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SMALL DAM REMOVAL

A Review of Potential Economic Benefits

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TROUT UNLIMITED

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Trout Unlimited is the nation's largest trout and salmon conservation organization. Trout Unlimited's volunteers and members, 130,000 strong, are committed to conserving, protecting, and restoring North America's coldwater trout and salmon fisheries and their watersheds. Trout Unlimited advocates for the selective removal of old, unsafe, and uneconomical dams that are causing more harm than good. Many of Trout Unlimited's volunteers have been actively involved in local projects to remove small dams for the purpose of habitat restoration. For more information, visit www.tu.org or call (703) 522-0200.

Rivers, Trails, and Conservation Assistance (RTCA), a program of the National Park Service, assists local communities and citizen groups revitalize nearby rivers, preserve valuable open spaces, and develop local trail and greenway networks. RTCA staff are based in 36 locations to help local coalitions develop strategic plans, bring together neighbors and other stakeholders, identify potential sources of funding, engage the public's imagination and build partnerships to achieve community-set goals. RTCA also provides support to national non-profit groups to compile information to help communities make decisions about local conservation issues. The RTCA webpage is available at www.nps.gov/ncrc/rtca.

Trout Unlimited established the Coldwater Conservation Fund (CCF) in 1993 to conduct and support scientific and economic analysis that advances TU's mission of conserving, protecting, and restoring North America's coldwater fisheries and their watersheds. The CCF is financed through annual contributions of individuals, TU chapters, businesses, and foundations. Donations support a slate of projects that complement TU's annual conservation agenda by providing sound scientific data relating to water quality, instream flows, and the conservation of America's native and wild salmonids. For more information, please visit www.tu.org/members/coldwater_conserv.html.

Cover photo: A stretch of Maine's Kennebec River formerly impounded by Edwards Dam (Trout Unlimited photo).

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Preface

Blockages in rivers and streams hinder the natural functions of flowing water, and can be especially damaging to fisheries and water quality. As an advocate for trout and salmon, Trout Unlimited (TU) has been working to lessen the impacts of dams on America's streams for more than 40 years.

As fragile species needing high water quality, trout and salmon are often considered indicators of watershed health. They require clean, cold water and connectivity between different river habitats for different needs over their life cycles. Migratory salmon particularly need connectivity to travel from the ocean to reach spawning grounds in smaller tributaries. Dams not only fragment this connectivity, but water sitting still in the sun behind dams can warm to a point where trout and salmon can no longer survive. In addition, many small dams built on rocky-bottomed areas with fast-moving water have destroyed spawning habitat for these species.

Recognizing that dams can and do provide important societal benefits, TU volunteers and professional staff work with dam owners and regulatory agencies to lessen the impacts of economically viable hydropower dams across the nation. As a result, many dams are becoming more "fish-friendly" with minimal impact on power generation, and power companies have more clearly defined operating procedures for the 30 to 50 year life of their operating licenses.

However, many dams — especially smaller ones more than 50 to 100 years old — no longer serve the purpose for which they were intended. Thousands of these old structures nevertheless continue to impede the natural functions of flowing water, and their harmful impacts worsen over time.

While changing societal needs have reduced the need for many of the older, smaller dams, they are also placing more value on clean water, healthy and intact ecosystems, and water-based recreation, such as angling and paddling, which benefit from free-flowing rivers. As societal values change, so do the economic values associated with them.

TU volunteers and professional staff continue to be at the forefront of growing efforts to restore fisheries and water quality through the selective removal of small dams. We are encouraged that fisheries and other environmental and public benefits are increasingly a part of the equation when a dam owner — often a local community — considers the future of their dam and its host river. But in the majority of cases where there has been a decision to remove a dam, the discussion was prompted by public safety concerns and the final determinant was, and continues to be, economic factors.

Our goal in writing this publication is to draw on current research and TU's experiences with small dam removal to help improve local decision-making processes by providing insight into some of the potential economic benefits associated with restoring fisheries and river health through the selective removal of small dams.

This report is not intended to be an in-depth economic analysis of dams and dam removal. Rather, it highlights many of the economic benefits that can arise from removing small dams.

While researching this report, it became decidedly evident that there is very little published research on small dam removal, particularly on its economic ramifications. One notable need for additional research is quantifying the effects of small dam removal on nearby land values and on local businesses, along with timescales of these effects. The results of such research would inform and thereby enhance decision-making processes. We have laid a foundation for some of this research throughout this report and appendices.

We believe that when small dam removal is considered on its merits, more dam repair/removal discussions will end with decisions to remove dams and restore the natural functions of flowing water — benefiting not just the fish, but the people and businesses of surrounding communities for generations.

Dams and Dam Removal: An Introduction

Dams provided the energy that made the early development of our nation possible. Especially in the Upper Midwest and Northeast United States, nearly every community grew up around a small dam that provided mechanical energy for milling and later generated hydroelectric power.

But many of our country's millions of small dams have become obsolete, victims of society's changing needs and the natural pressures of time, gravity, and rushing water.

Dams are the most visible of human impacts on rivers. Chances are, if someone once determined a site was economically viable for a dam, one was built there. According to one government estimate, roughly 2.5 million dams have been constructed throughout the United States.[1]

The nation's dams run the gamut from tiny structures over which one could step, to behemoths that harness our great Western waters. While there are many precise definitions of what a "dam" is, this report refers to dams as any structures that obstruct the flow of water across the width of a river or stream. Some agencies and organizations refer to the smallest of these structures as weirs.

According to the National Inventory of Dams, an inventory maintained by the U.S. Army Corps of Engineers along with other federal and state agencies, about 75,000 U.S. dams are large structures.[2] The majority of these large dams continue to provide important societal and economic benefits.

The planned life expectancy of a dam is commonly around 50 years, although a well-designed and maintained structure can last longer.[3,4,5] Many of the oldest dams were not constructed with a meaningful consideration of life expectancy and many of these dams are no longer around (see sidebar below). Older dams were typically built out of timber and rock or

Dams Can Degrade Over Time

Natural wear, especially the pressure of water, can degrade concrete structures. Without proper maintenance, these structures can fail abruptly during floods or even without a major precipitation event (known as a "sunny day" failure).

Bringing old dams up to today's safety standards can be very expensive. Often removing them is far less costly, and eliminates both safety hazards and expenses for future maintenance.

Structural cracks in Woolen Mills Dam in Wisconsin caused it to fail a 1980 safety inspection. It was removed in 1988 (photo courtesy of Wis. DNR).

Deteriorating concrete on Ontario Dam in Wisconsin resulted in a failed safety inspection in the late 1980s. It was removed in 1992 (photo courtesy of Wis. DNR).

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Structural cracks in Woolen Mills Dam in Wisconsin caused it to fail a 1980 safety inspection. It was removed in 1988 (photo courtesy of Wis. DNR).

Deteriorating concrete on Ontario Dam in Wisconsin resulted in a failed safety inspection in the late 1980s. It was removed in 1992 (photo courtesy of Wis. DNR).

mounds of earth. Many of these fell into disrepair; were often abandoned and quietly disintegrated.

Others were rebuilt with concrete and repaired or maintained for decades. When they no longer provided economic benefits to their owners, many were abandoned.

Today, obsolete dams — some over a century old — are placing economic burdens on owners struggling to bring these structures up to today's public safety standards. Many dam owners are small communities that are now or soon will be looking for financial help to make these repairs.

Even as obsolete and expensive-to-repair dams continue to degrade, the economic and environmental benefits of healthy, free-flowing rivers are becoming more well known. In recent decades, scientists have developed a clearer understanding of the far-ranging impacts of dams on rivers (Table 1).

Resource managers and conservationists today view selective removal of small dams as one of the simplest and most cost-effective methods of restoring naturally functioning rivers and fisheries (Table 2).

Table 1. How Small Dams Can Ecologically Harm Rivers and Streams

Impair water quality

- Increase water temperatures
- Decrease water oxygen levels
- Block or slow flushing river flows that can normally serve to dilute some pollutants

Obstruct passage

- Block or inhibit upstream and downstream fish passage
- Obstruct the movement of sediment, woody debris, and nutrients

Harm habitat

- Inundate wildlife habitat
- Alter timing and variation of river flows

Trout Unlimited, 2001

A recent report by Trout Unlimited, American Rivers, and Friends of the Earth identified more than 465 dams that have been removed in the past century. Many of these were removed at the dam owner's initiative. *Dam Removal Success Stories* shows that dam removal is not a new or radical notion. The National Park Service, for example, has removed more than 100 dams in the past 20 years on rivers and streams affecting our national parks. Most of these dams were owned by the National Park Service and removed because they were not essential to the use of the park and were not being maintained.[6]

While the concept of dam removal is not new, to a community that grew up around a dam it is usually a new idea to consider removing it. Typically there is strong sentimental attachment to a dam and its impoundment, and many times there is no one alive who remembers the river before there was a dam.

For these and other reasons, discussions about the future of a local dam are often emotionally charged and highly divisive. Many such discussions end with a decision to keep an old and obsolete structure — often at great cost to the river and the community.

But in cases where communities have opted for removal, public safety and economic factors have topped the list of reasons.

Typically, public safety concerns are triggered when a dam fails a safety inspection and a regulating agency orders its repair or removal. Small dam repair costs are often more than three times greater than removal costs.[7] While costs can vary significantly, a dam repair bill for a small dam can easily run $300,000 or more — a high price tag for a small community or individual dam owner.

When decision-makers are required to make a fiscally prudent decision, the commonly higher cost of repair alone is often enough to tip the scale in favor of removal.

Nonetheless, many communities faced with the repair/removal question have simply looked for repair money without considering removal as a viable option.

In recent years, however, citizen groups and resource managers have become increasingly successful in persuading communities or other dam owners to consider the merits of all options, including removal.

Table 2. Illustrated Benefits of Case Studies

All benefits of each river restoration are not included here. The Naugatuck, Baraboo, and Conestoga projects are ongoing and some of their benefits are projected.

State	River	Dam(s)	Economic and Other Benefits of Dam Removal	Page
OH	Chagrin	Chagrin Falls	Cost savings over repair Wetland restoration	9
OH	Little Miami	Jacoby Road	Cost-effective restoration Restored scenic value of free-flowing river	17
WI	Kickapoo	Ontario	Community economic development Cost savings over repair Fisheries improved Paddling opportunities improved	19
WI	Baraboo	3 dams	Potential community economic development Fisheries improved Watershed-wide restoration Restored rapids Cost savings over repair	21
WI	Tomorrow/ Waupaca	Nelsonville	First-class trout fishery restored Potential economic development Historical restoration	25
WI	Apple	Somerset	Community economic development Rapids restored New recreational opportunities	26
CT	Naugatuck	8 dams	Cost-effective water quality improvements Potential community economic development Watershed-wide restoration Fisheries improved	28
PA	Conestoga	17 dams	Cost-effective fisheries improvement Potential community economic development Increased angler income projected Watershed-wide restoration Allowed the return of migratory fish	29
WI	Willow	Willow Falls and Mounds	Scenic waterfall restoration Cost savings over repair Safety hazards removed	32
WI	Milwaukee	Woolen Mills	Community economic development Fisheries improved Safety hazard removed	34

Trout Unlimited, 2001

One university study documented what advocates for healthy rivers and fisheries already know — that dam repair/removal decisions are typically made with incomplete and inaccurate information on environmental and economic factors relating to dams and rivers.[7]

Because the majority of small dam removal decisions are ultimately made for economic reasons, it is unfortunate that comparative economic studies are sorely lacking. Decision-makers are often not aware of the potential economic benefits associated with dam removal, including benefits from restored rivers and improved aquatic habitat and water quality.

To help improve this decision-making process, Trout Unlimited gathered information and conducted original research on the potential economic benefits of selective small dam removal to create this report for concerned citizens, resource managers, dam owners, and elected officials.

A review of the literature turns up very few published studies on dam removal economics and none that look at economic impacts using post-removal data. Historically, this information has been limited because small dam removals have not been well documented. Today, dam removals are increasingly better documented, providing the potential for valuable analyses in the coming years.

The lack of post-removal economic analysis is particularly unfortunate in urban settings, where residents are often concerned that property values around an impoundment will dramatically decline after a dam is removed.

To begin to address this concern, Trout Unlimited studied the long-term impact of dam removal on property values at the site of the 1988 Woolen Mills Dam removal in West Bend, Wisconsin. At that site, property values have not declined dramatically more than a decade later, contrary to the pre-removal fears of local residents and homeowners.

The case studies and tables presented in this report are based on available information. The majority of historic dam removal information comes out of the state of Wisconsin, where more than 70 dams have been removed. The discussion of this information is augmented by firsthand experiences of the authors who have been closely involved in many small dam removals.

The result of this research and experience is a discussion of a number of economic benefits communities might reasonably expect from restoring a river through small dam removal, including:

- improved sport fisheries,
- increased paddlesport opportunities,
- improved water quality,
- community revitalization, and
- significant cost savings by eliminating the costs of maintaining a dam and its impoundment, both now and in the future.

As thousands of small dam owners and communities across the nation are grappling with aging and obsolete dams and their impacts on rivers, this report aims to assist them with their local decision-making processes.

A review of the case studies presented herein shows that the communities enjoying the greatest economic and quality-of-life gains seem to have something in common — they have reconnected with their free-flowing rivers through thoughtful plans that include building parks, riverwalks, and boat launches, and providing public access to the restored river.

"Small" Dams and Why They Are Significant

There is no universal specification defining the size of a "small" dam. Some state agencies consider dams less than 15 feet high as small. The National Inventory of Dams (NID) uses a combination of height and impoundment size as a cutoff for inclusion. The NID includes dams that are either 25 feet high with an impoundment of at least 15 acre-feet, or six feet high with an impoundment of at least 50 acre-feet.[2] (An acre-foot is an amount of water that would fill an acre to the depth of one foot). A particular small dam may or may not be regulated by state or federal agencies.

