resident fish have been seen in much larger numbers on the Conestoga.

According to Pennsylvania Fish and Boat Commission, Fish Passage Coordinator, Scott Carney, the dramatic change in the stream habitat after removal of the seven dams was "virtually amazing".

Within a year of each removal, the stream conditions greatly improved on the Conestoga. The stream banks are stabilized and no longer eroding, the stream gradient is greatly improved, the river flow is restored and moving sediment downstream, and stream organisms have returned—all of which suggest that the Conestoga is a much healthier river system. Unfortunately, no quantitative study of the improvements has been conducted. However, the Fish and Boat Commission has contracted with Pennsylvania State University to conduct a study of the impacts of the dam removals on fish and other stream organisms in the Conestoga watershed. This study will provide much needed quantitative information on the benefits—and potential costs—of restoring rivers through dam removal.

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FUTURE EFFORTS TO RESTORE THE RIVER

The dam removal effort in the Conestoga River and its tributaries is an on-going process for the Pennsylvania Fish and Boat Commission. In addition to the seven dams already removed in the watershed, eight more dams are scheduled to be removed before the end of 2000. As with the completed removals, these eight dams are being removed for one or more of the following reasons: eliminate barriers to fish migration, eliminate public safety hazards and threats to private property, reduce liability concerns for dam owners, restore the structure and function of stream ecosystems, improve habitat for stream plants and animals, reduce watercraft portage, and eliminate the need to construct, operate, and maintain expensive fish ladders to restore valuable fish populations.

The Fish and Boat Commission also has a shad and river herring stocking program that was started four years ago—and which, to date, has been successful. The Fish and Boat Commission has found that the stocked shad fry are surviving to the juvenile stage and were seen migrating out of the river in the fall. Other river restoration activities in the Conestoga River include a federal, state, and local effort currently underway to stabilize the river's stream banks, because erosion is one of the biggest problems that the watershed faces.

THE SIGNIFICANCE OF THESE REMOVALS

One of the most significant aspects of the dam removals on the Conestoga River is that the removal process and watershed approach developed by the Commonwealth of Pennsylvania provided benefits to all involved—the dam owners, the public, and the river. Also, remarkable is that the Fish & Boat Commission accomplished all seven removals and associated stream bank stabilization for only $218,500. Hopefully other states will follow Pennsylvania's lead as they develop procedures to cope with aging, obsolete dams—and degraded river systems. An approach similar to Pennsylvania's will not only restore rivers and improve public safety, but it will also save money for both dam owners and the public.

But perhaps equally significant is the anecdotal evidence that American shad have returned to the Conestoga River. This species once played a very significant role in the economy and recreation of not only the Conestoga River, but also the entire Chesapeake Bay watershed. Presence of American shad in the Conestoga, even if it is just anecdotal, signifies more than the restoration of a fish species—it signifies the restoration of the Chesapeake Bay's heritage.

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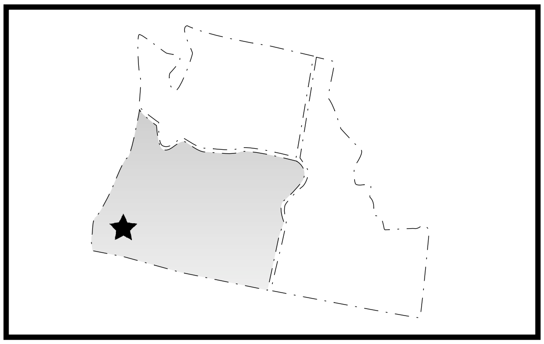

EVANS CREEK

REMOVAL OF THE ALPHONSO DAM IN OREGON

DAM REMOVAL BENEFITS: IMPROVED MIGRATORY AND RESIDENT FISH HABITAT, IMPROVED THREATENED SPECIES HABITAT

SUMMARY

The Alphonso Dam was built on Evans Creek in Oregon in the 1890s to divert water for irrigation. Throughout its lifetime, the dam prevented or delayed migratory and resident fish passage upstream. Although a fish ladder was installed during the 1970s, fish were not attracted to it and did not use it. Over time, the dam's impoundment filled with sediment, and eventually the owner abandoned the structure. The federal Bureau of Land Management (BLM) decided to remove the defunct dam as a means to restore historic fish passage conditions in that section of Evans Creek. The dam was demolished in July of 1999. Its removal will enable the threatened coho salmon and other fish species to migrate once again up the East Fork of Evans Creek and reach an additional 12 miles of spawning and rearing habitat for the first time in 100 years.

THE RIVER

Evans Creek begins as two forks in southwestern Oregon: the East Fork, near Shady Cove, and the West Fork, near Canyonville. The East Fork travels for about 14 miles and the West Fork for about 12 miles before the two converge. After the confluence, Evans Creek travels another 14 miles before discharging into the Rogue River, which flows into the Pacific Ocean. Migratory fish found in Evans Creek include native steelhead trout and coho and chinook salmon. The coho salmon is a federally-threatened species, and the steelhead trout is being considered for listing as threatened. Resident fish found in the creek include cutthroat trout and sculpin.

The East Fork of Evans Creek contains seven irrigation diversion dams and three major culverts. Of these, the Alphonso Dam imposed the largest barrier. Depending on the flow, the structures delay or completely block upstream fish passage.

THE IMPACT PRIOR TO REMOVAL

The Alphonso Dam was located on the East Fork of Evans Creek in a V-shaped bedrock-constrained canyon two miles upstream from the confluence of the forks. The dam was reportedly built in the 1890s by farmers and ranchers for irrigation. It was 10 feet high, 56 feet long, and 3 feet wide and was made of aggregate material and concrete. The impounded water behind the dam extended for a distance of approximately 550 feet, with an average width of 41 feet. By the time it was removed, the impoundment had filled with sediment and rocks, and the dam had been abandoned by its owner.

DAM REMOVAL FACTS:

- **Height: 10 ft; Length: 56 ft**
- **Impoundment: 200 acre-ft**
- **Built: 1890s**
- **Historic purpose: irrigation diversion**
- **Owner: abandoned**
- **Regulatory jurisdiction: BLM**
- **Estimated cost of repair: not examined**
- **Cost of removal: $55,000**
- **Removed: July 1999**
- **Removal method: heavy equipment**

For approximately 100 years, the Alphonso Dam prevented or delayed migratory and resident fish passage upstream, resulting in the decline of the fishery. Recognizing a need for fish passage, the Rogue Flyfishers Club installed a fish ladder at the dam in the 1970s. Unfortunately, fish were not attracted to the ladder and did not use it. The ladder was particularly ineffective for coho salmon, which typically have difficulty getting past blockages.

THE REMOVAL DECISION AND PROCESS

The BLM removed the Alphonso Dam as part of its ongoing effort to increase the population of the threatened coho salmon. Although the actual removal of the dam took place over only two days, July 19 and 20, 1999, the BLM spent three years working with other state and federal agencies to plan the project. Preparations included notifying stakeholders of the proposed project and getting their input, considering various removal methods, and performing an environmental assessment.

REMOVAL BENEFITS:

- **Restored 12 miles of spawning and rearing habitat for migratory fish**
- **Restored resident fish habitat**
- **Improved habitat for threatened coho salmon**

Prior to removing the dam, the BLM conducted several tests on the accumulated sediment in the impoundment, including tests for toxic substances, such as heavy metals. Because none were found, the BLM concluded that it would not be harmful for accumulated sediment to wash downstream after the dam was removed.

The first step in the dam removal was cutting a notch in the center portion of the dam to drain the impoundment. The dam was then demolished using heavy equipment, and the resulting debris was hauled away to a disposal area. During demolition, extensive efforts were made to minimize equipment operation within the stream channel. However, as a precautionary measure, spill containment booms were placed in the channel. After demolition, to help stabilize soils, all exposed impoundment areas were seeded with a grass mix and then mulched.

RESTORATION OF THE RIVER

During the winter of 1999 and 2000, the BLM expects the creek to flush out the sediment that had accumulated behind the dam. Fish will then be able to migrate easily up the East Fork of Evans Creek and reach an additional 12 miles of spawning and rearing habitat. According to the BLM environmental assessment, this is expected to increase the overall survival of fish in the East Fork, in part by reducing the migratory stress on adults, causing egg survival rates to improve. In addition, juveniles will be able to travel to better feeding and rearing spots, thus improving their survival rate.

FUTURE EFFORTS TO RESTORE THE RIVER

The BLM is working with a private land owner, as well as the Evans Creek Watershed Council, the Middle Rogue Steelheaders, the Oregon Department of Fish and Wildlife, and the Oregon Water Trust to remove the Williams-Waylon Dam on the mainstem of Evans Creek. This dam is in the middle of coho salmon and steelhead trout migration routes. At four feet high, it does not completely block fish movement upstream, but it does significantly delay it. Until recently, the dam was used by private landowners to divert water for irrigation. However, the Oregon Water Trust worked with the owners to find alternative irrigation methods and/or points of diversion, and consequently the dam is no longer in use. The Oregon Water Trust is now receiving technical and financial assistance from the BLM for the dam removal. The BLM is also looking into removing a dam on a tributary to the East Fork of Evans Creek. This dam completely blocks steelhead trout migration to upstream spawning and rearing grounds.

Both the Williams-Waylon Dam and the dam on the tributary to the East Fork of Evans Creek are on private property. However, the BLM is authorized to enter into agreements with willing owners to conduct work on private lands if that work will benefit biological resources on public lands. In the cases at hand, removal of the dams on private property would allow coho salmon and steelhead trout to more easily migrate to spawning and rearing grounds on upstream public lands.

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THE SIGNIFICANCE OF THIS REMOVAL

The Alphonso Dam removal is a good example of a public agency cooperating with a private owner on a project that benefits both parties, as well as the threatened fish species that make use of Evans Creek. It is also a good example of a pro-active dam removal carried out for the express purpose of restoring migratory and resident fish passage. BLM officials, encouraged by the success of the project thus far, are hopeful that dam removal will be used as a tool for restoring other streams in the Evans Creek watershed.

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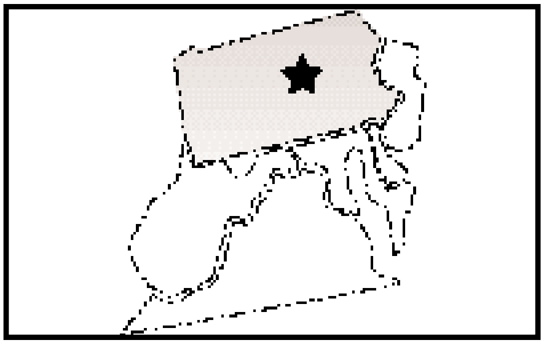

JUNIATA RIVER

REMOVAL OF THE WILLIAMSBURG STATION DAM IN PENNSYLVANIA

DAM REMOVAL BENEFITS: IMPROVED WATER QUALITY, ENHANCED RECREATIONAL OPPORTUNITIES, TAXPAYER SAVINGS

SUMMARY

The Williamsburg Station Dam on the Frankstown Branch of the Juniata River was an inactive dam that formerly supplied cooling water for a coal-fired power plant. Prior to its removal, the dam contributed to water quality and sedimentation problems in this section of the Juniata River and also prevented the movement of resident fish species. In 1996, the Pennsylvania Electric Company (Penelec) decided to remove the dam and the adjacent power plant, which had ceased to operate. When the dam was removed, the water quality and sedimentation problems once associated with the site were alleviated and the abundance of fish increased, providing local anglers with additional fishing opportunities. The Williamsburg Station Dam removal, which was one of the first dams removed in Pennsylvania with the help of the Pennsylvania Fish and Boat Commission, is an excellent example of how government and private industry can work together to restore rivers to their natural, free-flowing conditions.

THE RIVER

The Juniata River is the second largest tributary to the Susquehanna River and the Juniata watershed encompasses approximately 3,400 square miles. The predominant economic activity in the Juniata watershed is agriculture—and agricultural run-off is the largest source of stream impairment in the watershed. There are few large urban areas in the watershed and the population is approximately 335,000 people. In addition to agriculture, the economy of the surrounding area is largely based on tourism associated with fishing, hunting, and hiking. The Juniata River historically had populations of migratory fish such as American shad, river herring, and American eel. At the turn of the century, the Juniata River's American shad population may have been as large as 200,000 fish per year. The river also supports numerous smallmouth bass, walleye, muskellunge, and channel catfish. Many recreational opportunities exist along the Juniata River in addition to fishing and canoeing, including an 11-mile rails-to-trails pathway that follows the Frankstown Branch of the Juniata, providing scenic biking, hiking, and horse riding opportunities.

THE IMPACT PRIOR TO REMOVAL

Originally constructed in 1922, the Williamsburg Station Dam was a 13-foot tall and 260-foot wide concrete gravity dam. The dam, which was owned by Penelec and provided cooling water for the adjacent coal-fired power plant until the plant's retirement, was located approximately half a mile upstream of the Town of Williamsburg. The land upstream of the former dam site is largely undeveloped. The impacts prior to the removal of the Williamsburg Station Dam were numerous. In addition to preventing the movement of fish at the site, the dam prevented the transport of sediment and nutrients downstream, which resulted in a siltation problem in the dam's reservoir. Although, no testing was done prior to removal, the Pennsylvania Fish and Boat Commission reports that the impoundment created by the dam was characteristic of an algae-infested reservoir with dissolved oxygen content problems. The Williamsburg Station Dam and adjacent power plant were also an eyesore to this stretch of the Juniata River and created an attractive nuisance that posed somewhat of a safety hazard.

DAM REMOVAL FACTS:

- **Height: 13 ft; Length: 260 ft**
- **Impoundment: 199 acre-ft**
- **Built: 1922**
- **Purpose: cooling water for power plant (inactive)**
- **Owner: Pennsylvania Electric Company**
- **Regulatory jurisdiction: state**
- **Estimated cost of repair: not examined**
- **Cost of removal: $150,000**
- **Removed: summer 1996**
- **Removal method: hydraulic hammer & heavy equipment**

THE REMOVAL DECISION & PROCESS

In order to facilitate the removal of unneeded dams across the state, the Pennsylvania Department of Environmental Protection (DEP) adopted procedures that make it easier and less expensive for dam owners to remove unwanted and often unsafe dams. The process, which streamlines complicated permitting procedures, began by soliciting dam owners on all third order or larger streams to see if they were interested in removing their structures. If owners are interested, then all riparian landowners that are affected by the removal are notified and, depending on interest, public meetings are held to discuss the potential effects of the removal. After hearing public comments, an engineering design for the dam removal is created, environmental assessments are conducted, sediment and erosion control plans are established, and approval is sought from the US Army Corps of Engineers. This entire permitting process usually takes 12 to 18 weeks.

The Williamsburg Station Dam was removed under the above described restoration waiver process established by the Pennsylvania DEP. The removal of the Williamsburg Station Dam was initiated when Penelec decided to decommission the power plant to which the dam supplied cooling water. With the power station retired, Penelec found no compelling reasons to continue to maintain the dam and decided to remove it in order to limit the company's legal and financial liability. There was no local opposition to removing Williamsburg Station Dam, which helped simplify the decision.

The Williamsburg Station Dam was removed by using a large hydraulic hammer attached to heavy machinery. The removal was done by breaching the dam at the point at which the former stream flowed, allowing the reservoir to drain, and then removing the rest of the structure. Exposed mudflats were hydro-seeded to help them revegetate more quickly in order to prevent erosion along the streambanks. As the Williamsburg Station Dam contained no rebar, the rubble from the dam was used to stabilize the streambanks and to fill in the scour hole below the former dam site. None of the debris from the former dam had to be removed from the site, which helped lower the cost of removal. The entire dam removal process took approximately one week—and the dam was removed in its entirety. In addition to the Pennsylvania Fish and Boat Commission, the agencies involved in the removal were the US Army Corps of Engineers, US Fish and Wildlife Service, Pennsylvania DEP, and the local conservation district.

REMOVAL BENEFITS:

- **Restored resident fish habitat**
- **Will open over 20 miles to migratory fish (once fish passage is installed downstream)**
- **Increased recreational opportunities for growing area**
- **Improved water quality**
- **Enhanced local economic benefits expected due to new angling & boating opportunities**
- **Removed attractive nuisance**

RESTORATION OF THE RIVER

Only three years after the removal of the Williamsburg Station Dam, it is impossible to tell that the dam once existed in this stretch of the Juniata River. The entire area is revegetated, creating a picturesque spot for fishing and other river recreation activities. Further, since the removal of the Williamsburg Station Dam, the sedimentation and water quality problems once associated with this stretch of the Juniata River are no longer a concern, providing environmental as well as aesthetic benefits. Migratory fish can not yet reach the area above the former Williamsburg Station Dam due to downstream blockages. However, as soon as those obstacles are eliminated, fish such as American shad will likely be found upstream of the former Williamsburg Station Dam as its removal has created ideal spawning habitat for numerous migratory species. The removal of the dam also provided better habitat conditions for and opened over 20 miles to resident fish species. Local anglers have emphasized that fishing at the site is much better since the removal of the dam—and many more people visit this section of the river than prior to the removal of the Williamsburg Station Dam. According to the Pennsylvania Fish and Boat Commission, the local area is also likely to receive enhanced economic benefits due to the increased recreational fishing and canoeing opportunities created by the dam's removal.

FUTURE EFFORTS TO RESTORE THE RIVER

Downstream of the former Williamsburg Station Dam site is the Warrior Ridge Dam, an active hydropower project owned by American Hydro and regulated by the Federal Energy Regulatory Commission. The Warrior Ridge Dam does not currently have fish passage facilities, but as soon as fish start migrating up the Susquehanna River, due to the newly installed fish passage facilities on the dams located there, and reach the base of Warrior Ridge, American Hydro will be required to install fish passage. With fish passage installed at Warrior Ridge Dam, almost the entire length of the Frankstown Branch of the Juniata will be open to migratory fish species. There is one dam located upstream of the former Williamsburg Station Dam that does not have fish passage, but again its owners will be required to install passage once the migratory fish, such as American shad and herring, reach the base of the dam.

Other restoration efforts on the Juniata River include the Chesapeake Bay Foundation's Juniata River Project, which was initiated in 1997 to preserve and restore the Juniata River watershed. Additionally, the Pennsylvania Fish and Boat Commission's Shad Restoration Project is housed on the Juniata River. This is a project that was created to work with dam owners throughout the Susquehanna River basin in an attempt to restore shad to their historical levels by either removing dams or installing fish passage and culturing American shad fry, which are stocked throughout the basin.

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THE SIGNIFICANCE OF THIS REMOVAL

The Williamsburg Station Dam removal was one of the first removals conducted by the Pennsylvania Fish and Boat Commission. Further, the Williamsburg Station Dam removal was initiated and paid for by Penelec—a public utility in Pennsylvania. Such corporate leadership in restoring our nation's waterways is encouraging. Not only did Penelec decide to remove the dam, but they also did not burden taxpayers by seeking public funds to remove it. The removal demonstrated value not only to fish and wildlife, but also to corporate interests in removing dams as part of industrial site retirement activities. Penelec eliminated a liability and gained positive environmental publicity by removing the dam. Penelec was presented with an Environmental Stewardship Award from the Pennsylvania Fish and Boat Commission to recognize the company for its implementation of fish passage and its assistance with the effort to return the Frankstown Branch of the Juniata River to its natural free-flowing conditions. "It was an excellent example of how state and federal resource agencies and private industry can work together to achieve mutually beneficial goals," said Peter Colangelo, the Executive Director of the Pennsylvania Fish and Boat Commission.

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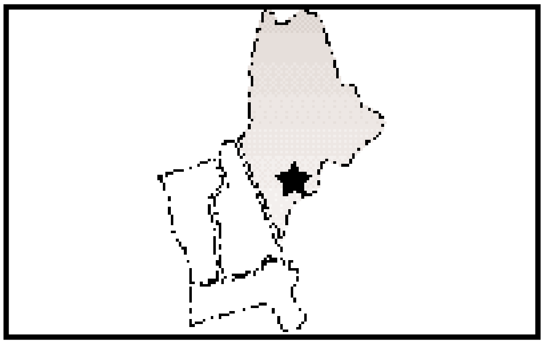


KENNEBEC RIVER

REMOVAL OF THE EDWARDS DAM IN MAINE

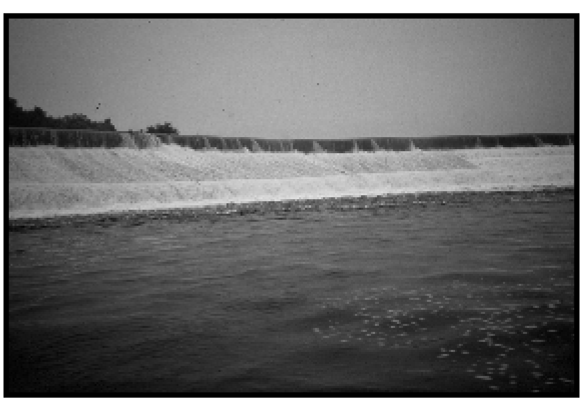
DAM REMOVAL BENEFITS: IMPROVED MIGRATORY FISH HABITAT, ENHANCED RECREATIONAL OPPORTUNITIES

SUMMARY

The Edwards Dam on the Kennebec River in Maine destroyed one of the richest and most varied fisheries in the country, and contributed to the degradation of a vital river ecosystem. However, through a long legal process and, in the end, a multi-party settlement, restoration of the Kennebec began as the Edwards Dam was removed in the summer of 1999. The removal of the Edwards Dam and the restoration of the Kennebec River's migratory fish has already begun to breathe new life into the riverside communities and create new opportunities for tourism, boating, and angling.

THE RIVER

The Kennebec River was once home to all ten species of migratory fish native to Maine. The lower portion of the river just below the Edwards Dam, known as Merrymeeting Bay, is the largest freshwater tidal estuary north of the Chesapeake Bay. The Kennebec's unique combination of upriver spawning habitat and nursery area made its fisheries enormously productive. Thriving commercial fisheries for Atlantic salmon, American shad, alewives, sturgeon, striped bass, and rainbow smelt helped secure the settlement of the Kennebec Valley in the early 1800s. Since the 1970s, the water quality of the Kennebec has improved dramatically due to the cleanup efforts required by the Clean Water Act, and the state has successfully restored small spawning populations of striped bass, American shad, and alewives to the lower Kennebec. The state of Maine adopted a comprehensive plan for managing the lower Kennebec River titled Kennebec River Resource Management Plan: Balancing Hydropower Generation and Other Uses. This plan establishes the goal of restoring seven species of migratory fish to the lower Kennebec: Atlantic salmon, Atlantic sturgeon, shortnose sturgeon, American shad, alewife, rainbow smelt, and striped bass. To achieve this restoration, the plan called for removing the Edwards Dam.