Clearly, "small" is a relative term. This report, which focuses primarily on small dams, discusses the removal of two dams that were around 60 feet high, not so small in the Great Lakes and Northeast, but still small by Western U.S. standards.

Contrary to common belief, most small dams, particularly those originally designed to power mills, do not provide flood control. In fact, some small dams increase upstream flooding problems because they impede flow, but do not have the capacity to store it. There are some small dams that do provide flood control, but such dams are designed with a lot of corresponding area available for storing flood waters. For example, many of the so-called PL-566 dams constructed by the Soil Conservation Service (now the Natural Resources Conservation Service) for flood control could be considered small dams.

In addition, hydroelectric dams that produce power for entire regions of the country would certainly not be considered "small" dams. Therefore, this report does not focus on the costs and benefits of flood control or large-scale hydroelectric facilities.

Despite their stature, small dams have significant impacts on streams and habitat. Such structures effectively block fish passage and otherwise damage river systems much like larger structures. The age of these structures is also ecologically significant. The longer a dam blocks a river, the more damaging the impact on the stream channel and its habitat. Small dams have fragmented many rivers and streams since colonial times.

Perhaps the most significant impact of small dams is their sheer number. Thousands of communities around the country have small dams. As a result, many rivers and streams are segmented every few miles by a dam. Data included in the National Inventory of Dams (NID) suggest that small dams create three to four times more total reservoir area in the country than large dams.[8] This ratio is likely even higher because the parameters for inclusion in the NID leave out many of the smallest dams. The cumulative impact of these structures and their impoundments can be devastating to rivers and their fisheries. The total effort of maintaining, repairing, or removing the sheer number of structures will be significant in the coming years from economic, environmental, and public policy perspectives.

The impact of dams is especially acute in "headwater" areas where rivers and streams originate. These smaller water bodies, often spring-fed coldwater streams (46 to 60 degrees F) that support coldwater species such as trout, are especially sensitive to temperature changes. Water is warmed as it sits impounded behind small dams, hindering the survival of coldwater fish above and below the dam.

In addition to impacts on water quality and fishery health, managing a small dam can become a burden to its owner, often an individual or small community. Safety issues come to the forefront as small dams age, and maintaining dams and their impoundments can become a financial burden.

Economic Benefits of Removing Small Dams

Despite the many environmental and societal benefits that can result from dam removal, discussions about the future of an old dam often boil down to money. How much money has to be spent to either repair a structure or remove it?

Removing a small dam can have distinct economic benefits. Depending on the site, economic benefits could include:

- significant cost savings over repairing and maintaining the dam,
- potential for community economic development through parks, riverwalks, and urban revitalization in and adjacent to the restored stream,
- new opportunities for local recreation and growth in tourism,
- increased income to local fishing and paddling industries, and
- decreased costs related to water quality improvements and fisheries management.

These benefits are not necessarily comprehensive, nor do all benefits mentioned apply to all dam removals.

Repair commonly costs more than removal

Over the past century, more than 465 dams have been removed from rivers and streams in the United States. Many removal situations began when a dam failed a safety inspection and the owner was issued an order to repair, rebuild, or remove it. From that point forward, decisions often hinged on economics.

The cost of removing a small dam has usually been much less than the cost of rebuilding or repairing it.

In most cases, the cost of removing a small dam is less than the cost of rebuilding or repairing it. Add to this the fact that many communities and dam owners have trouble finding the funds to repair and maintain their dams, and it is easy to see why removal is often the only affordable option.

Based on available data from dam removals in Table 3 and using lower-end repair estimates, cost estimates for dam repair versus removal from around the country show that repair has averaged three times more expensive than removal (see Chagrin River, p. 9). Of course, project costs can vary significantly and should be carefully evaluated when each new case arises. For example, note the one case on Table 3, Somerset Dam on the Apple River, where removing the dam cost more than repair estimates to make the dam safe.

Repair costs may include structural measures for safety purposes, such as fixing inoperable gates or repairing cracking concrete. In some cases, they may also include improvements to meet current standards for environmental protection, such as adding or improving fish passage.

Note that the values in Table 3 compare only short-term removal costs, not future costs for dam operation, ongoing maintenance, repairs, liability, or costs of environmental damage, which could make removal even more cost-effective. Also, Table 3 only includes information on dams that have been removed, not on dams that were ultimately repaired. Often when a dam is repaired, removal is not estimated or even considered (see sidebar, p. 11).

While dam owners are generally held responsible for the cost of repairing or removing a dam, often with publicly owned dams repair or removal is funded by taxpayer dollars. As taxpayers, citizens should be aware of how dam decisions are made and how the outcome affects them financially.

Table 4 shows repair and removal costs for 11 dam removal projects in Wisconsin, with costs converted to 1999 dollars for comparison. These projects were not randomly chosen, but were selected based on availability of

Table 3. Removing Small Dams Typically Costs Less Than Repair

A sample of dam repair estimates, dam removal estimates, and actual dam removal costs. Some data are shown as a range, either because the estimates involve several options or because the range reflects the best information available from sources closely familiar with the project.

State	River	Name of Dam (Year Removed)	Estimated Repair Cost ($)*	Estimated Removal Cost ($)*	Actual Removal Cost ($)*
CA	Butte Creek	Four dams (1998)	N/A	9,500,000	9,130,000
CA	Cold Creek	Lake Christopher (1994)	160,0000 - 180,000	N/A	60,000 - 100,000
FL	Chipola	Dead Lakes (1987)	N/A	32,000	32,000
ME	Kennebec	Edwards (1999)	9,000,000**	N/A	2,100,000
ME	Pleasant	Columbia Falls Hydro (1998)	80,000***	N/A	20,000 - 30,000
ME	Souadabscook	Grist Mill (1998)	150,000	N/A	56,000
MN	Cannon	Welch (1994)	N/A	120,000	46,000
MN	Kettle	Sandstone (1995)	1,000,000	300,000	208,000
NM	Santa Fe	Two-Mile (1994)	4,100,000	N/A	3,200,000
WA	Whitestone	Rat Lake (1989)	261,000	N/A	52,000
WI	Baraboo	Waterworks (1998)	694,600 - 1,091,500	N/A	213,770
WI	Willow	Mounds (1998)	3,300,000 - 6,000,000	1,100,000	500,000
WI	Willow	Willow Falls (1992)	5,000,000 - 6,000,000	622,000	450,000
WI	Yahara	Fulton (1993)	900,000- 1,000,000	N/A	375,000
WI	Black	Greenwood (1994)	500,000	N/A	80,000
WI	Embarrass	Hayman Falls (1995)	455,000 - 800,000	N/A	180,000
WI	Lemonweir	Lemonweir (1992)	700,000	N/A	190,000
WI	Manitowoc	Manitowoc Rapids (1984)	30,000 - 250,000	N/A	45,000
WI	Kickapoo	Ontario (1992)	100,000 - 200,000	N/A	47,000
WI	Prairie	Prairie Dells (1991)	725,000	N/A	200,000
WI	Apple	Somerset (1965)	30,000	N/A	75,000
WI	Milwaukee	Young America (1992)	313,000	N/A	74,000
VT	Clyde	Newport No.11 (1996)	783,000	N/A	550,000

* Dollars are assumed to be in the year the dam was removed.
** Cost of installing fish passage.
*** Cost to repair fish ladder.

Removing a Dam *and* Restoring Wetlands at a Fraction of Repair Costs

Chagrin River, Ohio

Chagrin Falls Dam once powered a grist mill on the Chagrin River, a state scenic river in northeastern Ohio. When the dam unexpectedly and catastrophically breached in 1994, a decision was made to remove the old structure as the cost of repairing the dam was estimated at over $1 million.

The actual cost of removing the dam *and* restoring its adjacent wetlands was just over $100,000, *one-tenth* the estimated cost to repair the dam. In addition to the cost savings, the project is significant because it is an example of wetlands establishment in conjunction with river restoration. Riparian wetlands (adjacent to rivers and streams) support diverse wildlife habitat, help alleviate flooding, and filter sediment and pollutants before they reach the stream.

Ivex Corporation, a paper processing company and owner of the dam, donated 80 acres of the former impoundment and surrounding riparian land to the village of Chagrin Falls. This valuable land, now Whitesburg Park Preserve, is located next to land owned by The Nature Conservancy, providing a continuous corridor of protected land along the Chagrin River.

Mudflats, exposed when Chagrin Falls Dam failed in 1994, were converted to riparian wetlands when the dam was removed (photo courtesy of Ohio DNR).

Riparian wetlands along the Chagrin River in Ohio provide diverse wildlife habitat. The wetlands were established along with the removal of Chagrin Falls Dam (photo courtesy of Ohio DNR).

Table 4. Removing Small Dams Saved Millions of Dollars in One State

Repair estimates versus removal costs for 11 Wisconsin dam removal projects. Wisconsinites saved between $6.1 and $10.2 million by choosing to remove these dams rather than repair them, and also restored many miles of free-flowing rivers. Values are converted to 1999 dollars for comparison.

Name of Dam	Low Cost Estimate for Repair ($)	High Cost Estimate for Repair ($)	Actual Cost of Removal ($)
Fulton	1,037,650	1,152,940	432,350
Greenwood	562,080	562,080	89,930
Hayman Falls	497,400	874,540	196,770
Lemonweir	831,220	831,220	225,620
Manitowoc Rapids	48,100	400,870	72,160
Mounds	3,372,880	6,132,520	511,040
Ontario	118,750	237,500	55,810
Prairie Dells	886,820	886,820	244,640
Somerset	158,670	158,660	396,670
Waterworks	709,940	1,115,610	218,500
Young America	371,670	371,670	87,870
TOTAL	**8,595,170**	**12,724,420**	**2,531,350**

Source: Trout Unlimited, 2001 calculated from Born, et al., 1996[9] and Wisconsin DNR dam files.

information. Only one of these dams, Manitowoc Rapids, was privately owned at the time of its removal. The others were either abandoned (which means responsibility fell to the state or local government) or owned by public municipalities or counties. The figures were converted to 1999 dollars to allow for a direct comparison of repair versus removal.

These projects show a sizeable cost savings to dam owners and taxpayers by choosing removal instead of repair.

The estimated total cost of repairs for the dams in Table 4 ranged from $8.6 to $12.7 million. These dams were all ultimately removed at a total cost of just $2.5 million, saving Wisconsinites between $6.1 and $10.2 million for choosing to remove these 11 dams, or about $550,000 to $920,000 per dam on average.

While short-term cost figures can indicate the magnitude of cost differences, a true comparison between keeping a dam and removing it requires looking at *all* the costs of each option.

For example, decisions to repair an aging dam — in effect, to keep the dam — often do not include future operation and maintenance costs. Estimates also often omit the cost of environmental damage (such as fishery habitat loss) or mitigation of these damages (such as fishery management costs).

The true cost of owning a dam must include all such expenses, including:

- general operation and maintenance,
- repairs (often multiple over time),
- maintaining the impoundment and its water quality,
- environmental costs (see sidebar, p. 12), and
- liability costs.

Opportunity Cost: The Cost of Making a Decision

Opportunity costs are relevant whenever a decision must be made about using resources for one purpose rather than another. The opportunity cost of a chosen action is the benefit (opportunity) lost by not choosing the next best alternative. It is the highest value alternative that was foregone. The lost opportunity of the next best option is considered a cost of the chosen action.

For example, when a decision is made to use funds to repair a dam rather than remove it, the opportunity for a free-flowing river is lost. So, the benefits associated with a free-flowing river may be the opportunity cost of repairing instead of removing a dam. The opportunity cost could also be an alternative use for the money, such as for road repair, health care, etc. Particularly when environmental costs are considered, money alone may not be the best measure of opportunity cost. While a restored river can provide economic benefits, many of its benefits are difficult to quantify financially (see 'willingness to pay' studies in Appendix II).

Similarly, when dam removal costs are presented to the public, related costs such as stream stabilization are often not included. The cost of removing a dam should include:

- removing structures,
- sediment management,
- associated stream channel work, if necessary,
- ongoing restoration and monitoring costs, if necessary, and
- replacing the dam's use(s), if necessary.

These costs are discussed in detail below.

Repair decisions should consider all costs

General operation and maintenance costs

Small dam operation and maintenance costs vary and typically are not widely publicized. Operation and maintenance refers to the day-to-day work to operate the structure and to keep it safe and in working order. It includes such things as keeping the gates and other structures operational, maintaining security, maintaining the property and facilities, and liability insurance. A good operation and maintenance plan can help maintain safety and prolong the time before major repairs are needed.

Such costs should be projected for the entire life of the dam. Costs can vary widely even for similarly sized dams depending on location, age, and other factors. For example, the estimated annual operation and maintenance costs of the 18-foot high Woolen Mills Dam in West Bend, Wisconsin, were $10,000 per year. Also in Wisconsin, the 16-foot high Ward Paper Mill Dam had annual operation and maintenance costs of $60,000 per year. The primary difference in cost was need for greater security measures at Ward Dam.[12]

Publicly owned dams should maintain clear records of operation and maintenance costs and make them available to the public. Only with accurate information will communities be able to make informed decisions when faced with a dam in need of repair or removal.

Costs of maintaining impoundments

One aspect of small dam maintenance often overlooked is the cost of maintaining the dam's impoundment.

An impoundment is the reservoir of water held back by a dam. However, dams not only hold back water, they also trap sediment that would normally be carried downstream. This sediment collects in the impoundment, gradually filling it in, a process known as sedimentation.

As impoundments fill in, they lose the ability to support the uses of the dam and impoundment. The time over which this occurs is determined by such factors as:

Benefit-Cost Analysis: What Is the Value of a Healthy Environment?