THE IMPACT PRIOR TO REMOVAL

The Edwards Dam was a 24-foot tall and 917-foot wide rock-filled timber crib structure. It was built in 1837 to facilitate upstream navigation and provide mechanical power to saw mills. Its presence helped fuel the economic growth of the Augusta area. However, barging on the Kennebec was abandoned in the mid-nineteenth century when rail traffic became available, and subsequently the mills powered by the dam were closed. Thus both of the dam's two original purposes were eliminated.

The Edwards Dam, at the time of its removal, was owned by a small, privately held company, the Edwards Manufacturing Co., Inc., that existed only to generate hydropower. In recent years the dam was licensed to generate power by the Federal Energy Regulatory Commission (FERC), with the City of Augusta as a co-licensee. The amount of power generated, however, was not significant. Before its turbines were shut down in January 1999, the Edwards Dam generated a mere 3.5 megawatts of electricity—one-tenth of one percent of the entire power supply for Maine. Furthermore, the electricity generated by Edwards Dam was sold under contract to Central Maine Power, the state's largest utility, at a price between four and five times higher than the market rate. It became clear that the dam was providing too little power at too high a price to make it an asset for the State of Maine.

DAM REMOVAL FACTS:

- **Height: 24 ft; Length: 917 ft**
- **Impoundment: 19,000 acre-ft**
- **Built: 1837**
- **Purpose: hydropower**
- **Generating capacity: 3.5 MW**
- **Owner: private company**
- **Regulatory jurisdiction: FERC**
- **Cost of installing fish passage: $9 million (1997 $ s)**
- **Cost of removal: $2.1 million for deconstruction, $800,000 for engineering & permitting**
- **Removed: July - October 1999**
- **Removal method: heavy equipment**

Meanwhile, the Edwards Dam was significantly contributing to the destruction of a valuable fishery. The dam, which never had fully functioning fish passage facilities, blocked any further restoration on the Kennebec River—literally. By obstructing the river, the Edwards Dam prevented migratory fish from reaching their historic upstream spawning grounds. The construction of fish passage facilities was not a solution because spawning populations of four of the species in question—shortnose sturgeon, Atlantic sturgeon, rainbow smelt, and striped bass—have never been passed at any dam. Even if the fish were to pass above the dam, the reservoir created by the Edwards Dam inundated 17 miles of upstream spawning habitat, which was the critical historic habitat for several of the fish species.

THE REMOVAL DECISION & PROCESS

The 30-year license to operate Edwards Dam expired in 1993, and the dam owner sought a new 30-year license from FERC. In response, four environmental groups—American Rivers, the Natural Resources Council of Maine, the Atlantic Salmon Federation, and Trout Unlimited and its Kennebec Valley Chapter—formed the "Kennebec Coalition" in 1989 to intervene in the relicensing process and advocate for removal of the dam. State and federal resource agencies also intervened and recommended removal. Because FERC had never ordered a dam to be removed against the wishes of the dam owner, FERC, state and federal resource agencies, the conservation community, and the hydropower industry viewed this relicensing as the test case for establishing FERC's authority to order dam removal to restore significant river ecosystems. In December 1994, as part of a separate policy-making process, FERC adopted a policy concluding that it had the authority to deny an application for relicensing and order a dam to be removed at the dam owner's expense.

In January 1996, FERC staff released its draft Environmental Impact Statement (EIS) for relicensing of the Edwards Dam. FERC's preliminary recommendation, contained in the draft EIS, was to relicense the Edwards Dam with fish passage. The Kennebec Coalition and state and federal resource agencies submitted filings before FERC demonstrating that four of the seven target fish species had never successfully used upstream passage devices; that even if fish passage were effective, the dam would still flood the critical spawning habitat for many of the target species; and that fish passage for just three of the species cost more than dam removal.

REMOVAL BENEFITS:

- ¥ Restored 17 miles of prime spawning & rearing habitat for migratory fish
- ¥ Restored numerous rapids and riffles creating diverse habitat
- ¥ Enhanced river recreation opportunities

In July 1997, FERC staff released its final EIS on the Edwards project. After taking a second look at the costs of dam removal, FERC staff recommended dam decommissioning and removal as the preferred alternative. The recommendation was based on the fact that installing fish passage for three target species would cost 1.7 times more than retiring and removing the dam. Staff found that dam removal would open 17 miles of historic upstream spawning habitat for shortnose sturgeon, Atlantic sturgeon, striped bass, and rainbow smelt (these four migratory fish do not use fishways and thus would not be helped with a fish passage system) and would increase overall wetland habitat, recreational boating, and fishing benefits.

On November 25, 1997, the FERC Commissioners voted to deny the application to relicense the Edwards Dam and ordered the licensees to develop by November 1998 a plan and schedule for removal, including a plan for financing the removal. This marked the first time that FERC had ever denied an application for relicensing.

To avoid a protracted court battle, in May 1998 all parties actively involved in the relicensing signed a settlement agreement that provided for a transfer of the dam's ownership to the State of Maine for the purpose of removing the dam. The agreement also provided for the dam removal costs and for a decade of planned fish restoration efforts (totaling over $9 million) to be financed principally by upriver dam owners in exchange for delaying their fish passage obligations and by a downstream shipbuilder as mitigation for expanding its shipyard operations. No state or federal funds were used for the dam removal. After removal, the 14 acres of riverfront property where the mill and powerhouse were located will be transferred to the City of Augusta free of charge. FERC approved the settlement and transferred the license to the State of Maine in the fall of 1998. On January 1, 1999, the dam and associated property passed into the State of Maine's ownership, and all electrical generation ceased.

The Edwards Dam was removed during the summer and fall of 1999. The planning process began during the summer of 1998 with the hiring of a consulting engineering firm to develop plans and prepare environmental permit applications. In late 1998 and early 1999, the state obtained permits for the removal from the US Army Corps of Engineers, the Maine Department of Environmental Protection, and the City of Augusta.

In June 1999, a temporary gravel cofferdam was constructed just upstream of a portion of the dam on the west side of the river. Once the cofferdam was in place, a 70-foot section of Edwards Dam, protected by the cofferdam, was removed. On July 1, as part of a nationally-covered ceremony, the cofferdam was breached to allow the reservoir's water and the river to flow through the 70-foot gap in

Edwards Dam. Once the river stabilized, construction moved to the east side of the river where another temporary gravel cofferdam was built above part of the dam, and approximately 200 feet of the dam was removed. This cofferdam was breached on August 12th and the river was re-diverted through this larger gap (which was able to safely pass a much larger flood event). A new temporary gravel roadway was then constructed to the west side of the dam, across the original breach. The remainder of the dam was removed with heavy construction equipment, working from east to west. The demolition debris was used to fill the power canal on the west bank and to fill other locations in order to restore the site for final use by the City of Augusta. Full removal of the dam was completed on October 12, 1999, a full month ahead of schedule and approximately $300,000 under budget. The removal costs totaled approximately $3 million—$2.1 million for construction and $800,000 for engineering and permitting.

RESTORATION OF THE RIVER

Just a few months after the Edwards Dam was breached, significant signs of a restored river were already being seen. Wildlife sightings and aquatic insect populations have improved significantly, both indicating that the Kennebec is healing itself. Numerous bird species, including osprey, bald eagles, kingfishers, great blue heron, sand pipers, and comerants, that were less common along this stretch of the Kennebec before the dam removal are now often seen flying overhead and feeding in the river. Prior to the removal, much concern had been expressed about the expected visual blight of exposed muddy banks of the former reservoir and the decision not to manually re-seed the area. Within only weeks, "volunteer" vegetation (self-seeding) had colonized these areas and grown waist deep. The removal of Edwards Dam has also revealed six sets of rapids that were inundated by the dam's reservoir. Local citizens are often seen kayaking and canoeing this stretch of river, which prior to the dam removal was not heavily used. As a local conservationist said: "Two years ago on Labor Day, we went out in a 14-foot outboard motor boat, spending a lovely late summer day almost totally alone on the river. We saw only one other boat all day. Today, two years later, instead of the impounded river that we saw two years ago, the Kennebec was alive and we far from alone. In addition to far more wildlife, there were people in canoes and kayaks, as well as people out walking along the river's banks."

In addition to wildlife and recreation improvements, populations of ten species of migratory fish in the Kennebec are expected to benefit as a result of the Edwards Dam removal. These include American shad, Atlantic salmon, striped bass, Atlantic sturgeon, shortnosed sturgeon, blueback herring, and alewife. Populations will not rebound immediately, but are expected to gain steadily over the next 20 years. Recovery rates for each species will depend on its unique lifecycle, the impact of other threats (e.g. over-fishing, other dam blockages, and predators), and the extent to which funding is provided for fisheries restoration projects designed to take advantage of the spawning habitat created by the dam removal. Nevertheless, recovery of the historic fishery has already begun. Less than three months after the removal of the dam, schools of striped bass were seen feeding on alewife upstream of the former Edwards Dam site, and before the dam was completely removed, stripers up to 40 inches long were being caught 18 miles upstream in the City of Waterville, to the delight of local anglers—a good sign that the Kennebec River is undergoing a restoration process.

FUTURE EFFORTS TO RESTORE THE RIVER

The settlement that allowed removal of Edwards Dam also provided $4.85 million for associated fish restoration efforts in the basin, including river restoration projects and stocking of some fish species. These funds, and additional funds being raised, will be critical to ensuring success of the fish restoration efforts in the Kennebec River basin.

Another critical component to the Kennebec fish restoration effort is installation of fish passage structures at upstream dams. Several upstream dam owners had been required to install fish passage at their dams by 1998. Because the Edwards Dam, which was downstream, still blocked fish migration, installing passage immediately at upstream dams made little biological sense. In exchange for funding part of the Edwards Dam removal and associated fish restoration efforts, these upstream dam owners were granted a delay in their fish passage obligations. Installation of passage at these upstream dams is now linked to biological triggers—as the fish return, passage will be built.

In addition, to improve fish passage opportunities and restore spawning habitat, one small dam was removed and a fish passage was built in the summer and fall of 1999 in the headwaters of the Sebasticook River—the largest tributary to the Kennebec.

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THE SIGNIFICANCE OF THIS REMOVAL

The removal of Edwards Dam reflects a shift in how society views rivers. The Edwards Dam decision is nationally significant because it means that the federal government, which controls many of the nation's dams, has finally recognized that a free-flowing, healthy river teeming with life can be more valuable than the electric power and private profit it produces. This was the first case where the balancing required of FERC in its licensing decisions fell in favor of the fishery rather than the dam owner. This was largely due to over ten years of coordinated work and dedication by the Kennebec Coalition and state and federal resource agencies.

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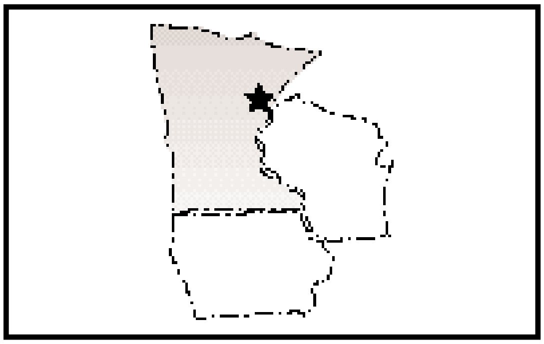
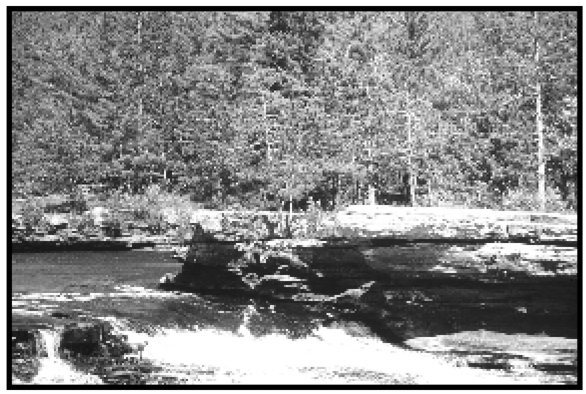


KETTLE RIVER

REMOVAL OF THE SANDSTONE DAM IN MINNESOTA

DAM REMOVAL BENEFITS: IMPROVED FISH HABITAT, ENHANCED RECREATIONAL OPPORTUNITIES, ELIMINATED PUBLIC SAFETY HAZARD, ENHANCED AESTHETICS, COST SAVINGS



SUMMARY

The Sandstone Dam was an inactive hydropower dam located on the Kettle River in eastern Minnesota. At the time of its removal, the Sandstone Dam had been obsolete for over 30 years and was a public safety hazard due to its deteriorated condition. The dam was located within Banning State Park at the bottom of one of the best whitewater stretches in Minnesota. In 1995, the Minnesota Department of Natural Resources (DNR) decided to remove the structure—a decision that returned the Kettle River to free-flowing conditions along its entire length. The removal of the Sandstone Dam not only provided significant recreational and aesthetic benefits by uncovering a stretch of whitewater rapids and a waterfall, but it also restored fish habitat for numerous species, including the rare lake sturgeon.

THE RIVER

The Kettle River flows through eastern Minnesota until it reaches the confluence of the St. Croix River. In 1975, the Kettle became the first stream designated as a Minnesota Wild and Scenic River. As it flows the 80 miles of its length, the Kettle varies in classification from scenic to wild and development is limited by law along its shoreline in order to protect the natural integrity and beauty of the waterway. A diverse fishery, the Kettle is home to at least 36 species of warmwater fish. The Kettle River is particularly famous for its lake sturgeon, which is a huge, but relatively scarce fish that is a species of special concern in Minnesota. The two largest fish ever caught in Minnesota, both lake sturgeons weighing over 90 pounds, were fished from the Kettle River. The fast flowing Kettle is also a favorite spot for whitewater recreation and is known for its class IV rapids. At the site of the former Sandstone Dam, the Kettle River runs through Banning State Park, a 6,237 acre park that provides habitat for over 184 species of birds, 17 species of reptiles and amphibians, and 34 species of mammals. Banning State Park also has over 17 miles of hiking trails and numerous camping facilities. With the removal of the Sandstone Dam, the Kettle River flows unimpeded for its entire 80-mile length.

THE IMPACT PRIOR TO REMOVAL

In 1908, the Kettle River Power Company built the Sandstone Dam, which was 20 feet tall and 150 feet wide, to provide power for the company's stone quarries. In 1923, the Sandstone Dam was sold to Minnesota Power & Light, which operated the facility to produce hydropower until 1963 when the cost of producing power at the site became too expensive. In 1967, Minnesota Power & Light gifted the dam and 200 acres of surrounding land to the Minnesota DNR, and in 1991 the dam became part of Banning State Park.

The Sandstone Dam was located approximately three miles downstream of one of Minnesota's best stretches of whitewater rapids. The reservoir created by the dam stretched two miles upstream of the dam site and inundated not only a stretch of these rapids, but also a 6- to 8-foot high waterfall. The site prior to the construction of the Sandstone Dam had been a favorite picnic spot for locals due to the beautiful waterfall and stretch of rapids, but the reservoir created by the dam did not provide the same appeal. The Sandstone Dam was also a safety hazard, especially for boaters and anglers, and in 1986 claimed the life of an angler who fell from the dam and drowned. Prior to its removal, the Sandstone Dam was in a dilapidated condition and had to be either repaired or removed in order to prevent the dam from failing.

The Sandstone Dam was a major impediment to fish and blocked the natural migratory routes of smallmouth bass, walleye, northern pike, and lake sturgeon, among other species. The dam prevented lake sturgeon, a Minnesota species of special concern, from accessing high quality spawning habitat located upstream of the dam site. The Sandstone Dam also impacted freshwater mussels, whose movements and habitat were limited by the dam. Fishing opportunities downstream of the Sandstone Dam were better than those upstream, as was the general quality of the Kettle River as indicated by the "wild" designation for the river section downstream of the dam versus the "scenic" designation upstream of the dam.

DAM REMOVAL FACTS:

- Height: 20 ft; Length: 150 ft
- Impoundment: 200 acre-ft
- Built: 1908
- Purpose: hydropower (inactive)
- Owner: Minnesota Department of Natural Resources
- Regulatory jurisdiction: state
- Cost of refurbishing dam for hydropower: over $1 million
- Estimated cost of removal: $300,000
- Cost of removal: $208,000
- Removed: 1995
- Removal method: wrecking ball & backhoe with heavy machinery

THE REMOVAL DECISION & PROCESS

In the 1980s there was renewed interest in refurbishing the Sandstone Dam to produce hydropower, but the cost estimates were prohibitively expensive. The cost to retrofit the Sandstone Dam to a working hydropower facility was estimated at more than $1 million. The estimate for removing the dam was significantly lower at $300,000 and in fact the actual cost of removal was lower still at $208,000.

Due to the many impacts of the Sandstone Dam, the Minnesota DNR concluded that removal of the dam would increase habitat diversity and within several years the fish populations in the former impoundment area would increase in both quality and quantity. Prior to the removal of any dam, the Minnesota DNR involves the general public in the decision-making process. The agency's goal is to reach a consensus on which action—repair or removal—is the most appropriate not only for the river ecosystem, but also for the surrounding community. The Minnesota DNR feels that it is important to have local buy-in and support before removing a structure from the river. In the case of the Sandstone Dam, some locals did oppose the removal of the dam, but there was no organized opposition to the removal—and in fact the majority of people were in agreement with the Minnesota DNR's decision to remove the dam. "When we first heard that the DNR wanted to take the dam out, a lot of people—I was one of them—thought it was kind of a dumb idea. Now though, a majority of folks here think it's a good idea to remove the dam and restore the Kettle to a natural condition. We believe that makes sense," said Sandstone Mayor Wayne Oak.

The funding, engineering, and removal of the Sandstone Dam were accomplished through the Dam Safety Program at the Minnesota DNR Division of Waters. A private company was employed to conduct the actual demolition of the Sandstone Dam, which took approximately two weeks to complete. The sediments were tested for toxics prior to removal, but no significant levels were found. The land use upstream of the former Sandstone Dam is largely undeveloped—there is little agriculture or industry—thus the Minnesota DNR did not expect to find toxics in the sediment. The dam was removed using both a wrecking ball and a jackhammer attached to a backhoe. Because the dam was constructed out of nicely cut sandstone, most of the debris from the removal was used to stabilize the adjacent riverbanks and to fill in the scour hole below the former dam. The remainder of the debris was hauled off the site in a dump truck. Due to limited funding, other than removing the dam and stabilizing the shoreline, little stream restoration was done in conjunction with the removal of the Sandstone Dam.

REMOVAL BENEFITS:

- **Opened 30 miles for fish migration**
- **Improved whitewater recreation**
- **Revealed 6- to 8-foot waterfall & numerous rapids**
- **Expected economic benefits as result of improved recreation**

Sediment that had built up behind the dam was allowed to wash down the river, which ultimately resulted in some erosion to a downstream landowner. The Minnesota DNR monetarily compensated the private individual for the damage caused to his land by the dam's removal. Further, removing the Sandstone Dam did drain some created wetlands, but the Minnesota DNR felt that the overall environmental benefits of the dam removal far outweighed any potential negative aspects.

RESTORATION OF THE RIVER

Since the removal of the Sandstone Dam, lake sturgeon, walleye, northern pike, and smallmouth bass, all fish native to the Kettle River whose migratory route was blocked for over 87 years, now have access to the entire length of the river. Removal of the Sandstone Dam also revealed rapids and a waterfall that had been hidden for over 87 years. "It already looks ten times better than we had expected. We had thought that, for the first few years at least, it would just be an ugly, scarred shoreline. But the waterfall is a beautiful surprise. We had seen pictures of it, and we knew that it had been a favorite picnic spot for years, before they built the dam. Now it's going to be a favorite picnic spot again," said Muriel Langseth, a Sandstone City employee.

The enhanced whitewater boating opportunities created by the removal of the dam are outstanding. Not only do kayakers no longer have to worry about the safety issues surrounding the dam, but the rapids uncovered by the removal of the Sandstone Dam are quite notable. Further, the difference aesthetically between this section of the Kettle River prior to the dam removal and after the dam removal has been called astonishing. Don Del Greco, the Assistant Manager at Banning State Park, commented that "We've seen changes in and along the river every day since we took out the dam." The before-and-after pictures of the dam site nicely illustrate the dramatic—and beautiful—visual differences created by the removal of the dam.

In addition to the removal of the Sandstone Dam, 2,000 native species trees were planted along the river as part of the restoration effort. New hiking trails were also built, as was a canoe portage to allow whitewater recreationists to maneuver around the newly exposed waterfall.

FUTURE EFFORTS TO RESTORE THE RIVER

Because the Kettle River has been restored to free-flowing conditions along its entire length, there are obviously no future dam removals planned for this river. However, there is ongoing work by the State of Minnesota to ensure that the Kettle River is maintained in a manner worthy of a Wild and Scenic River. The shoreline of the Kettle River is protected from development by law and its natural areas managed in an effort to continue to provide the public with a valuable resource, noted for both its outstanding natural and recreational qualities.

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THE SIGNIFICANCE OF THIS REMOVAL

At the turn of the century, the citizens of Sandstone used to gather at this section of the Kettle River because of the extraordinary beauty of the cascading waterfall and rushing rapids. When the Sandstone Dam was built in 1908 and covered the natural features from view, the site no longer held the same appeal. Then almost 90 years later with the removal of the Sandstone Dam in 1995, the treasures of yesteryear were uncovered, revealing a part of Minnesota's heritage. Now Minnesotans again gather at this magical spot and the Kettle River flows freely for its entire 80-mile length.

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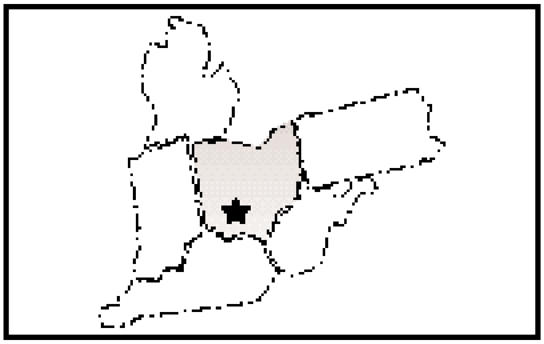

LITTLE MIAMI RIVER

REMOVAL OF THE JACOBY ROAD DAM IN OHIO

DAM REMOVAL BENEFITS: ENHANCED AESTHETICS, ENHANCED RECREATIONAL OPPORTUNITIES, ELIMINATED PUBLIC SAFETY HAZARD

SUMMARY

The Jacoby Road Dam was an obsolete low-head dam located on the Little Miami River—a State and National Scenic River—that was originally constructed to power a mill. The dam blocked fish migration around the dam and degraded the habitat for bi-valve mollusks. The partially breached dam also presented a safety hazard for canoeists—a frequent recreation activity on the river considering its scenic designation. In November 1997, the Ohio Department of Natural Resources (DNR) removed the Jacoby Road Dam with funds provided by the Ohio Scenic License Plate program.

DAM REMOVAL FACTS:

- ¥ Height: 8 ft; Length: 100 ft
- ¥ Built: post-1910
- ¥ Purpose: hydropower (inactive)
- ¥ Owner: private
- ¥ Regulatory jurisdiction: state
- ¥ Estimated cost of repair: not examined
- ¥ Cost of removal: $10,000
- ¥ Removed: November 1997
- ¥ Removal method: demolition hammer

THE RIVER

The Little Miami River was the first State and National Scenic River designated in Ohio and is located in the southwestern part of the state. The river was first designated as a scenic river in 1969 and now the entire river, approximately 105 miles, is protected. Many people consider the Little Miami to be one of the most historical and beautiful rivers in Ohio. This is in addition to its high water quality, numerous species of fish and wildlife, and superb recreational opportunities. The river boasts magnificent views as it flows from a small meandering stream in its headwaters through a sheer limestone gorge. As the Little Miami flows south, the streambed widens until it reaches 300-foot bluffs that line the river. In addition to its scenic appeal, the Little Miami River and its watershed were home to the Miami and Shawnee Indian tribes. Numerous Indian villages once prospered along the river's banks. Today, the county in which the former Jacoby Road Dam was located has approximately 300,000 residents and is largely rural—although it is quickly becoming urbanized.

Eighty-seven species of fish and 36 species of mussels (including five state endangered species) reside in the Little Miami. State and county parks line the Little Miami River, providing hiking, camping, fishing, and boating access and opportunities for the public. These parks also host an abundance of flora and fauna—including over 340 species of wildflowers. The Ohio Scenic Rivers Program is currently working to establish natural, free-flowing conditions in the Little Miami River, as well as 20 other current Scenic Rivers segments that it oversees. Since the removal of the Jacoby Road Dam, only three blockages remain on the Little Miami.

REMOVAL BENEFITS:
- ¥ **Restored State & National Scenic River**
- ¥ **Increased habitat for fish migration**
- ¥ **Improved habitat for bi-valve mollusks**
- ¥ **Improved safety for recreational boaters**
- ¥ **Cost-effective solution to failing dam**
- ¥ **Innovative use of license plate funds**

THE IMPACT PRIOR TO REMOVAL

The Jacoby Road Dam was an old low-head dam located on the Little Miami River in Northern Greene County Ohio. The dam was approximately 8 feet in height and 100 feet in length—and originally diverted water through a millrace to power a mill that no longer operates. The Jacoby Road Dam was in very poor condition, partially breached, and exposing rebar, which created a very dangerous hazard for canoeists. In addition to a being a hazard, the dam was also an impediment to the upstream migration of fish and bi-valve mollusks. Further, the portion of the Little Miami River directly downstream from the Jacoby Road Dam was one of the most biologically healthy of the entire river—and healthier than the section upstream of the dam. This suggests that the Jacoby Road Dam adversely affected the overall health of the Little Miami River system.

THE REMOVAL DECISION & PROCESS

In early 1996, the Ohio DNR's Scenic Rivers Program, with the assistance of the Little Miami Scenic River Advisory Council, decided to undertake the task of removing the Jacoby Road Dam. The Little Miami Scenic River Advisory Council made the necessary local contacts and secured permission from the two landowners adjacent to the Jacoby Road Dam to facilitate its removal. The Little Miami Scenic River Advisory Council also located a local farmer interested in taking the debris from the dam. The Ohio DNR contacted the local Civilian Conservation Corps Camp (another division of Ohio DNR) for assistance with the demolition and removal of the Jacoby Road Dam. It was determined that the dam removal would be funded through the Ohio Scenic Rivers License Plate program. This program provides money generated by the sale of specialized license plates for river restoration activities on Ohio's scenic rivers.

The Civilian Conservation Corps agreed to take on the demolition project and supplied a work crew including two heavy equipment operators. The equipment needed for the project included an excavator with demolition hammer and grapple attachments and a bulldozer. The total cost for the project including payment to the Civilian Conservation Corps Crew and equipment rental was just under $10,000 dollars. However, the Ohio DNR still needed to have the demolition debris hauled from the demolition site to the dumpsite. In an attempt to keep costs low, the Greene County Office of the Ohio Department of Transportation was contacted with the hope that they would agree to supply dump trucks in the spirit of inter-agency cooperation. The Greene County Manager agreed to supply trucks and drivers for one to two days for debris hauling at no cost.

After securing Clean Water Act section 404 and 401 permits from the US Army Corps of Engineers and the Environmental Protection Agency, and after addressing a few minor local concerns, the project was ready to commence in October of 1997. Work began October 27, 1997 under ideal environmental and weather conditions—that is there was no rain and a low stream flow on the Little Miami River. The Jacoby Road Dam was reduced to rubble within the stream channel and debris was pushed and pulled out of the stream using the excavator and bulldozer. Given the low flow conditions at the site, once the dam was fully breached all of the in-stream work was conducted under wet conditions. This eliminated the cost of building a cofferdam as well as the negative impacts to the river and surrounding riparian zone that are associated with constructing a cofferdam. Once the Jacoby Road Dam was completely demolished and the debris piled onto the adjacent stream banks, dump trucks were loaded and the debris was hauled to the dump. The final steps in removing the Jacoby Road Dam included some minor shaping of the streambed and adjacent banks to match surrounding contours as well as seeding and mulching at the site of the former dam. All of the work to remove the dam and restore the site was completed within ten days.

RESTORATION OF THE RIVER

Removal of the Jacoby Road Dam greatly improved boating safety on this stretch of the Little Miami River. Prior to the removal of the dam, the exposed rebar created hazardous conditions for canoeists and kayakers. Not only did the dam's removal provide an enhanced recreational resource by improving the aesthetics at the site and restoring this section of the Little Miami to free-flowing conditions, but it also removed a public safety hazard. Because of the Little Miami's National and State Scenic River designation and the number of visitors it receives each year, these safety and recreation improvements are particularly important.

While there have been no post-removal studies done at the former Jacoby Road Dam site, it is assumed that removal of the dam also will improve fish and bivalve mollusk habitat in the Little Miami River. The stretch of river located below the former dam site was the most biologically healthy before the removal of the dam—the removal of the Jacoby Road Dam should increase the span of this healthy section. Further, as there was limited sediment build up behind the Jacoby Road Dam, the Little Miami River should now be fully restored. In fact just days after the project was completed Little Miami Scenic River Advisory Council Member Milt Lord stated, "One could never tell that a dam was ever there."

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In 1984 the Foster Dam—which had been breached prior to its removal—was also removed on the Little Miami River. This coupled with the removal of the Jacoby Road Dam returned most of the Little Miami River to a free-flowing river. There are still three dams left on the river, but there are currently no plans to remove any of these—and one of the dams is still functional.

FUTURE EFFORTS TO RESTORE THE RIVER

Because the majority of the Little Miami River has been returned to free-flowing conditions, there are no future dam removals planned for this river. However, there is ongoing work by the Ohio DNR to restore the riparian corridor, stabilize stream banks, limit the impacts from urbanization, and maintain the high water quality on the Little Miami River. There is also an ongoing effort to ensure that the Little Miami River and its surrounding lands are maintained in a manner deserved of a National and State Scenic River. In order to continue to provide the public with a remarkable recreational and aesthetic resource, improvements are frequently made to hiking trails and camping facilities in the state and county parks.

THE SIGNIFICANCE OF THIS REMOVAL

One of the most significant—and for those involved, rewarding—aspects of the Jacoby Road Dam removal was the inter-agency cooperation through which it was accomplished. The combined efforts of two divisions within the Ohio DNR—the Scenic Rivers Program and the Civilian Conservation Corps—and the assistance of the Department of Transportation saved a great deal of money. If private contractors and equipment operators were hired, and hauling and dumping fees paid, the Jacoby Road Dam removal would have been substantially more expensive than $10,000—the final cost of the project. Another very significant aspect of this removal was the creative way in which it was funded—through the Ohio Scenic Rivers License Plate. The dam removal on the Little Miami River is a great example of how funds can be wisely and inventively used to protect and enhance the natural character of our nation's rivers.

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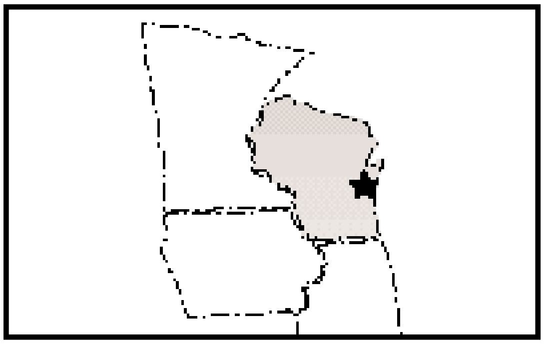

MILWAUKEE RIVER

REMOVAL OF THE WOOLEN MILLS DAM IN WISCONSIN

DAM REMOVAL BENEFITS: ENHANCED RECREATIONAL OPPORTUNITIES, IMPROVED FISH HABITAT, IMPROVED WATER QUALITY, ELIMINATED PUBLIC SAFETY HAZARD, TAXPAYER SAVINGS

SUMMARY

The Woolen Mills Dam was removed from the Milwaukee River in Wisconsin over a decade ago. The state had declared the structure unsafe, and its owner, the City of West Bend, decided to remove the dam instead of replacing it, largely because of economic factors. The removal was initially opposed by many in the community, but a public information process with heavy emphasis on citizen input helped replace feelings of loss and fear with positive visions of what could come after completing the project. Today visitors to the former dam site see a free-flowing river meandering through restored prairie and wetland, and can join area residents in experiencing the recreational opportunities, community economic development, and other quality-of-life factors associated with a river truly reborn. Sixty-one acres of "new land" from the former impoundment is today a heavily used park with an athletic field, canoe launch, riverbank fishing areas, footbridges across the river, and a Riverwalk that connects the park to downtown West Bend. The new Riverside Park is also the site of an annual jazz festival and other community events. Local businesses report positive economic impacts from the increased use of the restored river area, and many local residents on the impoundment who opposed the removal, today agree the restoration has been a huge success. Studies conducted at the site show dramatic improvements in the sport fisheries and important increases in biological diversity in this stretch of the river.

THE RIVER

The headwaters of the Milwaukee River are near the Town of Eden in Fond du Lac County in southeastern Wisconsin. From there the river meanders 98 miles southeast to the City of Milwaukee, where it meets up with the Menomonee and Kinnickinnic Rivers before flowing into Lake Michigan. "Milwaukee" means gathering of waters in the Potowatami language.

The Milwaukee River basin supports a population of over one million people on 850 square miles of land in seven counties. More than 50 dams remain within the Milwaukee River basin, although today none are used to power the grist and sawmills for which they were built in the early days of industrialization.

Continental glaciers shaped the distinctive topography of the Milwaukee River basin during the last great ice age nearly 12,000 years ago. The kettle moraine, through which the river flows, is a series of ridges formed between the Green Bay and Lake Michigan glacial lobes when millions of tons of sand, gravel, and boulders were deposited by an advancing and retreating glacier. The moraine is as much as 500 feet thick and extends several hundred miles in a generally north-south direction. The glacial features of this region are used as classic textbook examples throughout the world.

THE IMPACT PRIOR TO REMOVAL

Originally a wooden dam built by the City of West Bend in 1870 to power a sawmill, and later a woolen mill, the Woolen Mills dam was rebuilt in 1919 by Wisconsin Power and Electric as a concrete hydroelectric facility. By 1959, the hydropower dam was no longer economically viable. The company abandoned the dam and transferred ownership back to the City of West Bend. In 1980, structural flaws were found in the dam, and it was deemed a public safety hazard by the state. The community was faced with the decision to either remove or replace the obsolete dam.

DAM REMOVAL FACTS:

- ¥ **Height: 18 ft**
- ¥ **Impoundment: 67 acres**
- ¥ **Built: 1870**
- ¥ **Historic purpose: power for mills**
- ¥ **Owner: City of West Bend**
- ¥ **Regulatory jurisdiction: state**
- ¥ **Estimated cost of replacement: $3.3 million**
- ¥ **Cost of removal: $86,000**
- ¥ **Removed: 1988**

The crumbling structure posed serious public safety hazards. After more than a century of blockage, the impoundment was shallow from built-up sediment, and covered with algal blooms in the summer. Water quality was poor, oxygen levels were often very low, and the water was turbid. As a result, the fish composition in the warmed waters consisted of stunted carp and suckers. Recreational use was limited. There was also an increasing amount of pollution in the sediment accumulating behind the dam, including heavy metals leaching into the impoundment from a nearby landfill.

Nonetheless, homeowners on the impoundment wanted to keep the dam to maintain the scenic quality of the pond. They expressed concern that their property values would drop if the dam were to be removed.

THE REMOVAL DECISION & PROCESS

The community originally decided to keep the dam, but a $3.3 million price-tag for replacement during the economic recession of the early 1980s delayed action. When state funds became available for removal, the city requested studies to evaluate the option of dam removal. It eventually chose to remove the structure based largely on the high cost of rebuilding the dam compared to taking it out. A major deciding factor was the availability of funds through the Wisconsin DNR-Milwaukee River Priority Watershed Program for river restoration if the dam was removed.

Key to the success of this dam removal was the involvement of the community in a visioning process that helped ease doubts and fears about the dam removal. As with all dam removal situations, the community was concerned about how the area would look after the dam was taken out. Landscape architecture students at the University of Wisconsin-Madison were asked to put together sketches of the area following removal, based on planning standards that were developed jointly by the City of West Bend's Recreation and Forestry Department and the Wisconsin DNR. The sketches illustrated to the community that the dam removal and river restoration effort would not result in a large wasteland, but rather would add 61 acres of restored prairie and wetland to their existing Riverside Park. In addition to trails for hiking and biking in the former impoundment, citizen input early in the planning process resulted in the inclusion of an athletic field, canoe launch, and other public amenities. The trails connect to the city's Riverfront Parkway, completing a 4.5-mile path through the city. "I would recommend to any other communities in a similar situation to have a plan with what to do with the land," said Mike Miller, who has been mayor of West Bend since the year before the dam was removed. "Formed from the old impoundment area, the Riverwalk has truly become an asset to the City of West Bend."

REMOVAL BENEFITS:
- **Restored high quality warm-water sport fishery**
- **Developed Riverside Park from 61 acres of new municipal park property**
- **Improved water quality dramatically**
- **State threatened fish species now found in restored area**
- **Saved taxpayer money**

RESTORATION OF THE RIVER

The removal of Woolen Mills Dam has provided environmental, recreational, and financial benefits to the community. Sixty-one acres of once-submerged land has been added to the city's Riverside Park. This expansive park is heavily used by city residents and also draws visitors from outside the community. The Park is now home to the annual Kettle Moraine Jazz Festival, which attracts nationally-known musicians and thousands of appreciative fans. In a recent survey rating the quality of life in West Bend, 96 percent of residents replied that they were satisfied or very satisfied with the Riverwalk Project, one of the highest approval ratings in the survey. "We were against them taking the dam out because our view of the water would be gone," said one local resident. "But, lo and behold, with the dam gone there is a whole new adventure for us...It's really become kind of nice."

Restored to a rock-bottomed river channel with riffles, pools, and rapids, the river section now supports a high-quality warm water sport fishery readily accessible to city residents. With a naturally steep gradient, the running river is now re-oxygenated and water quality has improved as a result of separating the river from the landfill seeps. Clay barriers placed between the seeps and the river also now help contain landfill contaminants.

Recent scientific studies prove that the restoration is succeeding. Fisheries biologists found that five years after the dam removal, habitat quality was good to excellent, smallmouth bass abundance had increased substantially, carp populations had declined dramatically, and biotic integrity was good. At least one state-threatened fish species, the greater redhorse, is now found in this restored section of the Milwaukee River. The study concluded that the dam removal benefited the habitat, fisheries potential, and biotic integrity of the Milwaukee River.

The city paid for the structural removal of the dam. The city and state shared the cost of temporary seeding of the former impoundment, design and engineering (phase 1), permanent vegetation and stabilization, and design and engineering (phase 2). The city paid for sediment studies while the state paid for fish restoration. Since these initial expenditures, the city and state have invested more than $1 million in Riverside Park for expanded facilities over the past ten years—still less than one third of the estimated cost of repairing the old dam. Through the Wisconsin Stewardship Program, the DNR provided 50 percent funding for park improvements, including a canoe launch, athletic fields, trails with pedestrian bridges, riverbank fishing access, and parking. The community around West Bend has profited from the recreational opportunities brought about by the dam removal and the Riverwalk Project. Local retailers have stated that their businesses are benefiting from increased public use of the restored river. Economic studies are underway to begin to quantify the benefits to the community.

FUTURE EFFORTS TO RESTORE THE RIVER

The Milwaukee is a river on the road to recovery after many years of abuse and neglect. Through the Milwaukee River Priority Watersheds Program and other state, county and local programs, there is an ongoing comprehensive effort to restore water quality and habitat throughout the river basin. Since the removal of the Woolen Mills Dam on the river's main stem, there has been a partial removal of the North Avenue Dam within the City of Milwaukee (3.5 miles from where the river enters Lake Michigan). The North Avenue removal and restoration project is one of the most ambitious and comprehensive restoration efforts undertaken in the state, and it has faced challenges. The entire dam structure will not be removed due to the presence of highly contaminated sediments that would be disturbed with a complete removal. Removal of the center section of the dam allows water and fish to move freely, while remnants of the structure stabilize and hold back contaminated sediments.

THE SIGNIFICANCE OF THIS REMOVAL

The removal of the Woolen Mills Dam in the City of West Bend is a success in part due to the efforts to engage the community throughout the decision-making and planning processes. By helping the city's residents develop a positive vision for how the removal of the dam might benefit the community, these efforts increased their "comfort level" with the removal.

Ten years after the removal, scientific studies have quantified fisheries and water quality improvements realized as a direct result of the removal. The improvements to and expansion of the Riverside Park in the former impounded area have proved to be an asset to the community, both ecologically and in terms of recreation. Removing the dam saved taxpayer dollars, and the entire project continues to bring economic benefits to the community. Concerns that adjacent property values would drop after the dam removal never materialized. Rather, property values along the former impoundment have significantly increased with the development of the park, and increased recreational use of the area has helped bolster the local economy.

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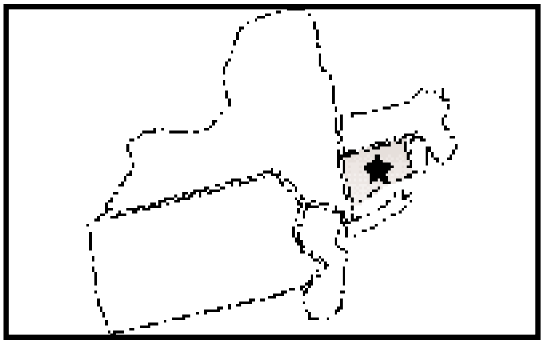

NAUGATUCK RIVER

REMOVAL OF THE ANACONDA, FREIGHT STREET, AND UNION CITY DAMS IN CONNECTICUT

DAM REMOVAL BENEFITS: IMPROVED MIGRATORY FISH HABITAT, IMPROVED WATER QUALITY, ENHANCED RECREATIONAL OPPORTUNITIES

SUMMARY

The Connecticut Department of Environmental Protection (DEP), in partnership with local Trout Unlimited (TU) volunteers and other private and public partners, has begun implementing an unprecedented plan to restore the Naugatuck River basin. The project includes dam removal or construction of fish passage at seven run-of-river dams and the upgrading of six municipal wastewater treatment plants.

In 1999, the Anaconda, Freight Street, and Union City Dams were completely removed. The remainder of the work is scheduled to be completed by 2001. The full project is expected to significantly improve water quality and restore 32 miles of river, allowing passage for sea-run brown trout, American shad, alewives, blueback herring, and other aquatic species for the first time in over a century. The project represents a remarkable commitment to river system restoration on a scale rarely attempted.

THE RIVER

The Naugatuck River originates near Torrington, in eastern Connecticut, and winds south almost 40 miles to meet the Housatonic River in Derby. It is the only major river with its source in the State of Connecticut. The Naugatuck has long been regarded as one of Connecticut's most polluted rivers. Throughout the 19th century, factories and municipalities along the river openly dumped sewage and factory waste into the river. By the 20th century, pollution and numerous dams had taken their toll on the river's health. Today the biggest problems facing the Naugatuck and its fisheries continue to be defunct dams and poor water quality.

THE IMPACT PRIOR TO REMOVAL

The Naugatuck historically supported migratory fish runs, including sea-run brown trout, American shad, alewife, and blueback herring. However, conditions started to deteriorate during the late 1700s, when the Naugatuck became one of the first rivers in Connecticut to be harnessed by dams. Dam construction continued during the industrial revolution of the 1800s. The dams provided power, cooling water, rinse water, and boiler water for industries, including brass and rubber manufacturing. These industries and the municipalities that grew up around them discharged untreated wastewater into the river. The fisheries were decimated. When the industrial boom ended, many businesses relocated or closed, leaving only the obsolete dams behind. Today the structures serve no flood control, hydropower or other economic purpose.