Benefit-cost analysis (BCA) is a framework used to assess proposed projects, indicating that a project should be undertaken if its benefits exceed its costs. It was first described in federal legislation in the Flood Control Act of 1936, which justified federal involvement in flood control "if the benefits to whomsoever they may accrue are in excess of the estimated costs."[13] Since that time, BCA has been used by federal agencies and others to assess thousands of projects.

While it sounds like a simple, objective approach, it is often complicated and subjective to assign values to many benefits and costs, particularly concerning environmental issues.

For example, what is a pristine view worth?

What is the extinction of a species worth?

How much is clean water worth?

Even though you may never go fishing in a faraway river, how much is it worth to know that you could if you wanted to some day? Or, that your grandchildren could?

Although placing a value on these things is certainly a challenge, the value of the environment has been included more and more in BCA.

Economists divide the values involved into use and non-use values. A use value is the value of a resource to people using it. A non-use value is the value to people who are not currently using the resource. Non-use values include such things as option values (to experience it in the future); existence values (to know it exists); and bequest values (to know future generations can experience it).[14]

While it is still a challenge, economists have developed surveying techniques to put values on environmental issues. One of these techniques, contingent valuation, is described in Appendix II.

- the size of the impoundment,
- the size of the watershed,
- land use within the watershed, and
- the operation and condition of the dam structure.[15]

Sedimentation reduces habitat for fish and affects recreational uses of the impoundment, such as fishing, boating, and swimming. Nutrients also build up along with the sediment, causing algae and plant life to become overgrown, in a process known as eutrophication. Such silt-filled ponds often become aesthetically unpleasant and smell of rotting vegetation.

Dealing with the effects of sedimentation and eutrophication can be costly. Many communities choose to periodically dredge their impoundments to attempt to maintain recreational uses and aesthetics.

Dredging involves using heavy machinery to dig material out of the impoundment and transport it away. Dredging is usually expensive, with costs ranging from $1 to $12 per cubic yard of sediment removed. The relatively wide range reflects different dredging techniques and varying disposal costs of dredged material. Dredging is not a permanent solution because it does not remove the problems that make dredging necessary. Consequently, an impoundment that needs to be dredged will likely need to be dredged again in the future.

Exact dredging cost estimates are difficult to generalize because of site-specific conditions. A few examples from Wisconsin show that though dredging costs are variable, it generally costs hundreds of thousands of dollars, even for small impoundments (Table 5). In addition, in areas where upstream land use changes for development or agriculture increase erosion and runoff, dredging needs to be done more often.

Some communities will harvest excessive vegetation from impoundments and lakes more frequently than dredging in order to maintain recreational uses and aesthetics. Such harvesting involves the use of heavy machinery to cut plants and remove them for transport, often to a composting site for agricultural use.[16] While aquatic vegetation harvesting is cheaper than

Table 5. Dredging Impoundments Is Costly

Dredging costs of several impoundments in Wisconsin, selected based on availability of information.

Date	Impoundment	Size of Impoundment (acres)	Sediment Removed (cu. yds.)	Cost ($)
1979	Henry Lake	44	200,000	413,000*
1981	Bugle Lake	35	250,000	191,000
1981	Angelo Millpond	N/A	160,000	260,000
1981	Hartford Millpond	N/A	42,000	394,000
1983	Marinuka Lake	107	500,000	700,000

* includes cost of dredging, and reducing sediment delivery rates

Source: Marshall, 1988.[15]

full dredging, it is often done every year and can amass considerable expenses over time.

Cost of repair

When an aging dam is reviewed for repair or removal, the true cost of repair is often underestimated because future repairs are not considered and immediate repair costs are often underestimated. Project managers often underestimate repair costs because they do not realize the necessary extent of repairs until the work has begun. Also, as with any old structure, when repair workers dig into an aging dam, surprises are common and the dam may be in worse condition than expected. Often, the interior of the dam structure is unknown, as current concrete could be encasing older timber or rock structures.

Maintaining an old dam can mean committing to a continuous stream of expenses.

Maintaining an old dam can mean committing to a continuous stream of expenses. In the long run, repair bills continue to be incurred, whereas removing a dam puts an end to repair costs.

Table 6 shows one example of a series of repair costs on the Little Falls Dam on the Willow River in Wisconsin, a 30-foot high structure built in the 1920s.

Communities should be prepared to pay for current and future costs of repairing and maintaining dams when they choose to continue operating a dam.

Environmental costs of dams on fisheries

Dams cause many environmental problems in river systems (Table 1). They can significantly impact fisheries by harming water quality, blocking movement and migration patterns, and altering habitat and natural river flows. The potential economic value of a restored fishery, as well as the costs of fishery management, should be considered when communities face a decision to remove or repair a dam.

The construction of a dam essentially changes the upstream environment from native riverine habitat to impounded lake habitat. As a result, the number, types, and diversity of aquatic species change.

Many fish species have different needs at different life stages. For example, migratory salmon need swift-flowing cold water and gravel beds, shallow tributaries, deep pools, and passage to the ocean or a lake and back at different stages in their life cycle.

Table 6. Aging Dams Can Need Continual Repairs

Selected repair costs on Little Falls Dam on the Willow River, Wisconsin. The dam was built in the 1920s and is 30 feet high and 370 feet long. This is not a comprehensive list of repairs. These items were selected to illustrate types of repairs and potential magnitudes of costs.

Year	Action	Cost ($)	Cost (1999 Dollars)
1980	Major Repairs*	1,000,000	2,021,840
1990	Installed Gate Operators	281,000	358,180
1991	Right Abutment Repairs and Associated Work	386,700	473,010
1996	Flood Warning System	279,000	296,250
TOTAL COST of REPAIRS			**3,149,290**

* included concrete and spillway repairs; new gate operators, bottom sluice, walkway, and fencing

Source: Wisconsin DNR dam files.

Without connectivity between these habitats, they cannot survive. Even non-migratory "resident" fish require connectivity for habitat needs throughout the seasons of the year and throughout different lifecycle stages, and to maintain genetic diversity.

Nearly half of the 496 animal species federally listed as threatened or endangered are freshwater species.[17] They are severely impacted by watershed management practices and particularly by dam operations. Millions of dollars are being spent in attempts to restore salmon, shad, and other species across the country as increasing numbers of fish and mussel species dwindle to the point of federal listing or consideration for listing.

Recognizing that dams block fish movement and migration and that waters and fish are public resources, some regulatory programs require dam owners to install devices that allow fish to pass over or around the dam. Fish passage technology is often not successful for all species and all life stages, and in many cases can be expensive to install and maintain.

The recreational value of fish can be substantial, and many dams are being removed or being considered for removal to restore highly valued fisheries. The economics of fisheries are discussed more extensively in the following pages in sections on sport fishing, trout fishing, and the economic ripple effect.

Safety issues and liability

Another cost of maintaining a dam is the risk associated with failure and other safety concerns, such as people boating or swimming near or playing on the structure.

Large dam failures in the United States have been devastating and costly. For example, when St. Francis Dam in California broke in 1928, more than 385 people were killed. The 1976 Teton Dam failure in Idaho and the 1982 Lawn Lake Dam break in Colorado also caused loss of life and resulted in damages of $900 million and $35 million respectively.

According to the Federal Emergency Management Agency (FEMA), "Despite the strengthening of dam safety programs since the 1970s, dams continue to fail, causing loss of life and millions of dollars in property damage."[18] Between 1960 and 1997, 23 dam failures caused loss of life, resulting in 318 deaths.

Damages due to dam failure are not exclusive to large dams. FEMA states, "Failure of even a small dam releases sufficient water energy to cause great loss of life, personal injury, and property damage."[3] A sudden, massive release of water and sediment can also devastate aquatic habitat.

The failure of one dam can also result in subsequent failures downstream. For example, during Tropical Storm Alberto in 1994, more than 230 dams failed in the state of Georgia alone.[18]

While the number of dam failures varies greatly from year to year, the National Performance of Dams Program (NPDP) estimates that on the order of one of every 10,000 dams fails each year.[19] The NPDP notes that failure rates have not been rigorously calculated in many years and that large dams probably fail less frequently than this rate. However, the failure rate of smaller dams is likely higher because small dams are commonly older structures, are often not as routinely maintained, and have less spillway space (where excess water flows) to relieve flood pressure.

Based on NPDP estimates, dam safety costs for America's aging dams will be approximately $1 billion per year for the next 20 years, including such things as costs to upgrade unsafe dams, dam failure costs, and state dam safety program costs.[20]

Dam structures can also be enticing yet dangerous places to play, swim, and boat, so-called "attractive nuisances." Small dams can be particularly dangerous for swimmers and boaters because of deceptively dangerous currents over and around the dam.[21] In 1997, a kayaker drowned in Pennsylvania's Kishacoquillas Creek from capsizing and getting stuck in powerful currents at a dam that was only four feet high.[22] Because of the dangers of dams, Pennsylvania recently enacted a law requiring all dams to have warning signs, and dams 200 feet long or longer to have buoys and exclusion zones above and below the dam.

The combined cost of insuring against dam failures and accidents can result in high liability costs. Generally, state and local governments and large dam owners are able to afford the cost of insurance. However, for the largest number of dams, those that are small and privately owned, dam insurance can be prohibitively expensive. Because of the uncertainty of risk, insurance companies charge rates according to worst-case scenarios.[3]

The extent of owner liability varies from state to state and can depend on whether the owner is private or public, federal or nonfederal. It can even depend on the design purpose of the dam. For example, the Flood Control Act of 1928 provided that the federal government cannot be held liable for any flood damages relating to any dam authorized for flood control.[23]

In general, government dam owners, from federal to municipal, may be exempt from liability simply from an old common law known as "sovereign immunity." Sovereign immunity provides that governments are exempt from liability unless statutes have waived this immunity. In many states, immunity has been statutorily waived for many circumstances, possibly exposing dam owners to liability from damages or drownings. For example, the Wisconsin Supreme Court abolished sovereign immunity for all Wisconsin municipalities in 1962, although in practice there have been some exceptions to this rule.[24] The issues of liability and immunity for government owners are complex and variable, making it virtually impossible to make blanket statements.

On the other hand, sovereign immunity does not apply to private dam owners, and it is likely that damages caused by a dam failure will lead to extensive litigation[25], exposing the owner to financial risk. FEMA offers financial assistance to owners only when a failed dam is located within a declared federal disaster area.

A National Research Council report on dam safety reports that courts are more often moving to compensate victims, stating that "most courts strain to invoke liability, particularly when personal injury or death is involved."[23]

Removal decisions should consider all costs

Costs of removing structures and restoring the river

Engineers and contractors commonly overestimate the cost of removing small dams. Table 3 shows a few such cases, including two where removal estimates were more than double actual removal costs. Overestimates may occur because of inexperience with dam removal operations. In such cases, contractors and engineers will estimate conservatively to be certain that all their costs will be covered. As more dams are removed, it is likely that increased familiarity will lead to more accurate estimates.

In the simplest cases, small dam removal costs include the costs of heavy equipment and an operator to demolish the dam structure. However, dam removals are often more complex and can include:

- project design,
- removal of structures,
- management of stored sediment,
- stream channel reconstruction or stabilization, and
- disposal of waste materials.

Depending on the size of the impoundment, amount of stored sediment, and the extent of environmental concerns, each dam removal project may not include all of the above measures or may include them to varying degrees or may even include items not listed here. But even when all of the measures are necessary, removal costs are frequently cheaper than rebuilding or repairing an aging structure (see Little Miami River, p.17).

Managing sediment can be the most costly and challenging physical aspect of a dam removal. Dam impoundments are collection areas for material flowing from upstream. Depending on past uses of land within the watershed, they may contain contaminants. Releasing contaminants into the environment or suddenly releasing large volumes of sediment can be damaging to downstream habitat. Sediment management plans should be carefully considered before proceeding with a dam removal, especially if contamination may be present.

Dam removal costs are often overestimated.

Because sediment dredging can be expensive (Table 5), alternative and less costly approaches are often taken, such as collecting sediment in downstream traps or slowly drawing down the impoundment to allow sediment to gradually stabilize.

Depending on the size and topography of the impoundment and the extent of channel restoration work, removing a dam may leave behind exposed, unvegetated banks. Seeding, erosion control matting and other methods are often used to prevent erosion. Depending on the site conditions, bank stabilization can be costly.

As one example based on available information, following the 1992 removal of Willow Falls Dam on Wisconsin's Willow River, bank stabilization costs totaled $370,000.[26] However, many small dams with small impoundments require minimal bank stabilization and little or no revegetation efforts. Former impoundments can be very fertile and full of seeds, which quickly sprout when exposed. New vegetation growth helps to hold the exposed soil in place.

Costs of replacing uses

An important consideration is the cost of uses that will be lost as a result of a dam's removal, some or all of which may need to be replaced. For example, the vast majority of small dams that are considered for removal are not economically viable as hydroelectric facilities. But if a dam does cost-effectively produce hydropower, the value of lost power production and the cost of replacement power should be considered in the decision-making process.

If a dam is a water supply source, alternative supplies would have to be explored. In addition to agricultural and municipal water supplies, some small dam impoundments are used as emergency water supplies for firefighting. A free-flowing river may still produce adequate water for these purposes, but engineers and resource managers should be consulted to determine potential problems and solutions.

While most small dams do not provide flood control, it is an important discussion point in the decision-making process. There is a common perception that all dams provide flood control, and the public should be informed about the functions and capabilities of a particular structure when it comes under consideration.

Some impoundments provide "lake" recreation. Surveys can help find the value to the community from tourism and other recreational uses of the lake if that information does not already exist. It is important to look at that information over time, since the quality of impounded water usually declines as it ages and area residents may not be aware of incremental changes.