DAM REMOVAL FACTS:
- **Restoration involves 7 dams: full removal of 4 & fish and/or boat passage constructed at 3**
- **Height: 4 ft to 20 ft**
- **Length: 100 ft to 330 ft**
- **Purpose: industrial (all obsolete at removal)**
- **Owner: towns and private owners**
- **Estimated cost of repair: not examined**
- **Cost of removal: $8 million for work at all 7 structures**
- **Removed: 1999 & ongoing**

THE REMOVAL DECISION & PROCESS

Despite its past environmental problems, the Naugatuck River still has the potential to provide excellent habitat for coldwater fish species. The Connecticut DEP and TU have begun implementing the Naugatuck River Restoration Project, an ambitious habitat restoration program involving dam removals and fish and boat passages. Volunteers garnered local support for the project, and their grassroots efforts evolved into a partnership with the Connecticut DEP and neighboring towns. All of the partners recognize the need to undo past damage to the Naugatuck; the mutual desire to meet this goal promises to be key to the project's success.

The project involves the removal or modification of seven dams in the Naugatuck River system, followed by other fish habitat restoration efforts and comprehensive revegetation of the river corridor.

The Dam Modifications:

- **Anaconda Dam** (Waterbury), **Freight Street Dam** (Waterbury), and **Union City Dam** (Naugatuck) were completely dismantled and removed in 1999.
- **Platts Mill Dam** (Naugatuck) was breached in 1999 and will be completely removed in 2000.
- A fishway will be constructed to allow migratory fish to pass **Bray's Buckle Dam** (on the tributary Mad River in Waterbury).
- A bypass channel for both migratory fish and recreational watercraft will be constructed at **Tingue Dam** (Seymour).
- Specific plans are being considered to construct fish passage on the **Plume & Atwood Dam** (Thomaston).

The Anaconda Dam in Waterbury was the first of the dam removals. Its dismantling came earlier than expected when an emergency situation arose in February of 1999. The dam was on the verge of breaking when high water and ice breached a 30 to 40 foot section of the structure, 3 to 4 feet below the surface. A flood surge was created that hit the western bank of the Naugatuck below the dam. The flow eroded the bank above and below a sewerline, compromising the stability of the line. Emergency permits were issued the next day, and the dam was fully removed within a week. Sediment has since moved downstream and the river has begun to reset its course. A full restoration plan for the de-watered areas of the prior reservoir is being developed and will be carried out in the summer of 2000.

The estimated $8 million cost of work on the seven dams is being funded by several sources. The State of Connecticut has provided bond funds and has also secured a $100,000 grant from the National Fish and Wildlife Fund's Iroquois Pipeline Fund. This fund was established pursuant to the settlement of an enforcement action by the US Attorney General's Office. Financing was also provided from a fund created by supplemental environmental payments in lieu of environmental enforcement penalties that are distributed by the Connecticut DEP. Finally, the City of Waterbury's wastewater treatment plant will pay $1 million of the restoration costs as mitigation for expanding its facility.

REMOVAL BENEFITS:

- **Improved migratory fish runs expected**
- **Improved recreational opportunities (fishing and boating)**
- **Restored water quality (long term)**
- **Expected economic benefits due to large-scale restoration effort**

RESTORATION OF THE RIVER

With the removal of three dams and the breaching of a fourth, the project has already restored fish passage along much of the Naugatuck River. Upon completion of the Connecticut DEP plan, 32 miles of the Naugatuck will be restored to a natural free-flowing river.

Along with the dam removal and fish passage projects, six municipal wastewater treatment plants that discharge into the Naugatuck are being upgraded with advanced treatment processes. The advanced treatment significantly reduces the quantities of organic pollutants, including carbonaceous and nitrogenous compounds, entering the river. The upgrades began in 1992 and five of the six have been completed. The sixth plant upgrade has faced a notable difficulty. After much consideration, a decision was made to dump partially treated waste into the river for a short time in order to speed up the completion of the upgrade. Nature dealt a blow to the project when the worst drought of the last century severely reduced the ability of the river to dilute the waste. The return of normal precipitation has alleviated the short-term problems. When this plant upgrade is completed in early 2000, the river's water quality is expected to dramatically improve.

FUTURE EFFORTS TO RESTORE THE RIVER

The treatment plant upgrades and dam removals and modifications are part of an overall watershed restoration project to bring the Naugatuck River back to a condition not seen since the 1800s. Additional restoration plans include the revegetation of areas along the river corridor; restoration of segments in three towns previously channelized for flood control; the scouring of sediment from tributary mouths; and the application of best management practices for stormwater discharges at industrial facilities. Additional fishery management plans being implemented should also help restore fish populations. In addition, the Chase Brass Dam, located between the Anaconda and Plume & Atwood Dams, is currently being investigated for possible removal. The total cost of the Connecticut DEP project, including dam removals, fish and boat passage construction, treatment plant upgrades, and channel and bank restoration is estimated at $225 million. Work on the Connecticut DEP plan is expected to be complete by 2001.

The towns along the Naugatuck River have also become involved in the state's restoration project. Each of the nine towns from the headwaters to the mouth of the river has begun a greenway concept to create a recreational river corridor along the length of the river. There are also plans to establish a formal canoe trail along the main stem of the river. TU is planning to build what will be the first park to return along the Naugatuck River, the River Bend Park in Beacon Falls. The Connecticut DEP is providing $40,000 for the project. In addition, TU has appointed a full-time "River Steward" for the Naugatuck, funded by local private interests, to monitor river and watershed restoration efforts.

THE SIGNIFICANCE OF THIS REMOVAL

The Naugatuck River restoration effort is noteworthy for at least three reasons. The first is clearly the resource and recreational benefits. The project is one of the most ambitious watershed restoration projects in the northeastern United States. The Connecticut DEP anticipates that annual runs of 23,000 American shad could be restored, making the long-troubled Naugatuck the third largest American shad fishery in the state. The project will restore other species of migratory fish as well, including blueback herring, alewife, and sea-run brown trout. The dam removals and alterations will also enhance recreational boating and fishing, and help to restore and maintain water quality.

Second, rather than being triggered by federal relicensing requirements or public safety concerns as many dam removals still are, the Naugutuck removals and modifications are being carried out in a pro-active manner for the express purpose of river and fisheries restoration.

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Third, rather than looking at each dam individually, resource professionals have assessed the cumulative impacts of the dams in the Naugutuck River system, reducing costs for all involved, including taxpayers, and creating a synergistic effect that promises phenomenal success in meeting project goals.

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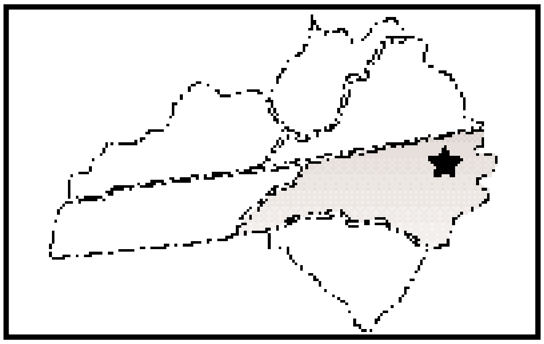

NEUSE RIVER

REMOVAL OF THE QUAKER NECK DAM IN NORTH CAROLINA

DAM REMOVAL BENEFITS: IMPROVED MIGRATORY FISH HABITAT

SUMMARY

The Quaker Neck Dam was built in 1952 in order to provide cooling water for a steam generating plant. Removal of the dam in 1997 and 1998 reopened over 1,000 miles of migratory fish habitat. The dam was removed voluntarily through a cooperative partnership of public and private stakeholders. When Carolina Power & Light (CP&L) decided it no longer needed the Quaker Neck Dam, a team was formed which included the dam owner, government agencies, and fisheries and conservation organizations. They worked together for almost five years to find a cost-effective plan that would satisfy legal and safety requirements. The removal of the dam was initiated in December 1997 and completed in September 1998. Migratory fish that spawn in this freshwater system are already benefiting from the restored access to the upper Neuse.

THE RIVER

The Neuse River, which flows from north central North Carolina to Pamlico Sound and then to the Atlantic Ocean, provides habitat for a number of important migratory fish, including striped bass, American and hickory shad, alewife, blueback herring, two species of sturgeon, and American eel. These species have historically formed a significant component of the fishery resources of the Albemarle-Pamlico Estuarine ecosystem. At the beginning of this century, more striped bass and American shad came out of North Carolina than any other state—and the Neuse River produced more American shad than any other river in North Carolina. However, all migratory fish species of this region have experienced an unprecedented population decline throughout much of their historic ranges. Water quality degradation, alteration or destruction of estuarine habitats, alteration of river flows, commercial and recreational over-fishing, and physical obstructions, such as dams, are all factors thought to have contributed to the decline of the fish populations.

THE IMPACT PRIOR TO REMOVAL

Many abandoned millpond dams and hydroelectric dams still remain in eastern North Carolina—and their presence prevents access to hundreds of miles of historic migratory fish habitat. Environmental agencies involved with migratory fish management on the Neuse River describe dams as the most detrimental obstruction to fish migration. One of these dams, the Quaker Neck, was located approximately 140 miles upstream of the mouth of the Neuse River. The 7-foot tall by 260-foot wide structure was built by the Carolina Power Company in 1952 in order to provide cooling water for a steam generating plant. Although relatively small, the dam blocked migratory fish species from reaching their historic spawning grounds located upstream of the site. The presence of Quaker Neck Dam also significantly affected species listed under the Endangered Species Act—the endangered shortnose sturgeon and the endangered dwarf wedge mussel.

Not only did the Quaker Neck Dam prevent the historic migration of fish species, but it also altered the heritage of many people in North Carolina. The dramatic decline in catches of American shad on the Neuse River—which fell from 700,000 pounds prior to the construction of Quaker Neck Dam to 25,000 pounds in 1996—clearly demonstrates the magnitude of the dam's impact on the economy of North Carolina. The decline in shad production associated with the Quaker Neck Dam also forced many North Carolina residents to change their source of livelihood—and this impact is immeasurable.

DAM REMOVAL FACTS:

- **Height: 7 ft; Length: 260 ft**
- **Impoundment: 360 acre-ft**
- **Built: 1952**
- **Purpose: water supply**
- **Owner: Carolina Power & Light**
- **Regulatory jurisdiction: state**
- **Estimated cost of repair: not in need of repair, removed voluntarily**
- **Cost of removal: $205,500**
- **Removed: Dec. 1997 - Sept. 1998**
- **Removal method: wrecking ball, hydraulic hammer**

THE REMOVAL DECISION & PROCESS

The early stages of the Quaker Neck Dam removal began as far back as 1989 when the US Fish and Wildlife Service classified the dam as an obstruction to migratory fish species. As a result of this classification, in 1991 the Coastal America Partnership identified the Quaker Neck Dam as a candidate for fish passage improvements. While the owner of the Quaker Neck Dam, the Carolina Power & Light Company, was not opposed to removing the dam, the company would only agree to removal if its water intake needs continued to be satisfied. In 1993, the US Army Corps of Engineers found a feasible alternative to the dam—a 75-foot weir dam constructed at the company's intake canal that does not block the Neuse River. However, it took another three years before all the complex financial, safety, and legal issues were worked out and dam deconstruction could begin. In December 1997, construction crews began demolishing the Quaker Neck Dam with a wrecking ball. The dam—even though it was small—was well constructed and consequently took until September 1998 to be fully removed. The long duration of the removal allowed the sediment trapped behind the dam to slowly disperse down the river.

Funding for the removal of Quaker Neck Dam was provided by the Environmental Protection Agency, the North Carolina Marine Fisheries Resource Grant Program, and the National Fish & Wildlife Foundation—and cost $205,500. Many government and non-governmental organizations worked together on the dam removal and the joint cooperative effort was critical to the project's success. The following organizations and agencies were involved in the removal process: North Carolina Department of Environment and Natural Resources, Carolina Power & Light Company, US Fish and Wildlife Service, National Marine Fisheries Service, Coastal America Partnership, Southeastern

Watermen's Association, North Carolina Division of Water Resources, The Neuse River Foundation, North Carolina Division of Marine Fisheries, North Carolina Fishermen's Association, North Carolina Division of Water Quality, North Carolina Wildlife Resources Commission, North Carolina Sea Grant, US Army Corps of Engineers, Albemarle-Pamlico Estuarine Study, North Carolina Marine Fisheries Commission, US Environmental Protection Agency, Coastal Conservation Association, National Fish and Wildlife Foundation, and North Carolina Coastal Federation.

RESTORATION OF THE RIVER

The Neuse River is now unobstructed all the way from its mouth at Pamlico Sound to Raleigh, North Carolina, approximately 218 miles upstream. Removal of the Quaker Neck Dam permanently restored access to fish spawning habitat along 75 miles of the Neuse River and 925 miles of its tributaries—which allows migratory fish stocks to return to 90 percent of their historic spawning grounds in the Neuse River. The dam removal benefits eight species of migratory fish, including striped bass, American shad, hickory shad, shortnose sturgeon, and American eel. These species have been blocked for 55 years from spawning in this freshwater river system. It is also expected that mussel species upstream of the dam will benefit, including the endangered dwarf wedge mussel.

REMOVAL BENEFITS:

- ¥ **Opened 75 miles of main stem river & 925 miles of tributaries to 6 species of migratory fish**
- ¥ **Improved habitat for endangered mussel**
- ¥ **Significant economic benefits expected as migratory fisheries recover**

Migratory fish are already starting to return above the former dam site. In the spring of 1998—even before the dam was completely removed—the North Carolina Wildlife Resources Commission reported that large numbers of migratory fish were spawning in the upper Neuse River upstream of Quaker Neck Dam. According to Fred Harris, the Chief of Inland Fisheries, "both stripers and shad were being caught inside the city limits of Raleigh," which is approximately 75 miles upstream of the old dam site.

North Carolina was once the number one producer in the United States of American shad and striped bass. By restoring these fisheries, the Quaker Neck Dam removal is likely to contribute to the economic prosperity of the entire state. Both recreational and commercial fishing should increase substantially—and if removing the Quaker Neck Dam has the impact planners predict, fish populations will return to levels predating the dam or maybe even higher. The economic returns on the low cost of dam removal—only $181,000—could generate significantly more income for the state through its fishing industry.

In addition to boosting the local recreational and commercial fishing industries, the return of the migratory fish will also help to improve the general ecological health of the Neuse. According to US Fish and Wildlife Service biologist Mike Wicker, migratory fish play an important role in the nutrient management of rivers. As juvenile fish swim downstream towards the Atlantic Ocean, they consume insects—and thus nutrients—that are carried downstream and add to the overall health of the river system. Additionally, adult fish accumulate nutrients from the ocean, which are returned to the river when they swim upstream to spawn and die—again improving the health of the Neuse River.

FUTURE EFFORTS TO RESTORE THE RIVER

The Cherry Hospital Dam on the Little River, which is a tributary that enters the Neuse River just a few miles downstream of Quaker Neck Dam, was removed in July 1998. The Cherry Hospital dam was built in order to impound water for Cherry Hospital's use. Recently, the hospital began purchasing water from the City of Goldsboro, eliminating the need for the dam. Removal of the Cherry Hospital Dam returned natural flows to 21 miles of the Little River and to 33 miles of its major tributary streams. Removal is expected to increase spawning areas for hickory shad, striped bass, and other commercial and recreational fish species. Removal of the Cherry Hospital Dam cost $69,000 and was financed through a program initiated by the Coastal America Foundation.

Efforts to remove the Rains Mill Dam, an old grist mill dam which is also on the Little River, are currently underway—and it is likely that the dam will be removed in late November or early December 1999. Removal of Rains Mill Dam will restore access to 49 miles of migratory fish spawning habitat, improve water quality by restoring natural flow to the river, and restore habitat for two endangered mussels (the dwarf wedge mussel and the tar spiny mussel).

THE SIGNIFICANCE OF THIS REMOVAL

While the 7-foot high, 260-foot long Quaker Neck Dam itself was small, the impact of its removal is very large. An incredible 1,000 miles of river habitat was reopened for migrating fish through removal of this small dam—at a cost of a mere $205 per river mile. Dollar for dollar, this was one of the most cost-effective river restoration projects in the United States.

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This project will also serve as an important model for future public and private efforts to remove dams that destroy fish and wildlife. The removal of Quaker Neck Dam demonstrates that deconstructing all or parts of dams to restore historic spawning habitat for migratory fish can be done through cooperative partnerships of public and private stakeholders—and to the benefit of all the involved parties. As Bruce Babbitt stated during the removal of Quaker Neck Dam, "We're removing a dam today in order to restore a river. By restoring a river and a fishery, we will restore and recapture part of North Carolina's heritage, and restore and repair part of the human spirit."

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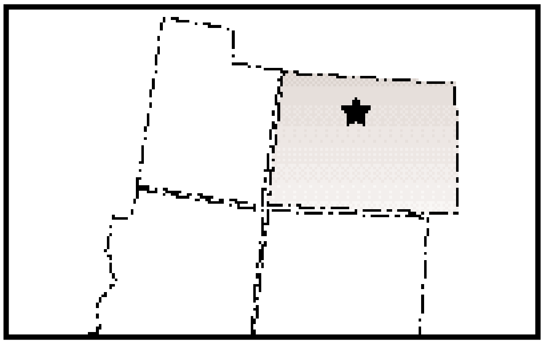

OUZEL CREEK

REMOVAL OF THE BLUEBIRD DAM IN COLORADO

DAM REMOVAL BENEFITS: ELIMINATED PUBLIC SAFETY HAZARD, ENHANCED AESTHETICS, IMPROVED THREATENED SPECIES HABITAT

SUMMARY

Bluebird Dam was built in 1904—and enlarged in 1920—on Ouzel Creek to increase the water storage capacity of a natural lake. The dam was located in the high alpine wilderness of Northern Colorado, in Rocky Mountain National Park. With establishment of the park in 1915, the dam became a safety liability as well as an eyesore in an otherwise pristine wilderness area. In 1982, following the failure of Lawn Lake Dam (also located in the park), the City of Longmont was ordered to repair or breach Bluebird Dam. In 1987, the National Park Service (NPS) purchased from the city the water rights and easements associated with Bluebird Dam. The 56-foot high Bluebird Dam was removed in the summers of 1989 and 1990. Removal eliminated significant dam safety hazards, made aesthetic improvements in an alpine wilderness, and improved flows for the threatened greenback cutthroat trout.

THE RIVER

Ouzel Creek is the natural outlet of Bluebird Lake, a glacier-formed alpine lake located just above tree line in the Wild Basin region of Rocky Mountain National Park. Ouzel Creek is located in the headwaters of the Platte River system, originating in northern Colorado at an elevation of 11,000 feet. From Bluebird Lake, it travels approximately three miles before it joins the North Fork of the St. Vrain River. Along the way it travels through Ouzel Lake and cascades over Ouzel Falls, popular stopping points for hikers on their way to Bluebird Lake. Ouzel Creek historically provided valuable coldwater spawning habitat in its lower section for the greenback cutthroat trout, a species listed as threatened under the federal Endangered Species Act.

The dramatic landscape of Rocky Mountain National Park attracts over three million visitors annually. Approximately one quarter of the park (100 square miles) is located above treeline, among the 14,000-foot high mountains of the Central Rockies. This includes Bluebird Lake, which is one of more than 150 lakes, and Ouzel Creek, which represents three miles of the over 450 miles of streams located in the Park.

THE IMPACT PRIOR TO REMOVAL

Built prior to the establishment of Rocky Mountain National Park, Bluebird Dam, which was 56 feet tall and 200 feet long, raised the natural level of Bluebird Lake in order to store irrigation water for the City of Longmont during peak summer demands. The dam eliminated the natural seasonal fluctuations of Bluebird Lake and Ouzel Creek associated with periods of freezing and snowmelt. The dam was particularly harmful to greenback cutthroat trout, which spawn in June just after the peak snowmelt releases additional flows.

When Bluebird Lake became part of Rocky Mountain National Park, the presence of Bluebird Dam became inconsistent with the goals of the park. Although not a congressionally designated wilderness, the Bluebird Lake area is managed as such by the NPS. In 1976, Rocky Mountain National Park's Master Plan established an objective to acquire alien water rights and eliminate impoundment structures within the park.

DAM REMOVAL FACTS:

- Height: 56 ft; Length: 200 ft
- Built: 1904
- Purpose: irrigation storage
- Owner: City of Longmont
- Regulatory jurisdiction: state
- Estimated cost of repair: not available
- Cost of removal: $1.9 million to purchase water rights and easements (including two other dams); $1.5 million for physical removal of Bluebird Dam
- Removed: 1989 - 1990
- Removal method: heavy machinery, helicopters

In addition to altering the natural flow regime of Ouzel Creek and creating an eyesore in an alpine wilderness, Bluebird Dam was a serious safety hazard. Safety concerns were identified as early as 1951, when the State Engineer's Office found it to be in poor condition. Concerns were raised again in 1956 when the NPS questioned its safety due to extensive leakage. By 1960, rehabilitation plans were in place and the facility was operating on partial storage restrictions, but rehabilitation was never implemented.

THE REMOVAL DECISION & PROCESS

The 1982 failure of Lawn Lake Dam, another alpine dam located in the park, generated serious concerns about Bluebird Dam. When Lawn Lake Dam failed, it unleashed approximately 500 acre-feet of water down the Roaring Fork River, causing the collapse of a downstream dam, killing three people, and inflicting $31 million in damage on the Town of Estes Park, located just outside of Rocky Mountain National Park. Immediately following this failure, the NPS and the State Engineer's Office inspected all dams within the park. During the 1982 inspection, Bluebird Dam and two other dams owned by the City of Longmont (Pear Dam on Cony Creek and Sand Beach Dam on Sand Beach Creek) were found to be seriously deteriorated and given a “significant hazard” rating. The State Engineer's Office directed the city to repair or breach the dams by the end of 1985. In the meantime, several campgrounds and hiking trails were closed until the reservoir levels could be reduced and the safety risks eliminated.

The City of Longmont had enough water storage available in the Buttonrock Reservoir (located downstream on the North St. Vrain River) that the additional storage created by Bluebird and the other two dams was insignificant. As a result, the NPS expressed interest for a number of years in acquiring the dams. In 1987, the NPS finally purchased the water rights and easements to Bluebird and the two other dams for $1.9 million. This enabled the NPS to move forward with its ultimate goal, removal of the dams. All three dams were removed between 1988 and 1990.