After generating values for current recreational use of the impoundment, decision makers should also assign values to the potential new habitat and recreational opportunities created by the restored river system. The various benefits of related community development, improved sport fishing and paddle sport opportunities, and water quality improvements are discussed in the following pages.

Restoring Scenic Beauty Through Creative Funding

Little Miami River, Ohio

The Ohio Department of Motor Vehicles sells scenic river license plates as an innovative method to fund restoration projects on Ohio's scenic rivers. These sales funded the removal of Jacoby Road Dam from the Little Miami River in 1997 at a cost of $10,000 to $12,000.

Ohio motorists can help preserve natural resources when they purchase license plates. Sales of this license plate fund conservation work on Ohio Scenic Rivers (photo courtesy of Ohio State License Plates).

Identifying available funding sources for dam removal is a task faced by many communities. Possibilities for funding include private, federal, state, and local sources.

Below are some national, regional, and state sources that have funded dam removals (for additional funding possibilities see American Rivers, 2000[27]).

National and Regional Funding:

- US Fish and Wildlife Service—Coastal Program and Partners for Fish and Wildlife
- National Fish and Wildlife Foundation
- National Marine Fisheries Service—Community Based Restoration
- US EPA—Chesapeake Bay Program
- Natural Resources Conservation Service—Wildlife Habitat Improvement Program (WHIP)
- Coastal America Program
- Great Lakes Fishery Trust

State Funding:

- Legislative Appropriations for Dam Removal
- State Natural Resources, Fisheries, or Environmental Protection Agencies
- Dam Safety Programs
- Dedicated Funds for Habitat Improvement, River Restoration, or Fishery Enhancement
- Special Revenue Funds from Fishing Stamps or License Plates
- Environmental Penalty Mitigation Funds

A restored river can be an opportunity for revitalizing a community

"Having a hard time revitalizing your downtown?" questioned a recent Wall Street Journal article, "You may want to consider knocking the dam down."[28] Restoring a river by removing a dam can relieve a financial burden, help a community grow economically, and serve as a catalyst for revitalization.

While some studies have estimated the effects that a proposed dam removal may have on a community, the effects that actually occur after a dam has been removed have not been well documented. Because of this lack of data, it is difficult to make generalizations on the long-term impacts of dam removals within communities. Nonetheless, ten case studies throughout this report highlight some of the dam removals that have led to increased economic activity.

> **"Having a hard time revitalizing your downtown? You may want to consider knocking the dam down."**
>
> ***— The Wall St. Journal (Oct. 8, 2000)***

Some communities benefit from the added income brought in when recreation industries capitalize on improved opportunities. For example, canoeing and fishing opportunities improved following the 1992 removal of Ontario Dam on the Kickapoo River (see Kickapoo River, p. 19). Income from these activities has been especially important to the small rural communities in southwestern Wisconsin.

Prior to the removal of Edwards Dam near downtown Augusta, Maine, the Kennebec River was viewed by many as little more than an obstacle separating one part of the city from the other. When the dam was removed in 1999, new fishing and boating opportunities helped the public rediscover the river. Developers, taking notice of the renewed interest, are purchasing properties along the riverfront, speculating that in several years they will be part of a popular riverside downtown area.

It appears that the communities that have realized the most economic benefit from dam removals are those that have specifically developed plans for restoring the river system and revitalizing the community.

More than a decade after the removal of Woolen Mills Dam in West Bend, Wisconsin (see Appendix I), local residents are benefiting from quality-of-life factors associated with increased recreation in the former impounded area. Local businesses are also benefiting from increased use of the area. The new recreational opportunities were incorporated into the restoration plan guided by input from the community and state natural resources agency. Implementing the plan converted 61 acres of reclaimed land from the impoundment into a park with restored prairie land, ball fields, hiking trails, and access for boating and fishing.

According to a recent survey of area residents, the riverwalk associated with the park received one of the highest approval ratings of any aspect of the city.[29] Local business representatives believe that the quality-of-life improvement helps them recruit and keep high-quality employees.[30]

As another example of revitalization planning, the community of Baraboo, Wisconsin, received financial assistance from the state in the form of a planning grant for their restoration efforts involving three dam removals. Among their revitalization efforts, the community is planning fishing access, a riverwalk, and a park to help highlight the restored river that flows through their downtown (see Baraboo River, p. 21).

A restored river can offer many recreational opportunities

Dam removal has been found to improve sport fisheries and other river-based recreational opportunities.[31,32,33] Along with providing direct recreational benefits for participants, these opportunities can also bring outside money into communities through

Bountiful Recreational Opportunities and Community Economic Development

Kickapoo River, Wisconsin

The removal of Ontario Dam from the Kickapoo River in southwestern Wisconsin improved recreational opportunities on the river and enhanced local fishing and canoeing industries.

The dam was inspected shortly after a drowning near the structure in the late 1980s and was declared a public safety hazard. It was removed in 1992 at a total cost of $47,000, compared to estimated repair costs of up to $200,000.

Ontario Dam on the Kickapoo River failed a safety inspection in the late 1980s. The dam was removed in 1992 (photo courtesy of Wis. DNR).

Canoeists paddle down the Kickapoo River. The number of canoe rental businesses has increased since the Ontario Dam removal (Trout Unlimited photo).

In concert with improving land use in the watershed, the removal of Ontario Dam has provided many benefits, including reduced flooding, improved fishing, better canoe access, and related financial benefits to rural communities along the river.

Since the early 1990s, the number of canoe rental businesses has increased and existing businesses have increased the number of canoes for rent. During the summer of 1999, an estimated 16,000 people canoed on the Kickapoo River.

According to a university study, non-local canoeists spent $1.2 million on lodging, canoe rentals, groceries, gas, and other items in 1999. This revenue helps support 36 area jobs, through both direct services to recreationists and the ripple effect of more income in the local economy.[34]

A young girl fishes in the Kickapoo River. Angler expenditures annually top $1 million in the rural Kickapoo Valley (Trout Unlimited photo).

The dam's removal has also resulted in cooler, less silty water. These conditions are much better for trout, and the Kickapoo is now a Class II trout stream supporting both brown trout and wild brook trout. Fishing is a popular activity in the watershed, and non-local angler expenditures are today more than $1 million annually.

tourism-related activities like shopping and lodging (see sidebar, p. 20).

Removing a dam restores a stretch of river to its free-flowing state, allowing it to more naturally support fish populations and habitat, which, in turn, can attract anglers. Removal may also result in increased use by canoeists and kayakers, who can freely and safely float without encountering slack water or obstructions.

The value of water-based recreation has been noted in numerous studies over the years, including many that attempt to attach economic values to particular types of activity. Walsh and others[35] compiled the results of many of these studies to estimate economic values of different types of recreation (Table 7).

Walsh's analysis suggests an interesting potential economic benefit of dam removal and revitalized riverine fisheries. The still water in dam impoundments can cause water temperatures to warm. Warming of even a few degrees can inhibit the survival of coldwater species. If a river naturally supports a coldwater fishery, removing a dam and restoring the natural and potentially more economically valuable trout or salmon fishery could be an economic boon for a community, especially if there are no other nearby coldwater fisheries. High quality coldwater habitat is relatively rare, and that scarcity can increase the value to anglers of sites that are high quality.

Dams also block runs of migratory fish that need to swim up freshwater streams in order to reproduce. Removing a dam can help restore both coldwater and migratory fish populations where rivers would normally support such populations. In other cases, by improving water quality and habitat connectivity, small dam removal can also help restore warmwater species such as smallmouth bass (see sidebar, p. 30).

Sport fishing is a growing industry

Many state economies get billions of dollars of income from sport fishing. If sport fisheries are improved following a dam's removal, the potential economic benefits to communities can be significant (see sidebar, p. 23).

Ripple Effect: How Recreation and Tourism Money Helps the Economy

The "ripple effect" captures the magnifying impact of a dollar spent in a community. As an example, the American Sportfishing Association's *The 1996 Economic Impact of Sport Fishing in the United States*[36] describes the ripple effect as follows:

Each dollar spent by an angler increases another person's income, enabling that person (or business) to spend more, which in turn increases income for somebody else. The process continues as a wide series of ripples through local, regional, and national economies until the spreading fragments of the original dollar become so small they can no longer be measured.

If you fish in southern Wisconsin, for example, you might have stopped in at the Ace Hardware store in La Crosse. Here sales clerk Ron Gehrke is liable to suggest some RC Buzzbait lures for the local, largemouth-bass fishing. So you plunk down $10 for a trio of likely lures and head happily for the nearest bass pond. Then that $10 starts a ripple effect, spreading outward just like the ripples made when your lure hits the water.

Part of that money goes into Ron's wages helping to buy clothes for his kids at the local Farm & Fleet store. Part goes for income taxes, and yet another part goes into the store's overhead, paying for things like the electric bill from Northern States Power. And part of that money goes to Bettendorf, Iowa, where Ryan Coon of RC Tackle has a part-time business assembling lures in the family basement. Ryan pays bills, too, of course, and the rippling cycle further spreads and repeats. Included therein is money for basic family needs such as health care and telephone repair, which is how the effect of your tackle purchase spreads far beyond the doors of a sporting-goods store.

Ten dollars isn't very significant, of course, but when 35 million anglers spend $37.8 billion in 12 months the result in jobs, wages, and other economic effects is both extraordinary and at the very foundation of America's economic health.

Revitalizing Downtown by Reconnecting with a Free-Flowing River

Baraboo River, Wisconsin

The removals of Waterworks Dam in 1998 and Oak Street Dam in 2000 from the Baraboo River in downtown Baraboo, Wisconsin, have helped bring the community back in touch with its namesake river. According to a local newspaper, the river restoration "has spurred an economic revitalization effort in the downtown area and has suddenly made the river a hot spot for canoeists and kayakers."[37]

The Baraboo River flows over the Oak Street Dam, a stone's throw from downtown Baraboo, Wisconsin. The old dam's 2000 removal is helping the city reconnect with the river (photo courtesy of River Alliance of Wis.).

A new grassroots group, Citizens for Waterfront Revitalization (CWR), has been leading development plans to revamp Baraboo's downtown. Working with business and civic leaders, the CWR is planning a riverwalk along the river, a riverside park, a fishing dock, and a renovated bridge to give motorists a better view of the river. In addition, the community is commemorating the dams and their historical contributions to the region with dam history displays and a photographic history book.

According to a leader of the CWR, "Removal of the dams along the Baraboo Rapids has brought a heightened awareness of the historical significance that the dams had on the Baraboo area and its initial development. CWR is taking a lead role in promoting both economic and aesthetic revitalization along the Baraboo Riverfront."[38]

The community hopes their beautification plans will draw more people to Baraboo's downtown and waterfront, which is also home to Circus World Museum, the historic winter home of the Ringling Brothers Circus, a popular tourist attraction.

Canoeists enter the restored "Baraboo Rapids" which had been covered by Oak Street Dam for over a century. This artist's sketch depicts revitalization plans for downtown Baraboo (sketch courtesy of CWR).

Removing the dams has also improved the Baraboo River's water quality and sport fishery. Since the dams were removed, researchers have found 13 more species in some stretches of the river, including darters and smallmouth bass, fish that do not tolerate poor water quality.[39]

When the downstream Linen Mill Dam is removed in 2002, 120 miles of river will be flowing freely for the first time in more than 150 years.

Table 7. The Value of Recreation

Estimated median net economic values per recreation day by type of activity. The median is the middle value of an ascending series and expresses a central value much like an average.

Activity	***Median Value*** (1999 dollars)*
Saltwater fishing	$78.24
Migratory fishing	$67.81
Coldwater fishing (e.g., trout)	$41.78
Boating, Motorized	$37.65
Boating, Nonmotorized	$37.19
Winter Sports	$35.77
Hiking	$34.64
Warmwater fishing (e.g., bass)	$33.00
Nonconsumptive fish and wildlife	$30.05
Sightseeing and off-road driving	$28.92
Camping	$27.75
Swimming	$27.28
Other recreation activities	$23.55
Picnicking	$18.80

* The standard unit of measurement is an activity day, defined as one person on-site for any part of a calendar day.

Adapted from Walsh, et al., 1992.[35]

According to a sport fishing survey, more than 35 million people fished during 1996 in the United States (Table 8). That is more than twice the number of people who attend NFL football games each year. Together anglers spend more than $37.8 billion on the sport. When other activities associated with fishing are included, such as wages earned by people working in tackle shops, the economic activity surrounding fishing rises to nearly $108 billion.[36] That is more than the gross state products of Montana, Idaho, Wyoming, North Dakota, and South Dakota combined.

Moreover, the sport fishing industry is growing in the U.S. While the total number of anglers has remained nearly steady from 1991 to 1996, total expenditures increased by $10.2 billion, or nearly 40 percent. This translates into an average value of more than $1,072 spent per angler per year, an increase in constant dollars of over $776 per angler from 1991.[36]

In addition, over the past several decades, the total number of anglers in the U.S. has increased significantly from 17.6 million in 1955 to 35.2 million in 1996.[40]

Sport fisheries, such as smallmouth bass, northern pike, trout, and salmon, often recover dramatically after dam removal (see Tomorrow/Waupaca River, p. 25). If it is assumed that the number of anglers from outside a community will increase if a sport fishery is restored or improved, then communities can also expect increased economic activity.

Appendix I discusses the case of Woolen Mills Dam in West Bend, Wisconsin, where the number of people fishing in the Milwaukee River increased after dam removal. Many other dam removals have also resulted in improved sport fisheries.

Paddling is a growing industry

Canoeing and kayaking are rapidly growing industries in the United States. According to the American Canoeing Association, 24.8 million people went paddling in 1995.[41] In 1996, canoe and kayak sales totaled nearly $100 million and sales continue to grow.

Kayaking in particular is among the fastest growing outdoor activities, increasing by 50 percent in only four years from 1995 to 1999, with now more than four million participants.[42]

Our nation's tens of thousands of dams can make finding free-flowing river stretches a challenge for paddlers. Furthermore, there are notably few remaining free-flowing stretches of whitewater. The swiftest flowing portions of rivers and streams, which are a delight to many paddlers, have generally been the best places to generate hydropower and consequently have been the most viable spots for dams. In some regions, the only meaningful opportunities for whitewater paddling today are when larger dams have scheduled water releases.

Water trails — stretches of river, lake, shoreline, or ocean that have been specifically established as trails for recreational boaters — are increasing in popular-

Angling Dollars Can Help Local Communities

Three recent studies assessed the economic impacts of trout fishing in local communities based on angler expenditures. These studies demonstrate the economic ripple effect by showing how revenue from trout fishing extends into other industries and supports jobs in local communities.

An angler hooks a trout. Nearly 11 million people fly fish in the United States (photo courtesy of Rebecca Herrin).

Delaware River headwaters, New York. Revenue from trout anglers is a vital part of the economy in four small communities located in the headwaters of the Delaware River. In 1996, 31,000 anglers took advantage of the river's trout fishing, bringing almost $18 million into the four communities, which have a combined population of about 6,800. Nearly half (41%) of that money stayed within the local economy, supporting other businesses and individuals. The revenue from trout fishing supports 350 jobs in the four small communities.[43]

Kickapoo River/Timber Coulee Stream, Wisconsin. From 1994 to 1999, trout fishing in the rural Kickapoo Valley increased from a $300,000 to a $1.1 million industry per year. The number of anglers who visit the region each year has more than doubled since 1994 and by 1999 was up to nearly 9,000, most of whom traveled from outside the region. Visitors are spending more per trip, too. Approximately $76 per angler was spent per trip in 1994. By 1999, anglers spent $168 on each trip, mostly on eating, drinking, and lodging. Today, trout fishing supports more than 40 jobs in the rural area, which has a total population of 227,000.[34,44]

Beaverkill-Willowemoc Watershed, New York. Trout angling is one of the largest industries in Rockland, a small community of 4,000 within the Beaverkill-Willowemoc watershed. Area trout angling generated $2.3 million in wages in 1994, which supported 177 jobs. In total, trout anglers bring $4.8 million into the community, half of which is spent on food, beverages, and accommodations.[45]

An angler releases a rainbow trout. Retail sales of fly fishing equipment and apparel have been strong and increasing in recent years (photo courtesy of Russ Herrin).

Trout Fishing Nationally. Fly fishing is a popular sport in the U.S., with nearly 11 million participants.[46] In 1998, these anglers spent $572 million on fishing gear and apparel, a 9.2% increase from the 1997 total of $524 million. Retailers report that sales of rods, reels, waders, and apparel have each been growing. In 1997, 64% of all retailers experienced an increase in sales.[47] As noted in the cases above, millions of dollars are additionally spent during fishing trips on food, lodging, and transportation.

Table 8.
The Economics of Sport Fishing

The economic state of sport fishing in the United States based on a 1996 survey (1996 dollars).

Item	*1996*
Anglers	35.2 million
Days	625 million
Expenditures	$37.8 billion
Overall Economic Impact	$108 billion
Wages and Salaries	$28. 3 billion
Jobs	1.2 million
State Sales Tax	$1.9 billion
State Income Tax	$450.6 million
Federal Income Tax	$3.0 billion

Source: Maharaj et al., 1998.[36]

ity in the United States. The use of existing trails is increasing greatly, more trails are being developed, and more communities are beginning to use water trails to promote tourism. Dams can be an impediment to water trail recreation in many places because they make rivers less navigable, can pose a safety risk, and necessitate increased portaging (i.e., boats must be lifted out of the water and carried around them).

According to North American Water Trails, a coalition of water trail organizations, dam removal can equate to greater economic opportunities for communities that wish to establish a water trail.[48] The presence of a water trail brings more people to the river and increases business for local outfitters.

With so few free-flowing river miles throughout the country, removing small dams can significantly improve opportunities for paddlers and potentially create new economic opportunities for communities as the paddlesport industry continues to grow (see Apple River, p. 26).

Dam removal is a cost-effective means for improving water quality

As relatively stagnant collection areas for nutrients and sediment, impoundments behind dams often have poor water quality. Excessive growth of algae and other vegetation common in impoundments can cause dissolved oxygen levels to drop, particularly during summer nights when plants are consuming the most oxygen. Decaying plant material in an impoundment can also contribute to declines in dissolved oxygen. Maintaining dissolved oxygen levels is crucial for aquatic life.

In addition, dams and their impoundments often cover stretches of natural river rapids because these steeper sites have high velocity flows to spin hydropower-producing turbines (see Apple, Baraboo, and Willow River case studies). Uncovering rapids by removing dams can help improve water quality because free-flowing rapids aerate water, maintain water temperature, and carry sediment downstream, clearing fish spawning gravels.

From an economic standpoint, poor water quality can inhibit recreational use of a water body and increase water treatment costs. Poor water quality can also reduce waterfront property values[49] (see land values section, p. 31).

Removing a dam can be one of the most cost-effective and efficient methods of improving the water quality of a river or stream. Dam removal can restore the flushing flows of moving water and eliminate the conditions that result in dissolved oxygen declines. Flowing water transports sediment and nutrients downstream rather than allowing them to accumulate in one place, and flowing water serves to dilute and distribute pollutants.

Section 303(d) of the Clean Water Act, established in 1972, requires that states maintain a list of 'impaired waters', those water bodies that do not meet that state's water quality standards. According to the law, states must develop Total Maximum Daily Loads (TMDLs) for the impaired waters and submit them along with the list to the Environmental Protection Agency (EPA) for approval. A TMDL is the maximum amount of pollutants that a particular water body can receive from all sources while remaining within water quality standards.[50]

Restoring a First-Class Trout Stream

Tomorrow/Waupaca River, Wisconsin

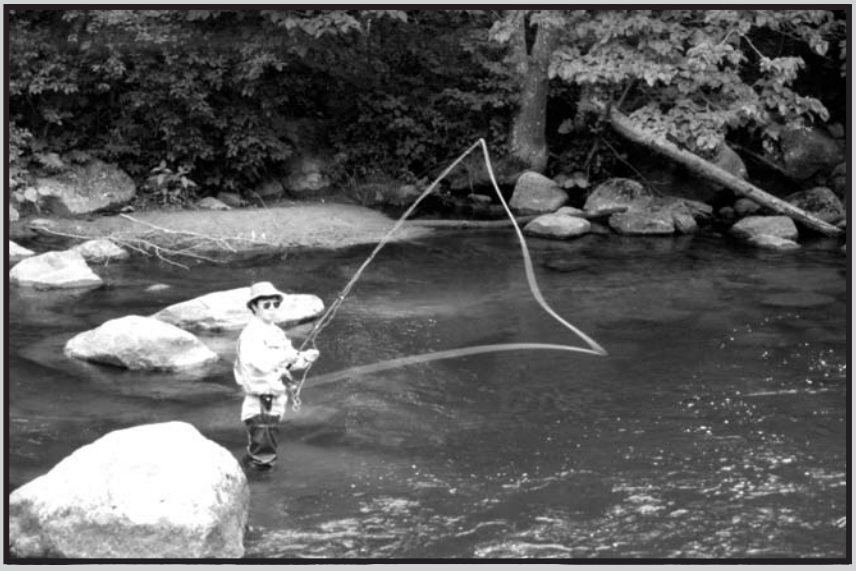
Nelsonville Dam on the Tomorrow/Waupaca River had the dual distinction of being Wisconsin's last commercially licensed water-driven gristmill and the first Wisconsin dam removed for the express purpose of improving a fishery.

Built in the 1860s, the dam blocked the river and significantly harmed native fish habitat. Agricultural runoff and sediment nutrients created undesirable algal blooms in the millpond, and the increased temperature of its impoundment caused a warmwater fishery to develop on this naturally high-quality coldwater trout stream.

Nelsonville Dam and its impoundment degraded fish habitat in the Tomorrow/Waupaca River in Wisconsin. The dam was removed for the express purpose of improving the fishery (photo courtesy of Wis. DNR).

The Wisconsin Department of Natural Resources (DNR) purchased Nelsonville Dam in 1984 for the purpose of removing it and restoring the spring-fed trout stream.

The removal of the dam, along with related bridge and roadwork, cost $62,000 and was partially funded by Wisconsin's Inland Trout Stamp Habitat Development Program. The former dam site was restored by planting vegetation, stabilizing the former impoundment bed with riprap, and stocking the river with trout.



An angler casts a fly on the Tomorrow/Waupaca River near Nelsonville. When Nelsonville Dam was removed, over a mile of highest quality trout stream was restored (photo courtesy of George Sroda).

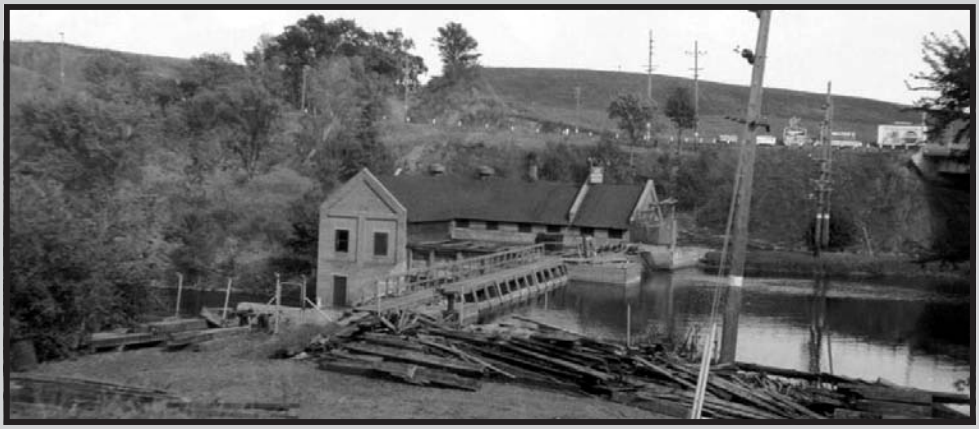
The old mill building was deeded to the Portage County Historical Society. It now provides a facility for art shows, concerts, and other community events.

According to the Wisconsin DNR, water quality below Nelsonville has improved, and over a mile of highest-quality (Class I) trout stream has been restored in and above the old millpond site. Today some 38 miles of the Tomorrow have naturally reproducing brook and brown trout above the former dam site.

New River Businesses

Apple River, Wisconsin

The removal of Somerset Dam in northwestern Wisconsin allowed new businesses to grow, including a thriving tubing industry.



Somerset Dam stood for more than a century in Wisconsin's Apple River. The dam failed in the early 1960s and was removed in 1965 (photo courtesy of Wis. DNR).

Somerset Dam was built on the Apple River for hydropower during the 1850s. The dam washed out during a flood in the early 1960s.

Tubers approach the renewed rapids at the former Somerset Dam site. The dam's removal reconnected eight miles of the river, helping the tubing industry to thrive (photo courtesy of Apple River Hideaway).

Northern States Power (NSP) transferred ownership of the dam to the City of Somerset in 1963, and the remaining structure was completely removed in 1965. NSP and Somerset shared the $75,000 cost of removal.

Since the removal of the dam, tubing and camping businesses have prospered, including the establishment of several new businesses. The former dam site now marks the beginning of a series of rapids that are popular with river floaters.

Currently, five businesses offer tube rentals and access to an eight-mile stretch of free-flowing water between the Apple's two remaining dams.

One area resource manager notes, "The tubing industry wouldn't be what it is today without the dam removed."[51]

Scientists and resource managers are increasingly recognizing the role of dams in deteriorating water quality. Selectively removing dams is being explored in some places as a potentially cost-effective option to achieve TMDL goals. In 2000, Ohio EPA recommended the removal or modification of two dams on the middle Cuyahoga River to eliminate drops in dissolved oxygen caused by algae growth and stagnant water in the dams' impoundments.[52] The middle Cuyahoga is on Ohio's 303(d) impaired waters list. Both the Munroe Falls and Kent Dam impoundments have had dissolved oxygen measurements that violate standards. The Ohio EPA recommendations state, "Elimination or modification of the dams would greatly improve habitat conditions and dissolved oxygen concentrations and would allow fish to migrate." Without removing or modifying the dams, two wastewater treatment plants on the river would have to undergo expensive improvements to reach TMDL goals.

On the Naugatuck River in Connecticut, eight dams are being removed or modified along with wastewater treatment plant upgrades in an effort to clean up a river that has been degraded by industrial pollution for decades. (see Naugatuck River, p. 28).

Removing small dams can help restore river systems

Because a single dam removal can potentially restore many river miles, small dam removal is increasingly being considered as a tool for restoring river systems on a watershed basis. A watershed is the land that drains to a certain water body. The river systems of many watersheds in the United States are fragmented by tens to hundreds of small dams with cumulative effects that impair water quality, damage fish habitat, and prevent natural river function. Federal and state environmental and natural resources agencies are increasingly making comprehensive assessments of entire watersheds and river systems, and implementing plans for watershed-wide restoration efforts. With this broader water-based focus, they are beginning to remove small dams and reduce the impacts of remaining dams (e.g., through improved operation or effective fish passage devices) to benefit entire river systems.

Dam removal can be the most cost-effective *and* biologically effective means of restoring habitat.

Two examples of these watershed-wide efforts include the Connecticut Department of Environment Protection's projects in the Naugatuck River watershed and the work of the Pennsylvania Fish and Boat Commission in the Susquehanna River watershed. Both of these efforts are comprehensive plans to improve fish habitat and water quality and include the removal or modification of several dams throughout a river system.