Physical removal of Bluebird Dam was a unique challenge due to the elevation, remote location (seven miles from the nearest access road), and size of the dam, as well as weather concerns and the sensitive alpine tundra ecosystem. A "walking excavator"—a unique machine built to operate on very rough terrain—was flown to the dam site by helicopter. Fitted with a hydraulic hammer, the excavator did most of the demolition in the spring and summer of 1989, leaving just a fraction of the 56-foot concrete structure to be removed the following summer. All materials from the demolished dam were removed using a specially-equipped helicopter. These waste materials were transported to a lower elevation in order to limit impacts to the ecosystem. Full removal and restoration of the site required two seasons and 925 helicopter flights to remove 5.3 million pounds of concrete and steel. The cost of removal, not including the purchase of the water rights, was $1.5 million. Upon successful completion, the project was awarded the 1990 National Park Service Director's Safety Achievement Award

REMOVAL BENEFITS:
- **Eliminated safety risks**
- **Restored alpine wilderness aesthetics**
- **Returned alpine lake and creek to natural flow regime**
- **Improved habitat for threatened greenback cutthroat trout**

RESTORATION OF THE RIVER

Removal of Bluebird Dam not only eliminated a very serious safety concern, but also returned a wilderness area to its natural state. Bluebird Lake is now at its natural elevation and fluctuates seasonally, as an alpine lake should. As a result, Ouzel Creek has also returned to a more natural flow regime, benefiting the threatened greenback cutthroat trout that inhabits the creek below the former dam site.

Prior to removal of Bluebird Dam—as well as Pear Dam and Sand Beach Dam—a lack of spawning habitat limited restoration opportunities for the greenback cutthroat population in this part of the North St. Vrain watershed. With the return to natural flow regimes and the elimination of structural impediments (Pear Dam and Sand Beach Dam prevented the fish from accessing habitat), the US Fish and Wildlife Service and the NPS have begun restoring the greenback cutthroat trout to these three tributaries of the North St. Vrain.

After removal, Rocky Mountain National Park staff decided not to actively restore the site beyond a minimal amount of willow plantings that provide shade habitat in the creek. Instead, their management strategy has been to allow the 100-acre area to revegetate itself. A three-acre mudflat, which was exposed when Bluebird Lake retreated to its natural elevation, was completely revegetated within five years. The "bathtub ring" on the surrounding rocks, exposed when the lake returned to its natural elevation, is expected by NPS biologists to be covered by lichen in 50 to 100 years.

Beyond the ring on the rocks, the only remaining physical evidence that there was once a dam at the location is an interpretive plaque which documents the removal process. The NPS estimates that 500 to 1,000 visitors per year travel the seven miles into the wilderness to reach this remote alpine lake and stream. When they arrive, they are met with an astounding alpine vista, unaware of the 56-foot high man-made structure that once dominated the landscape.

FUTURE EFFORTS TO RESTORE THE RIVER

With the removal of Bluebird Dam, the largest threat to the health of Ouzel Creek was eliminated and the creek now flows unimpeded to the North St. Vrain River. Greenback cutthroat trout are being actively restored in the watershed, but beyond that there is currently no need for further restoration efforts on Ouzel Creek. Park resources are now focused on other riparian protection issues, including water quality problems associated with erosion.

THE SIGNIFICANCE OF THIS REMOVAL

The physical removal of Bluebird Dam was like no other to date. The unique challenges of elevation, sensitive terrain, weather, equipment, and material disposal were met with great success by the NPS, using innovative methods. This project can serve as a model for other removals in remote or alpine locations.

The primary purpose of this particular dam removal project was the elimination of a safety risk and an eyesore. However, the NPS accomplished the desired result with a keen eye towards habitat protection and restoration. This perspective is a valuable lesson for any community, agency or dam owner thinking about removing a dam primarily for safety reasons.

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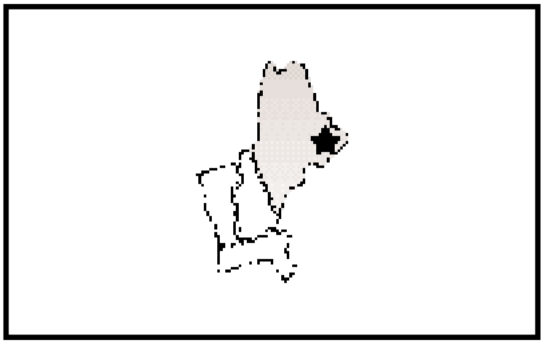

PLEASANT RIVER

REMOVAL OF THE COLUMBIA FALLS HYDRO DAM IN MAINE

DAM REMOVAL BENEFITS: IMPROVED MIGRATORY FISH HABITAT, COST SAVINGS

SUMMARY

The Pleasant River on Maine's coast is home to one of the last wild spawning grounds for the beleaguered Atlantic salmon. Although salmon populations continue to decline in Maine, the 1990 breaching of the Columbia Falls Hydro Dam near the mouth of the Pleasant may save the fish from extirpation. The hydropower dam was inefficient and uneconomical from the start, and an adjoining fish ladder was poorly designed and ineffective. The dam owner faced both community and federal pressure to repair the fish passage, but could not afford the expense. As part of a mitigation plan for constructing a dam on the Penobscot River, Bangor Hydro-Electric Company purchased the Columbia Falls Dam for the State of Maine and funded its removal. The removal opened up approximately 28 miles of river, including four miles of Atlantic salmon spawning habitat and 13 miles of rearing habitat.

THE RIVER

Originating at Pleasant Lake, the Pleasant River meanders 28 miles before flowing into Pleasant Bay at Columbia Falls. The 85 square-mile watershed is characterized by over 6,000 acres of raised heath, a flowering evergreen shrub, making it the largest heath area in Maine. This habitat makes the mostly rural watershed a beautiful area for bird watching. Other common recreational activities in the watershed include canoeing, deer hunting, and fishing. Historically known for its native Atlantic salmon, the river also supports resident brook and lake trout, as well as alewife and smelt runs.

According to a fish story related in a 1987 *New York Times* article, the Pleasant River "once was so full of Atlantic salmon that a fisherman could walk across the river by stepping on the backs of the fish." Half a million Atlantic salmon once populated rivers and coastal bays on the East Coast of the United States. However, 200 years of overfishing, loss of spawning habitat, and pollution have caused a dramatic decline in the population. By 1800, Atlantic salmon no longer existed in many New England streams. As early as 1860, commercial Atlantic salmon fishing remained profitable only in Maine. In 1997, the Atlantic Salmon Federation estimated that fewer than 2,000 Atlantic salmon now return to spawn in US rivers.

THE IMPACT PRIOR TO REMOVAL

The Columbia Falls Dam, which was 9 feet tall and 350 feet long, was built by a local landowner between 1981 and 1983. Designed for hydropower, new laws intended to reduce dependence on oil and find alternative power sources supported its construction. The dam cost $250,000 to build. It spanned from ledge to ledge across the entire channel near the mouth of the Pleasant River where it flows into Pleasant Bay and the Atlantic Ocean. To aid fish passage, a fish ladder was installed during construction. However, it was poorly designed and almost completely ineffective. The bottom pool was at least a foot and a half too high to allow fish to pass from downstream.

The obstruction severely affected migrating Atlantic salmon, one of the most highly sought after game fish in both freshwater and saltwater. Prior to the dam's construction, a 1961 study estimated 225 to 300 adult Atlantic salmon in the Pleasant River. By January 1986, the Atlantic Salmon Commission had closed the river to Atlantic salmon fishing. The number of adults had dwindled down to only ten by 1988, five years after the dam was completed. Although construction of the Columbia Falls Dam did not initiate the decline of migrating salmon on the Pleasant River, one local fisheries expert proclaimed that it may have been "the nail in the coffin."

DAM REMOVAL FACTS:

- **Height: 9 ft; Length: 350 ft**
- **Built: 1983**
- **Purpose: hydropower**
- **Owner: purchased for removal by Bangor Hydro-Electric Company from a local landowner**
- **Regulatory jurisdiction: FERC**
- **Estimated cost of repair: $80,000 for fish ladder repair**
- **Cost of removal: $20,000 - $30,000**
- **Removed: half removed in 1990, another piece in 1998**
- **Removal method: explosives & heavy machinery**

Atlantic salmon was not the only fish species affected by the dam. The dam was located at the head-of-tide, the place at which smelt spawn. Adult smelt would come in at high tide and spawn in a gravel bed near the dam. When the tide went back out, the relatively small amount of springflow from the dam supplied insufficient water and oxygen to the eggs, resulting in minimal hatches.

Upstream from Columbia Falls, a small, abandoned dam at Saco Falls still prevents fish passage at low flows. Although this dam is located upstream of historic spawning grounds, a fish ladder was constructed in 1955 to attempt to expand spawning habitat. Only sparsely utilized by fish, it has been a questionable success.

THE REMOVAL DECISION & PROCESS

Because of generator inefficiency and the relatively small river flow, the Columbia Falls Dam was uneconomical from the beginning. Despite federal subsidy, it never produced a profit, and equipment problems had caused the power generators to be shut down at times, once for more than a year. Not long after the dam was built, local anglers began lamenting the decline of their favorite fishing ground. By 1987, the community had organized, signing a petition demanding a hearing with the state to find some way of bringing Atlantic salmon back to the river. Around this time, the US Fish and Wildlife Service warned the dam owner that the Federal Energy Regulatory Commission would revoke its operating permit if the fishway was not repaired. Another pool was needed at a cost of approximately $80,000 and the owner could not afford it. Furthermore, the financing bank was threatening to foreclose on the dam property, and the town government had placed a lien on the property for two years of back taxes.

REMOVAL BENEFITS:

- **Restored 4 miles of spawning habitat and 13 miles of rearing habitat for declining Atlantic salmon populations**
- **Restored freshwater flow to smelt tidal spawning habitat**
- **Removal saved money over cost of repair**

In the late 1980s, Bangor Hydro-Electric Company built the West Enfield Dam on the Penobscot River, west of the Pleasant River. As part of the mitigation for that construction, Bangor Hydro agreed to purchase the Columbia Falls Dam for the state and fund its removal. In 1990, half of the dam from the right bank was removed with explosives and heavy machinery. The dam was only seven years old when it was breached. Bangor Hydro turned the site over to the state, and the former power plant is now leased by the Wild Salmon Resource Center.

RESTORATION OF THE RIVER

Although the breaching did not result in a dramatic rebound of Atlantic salmon, fisheries experts believe that the dam removal may have saved the species on the Pleasant River. Since the removal, the river has maintained a small but stable salmon population. In the early 1990s, the Pleasant River was reopened to catch-and-release Atlantic salmon fishing. The dam removal was also a resounding success for other species, including blueback herring, alewife, lamprey, sea-run brook trout, striped bass, and American eel.

When the dam was breached in 1990, half of the dam on the left bank remained standing because of concerns that sediment flows from behind the dam would destroy smelt spawning habitat just downstream. However, it was soon realized that the river's freshwater flow was still not adequate for a normal smelt hatch. In 1998, another piece of the dam was removed to increase the flow. This additional removal has been a limited success, and the Downeast Salmon Federation is seeking funds through the Natural Resources Conservation Service's Wildlife Habitat Incentives Program to remove another one and a half feet of the dam.

FUTURE EFFORTS TO RESTORE THE RIVER

Controversial plans will guide habitat restoration on the Pleasant River for the next several years. In March of 1997, the National Marine Fisheries Service, US Fish and Wildlife Service, and the State of Maine drafted the Atlantic Salmon Conservation Plan, focusing on seven rivers on Maine's coast, including the Pleasant River. The Atlantic Salmon Federation (ASF) estimates that each year only 60 to 120 adult Atlantic salmon return to these seven rivers to spawn. The Plan is a cooperative set of programs sponsored by private organizations and state and federal agencies. It includes goals for habitat improvement, stocking in some rivers, construction of fish weirs, changes in agriculture and aquaculture, and monitoring and research. The Plan also established the Pleasant River Watershed Council, a volunteer group charged with maintaining and enhancing the quality of the river and improving the health of the surrounding watershed. ASF and Trout Unlimited argue that, while the Plan is a good set of guidelines, it needs more funding, enforcement, and accountability. Salmon populations continue to decline, and the organizations believe that stronger protection is necessary. They are currently seeking to have Atlantic salmon protection strengthened through the Endangered Species Act.

While the Atlantic Salmon Conservation Plan has come under fire as insufficient, some steps are progressing toward improving habitat on the Pleasant River. In the summer of 1998, withdrawal limits were placed on blueberry irrigation to maintain flow for salmon. Cherryfield Foods, the watershed's largest landowner, has also begun several projects to control non-point source pollution in the river. In September of 1999, crews of correctional facility inmates removed beaver dams along the river to increase flows and give salmon unobstructed access to spawning areas. Additional plans include the removal of an old tidal barrier on the west branch of the river, which was built to develop agriculture in the area, but is now obsolete.

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The long migratory journeys of Atlantic salmon (up to 2,800 miles to feeding grounds in Greenland and Newfoundland) are teacherous, and even in good conditions, only one to three percent survive to spawn. Because of this low return rate from the ocean, the ASF has been trapping and removing young salmon from the Pleasant River before they migrate to sea. These salmon are reared in hatcheries with the intention of returning them to the Pleasant River to spawn. However, this program took a devastating blow in the fall of 1998, when a rare virus killed hundreds of salmon at two separate hatcheries. The outbreak leaves the Pleasant River without a source of broodstock for restoration efforts. The restocking program will again begin trapping young salmon in the river, with the hopes of establishing a healthy broodstock. While there is hope that Atlantic salmon will recover in the Pleasant River, with the number of returning adults approaching zero, the outlook is uncertain.

THE SIGNIFICANCE OF THIS REMOVAL

The removal of the Columbia Falls Hydro Dam opened up the entire Pleasant River system to migratory fish, restoring habitat for one of the last remaining wild runs of Atlantic salmon in the United States. The dam removal was a vital step that may save native Atlantic salmon from extirpation on the Pleasant River. Once a famous fishing ground, only 12 Atlantic salmon were caught and released by anglers in 1999 on the seven rivers included in the Atlantic Salmon Conservation Plan. The continued restoration of coastal rivers in Maine will be crucial to the survival of Atlantic salmon.

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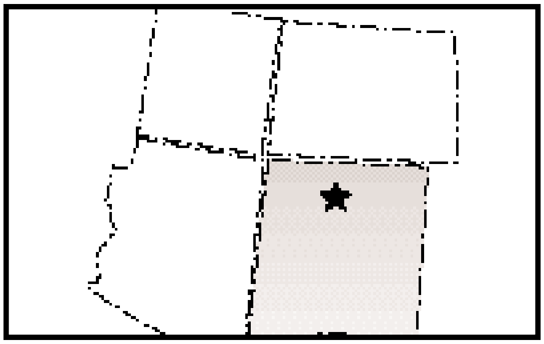

SANTA FE RIVER

REMOVAL OF THE TWO-MILE DAM IN NEW MEXICO

DAM REMOVAL BENEFITS: ELIMINATED PUBLIC SAFETY HAZARD, IMPROVED WILDLIFE HABITAT, COST SAVINGS

SUMMARY

The Two-Mile Dam, located on the Santa Fe River, was removed by its owner, the Sangre de Cristo Water Company (Sangre de Cristo), in 1994 because the century-old dam was structurally unsafe and too costly to repair or replace. The dam was part of a system of storage dams that provide municipal water to the City of Santa Fe. Upon draining the reservoir in order to repair a crack in the face of the dam, it was discovered that the dam lay on an active fault line and structural damage was actually worse than first anticipated. A solution was crafted which eliminated the safety risk through dam removal without losing valuable water storage for a growing city in the arid Southwest. Removal was also a less expensive option for resolving the serious public safety problems with Two-Mile Dam.

DAM REMOVAL FACTS:

- ¥ Height: 85 ft; Length: 720 ft
- ¥ Impoundment: 500 acre-ft
- ¥ Built: 1894
- ¥ Purpose: municipal water supply
- ¥ Owner: Sangre de Cristo Water Company
- ¥ Regulatory jurisdiction: state
- ¥ Estimated cost of replacement: $4.1 million
- ¥ Cost of removal: $3.2 million
- ¥ Removed: 1994
- ¥ Removal method: heavy construction equipment

THE RIVER

The headwaters of the Santa Fe River are located in the southwestern extent of the Sangre De Cristo Mountain range. The river begins here, within the Santa Fe National Forest, north and east of the City of Santa Fe. The river enters the city within three miles after exiting the National Forest, and in that short distance is slowed by two (previously three) storage dams for municipal water supply purposes. As the Santa Fe River travels through the city it takes on more of the lined channel character which makes up most of the river from Santa Fe to its confluence with the Rio Grande. The Santa Fe is an intermittent stream—water is not always present in the system, particularly below the storage dams.

THE IMPACT PRIOR TO REMOVAL

Two-Mile Dam, which was constructed in 1894, was an 85-foot high and 720-foot wide earthfill municipal water supply dam that impounded approximately 500 acre-feet of water. The dam was owned by the Sangre de Cristo Water Company, which is the principal water supplier for the City of

Santa Fe. In May 1992, a crack was discovered in the crest of the earthen dam. This was considered a serious public safety risk, particularly with the dam's proximity to the City of Santa Fe, with a population of over 40,000. In addition to the potential liability issues created by the danger of dam failure, the likely costs of either repairing or rebuilding Two-Mile Dam were not economically feasible. Cost estimates for reconstruction of the dam were nearly $1 million over the cost of just removal.

THE REMOVAL DECISION & PROCESS

Following the discovery of the crack in Two-Mile Dam, Sangre de Cristo initially decided that the dam should be removed and a new dam would be built in its place to hold the existing water supply. The first phase of the project involved an inspection to determine the cost of the project. It was estimated that removal and reconstruction of the dam would cost $4.1 million, not including any environmental management.

REMOVAL BENEFITS:

- **Elimination of public safety threat**
- **Least cost solution to failing dam**
- **Creation of wetland area, waterfowl habitat**

During the next phase of inspection, a private geotechnical firm examined the dam and discovered a fault running parallel to the dam in close proximity to the base of the structure. In light of this, Sangre de Cristo decided instead of rebuilding the dam in the same location they would remove the dam and transfer the water supply to the two existing upstream reservoirs.

A Clean Water Act section 404 permit application, including plans for removal of the dam and reconstruction of the reservoir area to avoid siltation movement problems, was submitted to the US Army Corps of Engineers (Army Corps). These plans were posted for public viewing and a public hearing was held in Santa Fe. There was a large amount of public opposition to the dam removal; one citizen went so far as to suggest that the Sangre de Cristo Water Company had planted a bomb in order to create the original break in the dam. The Army Corps permit became inconsequential when the New Mexico State Engineer ordered an emergency removal. The State Engineer feared that Two-Mile Dam was in serious danger of failure and that the safety of the residents of Santa Fe was in jeopardy.

The removal of Two-Mile Dam was completed over a five-week period in 1994. Deconstruction activity was scheduled to begin on May 1 in order to avoid any potential complications associated with the spring run-off. In addition to this provision, a historical/archeological preservationist was required to document the entire process and prepare a report for the Army Corps. The dam was demolished using standard construction equipment. During removal, the concern of dam failure was validated by the muddy and unstable condition of the base of the dam. This condition was undoubtedly caused by water that had passed through the crack near the base. It was so muddy and difficult to remove that sand was added to soak up the water before dredging the area. The total cost of removing Two-Mile Dam, including environmental, hydrologic, and geotechnical studies, as well as design, construction, and site restoration, was $3.2 million. The cost was covered by the Sangre de Cristo Water Company and was reflected in a slight rate increase for the company's customers.

RESTORATION OF THE RIVER

After the removal of Two-Mile Dam, the exposed area was recontoured and revegetated in order to protect the slope at the former dam site from slippage and erosion. Western wheat grass was planted and a riprap rock bottom was put in the basin. Dissipaters were also put in to protect the soil during large run-off episodes. A small berm was built at the original site of the dam in order to create a small pond and wetland area of approximately five acres. The site is now home to waterfowl and other small animals.

Of the two remaining upstream dams, the larger McClure Dam holds most of the water once contained in the Two-Mile Dam. McClure Dam's spillway capabilities were upgraded to the "probable maximum precipitation capability." During the first spring run-off after the removal of Two-Mile Dam, McClure Dam retained the additional 500 acre-feet impoundment and the municipal water supply levels were reached. Removal of Two-Mile Dam provided significant safety benefits to residents of Santa Fe at a lesser cost than the repair or replacement alternatives.

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FUTURE EFFORTS TO RESTORE THE RIVER

The land alongside the former Two-Mile Dam site is now owned by the City of Santa Fe, but is presently not open to public access. At last report, the city was considering using it as a public park or nature preserve, but this does not appear to be in the planning stages yet.

THE SIGNIFICANCE OF THIS REMOVAL

The removal of Two-Mile Dam highlights several important issues. First, it demonstrates the often hidden dangers inherent with aging dams all across the country. There are innumerable dams, like this one, that have long since surpassed their life expectancy and may have significant public safety problems lurking beneath the surface. Second, it is an excellent example of where the dam owner recognized that the most cost-effective solution to addressing the safety problems was dam removal. And third, the experience of Two-Mile Dam demonstrates how a private dam owner—and those who had benefited from the dam—were able to pay for the removal, rather than the costs falling on the general taxpayer.