When restoring a river system and its habitat, various restoration alternatives often need to be examined in order to determine cost-effective approaches and the most efficient means for accomplishing objectives. Removing small dams can be the most cost-effective and biologically effective means of restoring fish habitat and increasing fish populations (see sidebar, p. 30). Although costs can vary widely, according to the Wisconsin Department of Natural Resources, a small dam can be removed for about the cost of two miles of instream trout habitat work (including such work as installing habitat structures and associated bank stabilization), while potentially restoring many miles of habitat.[53]

On the Conestoga River in Pennsylvania, ten small dams have so far been removed, improving river habitat at a cost of less than $12,000 per mile (see Conestoga River, p. 29). For comparison, in-stream restoration efforts for fish habitat — including such measures as bank stabilization and installation of fish habitat structures — can cost $30,000 to $50,000 per mile. Note that the cost-effectiveness of restoration techniques cannot be directly compared because each application has site-specific issues. This comparison is intended to give an idea of cost ranges.

A study on the Milwaukee River South watershed in Wisconsin found that small dam removal costs less per acre of habitat restored for smallmouth bass than implementing best management practices or purchasing streambank easements.[54]

A Watershed-Wide Water Quality Improvement Plan

Naugatuck River, Connecticut

During the industrial boom of the 19th century, factories and municipalities openly dumped waste into Connecticut's Naugatuck River.

By the late 20th century, the Naugatuck was considered one of the most polluted rivers in Connecticut. Numerous dams along the river inhibited its natural flow patterns, which otherwise would have helped dilute the pollutants.

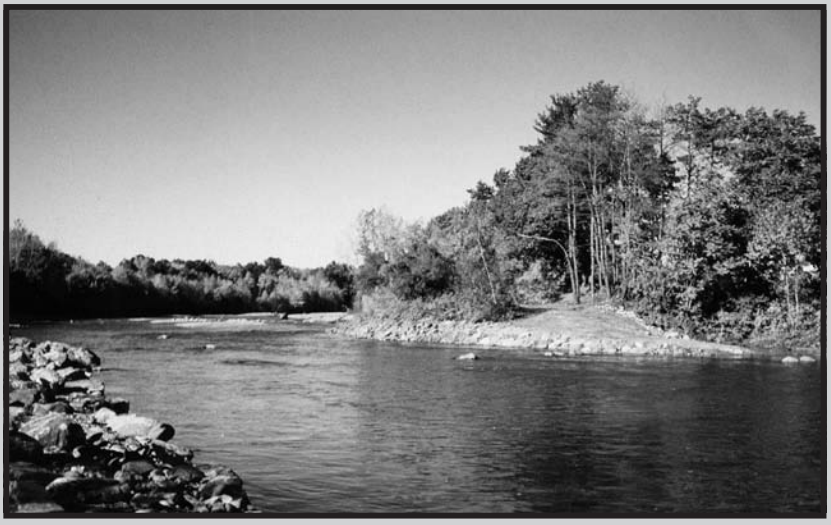
The Connecticut Department of Environmental Protection (DEP), local Trout Unlimited volunteers, and other partners recently began an unprecendented watershed-wide effort to restore the Naugatuck River. The plan involves removing or modifying eight dams and upgrading several wastewater treatment plants that discharge into the river.

Union City Dam on the Naugatuck River was one of eight dams modified or removed. The unprecented watershed-wide clean-up is improving the river's habitat and water quality (photo courtesy of Milone & MacBroom).

As a result of the Naugatuck Restoration Project, four dams have been removed as of 2000, at the following costs:

- Union City — $139,300
- Freight Street — $75,700
- Anaconda — $56,000
- Platts Mill — $111,400

Four additional dams are either pending removal or are being modified to provide fish passage.



A stretch of the Naugatuck River flows freely following the removal of Union City Dam. The swift-flowing upstream riffles help improve water quality by speeding diluting flows and aerating the water (photo courtesy of Milone & MacBroom).

Along with treatment plant upgrades that have been completed, dam modifications and removals have been a cost-effective means of dramatically improving the Naugatuck's water quality.

At its completion, the pro-active project will have improved habitat and water quality in 32 miles of the Naugatuck River, restoring passage for sea-run brown trout, American shad, alewives, blueback herring, and other aquatic species.

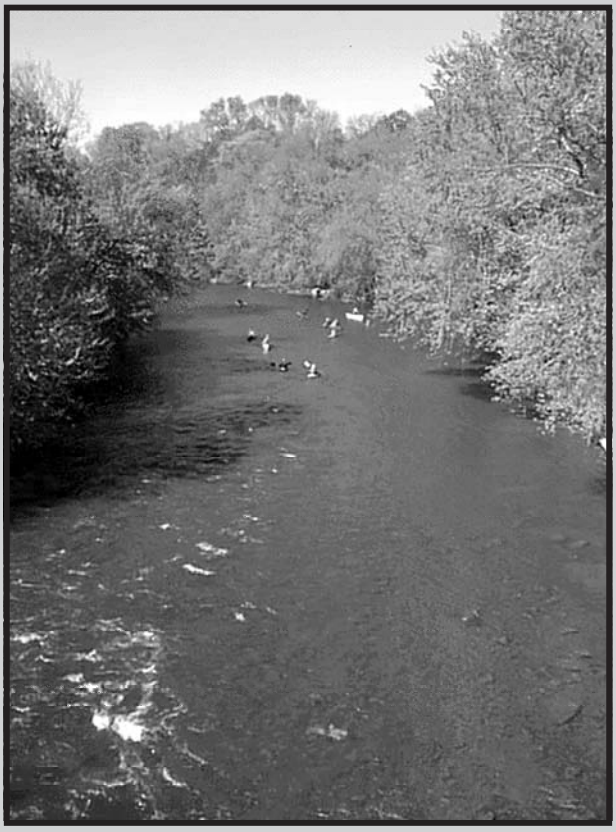
A Cost-Effective Tool for Fisheries and Watershed Restoration

Conestoga River, Pennsylvania

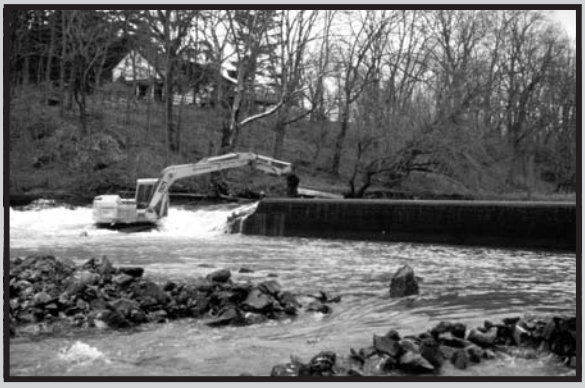
Ten dams were removed from the Conestoga River and its tributaries in Pennsylvania between 1996 and 2000 as part of a watershed-wide effort to restore the river's once vibrant fisheries.

With seven more dams pending removal, the goal is to restore the river's historical American shad runs. Many years ago, shad would migrate from the Atlantic Ocean through Chesapeake Bay and the Susquehanna River to reach spawning grounds in the Conestoga. However, since 73 blockages were built on the river and its tributaries, the migratory shad have been unable to reach these historic spawning grounds.

The dam removals are proving to be a cost-effective tool for restoring aquatic habitat in the Conestoga. The first nine dams were removed at a total cost of under $300,000. Their removal has opened up more than 25 miles of river to migratory shad and other species, at a cost of less than $12,000 per mile.



Boaters paddle down a restored free-flowing stretch of the Conestoga River. Ten dam removals on the river have helped both recreation and fish habitat (photo courtesy of Lancaster County Canoe Club).



The Conestoga River rushes through a breach in the Rock Hill Dam, one of ten dams removed from the watershed from 1996 to 2000. Seven more dams are scheduled for removal as part of a watershed-wide effort (photo courtesy of Penn. Fish & Boat Comm.).

The Pennsylvania Fish & Boat Commission estimates the improved habitat will result in 50,000 angler trips to the river each year to the restored American shad runs. Pennsylvania expects this to generate another $2 to 3 million per year for local economies.[55]

In the spring of 2000, American shad that were stocked as young, recently hatched fish four years earlier, were found as adults in stretches of the river. After being absent from the river for 88 years, these fish were able to imprint on the Conestoga. In other words, they instinctively returned to its free-flowing reaches after their migratory journey to the Atlantic Ocean.[56]

Dam Removal Is Biologically Effective for Restoring Habitat

Fisheries biologists were among the first to recognize that removing dams can be an effective way to restore fish habitat. One study by fisheries biologists on the Milwaukee River South watershed modeled the fish habitat that would be created by different management techniques. Their modeling showed that removing dams would restore more habitat for two highly valued sport fish, smallmouth bass and northern pike, than other fishery management techniques, such as buffer strips and sediment control techniques (Figure 1).

The benefit of dam removal to fisheries is increasingly confirmed by real-world cases. A fish survey on the Baraboo River following the removal of Waterworks Dam found 24 species of fish, more than double the 11 species found during a survey two years earlier with the dam in place. Species diversity is an indicator of river health. The survey also found 87 smallmouth bass in a stretch where only three were found before the dam's removal.[39]

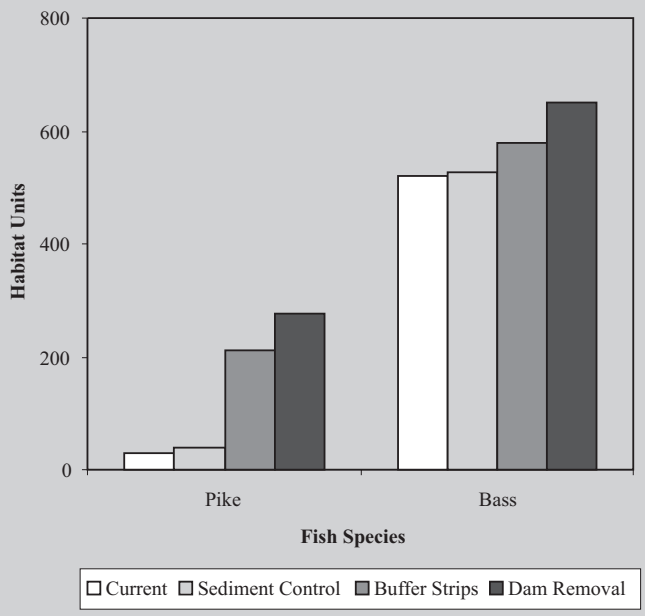
Just one year after the removal of Edwards Dam from the Kennebec River in Maine, alewives and other species returned in numbers that had not been seen for more than 160 years since the dam was built. After the removal of Woolen Mills Dam from the Milwaukee River, smallmouth bass populations increased substantially from nearly zero in portions of the river.[31]

After the removal of ten dams from the Conestoga River in Pennsylvania, American shad migrated back from the Atlantic Ocean for the first time in 88 years.[56]

The number of examples like these continues to grow, attesting to the success of restoring fish and other habitat by removing dams.

Figure 1.
Dam Removal Improves Habitat

Total potential habitat for representative fish species under various habitat management options for the Milwaukee South watershed. Fisheries biologists recognize dam removal as one of the most effective means for habitat restoration.



A habitat unit is equal to one acre of "optimum" habitat for a species.

Source: Pajak, 1992.[54]

Land Values and Small Dam Removal

One of the most controversial issues in discussions about dam removal versus repair concerns the effect removal might have on neighboring property values. A common assumption is that when the impoundment is gone, nearby property values will drop. To date, there have been few studies that address this topic, but anecdotal evidence and some preliminary research indicate that property values do not necessarily decline after a dam is removed.

Because little hard data is available and the potential economic impact on land around former impoundments is a common sticking point in dam removal discussions, Trout Unlimited conducted preliminary research on the topic (see Appendix I: The Case of Woolen Mills Dam and the Milwaukee River). The study looked at a case in a small community where a small dam had been removed 10 years earlier, and the river and former impoundment restored in a thoughtful manner. According to property owners and a local realtor, the predicted decrease in property values around the former impoundment did not occur.

Property values can decline with a dam in place.

In fact, property values can decline with a dam in place. Because of sedimentation, eutrophication, and the general lack of oxygenated flushing river flows, dam impoundments often have poor water quality. Several studies have shown that poor water quality adversely affects nearby property values. For example, one study in Massachusetts showed that residents around the Neponset Reservoir suffered financial loss due to changes in water quality that reduced the reservoir to an unsightly and obnoxious nuisance in the summer. The study estimated that the 160 lots around the reservoir were worth $13.7 million less than they would have if the reservoir water were clean — a 40 percent loss in value.[57]

Another study, of homes adjacent to St. Albans Bay in Vermont, estimated a 20 percent decline in property values due to poor water quality.[58] A study of a large number of lakes in Maine concluded that changes in water clarity caused a decline in shoreline property values. Every meter of water depth visibility lost due to poor water quality caused property values to drop by five percent.[59]

Studies have also shown that properties near open space can have higher sales prices, better marketability, and faster sales than properties away from open space.[60,61,62,63,64,65,66] Both the lake environment of a dam impoundment and the riverine environment following a dam removal can be considered open space and accordingly, either could add value to a property. Similarly, when a dam is removed, the land formerly covered by the impoundment is often some type of open space and could enhance property values, whether it is restored wetlands[67] or other natural environment, or converted to parkland (see Willow River, p. 32). One study in Michigan found that property frontage along the AuSable River "was at least equal to, if not more valuable than, 'lake' or reservoir frontage."[68]

Proximity to natural areas in general is typically a desirable trait for real estate. Following a preference in the late 1980s for proximity to so-called "built" environments (e.g., tennis courts, fountains), trends, begun in the 1990s, appear to be heading toward preferences for more natural environments. In addition, the relative scarcity of these environments can increase their value. As more and more dams are removed, homebuyers may make the distinction between the built environment of a dam, versus the natural environment of a free-flowing river.

The effect of dam removal on property values around an impoundment is a subject that needs more study, but enough research and anecdotal evidence exists to indicate that one should not assume property values will decline. In many cases, when dam removal includes thoughtful restoration — of the river and adjacent lands — property values need not decline. Indeed, when the dam removals of today are evaluated 10 years hence, some property values may even increase, especially where poor water quality in the impoundment was a factor.

Restoring Natural Beauty

Willow River, Wisconsin

Willow Falls Dam and Mounds Dam were both built on the Willow River in northwestern Wisconsin in the late 1800s to power lumber and flour mills. The dams were later used to produce electricity.

By 1963, neither of the dams was in use, and both were donated to the state — along with 1,300 acres of land — for what would become Willow River State Park.

Willow Falls Dam stood 60 feet over the Willow River downstream. Time and flowing water rotted the concrete structure and it was removed in 1992 (photo courtesy of Wis. DNR).

By the 1990s, the dams were in very poor condition. Willow Falls Dam was found to be beyond repair, and repair costs for Mounds Dam were estimated at $3.3 to 6 million. Estimates for removing the dams were $622,000 for Willow Falls and $1.1 million for Mounds Dam. Willow Falls Dam was removed in 1992. Following lengthy and controversial debate, removal was determined to be the best option for Mounds Dam as well because of the cost differences between repair and removal. The structure was removed in 1998.

Both dams cost much less than originally estimated to actually remove — $450,000 for Willow Falls and $500,000 for Mounds.

Removing the dams has been positive for both the fisheries and Willow River State Park. Four miles of the Willow River was restored and now sustains a trout fishery. (However, a dam subsequently repaired upstream is keeping water temperatures too warm for the trout population to reproduce naturally.)

Willow Falls is a centerpiece of Willow River State Park. The natural flows of the scenic waterfalls were restored by the removal of Willow Falls Dam (photo courtesy of David Gilbraith).

Willow Falls Dam removal also restored natural flows to scenic Willow Falls. The Falls are now a popular attraction at Willow River State Park, which is just outside of Minnesota's Twin Cities and draws more than 300,000 visitors a year.

Conclusion

As the hundreds of thousands of small dams that helped power our nation's growth continue to age, more and more communities are faced with decisions to repair or remove these structures. These decisions are often contentious, marked by confusion and misinformation, and narrowly focused on a small number of the many issues. While having more complete and accurate information may not relieve all of the tension, it can help communities make more informed decisions.

Many communities that have chosen to remove a small dam continue to realize a number of economic benefits. The most obvious benefit, and the one that drives many decisions to remove small dams, is that repairing a dam is usually more expensive than removal. In the cases studied in this report, the cost of repairing a dam averaged more than three times the cost of dam removal. In some cases the cost difference can be even greater.

Removing a dam can relieve the financial burden of maintaining and repairing the dam structure as well as the safety liability associated with the structure. It can also relieve recurring costs associated with maintaining water quality and fishery management.

Many of the benefits of dam removal, as well as many of the costs and benefits of repairing and maintaining a dam, occur over the long term. A thorough decision-making process needs to include more than a simple comparison of the short-term cost of repairing a structure versus the demolition cost of removal. It needs to consider all of the costs and benefits of each option, both immediate and well into the future.

Experience has shown that communities that embrace the opportunity to reconnect with a naturally functioning, free-flowing river through a thoughtful restoration plan are the most likely to see the greatest economic benefits from a small dam removal. Such plans include the concerns of the resource agencies, the community, and other stakeholders, including water users.

As the local community is brought in touch with the river through such amenities as riverwalks, parks, and increased access for boating and fishing, the improved recreational opportunities build an additional potential for tourism and associated commercial benefits. In several communities, small dam removals have been catalysts for downtown revitalizations, local fishing and boating industry development, and watershed-wide recreation plans. As more people come to experience the river, associated economic benefits come to the communities that provide access to the river.

While not all of the benefits of removing a small dam will occur in every case, an understanding of the potential benefits can help communities imagine the possibilities. When managed thoughtfully, a community's loss of a small dam can bring about meaningful gains in recreational and commercial opportunities, and in the health of the river.

Appendix I: The Experience of West Bend, Wisconsin, and the Milwaukee River Restoration

In 1988, Woolen Mills Dam was removed from the Milwaukee River in West Bend, Wisconsin. While every dam removal has unique aspects because of different socioeconomic, biological, and engineering issues, this project is highlighted here primarily for two reasons. First, although the decision-making process was contentious at times, overall the dam's removal and the restoration of the river and surrounding land was managed particularly well by the community and resource managers. Second, the project has more complete pre- and post-monitoring data than most projects, including economic, water quality, and fisheries information. Woolen Mills Dam was removed more than a decade ago, allowing time for reflection on the project and its impacts on the river and the community.

The Woolen Mills Dam removal is characteristic of the issues many communities are facing with respect to the dam's size and condition, small town surroundings, safety issues, current and former dam uses, fisheries issues, water quality issues, sediment issues, project costs, and concern about property values.

In other ways, the dam's removal is not typical; a great deal of land was regained for public use from the impoundment and, at the time, it was uncommon to have such a comprehensive restoration plan developed by the community and resource managers. Inevitably, the most successful restoration projects are guided by thoughtful plans, both to physically restore the environment and to provide benefits for the surrounding community.

The Story

Woolen Mills Dam was originally a wooden structure built in 1870 by the city of West Bend to power a sawmill, and later a woolen mill. In 1919, Wisconsin Power and Electric (WPE) rebuilt the dam as a concrete hydropower structure. The reservoir created by the 18-foot high dam was locally known as West Bend Pond. When built, the pond had a surface area of 67 acres and a mean depth of about 15 feet.

In 1959, when it was no longer economical to maintain the dam as a hydropower facility, WPE legally abandoned it and transferred ownership to the city of West Bend.

By 1980, the dam was badly deteriorating and had become a public safety hazard. It was no longer generating hydropower, and its impoundment was sparingly used for recreation, including some fishing, swimming, and ice-skating. Following a safety inspection, the Wisconsin Department of Natural Resources ordered that the dam be repaired, rebuilt, or removed. After long contemplation and public discussion, it was agreed that the dam should be removed, primarily because of the high cost of the necessary rebuild.

Woolen Mills Dam stood in the Milwaukee River in West Bend, Wisconsin, for 118 years. The deteriorating structure was removed in 1988, avoiding a $3.3 million cost to rebuild it (photo courtesy of Wis. DNR).

Ultimately, the community gained a more healthy and naturally functioning river, including associated wetlands. Water quality improved and recreational opportunities increased. Sixty-one acres of land were reclaimed from the former impoundment and were used to

expand the existing Riverside Park. The park today includes heavily used hiking and biking trails, footbridges, fishing access, a canoe launch, and athletic fields. A walking path winds around a restored native prairie and crosses over several scenic walking bridges that span the river.

The following describes many of the costs and benefits of the decision.

Who Paid?

The city of West Bend paid for the $86,000 cost of the structure's removal. Through the Wisconsin Stewardship Program, the state Department of Natural Resources assisted the city with restoration efforts by paying 50% of the costs for park development, including a canoe launch, athletic fields, trails, pedestrian bridges over the river, fishing access, and parking. The city and the state also shared project costs of design and engineering, seeding, and riverbank stabilization work.

Cost Comparison

The decision to remove Woolen Mills Dam hinged on the substantial difference between the direct costs of rebuilding and removing the dam. On one hand, the cost estimate to rebuild the dam was $3.3 million, including associated costs of extending a road and bridge over the dam. West Bend, a moderate-sized community of around 24,000 people, could not afford a cost of this magnitude. On the other hand, it cost $86,000 to remove the structure.

However, a comparison of these direct costs does not tell the entire financial story. Both rebuilding and removing the dam had additional costs that either were incurred or potentially would have been incurred (Table 9 and Table 10). For example, Woolen Mills Dam had operation and maintenance costs of approximately $10,000 per year. A rebuilt dam may or may not have cost the same to operate, but certainly would have had annual costs which, along with potential costs for future repairs, would have added up over the life of the dam.

In addition, there were liabilities associated with the dam because it had no capacity to store floodwaters. Following one large storm, the city paid over

Table 9. Estimated Costs of Rebuilding Woolen Mills Dam

Estimated costs for rebuilding Woolen Millls Dam, along with associated bridge construction and West Bend Pond water quality management.

Activity	*Cost ($)*
Rebuilding dam, bridge, and road extension	3,300,000
ADDITIONAL COSTS	
Dredging West Bend Pond	972,000
Additional pond water quality management (macrophyte harvesting, nutrient inactivation, sediment covering)	11,900 per year
Improved watershed management practices (erosion control and urban land management)	24,800 per year
Operation and maintenance of the dam	not estimated*
Future dredging of West Bend Pond	not estimated*

* included to show costs that should be considered but were not estimated

Source: West Bend Parks Dept. Files, 1979, SEWRPC

Table 10.
Costs of Woolen Mills Dam Removal, River Restoration, and Recreational Park Development

Activity	*Cost ($)*
Dam Removal	82,000
Initial seeding	33,000
Engineering and contract hydrologic studies, design work	73,000
Final grading and seeding	861,000
Bridge construction and river rerouting	800,000
Park Development	549,000
Fish Restoration	32,000
TOTAL INITIAL COSTS	**2,430,000**
ADDITIONAL COSTS	
Park operations and maintenance	~ 8,000 per year
Potential future repairs and upgrades to park facilities	not estimated*

* included to show costs that should be considered but were not estimated

Source: West Bend City Engineering Dept. and West Bend Parks Dept.

$100,000 for property damages caused by upstream flooding exacerbated by the dam. If a new dam were rebuilt, a more effective spillway could have reduced some of the risk of flood damage, but the impoundment still would not have had the capacity to store floodwaters. By removing the dam, this liability was removed.

In 1979, the Southeast Wisconsin Regional Planning Commission (SEWRPC) recommended a variety of management procedures to improve the degraded impoundment's long-term water quality (Table 9). The overall objective was to reduce the pond's nutrient levels and restore its depth to an average of 15 feet from its six-foot depth at the time of the study. Dredging the impoundment to this depth would have cost $972,000 in 1980 dollars.

Dredging would have restored the depth of the pond, but the pond would have started to fill in again as the river deposited sediment and nutrients from the largely agricultural areas upstream of the dam. To reduce this buildup of material and delay the time between dredgings, improved management practices for the entire watershed would be needed. These practices, included in the SEWRPC recommendations, would have reduced amounts of sediment and nutrients in the water and generally improved water quality. Improved watershed management would have cost approximately $24,800 per year. Even with the dam removed, these management practices may have still been advisable, but the dam's removal ended the accumulation of materials in West Bend Pond.

River restoration and park development were the most substantial costs associated with the project (Table 10). In addition, the new bridge that was originally proposed as part of the dam repair was still built in conjunction with the dam removal, at a cost of $800,000. In all, the costs of removing the structure, building a bridge, restoring the stretch of river, and developing the park added to $2,430,000, still almost $1 million less than the cost of rebuilding the dam.

Park facilities also have operation and maintenance costs, and these costs are approximately $8,000 per year at Riverside Park. Over the long term, the park will likely need upgrades, which could amount to significant investments. The original cost of $549,000 for developing the park gives a general sense of what future upgrades could cost.

In the end, the choice for West Bend came down to rebuilding the dam, and thus preserving its moderately used impoundment, or removing the dam and

Four walking bridges span the Milwaukee River in West Bend. The bridges connect trails over parkland that was covered by water for more than a century. The trail system also connects to the downtown area (photo courtesy of West Bend Parks Dept.).

developing a well-used park at a cheaper price. The removal of the dam brought additional economic benefits for recreation, community development, and for local businesses.

Recreational Benefits

Restoring a free-flowing stretch of the Milwaukee River and developing Riverside Park has created a number of recreational opportunities for the surrounding community.

According to local officials, prior to the removal of Woolen Mills Dam, few residents used the impoundment and surrounding area, with the exception of adjacent landowners. Following the removal, however, the city's Parks Department estimated that, combining all activities, there were more than 37,000 users in the newly developed section of the park in one year alone (Table 11).

Although there may be some overlap between people participating in different activities in the park, the overall number of users is greater than the entire population of West Bend. Possible dollar values of many of these new recreational opportunities were presented earlier (Table 7), and give a general sense of the increased overall value of the area to the community.

Before Woolen Mills Dam was removed, researchers from the University of Wisconsin-Stevens Point surveyed the recreational uses of West Bend Pond over a 25-day period in the summer of 1986.[69]

The survey observed eight people swimming in the impoundment and one person fishing during that entire period. It was concluded that recreational activities were stifled due to poor public access for boats, the absence of a sport fishery, and a silty pond bottom.

The researchers also noted that people fished and swam almost twice as much in the free-flowing sections of the Milwaukee River just outside of West Bend.

Following the dam's removal, fishing in the former impoundment increased. During the summer of 1990, just two years after the dam was removed, a study found 51 anglers within the new, free-flowing section of the river. These anglers contributed over 2,000 angler hours of fishing.[71]

While improved public access has contributed significantly to increased swimming and fishing in the restored river, improved water quality has also played a crucial role. Simply based on observation, a sediment-filled pond was turned into a free-flowing river with higher water quality that is fundamentally more attractive to anglers and swimmers.

A study five years after the dam's removal found that carp, a species tolerant of poor water quality conditions that had been abundant in the impoundment, had essentially been replaced by smallmouth bass, a species that does not tolerate poor water quality.[32] In addition, during that time, the overall index of biotic integrity, a measure of stream health, improved from 'poor' in the reaches above the dam to 'good.'

Table 11. Former Impoundment Became a Recreational Area

Estimated number of users by activity in the expanded Riverside Park following the removal of Woolen Mills Dam. The figures are based on observation and some tracking by the West Bend Parks Department. Numbers are conservative estimates.