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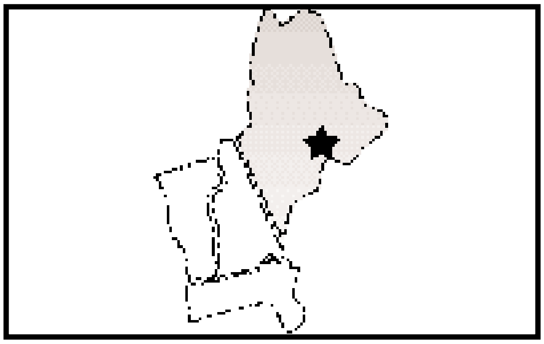

SOUADABSCOOK STREAM

REMOVAL OF THE GRIST MILL DAM IN MAINE

DAM REMOVAL BENEFITS: IMPROVED MIGRATORY FISH HABITAT, ELIMINATED PUBLIC SAFETY HAZARD, ENHANCED RECREATIONAL OPPORTUNITIES, COST SAVINGS

SUMMARY

The Grist Mill Dam was built in the late 1700s to provide mechanical power for a mill on the Souadabscook Stream near Hampden, Maine. The Grist Mill Dam was later converted to a hydroelectric facility that was regulated by the Federal Energy Regulatory Commission (FERC). The dam, which was located at the head-of-tide, was the first blockage from the Atlantic Ocean on the Souadabscook and prevented migratory fish passage upstream of the site. In the late 1990s the dam needed significant repairs, recognizing the enormous cost required to repair and provide adequate fish passage for the Grist Mill Dam, the owner petitioned FERC for approval to remove the hydropower dam. Through a cooperative effort involving numerous governmental and non-governmental organizations, the dam was removed in October 1998. Less than one month after the Grist Mill Dam was removed, Atlantic salmon from the Penobscot River returned to the Souadabscook Stream where they had been absent for over 200 years.

THE RIVER

Souadabscook Stream, a tributary to the Penobscot River in central Maine, has a drainage area of approximately 160 square miles. Due to the abundant cold water tributaries, bogs, and ponds that feed into the Souadabscook, the stream provides exceptional spawning and rearing habitat for migratory fish. This is unlike the Penobscot River, which during the summer months can become too warm for optimal fish spawning. Further, the high gradient of the Souadabscook causes the transport of gravel downstream. This creates ideal habitat for fish spawning in the lower reaches of Souadabscook Stream—habitat that was impounded by the Grist Mill Dam.

THE IMPACT PRIOR TO REMOVAL

The Grist Mill Dam on Souadabscook Stream, located at the head-of-tide and the first obstruction fish met when migrating up from the Atlantic Ocean, was the most significant barrier to migratory fish on this stream. The dam, originally built in the late 1700s to power a hydro-mechanical mill, was a 14-foot tall, 75-foot wide, inactive hydroelectric power facility with an inoperable fish ladder. For approximately 200 years, the Grist Mill Dam blocked access to habitat upstream of the site and effectively eliminated the migratory fishery on the Souadabscook. Because the Souadabscook watershed is historic fishing waters and hunting grounds for the Penobscot Indian Nation, there were also significant cultural impacts associated with the dam's elimination of the Souadabscook migratory fishery.

DAM REMOVAL FACTS:

- ¥ **Height: 14 ft; Length: 75 ft**
- ¥ **Impoundment: 58 acre-ft**
- ¥ **Built: late 1700s**
- ¥ **Original purpose: mechanical power for mill**
- ¥ **Later purpose: hydroelectric generation**
- ¥ **Generating capacity: active**
- ¥ **Owner: private individual**
- ¥ **Regulatory jurisdiction: FERC**
- ¥ **Estimated cost of repairing & maintaining dam: $150,000**
- ¥ **Cost of removal: $56,000**
- ¥ **Removed: October 1998**
- ¥ **Removal method: excavator with power hammer**

Not only were migratory fish significantly impacted by the dam's existence, but the dam also caused flooding, safety, recreational, and aesthetic problems on the Souadabscook. The dam was considered a serious public hazard due to the precarious position of the impoundment, which abutted US Route 1. The Maine Department of Transportation acknowledged that the reservoir caused significant damage to—and monetary expenditure for—US Route 1 and the bridge over the dam. Potential flooding of nearby properties was also a liability associated with the Grist Mill Dam. Many people felt that dam degraded the aesthetics of the Souadabscook—and that it's removal would make the stream a more valuable seasonal canoeing and kayaking resource.

THE REMOVAL DECISION & PROCESS

Although, it was not producing hydropower at the time of its removal, the Grist Mill Dam was regulated by the Federal Energy Regulatory Commission. The dam owner, who purchased the dam in the mid-1990s, was unaware at the time of purchase that the dam would require extensive repairs to its concrete face and inoperable fish ladder. After realizing that the dam would be costly to repair—and that there was no guarantee of a buyer for the generated power—the owner sold it to the Facilitators Improving Salmonid Habitat (FISH) for one dollar. The sale of the Grist Mill Dam was made with the understanding that it would be removed.

Primary funding for the Grist Mill Dam removal was through the Coastal America Partnership and the US Department of Agriculture's Wildlife Habitat Incentives Program (WHIP). Many other governmental and non-governmental organizations provided funding, technical assistance, and volunteer assets, including: National Resource Conservation Service, US Fish and Wildlife Service, USFWS Gulf of Maine Project, Federal Energy Regulatory Commission, Coastal America, Penobscot Indian Nation, Maine Atlantic Salmon Authority, Maine Department of Marine Resources, Maine Department of Environmental Protection, Penobscot County Soil and Water Conservation District, Maine Department of Inland Fisheries and Wildlife, Town of Hampden, Hampden Water District, SAD 22/Reeds Brook Middle School, John Jones, National Fish and Wildlife Foundation, Trout and Salmon

Conservation Foundation, Duke Energy Corporation-Maritimes Northeast Pipeline LLC, Heart of Maine Resource Conservation and Development Area, Maine Council Atlantic Salmon Federation, Atlantic Salmon Federation, Trout Unlimited/Sunkaze Chapter, Penobscot Fly Fishers, Veazie Salmon Club, Eddington Salmon Club, and Penobscot Salmon Club. The groups involved in the restoration of Souadabscook Stream raised over $60,000 in private donations to aid in the removal of the Grist Mill Dam.

REMOVAL BENEFITS:

- **Opened 3 miles of migratory fish habitat**
- **Restored historic fishing waters of Penobscot Nation Indians**
- **Improved overall health of river system**
- **Reduced likelihood of flooding to nearby properties**
- **Improved aesthetics at former dam site**
- **Increased canoeing & kayaking opportunities**
- **Eliminated damage to US Route 1 & associated costs**

To prepare for the removal, the Grist Mill Dam's reservoir was drained in August 1998. During the draining, Atlantic salmon trying to move upstream were seen below the dam's spillway. Numerous pools and gentle riffles were revealed once the Grist Mill reservoir was drained—all of which provide exceptional spawning habitat for migratory fish. In October 1998, the Grist Mill Dam was removed mechanically with a backhoe and other heavy equipment.

RESTORATION OF THE RIVER

The removal of the Grist Mill Dam significantly benefited migratory fish such as Atlantic salmon, sea-run brook trout, American shad, smelt, and alewife. In December 1998, less than four months after the Souadabscook Dam was removed, Atlantic salmon spawning sites were discovered above the former dam site for the first time in 200 years. This is in addition to improvements in the Souadabscook Stream's striped bass and alewife fisheries. Since the removal of the Grist Mill Dam, alewife are returning to Souadabscook Stream in record numbers. Further, restoration of the site improved the temperature, food availability, and flow conditions for all resident fish species, including brook trout.

Water quality has also improved at the site due to increased aeration of water—a result of restoring natural flows—and decreased water temperature—attributed to the elimination of the reservoir. The ecological changes associated with the removal of the Grist Mill Dam will create a substantially better forage base and habitat for Souadabscook Stream wildlife—including species such as bald eagles, osprey, herons, and river otters.

Increased recreational fishing opportunities for salmon, trout, and smelt—which are all economically valuable species—are likely to occur due to the Grist Mill Dam's removal. Additionally, commercial fishing opportunities for alewife and American eel are also expected to improve significantly with the removal of the dam. Hampden and the surrounding area should benefit monetarily from the increase in both commercial and recreational fishing generated by the Grist Mill Dam removal. Canoeing and kayaking opportunities, which are frequent activities on the Souadabscook, will be enhanced upstream by the removal of the dam. And the overall aesthetics of the site is already greatly improved and will serve as a valuable public resource for the Town of Hampden, especially as further restoration activities occur. Additional benefits from the Souadabscook Dam's removal include eliminating the risk of flooding to nearby properties, decreasing the expenditure for repairs to US Route 1 caused by the impoundment, and decreasing the safety risks associated with the impoundment's close proximity to this major thoroughfare.

Not only will these improvements provide an enhanced recreational resource for the state of Maine, but the removal of the Grist Mill Dam also aides in the restoration of the Penobscot Indian Nation's fishing heritage. Because the Souadabscook Stream and its tributaries are historic fishing waters for this tribe, the return of Atlantic salmon to the stream provides some hope that the Penobscot Indian Nation's native fishing waters will be restored.

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FUTURE EFFORTS TO RESTORE THE RIVER

Efforts to continue the restoration of Souadabscook Stream occurred this summer when the Souadabscook Falls Dam was removed and the Hampden Recreation Area Dam was breached. Removal of the Souadabscook Falls Dam, which was located three miles upstream of the Souadabscook Dam, will significantly improve fish passage, as well as canoeing and kayaking at the site. The dam, which was partially breached, prohibited migratory fish passage during low flows and often hindered fish passage during high flows when debris became trapped behind the dam. Souadabscook Falls Dam at one time generated hydropower, but was inactive prior to its removal and not regulated by FERC.

The Hampden Recreation Area dam was located 300 yards downstream of the Souadabscook Falls Dam. The height of the dam was very small—only two feet. However, during low flows, it prohibited the upstream passage of fish. Further, the reservoir, which at one time served as a community swimming hole, contributed to water quality degradation of the Souadabscook Stream. Breaching of the dam will improve both fish passage and water quality at the site.

THE SIGNIFICANCE OF THIS REMOVAL

The removal of the head-of-tide dam on the Souadabscook Stream brought about numerous and substantial benefits in the ecological health to this river system. But perhaps the most significant was the discovery last December—less than four months after the dam's removal—of four salmon spawning sites upstream of the former Grist Mill Dam. This is a true testament to the vitality of Atlantic salmon. After being blocked from spawning in the upper Souadabscook for over 200 years, the species was able to resume its lifecycle in this ideal habitat.

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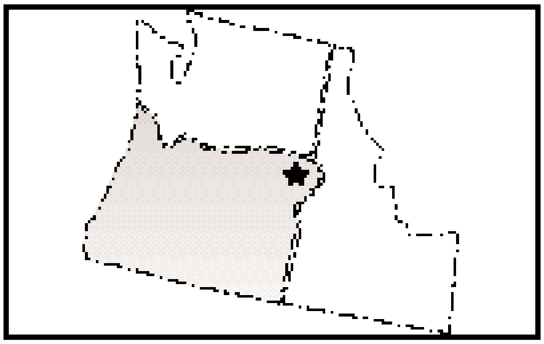

WALLA WALLA RIVER

REMOVAL OF THE MARIE DORIAN DAM IN OREGON

DAM REMOVAL BENEFITS: IMPROVED MIGRATORY FISH HABITAT, IMPROVED THREATENED SPECIES HABITAT

SUMMARY

The original Marie Dorian Dam was built in the 1880s on the Walla Walla River near Milton-Freewater in northeastern Oregon. It was probably used for irrigation purposes. In 1952, the US Army Corps of Engineers (Army Corps) upgraded the dam to an 8-foot high concrete structure for compatibility with levees being built at that time. In more recent years, only three irrigators were using the dam. The structure hindered the upstream passage of migratory fish, including summer steelhead, to spawning grounds. In addition, it prevented upstream and downstream populations of resident fish from mixing, which may have contributed to inbreeding and weakened stocks.

Because of fish passage concerns, the dam was scheduled for removal in the fall of 1997. However, the dam became undermined during a high water event in February of that year, leading to an emergency removal. The removal was the result of cooperation among more than seven different entities including federal, state, tribal, and local government agencies, non-profit environmental organizations, and private landowners. Removal has restored 20 miles of unhindered migratory fish passage and reconnected upstream and downstream resident fish populations for the first time in 110 years.

THE RIVER

The Walla Walla River starts off as two forks in the Blue Mountains of northeastern Oregon, with the East and West Forks extending 15 and 25 miles, respectively. They converge not far from the city of Milton-Freewater. The Marie Dorian Dam was located on the main stem, between this confluence and the city. Near Milton-Freewater, the Walla Walla turns north and heads into Washington, where it eventually discharges into the Columbia River. The main stem of the Walla Walla extends over 55 miles.

Salmon, including strong populations of native spring chinook, have historically inhabited the Walla Walla River basin. However, today all salmon species have been eliminated from the river. Several non-game fish species exist in the river, including white-fish, sculpin, and western brook lamprey. The river also contains redband trout, which is on the Oregon Sensitive Species list. The South Fork has a healthy population of bull trout, which is a federally-listed threatened species. Summer steelhead, also federally-listed as threatened, is found in the Walla Walla as well. The population on the Oregon stretch of the river is unique because it is wild; hatchery steelhead have never been released there.

DAM REMOVAL FACTS:

- ¥ Height: 8 ft; Length: 100 ft
- ¥ Built: 1880s
- ¥ Rebuilt: 1952
- ¥ Historic purpose: irrigation diversion
- ¥ Owner: Milton-Freewater Control District
- ¥ Regulatory jurisdiction: state
- ¥ Estimated cost of repair: not examined
- ¥ Cost of removal: $30,000 plus $15,000 to install well for irrigation to replace diversion from dam
- ¥ Removed: April 1997
- ¥ Removal method: track-hoe with a large claw

THE IMPACT PRIOR TO REMOVAL

The impacts of the Marie Dorian Dam are closely tied to its history. The Walla Walla River was blocked in some form by a dam for approximately 110 years. The first dam was reportedly constructed of wooden splashboard in the 1880s, and was probably used for irrigation. It assumed its final form in 1952 when, during a levee construction period, the Army Corps upgraded the dam to an eight-foot high concrete structure for compatibility with nearby levees. It spanned the entire 100 feet of river width and was used for irrigation. In 1961, owner-ship of the dam passed to the Milton-Freewater Water Control District. In recent years, only three irrigators were using the dam.

Early on, and still today, irrigation withdrawals dewatered large sections of the river, contributing to the elimination of spring and fall chinook salmon runs in the Walla Walla. When the Marie Dorian Dam was upgraded in 1952, it presented an eight-foot high obstacle to upstream fish passage that often prevented migratory fish from reaching spawning grounds. Moreover, the dam created a fish “traffic jam,” as fish would reach the dam, be unable to leap over it, and then remain there trying to do so. This congregation of fish at the dam subjected them to increased poaching. If adults did succeed in jumping the dam, some landed on exposed rebar, and some were exhausted by the effort, both of which may have resulted in delayed mortality or prevented them from reproducing. The situation was even worse for juveniles that had forayed downstream, but were not yet ready to migrate out to sea and not yet strong enough to jump the dam. Such juveniles were stranded below the structure, and could not move upstream to additional rearing and feeding grounds.

While the Marie Dorian Dam was a challenge for migratory fish, it was a complete barrier to resident fish, which are not equipped to jump at all. This meant that the bull trout population in the Walla Walla’s main stem could not mix with the healthier South Fork population further upstream. Some fish biologists feared that main stem bull trout would eventually inbreed to the point of extinction.

In February 1997 when a scour hole developed underneath the dam, causing it to become undermined, the Marie Dorian became a barrier to all fish, both migratory and resident. The river squeezed beneath the dam in high-velocity turbulent currents, instead of flowing over the top, making fish passage impossible. Migratory steelhead were already arriving, and so until the dam was removed two months later, fish crews trapped and hauled the steelhead by truck to their upstream spawning grounds.

THE REMOVAL DECISION AND PROCESS

Due to fish passage concerns, the Army Corps recommended removal of the Marie Dorian Dam in 1996. The Army Corps recommended this removal as a habitat restoration project pursuant to Section 1135 of the Water Resources Development Act. The removal was scheduled for the fall of 1997.

REMOVAL BENEFITS:

- ¥ **Provided native migratory fish with access to historic spawning grounds**
- ¥ **Allowed upstream and down stream non-migratory fish populations to mix more easily, thereby ensuring genetic diversity**
- ¥ **Implemented first step in series of river restoration projects**

However, in February of 1997, a scour hole developed underneath the dam, and the river flow undermined the structure, resulting in an emergency situation. In addition to completely blocking fish passage, water was no longer available to three irrigators, and there was the possibility that an irrigation ditch 1,500 feet upstream of the dam, which served 35 to 45 families, might also be affected. The Army Corps was also concerned that the scour hole might move laterally and damage levees in the area during a high flow event associated with spring snow melt.

The state and water district considered several options to remedy the problems, but all were eventually ruled out. Finally, the Army Corps arranged two meetings for the various stakeholders to develop a plan for addressing the situation. Participants included representatives from the city of Milton-Freewater, the Milton-Freewater Water Control District, the Oregon Department of Fish and Wildlife, affected irrigators, the Confederated Tribes of the Umatilla Indian Reservation, and two non-profit organizations—the Tri-State Steelheaders and Trout Unlimited. The Army Corps acted as a facilitator and technical advisor. Although the Army Corps had committed resources to removing the dam in the fall of 1997 as a restoration project, once the removal became an emergency situation, the Army Corps no longer had the authority to conduct (or fund) the removal.

The group decided to remove the dam and drill a shallow well to serve the three irrigators who were no longer receiving water. A wait and see approach was adopted for concerns about possible impacts of dam removal on the upstream irrigation ditch. (Thus far, the ditch has not been affected.) Over seven entities contributed a total of $15,000 to drill the shallow well. The Confederated Tribes paid for the $30,000 needed for the emergency removal of the Marie Dorian Dam out of funds they had been allocated from the Bonneville Power Administration.

The group assembled by the Army Corps had decided against blasting because of possible impacts on adult steelhead that were already in the river. Instead, removal was accomplished using a track-hoe equipped with a large claw that chewed through the dam's three-foot thick concrete walls. In order to minimize the turbidity associated with the removal, the track-hoe entered the water only to reach a gravel bar in the river. From there, it extended its arm out over the water to the dam. The Marie Dorian Dam was removed over two days, April 3 and 4, 1997.

RESTORATION OF THE RIVER

The removal of the Marie Dorian Dam opened 20 miles of unhindered migratory fish passage. This allows adult migratory fish to reach upstream spawning grounds more easily and prevents juveniles from becoming stranded downstream, both of which are expected to help increase the Walla Walla's summer steelhead population.

The dam removal also allows downstream and upstream non-migratory fish populations to mix more readily, thereby strengthening their genetic makeup. This is expected to prove particularly beneficial for the Walla Walla's main stem bull trout population, by helping it reconnect with the healthier South Fork population. A related project, the 1998 removal of the Maiden Dam from the Walla Walla's primary tributary, the Touchet River in Washington, has also aided in the river's restoration.

FUTURE EFFORTS TO RESTORE THE RIVER

The Army Corps, in cooperation with the Confederated Tribes of the Umatilla Indian Reservation, is planning to construct a fish ladder at the Nursery Bridge Dam, roughly three miles downstream of the former Marie Dorian Dam site. The Nursery Bridge Dam already has a fish ladder, dating back to 1967, but it is ineffective because it was placed on the bank opposite that of the main flow and has an obsolete design. Upstream migrating fish naturally follow the stronger, main flow, and thus, many ascending adults are unable to locate the fish ladder. They may spend days, or even weeks, attempting to get past the dam. Some adults never succeed, and some perish in the attempt. A correctly designed and placed fish ladder, scheduled for construction in the summer of 2000, is expected to greatly enhance upstream fish passage.

Other river restoration efforts being planned by a combination of federal, state, tribal, and local interest groups include: habitat protection and restoration, instream flow augmentation, fish passage improvements for both adults and juveniles, and the reintroduction of the native spring chinook salmon.

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THE SIGNIFICANCE OF THIS REMOVAL

The removal of the Marie Dorian Dam restored 20 miles of river for migratory and resident fish, including federally-threatened bull trout and summer steelhead. The removal process involved the cooperation of over seven different entities including federal, state, tribal, and local government agencies, non-profit environmental organizations, and private landowners.

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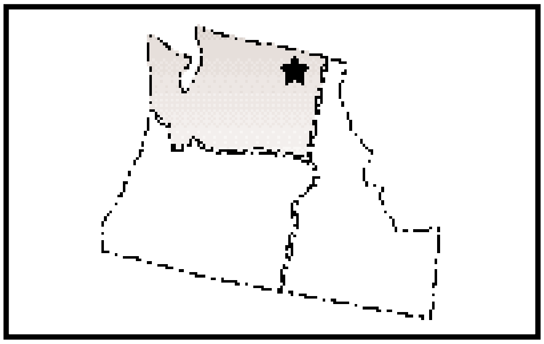

WHITESTONE CREEK

REMOVAL OF THE RAT LAKE DAM IN WASHINGTON STATE

DAM REMOVAL BENEFITS: ELIMINATED PUBLIC SAFETY HAZARD, IMPROVED WILDLIFE HABITAT, RESOLVED LEGAL LIABILITY DISPUTE

SUMMARY

Rat Lake Dam was a 32-foot high earth-embankment dam built in 1910 on Whitestone Creek to augment the natural storage of Rat Lake. The dam was removed in 1989 due to severe safety deficiencies identified during inspection by state and federal agencies in 1978. The structure was determined to have inadequate spillway capacity to pass a 100-year flood, and overtopping of the dam would have caused very rapid failure. Requests by local landowners and elected officials to pursue repair or replacement of the dam were considered, but analyses by the Washington State Department of Ecology (DOE) of potential costs and benefits identified dam removal as the least cost alternative. A dispute over legal ownership of the dam and who was responsible for resolving the safety problems delayed implementation of a final decision for several years. In 1987, Washington State filed suit seeking a court order to force the property owner to either repair or remove the dam. A subsequent settlement agreement was reached in which all parties agreed that the threat posed by the dam was the top priority, and the landowner agreed to remove the dam. The removal of Rat Lake Dam, which was one-fifth the cost of the next cheapest alternative, eliminated numerous public safety hazards created by the dam.

THE RIVER

Whitestone Creek is a tributary of Swamp Creek, which flows into the Columbia River in north-central Washington State. It drains a watershed of approximately 29 square miles in Okanogan County just north of the Town of Brewster. The basin is a semiarid area, sparsely forested with pine trees accompanied by scattered brush, sage and grasses. It is a popular fishing spot for anglers pursuing rainbow trout and other resident species. The basin is in a remote, rural region of Washington State, with some small ranches, orchards and farms located in the basin.

IMPACTS PRIOR TO REMOVAL

Rat Lake Dam was built by the Okanogan Power & Improvement Company (OPIC) to increase the irrigation capacity of the already existing lake. The dam had a storage capacity of 1,500 acre-feet, with a 22-inch wood-stave outlet pipe and a control valve on the downstream end. The original concrete spillway was constructed high on the right side of the embankment and apparently never functioned. The gate on the outlet works was never closed and the wood-stave pipe acted as a spillway. OPIC dissolved in 1929 and the operation of the dam was taken over by the Town of Brewster. Citizens of the town considered it to be an effective flood control device, irrigation source, and recreational area.

DAM REMOVAL FACTS:

- ¥ Height: 32 ft; Length: 240 ft
- ¥ Impoundment: 1,500 acre-ft
- ¥ Built: 1910
- ¥ Purpose: irrigation, flood control, recreation
- ¥ Owner: private (though disputed)
- ¥ Regulatory jurisdiction: state
- ¥ Estimated cost of repair: $261,000
- ¥ Cost of removal: $52,000
- ¥ Removed: 1989
- ¥ Removal method: heavy equipment

The dam was constructed of porous native materials that became very unstable when saturated. In 1950, saturation occurred when the wood outlet pipe collapsed causing the lake level to rise. Because this was considered a hazard to the Town of Brewster, emergency actions were taken. A partial course rock filter was placed at the downstream toe in addition to a wider crest constructed by bulldozing materials to the downstream slope. Washington State also recommended a more adequate spillway and a new outlet structure. In 1952, the plans for the new outlet were approved and it was constructed shortly thereafter. However, in lieu of constructing a new spillway, embankment material to the right of the old spillway was removed to 3.2 feet below the dam crest and the old spillway was left in place. It is not known why these measures were taken instead of those recommended by the state.

REMOVAL DECISION & PROCESS

In July of 1978, representatives of the US Army Corps of Engineers and the Washington DOE inspected the dam under the National Dam Inspection Act. Several major structural deficiencies were found during the inspection. These included no formal warning system or plan of action in the event of dam distress; improper construction methods and procedures used in the 1952 modifications that could have led to internal erosion of the dam and instability of the downstream slope; improper dam maintenance, a lack of any operation records and no plan for regular operation and maintenance; and most importantly, inadequate spillway capacity which could have led to overtopping and very rapid dam failure.

The Washington DOE estimated that a dam failure would have produced a flood peak discharge on the order of 10,000 cubic feet per second (cfs) and would have reached the Town of Brewster within an hour of failure. The resultant property damage could have easily extended into the millions of dollars, and there would have been a very high potential for loss of life.

A report was prepared by the Washington DOE to evaluate various options for rehabilitating the dam. It included information on benefits and estimated construction costs for a range of alternatives, as well as potential sources of funding for financing each option. The Washington DOE identified four primary options: 1) removing the dam at a cost of $52,000; 2) rehabilitating the existing dam and spillway at a cost of $261,000; 3) enlarging the existing dam by 30 feet and constructing an auxiliary spillway at a cost of $798,000; and 4) constructing a new 120 foot high dam downstream and removing the existing Rat Lake Dam at a cost of $3,021,000. In light of the fact that it was by far the cheapest alternative, dam removal was selected as the most cost-effective option for resolving the numerous safety problems at Rat Lake Dam.

However, because the ownership of the dam was in question, the removal process was delayed. After OPIC dissolved in 1929, operation of the dam and reservoir reverted to the Town of Brewster, while the land became property of Gebbers Farms. When questions of dam ownership surfaced in the 1980s in context of dam safety issues, Gebbers Farms would not take responsibility for ownership even though they had been paying property tax for the land on which the dam was located. A lawsuit was filed in 1987 by Washington State to declare ownership and require that the rightful owner take the necessary actions to either fix or remove the dam. Under state law, the Attorney General has the power seek the abatement of an unsafe dam that is assumed to be a nuisance. A settlement was reached in 1988 in which the Washington DOE, Gebbers Farms, and the Town of Brewster agreed that the issue of ownership was not as important as the safety of the townspeople. Gebbers Farms agreed to remove the dam in the interest of public safety.

REMOVAL BENEFITS:

- ¥ **Eliminated public safety threat**
- ¥ **Provided least cost solution to failing dam**
- ¥ **Restored natural river and lake shoreline habitat**
- ¥ **Resolved legal liability dispute**

A work permit was issued in 1988 that included plans to use bulldozers and scrapers to remove the dam and restore the natural outlet of the lake. All work took place while the lake level was below the natural outlet of lake. Excess excavation materials were placed on upland sites away from natural waterways and the vicinity of the dam was restored to its original form. Because of the emergency situation, the removal was exempt from the Washington State Environmental Policy Act and provisions of Shoreline Master Program permits. There were no special precautions taken for sediment because of the emergency situation and because no significant sediment had built up behind the dam.

RESTORATION OF THE RIVER

There were no complications with the removal, and the site was restored to the shape of the original canyon. Rat Lake returned to its natural shoreline with a surface area of about 60 acres and a maximum depth of 60 feet. All disturbed areas were revegetated to restore the natural flora and reduce the invasion of any noxious weeds. The impact on recreational use of Rat Lake was minimal, and the former dam site is now used as a campsite, fishing spot, and public access to the lake. Removal of the dam did result in the loss of some flood control protection downstream, but there have not been any reported problems to date.

FUTURE EFFORTS TO RESTORE THE RIVER

With the removal of Rat Lake Dam, there are no current plans for additional restoration activities in the Whitestone Creek watershed. Fishing in Rat Lake remains popular, and the Washington Department of Fish and Wildlife regularly stocks rainbow and brown trout in the Lake. Unfortunately, there currently is not strong interest from the local community to pursue the numerous riparian habitat restoration and enhancement opportunities that exist along Whitestone Creek.

THE SIGNIFICANCE OF THIS REMOVAL

The case of Rat Lake Dam highlights the need for strong dam safety inspection programs and the value of dam removal as a cost-effective means for addressing deficiencies identified during those inspections. With the rising number of aging and neglected dams across the country, the removal of Rat Lake Dam illustrates the potential dangers of "deadbeat dams" abandoned by their owners, and provides an excellent example of how dam removal is often the most cost-effective way to address pressing public safety issues. Removal of Rat Lake Dam was one-fifth the cost of the next cheapest alternative to resolve the public safety problem created by the dam. The protracted political and legal process leading up to the final decision about Rat Lake Dam also demonstrates the need for state and federal agencies to develop clear policies and procedures to cope with aging dams and the value of establishing decommissioning funds to pay for the removal of such dams.

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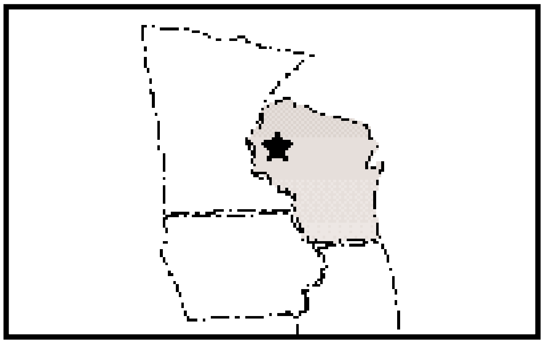


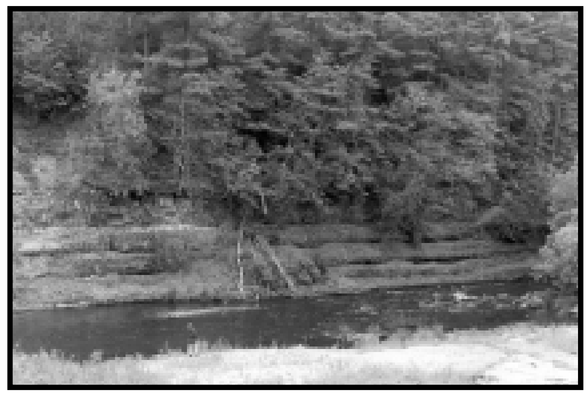
WILLOW RIVER

REMOVAL OF THE WILLOW FALLS AND MOUNDS DAMS IN WISCONSIN

DAM REMOVAL BENEFITS: IMPROVED FISH HABITAT, ENHANCED AESTHETICS, IMPROVED WATER QUALITY, ELIMINATED PUBLIC SAFETY HAZARD, COST SAVINGS

SUMMARY

The Willow Falls and Mounds Dams were both removed during the 1990s from the Willow River in northwestern Wisconsin. The dams were located in the Willow Falls State Park, just across the border from the Twin Cities of Minneapolis-St.Paul, Minnesota. Public safety factors triggered both removals, and both removal decisions were made primarily for economic reasons.



There were three dams on the Willow in the state park. The steep gradient that made these sites ideal for power generation also made them visually striking restorations. The Willow Falls Dam (the middle of the three dams) was taken out in 1992, restoring a valuable coolwater fishery, as well as the dam's namesake, Willow Falls. The removal also uncovered a stunning limestone gorge, a scenic waterfall, and cold springs. The Mounds Dam, upstream from the former Willow Falls Dam site, came out in the winter of 1998, exposing a narrow and steep stream channel with cascading riffles. Removal of both dams together has restored four miles of trout stream.

THE RIVER

The Willow River is naturally a coolwater stream. It flows from its headwaters in Polk County, northeast of the town of Deer Park, 40 miles southwest through the heart of the Willow Falls State Park, to the federally-designated Wild and Scenic St. Croix River near North Hudson. (The St. Croix then continues on to the Mississippi River.) The Willow River segment that flows through the park has a steep gradient and steep sides. In the late 1850s, before any of the three dams had been built, the Willow's picturesque gorge was a fashionable place to picnic. Today the river corridor and park, located along the Mississippi Flyway, provide habitat for over 200 species of birds.

THE IMPACT PRIOR TO REMOVAL

Although the reported dates vary, it appears that all three dams were originally built in the late 1800s to power lumber and flourmills. All were later used to produce electricity. Northern States Power Company, the last private owner of the dams, stopped generating power on the river in 1963 and shortly thereafter donated the dams and 1,300 acres of land to the state for a park.

Damming the Willow River destroyed its historic cool water fishery and rerouted water away from the scenic Willow Falls. The dams caused unnatural and damaging changes in river flows, temperatures, and oxygen levels. The solar heat in the impoundments was especially damaging to trout populations. The Mounds impoundment had very poor water quality largely due to polluted runoff from farmland and urban areas. Prior to removal sediments built up behind the dams and filled the impoundments with silt. Floating vegetation and debris were present three seasons of the year, and were particularly prolific during summer months, making recreational values of the impoundment poor.

WILLOW FALLS & MOUNDS DAM REMOVAL FACTS:

- **Height: 60 ft & 58 ft**
- **Impoundment: 100 acres & 57 acres**
- **Built: 1870 & 1926**
- **Purpose: power for mills (both)**
- **Owner: Wisconsin DNR (both)**
- **Regulatory jurisdiction: state (both)**
- **Estimated cost of repair: concrete beyond repair, no estimates made & $3.3 million to $6 million**
- **Estimated cost of removal: $622,000 & $1.1 million**
- **Cost of removal: $450,000 & $170,000**
- **Removed: 1992 & 1998**

THE REMOVAL DECISION & PROCESS

There was considerable study of all three dams. In the late 1980s, the owner of the dams, the Wisconsin Department of Natural Resources (DNR), formed the Willow River Dams Task Force to address complex issues involving the state's ownership of the dams. A 1988 report showed overwhelming public support for the repair of all three structures, but concrete testing showed that the Willow Falls Dam was in such bad condition it was literally beyond repair. The state proceeded with removal of the Willow Falls Dam. The actual cost of removal was approximately 85 percent less than estimated.

The state was planning to repair the Mounds Dam when a 1989 inspection found the structure did not meet safety standards. Preliminary repair estimates for the Mounds Dam were $1.5 million. But, within a few years, these estimates increased to at least $3.5 million, and by 1997 repair estimates skyrocketed as high as almost $7 million. (Wisconsin experiences show that underestimation of dam repair costs is typical. In the early 1990s, for example, the Mounds Dam underwent sluice gate repairs that were estimated to cost $35,000, but actually cost $102,500—a nearly 300 percent increase from the estimate.) In contrast, estimates for the removal of the Mounds Dam in 1997 were $1.1 million. For economic reasons, the state decided to proceed with removal. The actual cost of removal was only $170,000.

RESTORATION OF THE RIVER

The two-mile river segment restored by the Mounds Dam removal contains a 37-foot drop in elevation. Removal of both dams has restored a total of four miles of the Willow River. This stretch of the river now features a narrow and steep stream channel with cascading riffles, several small waterfalls, cold springs, and a stunning limestone canyon. The restored Willow Falls waterfall has become one of the most popular attractions in the park. In 1996, it graced the cover of the city of Hudson's promotional brochure.

REMOVAL BENEFITS:

- **Restoration of 4 miles of trout fishery**
- **Recreational improvements to the Willow River State Park, including a new trail system**
- **Restoration of scenic Willow Falls and other natural landscape features**
- **Removal of safety threat to park visitors**
- **Saving of taxpayer dollars**

Following removal of the Mounds Dam, the river's natural flushing ability gradually moved sediment downstream from the reservoir. The exposed lakebed was then riprapped and seeded, and stream stabilization structures were installed. The stream segment is now managed as habitat for brown, brook, and rainbow trout. Just one year after the Mounds Dam removal, a fish survey found 13-inch brown trout and 15-inch rainbow trout in the restored stream segment.

A new series of hiking and running trails now runs along the restored stream, providing easy public access to the water and overlooking many scenic vistas restored through the dam removal. Visitors to Willow Falls State Park might also be interested in visiting the nearby town of Somerset (11 miles north), where river tubing businesses now thrive on the Apple River, following removal of the Somerset Dam in 1965.

FUTURE EFFORTS TO RESTORE THE RIVER

According to local anglers, the trout fishery below Willow Falls was excellent after the removal of the Willow Falls Dam. As expected, following the removal of the Mounds Dam upstream, the fishery has been degraded as years of sediments continue to flush downstream. However, the river segment was stocked last season with trout, and now maintains a healthy fishery. Some sediment from the removal of the Mounds and Willow Falls Dams has settled downstream in Little Falls Lake (formed by the Little Falls Dam). The Wisconsin DNR is considering dredging this sediment from the impoundment when funding becomes available. There are no plans to remove Little Falls Dam.

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THE SIGNIFICANCE OF THIS REMOVAL

The Willow Falls State Park is one of the most popular in the state, not only for its scenic beauty, but also because of its close proximity to the Twin Cities area (Minneapolis-St. Paul, Minnesota) which has a population of over two million people. The removal of the Willow Falls and Mounds Dams restored four miles of trout waters adjacent to this large and rapidly growing metropolitan area. The dam removals also restored the scenic beauty of the original gorge. The restoration saved taxpayers the high costs of repairing the two old structures and the burden of future repair and liability.

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DAM REMOVAL SUCCESS STORIES:
Restoring Rivers through Selective Removal of Dams that Don't Make Sense

APPENDICES

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DAM REMOVAL SUCCESS STORIES:

Restoring Rivers through Selective Removal of Dams that Don't Make Sense

APPENDIX A
LESSONS LEARNED FROM THE FORT EDWARD DAM REMOVAL

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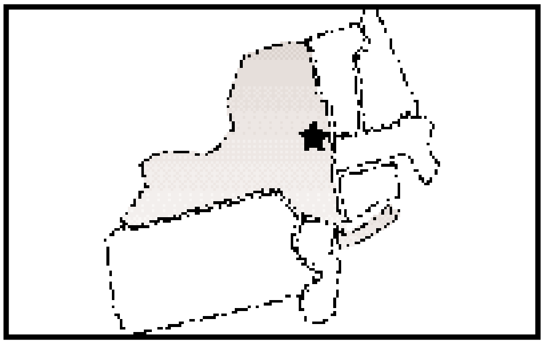

HUDSON RIVER

REMOVAL OF THE FORT EDWARD DAM IN NEW YORK

DAM REMOVAL LESSONS LEARNED

SUMMARY

In the history of dam removals, the Fort Edward Dam experience is in many ways a testimony of what not to do. Fort Edward Dam was built in 1898 on the Hudson River, approximately 54 miles upstream of Albany, New York. By 1969, the condition of the dam was poor, and engineering studies showed that repair or replacement of the project was uneconomical. The owner, Niagara Mohawk Power Corporation, decided in 1971 to remove the structure to avert the danger of dam failure. Unfortunately, inadequate research and engineering analyses were conducted prior to removal of the dam in 1973. As a result, several tons of PCB-laden sediments from behind the dam were released downstream following dam removal, adversely affecting navigation, fish and wildlife, water quality, flood control, and public health. Large-scale cleanup and restoration efforts were required to address the serious environmental and economic damage resulting from the Fort Edward Dam removal. While this dam removal is clearly not a success story, it does provide valuable lessons to help ensure that future dam removals do not repeat the mistakes made on the Hudson River.

DAM REMOVAL FACTS:

- ¥ Height: 31 ft; Length: 586 ft
- ¥ Impoundment: 195 acres
- ¥ Built: 1898
- ¥ Purpose: hydropower
- ¥ Generating capacity: 2.85 MW
- ¥ Owner: Niagra Mohawk Power Corporation
- ¥ Regulatory jurisdiction: FERC
- ¥ Estimated cost of replacement: $3,947,250
- ¥ Cost of removal: $464,000 (does not include cleanup costs)
- ¥ Removed: 1973
- ¥ Removal Method: heavy construction equipment

THE RIVER

The source of the Hudson River is Lake Tear of the Clouds in the High Peaks region of the Adirondack Mountains. From there, the river flows in a southerly direction for 315 miles to Battery Park at the southern tip of Manhattan, draining nearly 14,000 square miles. The area surrounding the river in the vicinity of Fort Edward Dam is urban and industrial, with numerous manufacturing plants that produce a variety of products. The river is used heavily for navigation and shipping and as a water supply source for numerous communities along the river.

IMPACTS PRIOR TO REMOVAL

Fort Edward Dam was a timber crib dam originally built in 1898. It was 586 feet long with a maximum height of 31 feet and impounded approximately 195 acres along 2.5 miles of the Hudson River.

The accompanying 98-foot long powerhouse with four turbine generators had a total capacity of 2.85 megawatts. The dam was owned by the Niagara Mohawk Power Corporation, an investor-owned electric and gas utility and was one of six dams under a license by the Federal Power Commission (now the Federal Energy Regulatory Commission). In 1969, Niagara Mohawk conducted an engineering evaluation of the aging Fort Edward Dam and concluded that the poor condition of the dam made the project a public safety hazard. Fearing an imminent dam failure, a dike was constructed on the southwest end to protect the dam from flood flows. Even with this modification, Fort Edward Dam remained a significant threat to people and property downstream of the dam.

REMOVAL DECISION & PROCESS

Engineering studies conducted in the early 1970s showed that repair or replacement of the Fort Edward Dam and continued electrical generation were uneconomical. These studies concluded that the cost of new construction and turbine generator modifications were far greater than the value of the dam. Niagara Mohawk determined that retirement was the most cost-effective solution to the safety problems associated with the dam, so the company developed a removal plan. In 1972, Niagara Mohawk applied for and received a Stream Protection Permit for the removal from the New York State Department of Environmental Conservation (NYSDEC). The Federal Power Commission conducted one of its first Environmental Impact Statements on the proposed removal of Fort Edward Dam. Pursuant to this review, the Commission approved the removal in 1973. Local communities in the area near the dam were consulted, and they too consented to the removal of Fort Edward Dam.

Various stipulations were required by NYSDEC in allowing the removal to take place. Dikes were constructed in the disposal areas to prevent water contamination during demolition. Some water quality deterioration was predicted, but considered acceptable. The New York State Department of Health was consulted regarding mosquito breeding control in the exposed riverbeds. The permit mandated that Niagara Mohawk cooperate with the paper mill located next to the powerhouse in order to maintain the quality of the mill's water supply. In addition, because Lock #7 of the Champlain section of the New York State Barge Canal was located immediately downstream of the dam site, the permit required that the dam removal cause no unreasonable interference with navigation.

Niagara Mohawk's removal plan anticipated the presence of very little silt behind the dam. Approximately 3,200 cubic yards of sediment (considered to be a small amount) were to be removed before breaching the dam. The removal was expected to expose approximately 100 acres of former reservoir bottom, which would be allowed to recover naturally.

The actual removal process took approximately two months during late summer 1973. The stone-filled timber crib dam, 3,400 cubic yards of sediment, the power house units, the bridge across the forebay, and the concrete spillway were removed using heavy construction equipment. Some scrap materials were deposited in the old forebay, which was covered with topsoil and planted with grass. Total project costs were $464,000, and the operation seemed to have been finished without a hitch.

However, in the subsequent months and years, significant navigation and water quality problems arose due to poor analysis of the amount and content of sediments behind the dam. Removal released an estimated 30,000 cubic yards of bedload materials from the former impoundment in 1974, with the amount increasing in subsequent years. In addition, as the river's water level dropped 20 feet at the dam site following removal, approximately 90 previously submerged stone-filled timber cribs historically used in river log drives were discovered in the river upstream of the dam site. With exposure to air and new river currents, these cribs began to deteriorate, causing navigation problems. Although the cribs had been exposed during previous drawdowns, their existence was not considered during the planning for dam removal.

The accumulation of silt and stone cribs in the Hudson River's navigation channel effectively closed all shipping in 1974 in that stretch of the river. The east channel was blocked to navigation, the west channel was significantly reduced in depth, and around Lock #7 the river was reduced to a depth of four feet. The sediment deposits also clogged a marina, a recreational park, several industrial sites, and other downstream areas. The reduced channel capacity caused by the increased sediment load also created a serious flood hazard for the village of Fort Edward.

In addition, the removal created unanticipated water quality problems. The sediment deposits and restricted water flow posed a public health hazard due to the stagnation of untreated raw sewage that flowed into the Hudson River. Even more problematic was the discovery of polychlorinated biphenyl (PCB) contaminants in the river sediments moving downstream. These PCBs originated from the electrical manufacturing plants upstream of the dam site and had accumulated behind the dam. The removal re-released these contaminated sediments and dispersed them downstream at an unsafe level, requiring extensive cleanup efforts.

LESSONS LEARNED

¥ Where historic records of upstream activities indicate possible presence of pollutants in the river, test accumulated sediment upstream of dam for potential pollutants
¥ Determine volume of sediment upstream of dam and potential impacts of sediment on downstream navigation, structures, and other river uses
¥ Investigate potential hazards and blockages in reservoir that become exposed with dam removal
¥ Determine clear and unambiguous conditions in removal authorizations

RESTORATION OF THE RIVER

Litigation over the serious environmental and economic damage resulting from the Fort Edward Dam removal was filed in the New York Court of Claims. While settlement discussions to resolve the legal issues were being held among all involved parties, numerous cleanup and restoration efforts were undertaken.

To address the blockage of the navigation channel, the State of New York requested assistance from the US Army Corps of Engineers. From 1974 to 1976, New York dredged 615,000 cubic yards of sediment in order to restore and keep open the navigation channel, as well as to lessen the flood danger. Routine, smaller-scale dredging has been utilized in subsequent years to maintain this river stretch as a navigation channel.

The significant water quality problems created by PCB-contaminated sediments released from behind the dam and directly released into the river at the upstream electrical manufacturing plants led to extensive cleanup and restoration efforts by state and federal agencies. From 1974 to 1977, sediment samples were taken and monitored by the US Environmental Protection Agency (EPA), NYSDEC, and a private consultant. In 1976, New York State closed the Hudson River for fishing, decimating a $40 million striped bass fishery. In 1977 and 1978, approximately 180,000 cubic yards of contaminated sediments were removed from the river by the state. And in 1983 the EPA declared a significant stretch of the river a federal Superfund site due to the PCB contamination. EPA and NYSDEC continue to evaluate options for addressing this extensive PCB contamination. Full remediation has yet to be completed.

THE SIGNIFICANCE OF THIS REMOVAL

Fort Edward Dam provides valuable lessons on some steps to take in planning a dam removal to ensure that mistakes made in the Fort Edward removal are not repeated. Pursuant to hearings conducted by the Federal Power Commission, the dam owner, the Commission, and state and local officials were found not to have exercised due diligence in planning for and completing the dam removal. The Commission also made the following recommendations for future dam removal decisions:

- Precise and unambiguous conditions in the authorizations for dam removals are necessary to avoid differing interpretations;
- Conditions should be prescribed that require adequate investigations to be made of the entire area retained by the dam; and
- The effect of lowering the level above the dam removal site must be evaluated; specifically, susceptibility to erosion or movement of materials in and near the riverbed.

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The problems encountered in the Fort Edward Dam removal resulted not only from mismanagement, but also from a lack of experience in major dam removals. As the Federal Power Commission concluded in 1978, "Any license for dam removal in the future will be drafted differently, with the lessons of Fort Edward in mind."

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DAM REMOVAL SUCCESS STORIES:
Restoring Rivers through Selective Removal of Dams that Don't Make Sense

APPENDIX B
COLOR PHOTOGRAPHS

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Waterworks Dam - Baraboo River, WI

Before Removal

Source: River Alliance of Wisconsin

After Removal

Source: River Alliance of Wisconsin

Jackson Street Dam - Bear Creek, OR

Before Removal

Source: Medford Urban Renewal Agency

After Removal

Source: Lance Smith, National Marine Fisheries Service

McPherrin Dam - Butte Creek, CA

Before Removal

Source: US Bureau of Reclamation

After Removal

Source: US Bureau of Reclamation

Welch Dam - Cannon River, MN

Before Removal

Source: Craig Regalia, Minnesota DNR

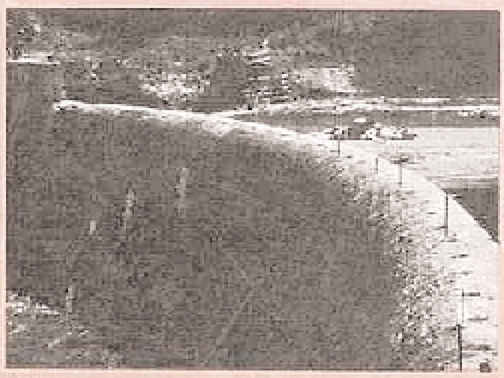
After Removal

Source: Craig Regalia, Minnesota DNR

Grangeville Dam - Clearwater River, ID

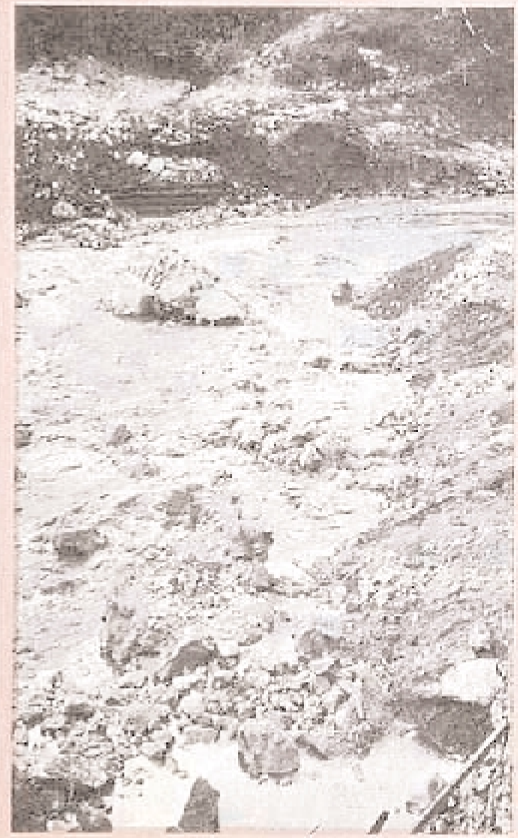
Photos courtesy of the Izaak Walton Magazine, Outdoors America, November 1963

Here is the dam in operation before demolition operations were started



The center mass of concrete was 440 feet long; 30 feet wide at the base

Five tons of dynamite in holes 35—45 feet deep made this vast explosion



The entire dam was wiped out except piece at right kept to contain road fill

Newport No. 11 Dam - Clyde River, VT

Before Removal

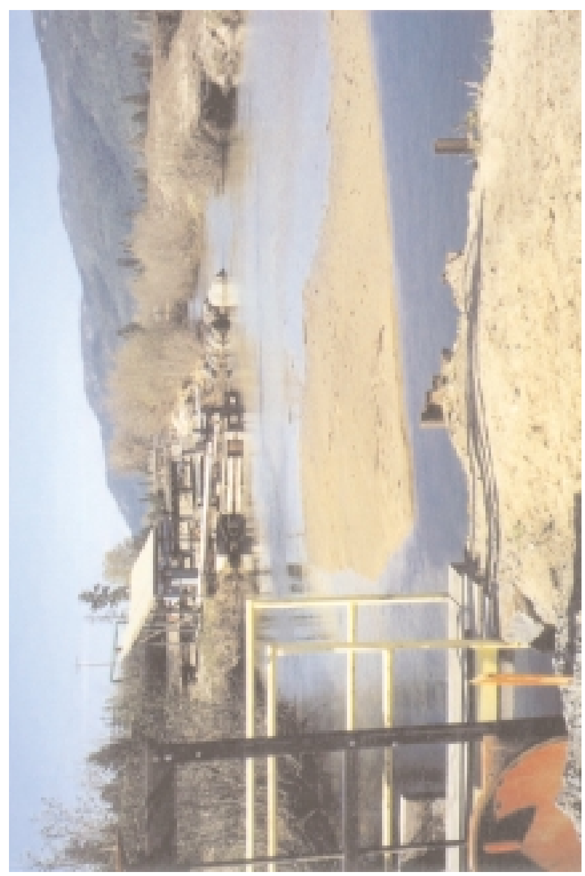
Source: Paul O. Boisvert

After Removal

Source: Paul O. Boisvert

Colburn Mill Pond Dam - Colburn Creek, ID

Before Removal



Source: Crown Pacific Partners, L.P.

After Removal

Source: Crown Pacific Partners, L.P.

Lake Christopher Dam - Cold Creek, CA

Before Removal

Source: California Tahoe Conservancy

After Removal

Source: Natural Resources Conservation Service

Rock Hill Dam - Conestoga River, PA

Before Removal

Source: Pennsylvania Fish & Boat Commission

After Removal

Source: Pennsylvania Fish & Boat Commission

Alphonso Dam - Evans Creek, OR

Before Removal

Source: Jayne LeFors, Bureau of Land Management

After Removal

Source: Jayne LeFors, Bureau of Land Management

Williamsburg Station Dam - Juniata River, PA

Before Removal

Source: Pennsylvania Fish & Boat Commission

After Removal

Source: Pennsylvania Fish & Boat Commission

Edwards Dam - Kennebec River, ME

Before Removal

Source: American Rivers

After Removal

Source: Steve Brooke

Sandstone Dam - Kettle River, MN

Before Removal

Source: Ian Chisholm, Minnesota DNR

After Removal

Source: Ian Chisholm, Minnesota DNR

Woolen Mills Dam - Milwaukee River, WI

Before Removal

Source: River Alliance of Wisconsin

After Removal

Source: River Alliance of Wisconsin

Anaconda Dam - Naugatuck River, CT

Before Removal

Source: Milone & MacBroom, Inc.

After Removal

Source: Milone & Macbroom, Inc.

Quaker Neck Dam - Neuse River, NC

Before Removal

Source: Coastal America Partnership

After Removal

Source: Coastal America Partnership

Bluebird Dam - Ouzel Creek, CO

Before Removal

Source: Rocky Mountain National Park

During Removal

Source: Rocky Mountain National Park

Columbia Falls Dam - Pleasant River, ME

Before Removal

Source: Maine Atlantic Salmon Commission

After Removal

Source: Maine Atlantic Salmon Commission

Grist Mill Dam - Souadabscook Stream, ME

Before Removal

Source: Roger D'Errico

After Removal

Source: Roger D'Errico

Marie Dorian Dam - Walla Walla River, OR

Before Removal

Source: US Army Corps of Engineers

After Removal

Source: US Army Corps of Engineers

Mounds Dam - Willow River, WI

Before Removal

Source: River Alliance of Wisconsin

After Removal

Source: River Alliance of Wisconsin

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DAM REMOVAL SUCCESS STORIES:

Restoring Rivers through Selective Removal of Dams that Don't Make Sense

APPENDIX C
GLOSSARY

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GLOSSARY

acre-foot - the amount of water required to cover one acre to a depth of one foot
algal bloom - an excessive growth of algae
anadromous - pertaining to species that migrate from the sea to freshwater to spawn or reproduce (for example, Atlantic salmon)
breach - a break or opening in a dam
broodstock - adult fish used to propagate the subsequent generation of hatchery fish
bypassed reach - the section of a river from which water is removed to generate hydropower. Water is often diverted from the river at the dam, transported through channels or penstocks downstream, and released back into the river at the powerhouse. Bypassed reaches can be as short as a few hundred feet to as long as several miles.
bypass system - structure at a dam that provides a route whereby fish may move through or around the dam without going through the turbines
catadromous - pertaining to species that migrate from fresh water to the sea to spawn or reproduce (for example, American eel)
channelization - the modification of a natural river channel; may include deepening, widening, or straightening
cofferdam- a temporary dam built to keep the riverbed dry to allow construction of a permanent dam or infrastructure
decommissioning - the act of retiring or dismantling a dam
drawdown - the lowering of a reservoir's surface elevation and water volume by releasing (spilling or generating) the reservoir's water at a rate greater than the rate at which water flows into the reservoir
endangered species - any species of plant or animal designated through the Endangered Species Act as being in danger of extinction throughout all or a significant portion of its geographical range
extirpation - local extinction of a species
fish ladder - a series of ascending pools of running water constructed so that fish may swim upstream around or over a dam
Federal Energy Regulatory Commission (FERC) - a quasi-judicial independent regulatory commission within the US Department of Energy. Regulates power projects on navigable waters and the transmission and sale of electricity in interstate commerce. FERC is composed of five commissioners appointed by the President, of which no more than three can be from any one political party.
head-of-tide - the point farthest up a coastal river that has a tidal influence (varies based on seasonal flow of the river)
headwaters - streams at the source of a river
impoundment - a body of water that is confined by a structure (usually man-made) such as a dam
landlocked (migratory fish species) - similar to anadromous species but do not migrate to the sea. The landlocked migratory species enter river tributaries from lakes to spawn.
levee - a long, narrow, earthen embankment usually built to protect land from flooding. If built of concrete or masonry the structure is referred to as a floodwall.
megawatt (MW) - a unit of electrical power equal to one million watts or one thousand kilowatts
migratory - see anadromous and catadromous
mitigation - measures taken to offset, or compensate for, damage to natural systems caused by a particular project or human activity
PCBs (polychlorinated biphenyls) - a large class of oily, synthetic chlorinated hydrocarbon

compounds with various industrial applications that are poisonous environmental pollutants and can be biologically amplified in food chains

penstock - a conduit used to convey water under pressure to the turbines of a hydroelectric plant

reservoir - see impoundment

resident fish - fish species that reside in freshwater throughout their lives (also called riverine fish)

riparian habitat - the habitat found on stream or river banks where semi-aquatic and terrestrial organisms mingle

riprap - rocks, concrete, or other material used to stabilize stream or river banks

riverine - relating to or formed by a river

sluice - a structure with a gate for stopping or regulating flow of water

small dam - there are many technical definitions for a "small" dam that typically include a combination of dam height and impoundment size

smolt - a juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt its body from a freshwater to a saltwater environment

spawning - the release and fertilization of eggs by fish

streambed - the channel or bottom of a river or stream

tailwater - flowing water below a dam that is released from an upstream impoundment

threatened species - an animal or plant species whose numbers are so low that they could become endangered in the near future, and that is awarded protection under the federal Endangered Species Act (see endangered species)

timber crib - a crib constructed of timber or planks in or along the margin of a water body to create habitat or to stabilize a bank

tributary - a stream or river that flows into another stream or river and contributes water to it

turbidity - the thickness or opaqueness of water caused by the suspension of matter

turbine - machinery that converts kinetic energy of moving fluid, such as falling water, to mechanical or electrical power

water quality - the condition of water as determined by measurements of such factors as suspended solids, acidity, turbidity, dissolved oxygen, and temperature and by the presence of organic matter and/or pollution chemicals

water rights - a legal right to use a specific amount of water from a natural or artificial body of surface water for general or specific purposes such as irrigation, mining, power, domestic use, or instream flow

watershed - all the land drained by a given river and its tributaries

wetland - an area that is regularly wet or flooded and has a water table that stands at or above the land surface for at least part of the year

Wild & Scenic River - defined in the federal Wild and Scenic Rivers Act as "those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and water unpolluted. These represent vestiges of primitive America."

For a more extensive glossary of river and dam terminology, please see *American Rivers* website:
URL: www.amrivers.org/glossary.html

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DAM REMOVAL SUCCESS STORIES:
Restoring Rivers through Selective Removal of Dams that Don't Make Sense

APPENDIX D
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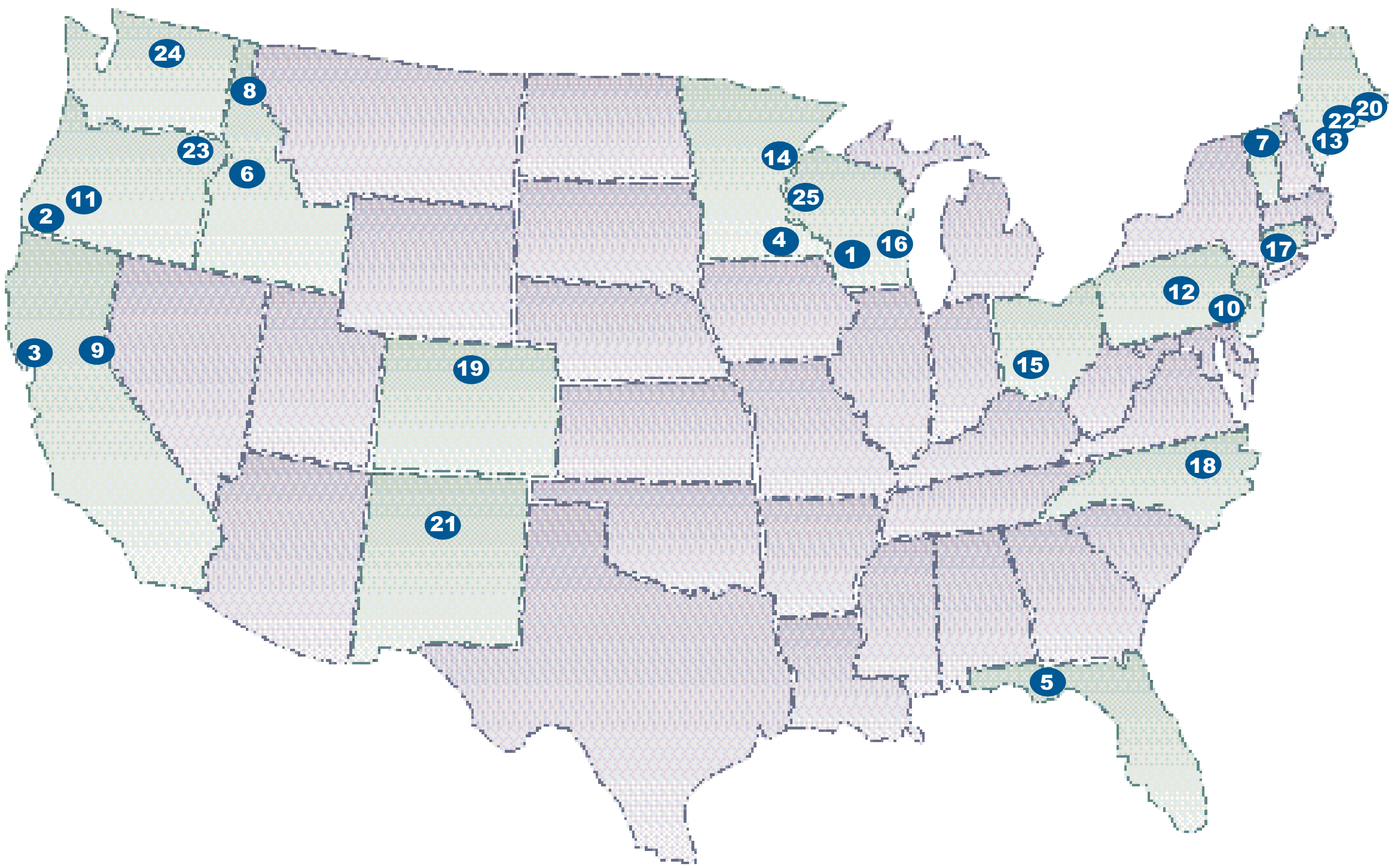
INDEX OF REASONS FOR REMOVAL

	Aesthetic Enhancement	Alternative to Dam	Community Revitalization	Cost Savings	Fish & Wildlife Habitat Improvement	Public Safety Hazard Removal	Recreational Improvement	Water Quality Improvement
California								
Butte Creek		X			X			
Cold Creek	X				X			X
Colorado								
Ouzel Creek	X				X	X		
Connecticut								
Naugatuck River					X		X	X
Florida								
Chipola River					X		X	
Idaho								
Clearwater Creek					X			
Colburn Creek					X			
Maine								
Souadabscook Stream				X	X	X	X	
Kennebec River					X		X	
Pleasant River				X	X			
Minnesota								
Cannon River				X	X	X	X	
Kettle River	X			X		X	X	
New Mexico								
Santa Fe River				X	X	X		
North Carolina								
Nuese River		X			X			
Ohio								
Little Miami River	X					X	X	
Oregon								
Bear Creek		X	X		X			X
Evans Creek					X			
Walla Walla River		X			X			
Pennsylvania								
Conestoga River					X		X	
Juniata River				X			X	X
Vermont								
Clyde River				X	X		X	X
Washington								
Whitestone Creek				X	X	X		
Wisconsin								
Baraboo River			X	X	X			X
Milwaukee River			X	X	X	X	X	X
Willow River	X			X	X	X		X

This is not an exhaustive index of the dam removal benefits in this report. Rather it lists the more frequently desired and realized outcomes of dam removal, and is intended to help locate benefits of interest. For example, improved water quality is a expected from every success story in this report, but the "Water Quality Improvement" category contains only those cases for which water quality improvement was a specific goal, or for which water quality improvement was particularly notable. Benefits unique to certain cases are noted in those case studies and are not captured here.

DAM REMOVAL SUCCESS STORIES



1. BARABOO RIVER, WISCONSIN – Waterworks Dam
2. BEAR CREEK, OREGON – Jackson Street Dam
3. BUTTE CREEK, CALIFORNIA – 4 dams
4. CANNON RIVER, MINNESOTA – Welch Dam
5. CHIPOLA RIVER, FLORIDA – Dead Lakes Dam
6. CLEARWATER RIVER, IDAHO – Grangeville Dam & Lewiston Dam
7. CLYDE RIVER, VERMONT – Newport No. 11 Dam
8. COLBURN CREEK, IDAHO – Colburn Mill Pond Dam
9. COLD CREEK, CALIFORNIA – Lake Christopher Dam
10. CONESTOGA RIVER, PENNSYLVANIA – 7 dams
11. EVANS CREEK, OREGON – Alphonso Dam
12. JUNIATA RIVER, PENNSYLVANIA – Williamsburg Station Dam
13. KENNEBEC RIVER, MAINE – Edwards Dam
14. KETTLE RIVER, MINNESOTA – Sandstone Dam
15. LITTLE MIAMI RIVER, OHIO – Jacoby Road Dam
16. MILWAUKEE RIVER, WISCONSIN – Woolen Mills Dam
17. NAUGATUCK RIVER, CONNECTICUT – 3 dams
18. NEUSE RIVER, NORTH CAROLINA – Quaker Neck Dam
19. OUZEL CREEK, COLORADO – Bluebird Dam
20. PLEASANT RIVER, MAINE – Columbia Falls Dam
21. SANTA FE RIVER, NEW MEXICO – Two-Mile Dam
22. SOUADABSCOOK STREAM, MAINE – Grist Mill Dam
23. WALLA WALLA RIVER, OREGON – Marie Dorian Dam
24. WHITESTONE CREEK, WASHINGTON – Rat Lake Dam
25. WILLOW RIVER, WISCONSIN – Willow Falls Dam & Mounds Dam