Activity	*Estimated Number of Users in 1999*
Trail Access: Canoeing, Fishing, Biking, Walking, Jogging, Rollerblading, Skateboarding, Picnicking, Sculpture Showcase Viewing, Wildlife Appreciation, Skiing, etc.	27,000
Adult Flag Football League on Football Field	800
Youth Football Instruction on Football Field	30
YMCA Youth Soccer League on Soccer Field	800
July 4th Fireworks Display from Parking Lot	5,000
Kettle Moraine Jazz Festival on Football Field	4,000
TOTAL	**37,630**

Source: Pruit, 1999.[70]

Community Benefits

Riverside Park, connected to downtown West Bend with walking trails, has become a center for community activity. There is a sense that the revitalized river and parkland have brought a feeling of pride to the community. In a 1999 West Bend quality-of-life survey, residents gave the riverwalk, which winds through Riverside Park, one of the highest approval ratings of any feature of the city.[29]

Kids fish in the Milwaukee River in Riverside Park. Fishing has become popular in the river since the Woolen Mills Dam removal led to improved water quality and fish habitat (photo courtesy of West Bend Parks Dept.).

A member of the city's Rotary Club describes community sentiment about the changes, "People at first were very, very skeptical of what was going to happen. But of course now people know very well what's happened and the whole city is enjoying it...the whole attitude has changed and now people want to be down not only sitting along the river, walking along the river, but they also want to even be experiencing and touching the river. And so it really is a nice benefit for the public to have."[72]

One new community benefit resulting from the dam removal is the annual Kettle Moraine Jazz Festival held in Riverside Park. The festival is hosted by the West Bend Sunrise Rotary Foundation, which raises money for local charities. The Rotary chose to hold the Jazz Festival in Riverside Park because of its unique ambience, natural beauty and restored character. The dam's removal

and park development created a new venue that made the festival possible in that area[73] and is now a continuing source of community pride and charitable income.

Benefits to Local Businesses

Restoration of the river and surrounding land is bringing important benefits to local businesses by bringing more people downtown and generally improving the quality of life in the community.

While there have been no studies yet quantifying changes in business activity within downtown West Bend following the removal of Woolen Mills Dam, having thousands more people coming downtown to use the adjacent Riverside Park and the Milwaukee River brings more visibility, and consequently money, to downtown businesses.

However, attracting more people downtown is not the only benefit to area businesses. Riverside Park and the free-flowing Milwaukee River have become amenities that help businesses attract employees.

As the CEO of one local business described, "It is absolutely amazing to me that we could be so blind to this wonderful asset for so many years. You know, you don't realize what a wonderful thing having a river flowing through your town is. What does that mean when you're in business? Well, I have to recruit people to come to this town to go to work for this company. I can walk them down to our river and I can show them this beautiful river and kids fishing and public sculptures along the river, and I can take them to our cultural district, which is not too far from the river, and show them those things. It's a big selling point in recruiting people to come to work for this company and in keeping them."[30]

Property Values

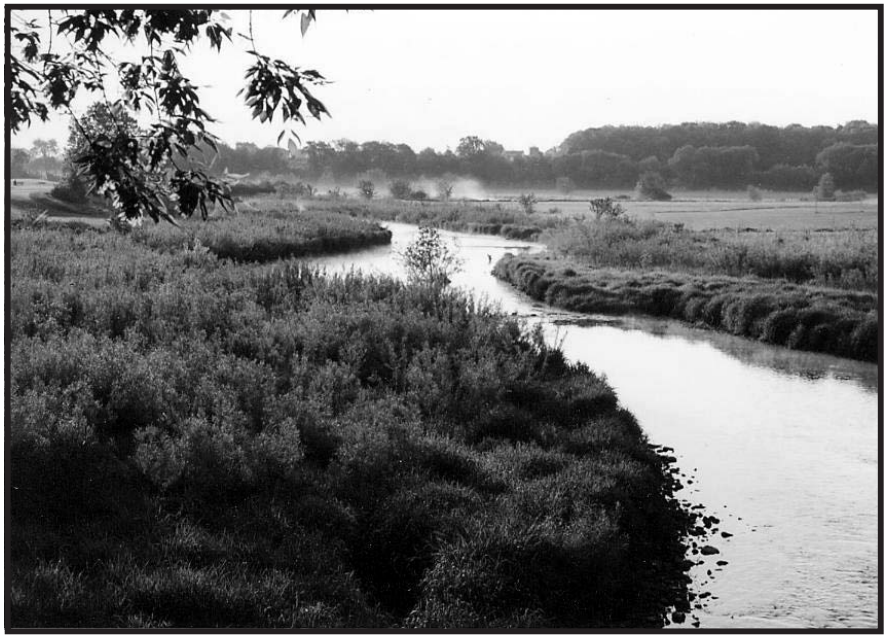
During the planning process to rebuild or remove Woolen Mills Dam, one issue in the forefront of many people's minds was how the removal would affect property values. Many residents were concerned that draining West Bend Pond would decrease nearby property values.

Bill Yoder of Appraisals, Inc., an appraiser in West Bend and surrounding Washington County for more than 20 years, including when Woolen Mills Dam was removed, shared this concern anticipating that adjacent property values would suffer.

However, eleven years later, having observed the changes that actually occurred, Yoder concluded that the removal of Woolen Mills Dam has had no effect on adjacent property values.

Phone interviews with four nearby residents support the appraiser's conclusion that property values were not affected. Property owners selected for the interview were those still in the community who had owned property adjacent to the former impoundment both before and after the dam removal. Four residents met those criteria. Although this is a small sample, it nonetheless consists of a majority of the adjacent landowners who have been present before and after the dam was removed.

Three of these four residents were against the removal of the dam at the time, and still oppose the decision. Nonetheless, only one now believes that



The Milwaukee River flows through restored prairie in Riverside Park. Many local residents were concerned that this area would become unsightly mudflats after the Woolen Mills Dam removal (photo courtesy of West Bend Parks Dept).

the property decreased in value. The remaining three homeowners believe that the dam's removal had no effect.

Sales records in West Bend suggest a similar conclusion. Records show that five parcels adjacent to the former impoundment have been sold since 1996 (Table 12). These sales were compared to similar property sales within West Bend that were not adjacent to the former impoundment.

In Table 12, "adjacent" properties refer to homes that were once next to the former impoundment, but are now next to Riverside Park. "Nonadjacent" parcels refer to other properties in West Bend that are less than a half-mile from a park other than Riverside.

Because many variables are included in establishing the value of a home, attempts were made to minimize variation by comparing single-family homes with similar characteristics, such as date sold, lot size, square footage, total number of rooms, and the age of each home.

Table 12 shows five side-by-side comparisons of adjacent and nonadjacent homes with similar characteristics. For the most part, the results show very similar sales prices for each of the comparisons.

Table 12. Property Values Remain High on Former Impoundment

Comparison of property values from land adjacent to the former West Bend Pond with similar property sold in a different location within the city of West Bend. Property values adjacent to the former impoundment have remained comparable with land near other parks in the city.

	Location	Date Sold	Sale Price ($)	Lot Size (ft.)	Square Footage	Sale Price per Square Foot ($)	Total Rooms	Age
1	Adjacent	6/96	134,900	85x154	1680	80.30	7	1967
	Nonadjacent	5/96	135,000	85x144	1622	83.23	7	1967
2	Adjacent	11/96	126,900	82x159	1522	83.38	7	1968
	Nonadjacent	9/96	125,000	89x130	1562	80.03	7	1958
3	Adjacent	7/98	136,000	82x159	1522	89.36	7	1968
	Nonadjacent	1/98	138,500	94x120	1793	77.24	7	1971
	Nonadjacent	8/98	122,900	110x126	1492	82.37	8	1963
4	Adjacent	1/98	156,000	112x106	1932	80.75	7	1968
	Nonadjacent	5/97	151,900	75x143	1826	83.19	7	1966
5	Adjacent	1/99	126,500	180x114	1616	78.28	6	1960
	Nonadjacent	6/99	105,000	140x120	1677	62.61	6	1950

"Adjacent" = properties that were next to the impoundment, and are now next to Riverside Park.

"Nonadjacent" = other properties in West Bend that are less than a half mile from a park other than Riverside.

The largest difference appears in comparison 5, where the selling price of the adjacent property was 20 percent more than the nonadjacent value. These properties are located on the same street, with the nonadjacent parcel next to the Milwaukee River, downstream from where Woolen Mills Dam formerly stood. The adjacent property is upstream from the former dam and formerly had a view of and access to West Bend Pond.

These results show that property values adjacent to the former impoundment hold similar value to properties adjacent to other parks in the area. In combination with the analysis of the local appraiser and interviews with property owners themselves, it is evident that property values have not declined dramatically more than a decade following the dam's removal. This conclusion is based on a preliminary study and on anecdotal information confirmed by local expert opinion. The scientific community could supply crucial information for decision-makers by conducting additional research on this topic at different sites around the country.

Appendix II: Selected "Willingness To Pay" Studies

Studies from across the country increasingly show citizen support to restore rivers and remove dams. So-called "willingness to pay" studies are one way economists attempt to capture nonmarket values of such things as clean water, scenic beauty, or environmental preservation for future generations. The following discusses four such willingness to pay studies.

Elwha River: Elwha and Glines Canyon Dams

A study was conducted in 1996 to estimate the public's willingness to pay for restoring the Elwha River ecosystem and its migratory fishery by removing two dams on the Olympic Peninsula in Washington State.[74] The two dams, Elwha and Glines Canyon, are both large dams with heights of 108 feet and 210 feet respectively.

Removal of the dams would restore 70 miles of free-flowing river for declining fish populations. The willingness to pay estimates were based on expected increases in four species of salmon and steelhead associated with removing the dams. The study area included:

- a sample of residents in Clallam County, where the dams are located,
- all other residents in the state of Washington, and
- households throughout the rest of the United States.

The researchers surveyed people using a method known as contingent valuation. Simply put, respondents to a contingent valuation study estimate a value that they would be willing to pay for an activity to occur or not occur.

The estimated annual value per household for removing the two dams (Table 13) shows that residents in Clallam County were willing to pay $59 per household annually, while residents in the rest of Washington were willing to pay $73 per household annually. Residents from the rest of the United States were willing to pay $68 per household annually.

These values translate into a total benefit to Washington residents of $138 million annually for 10 years as a result of removing Elwha and Glines Canyon Dams. The estimate of total nonmarket benefits to all U.S. residents, including Washington, ranges from $3 to $6 billion.

The researchers conclude that the results show a substantial nonmarket willingness to pay to remove dams to restore salmon and steelhead runs in the Pacific Northwest.

Clyde River: Newport No. 11 Diversion Dam

The University of Vermont and the National Wildlife Federation conducted a willingness to pay study on the removal of Newport No. 11 Diversion Dam on the Clyde River in northern Vermont.[75] The relatively small dam, 17 feet high and 90 feet long, blocked spawning and feeding grounds of declining landlocked Atlantic salmon populations.

The Department of Public Service (DPS) estimated that generating power from the dam would result in a total net benefit of $42,000 for Citizens Utilities' ratepayers over a 40-year licensing period. The DPS also estimated that operating the dam would save a projected $44,820 from "avoided air emissions" of other energy production. Together, these yield a benefit of $88,850 to continue dam operations.

The willingness to pay report assessed the value of removal within Orleans County, where the dam is located, as well as the rest of Vermont.

Similar to the Elwha study, the Clyde study used contingent valuation to estimate the demand (willingness to pay) for removing the Newport Dam to help restore the Clyde River and landlocked Atlantic

Table 13. Citizens Value Elwha River Restoration

Willingness to pay for Elwha and Glines Canyon Dam removals. Units are average annual dollar values per household.

Clallam County	Rest of Washington	Rest of United States
$59	$73	$68

Source: Loomis 1996.[74]

salmon populations. In addition, the study assessed the willingness to pay for different types of recreation.

The results of the findings are shown in Table 14. The study shows support throughout Vermont to remove the Newport No. 11 Diversion Dam and its power generator. The combined willingness of Orleans County households to pay $389,000 per year greatly exceeded the benefits of repowering the No. 11 generator.

Table 14. Citizens Value Clyde River Restoration

Willingness to pay to remove Newport No. 11 Diversion Dam by subset of sample. Units are average annual dollar value per household.

Subset of Sample	Orleans County ($)	Rest of Vermont ($)
All Households in Sample	65.43	50.98
River Recreationists	67.35	57.39
Non River Recreationists	62.55	41.99
Clyde River Recreationists	70.03	*
Non Clyde River Recreationists	60.97	49.66
Clyde River Anglers	72.14	*
Non Clyde River Anglers	64.56	*

* WTP values could not be calculated due to small sample sizes.

Source: Gilbert, et al., 1996.[75]

It is interesting to compare the Clyde River and Elwha River studies. While both studies show support for removing dams, note that in Table 13, Clallam County (site of the dams) was less willing to pay for the Elwha dam removals than the rest of Washington state. In contrast, Orleans County (site of the dam) was more willing to pay for the Clyde River dam removal than the rest of Vermont (Table 14).

This contrast gives some evidence of the different socioeconomic environments for dam removal in different communities and in different regions of the country.

Kennebec River: Edwards Dam

Freeman and others[76] reviewed a study by Boyle and others[77] that estimated anglers' willingness to pay to remove Edwards Dam from the Kennebec River in Maine. For more than 160 years, the 24-foot high Edwards Dam blocked flows on the Kennebec without adequate fish passage.

The Boyle study used contingent valuation to estimate the dollar value derived from improved fishing opportunities expected from the removal of Edwards Dam. The estimates were based on a sample of Maine residents and non-residents holding inland fishing licenses. The results of this study are illustrated in Table 15.

Note that the values are significantly lower than in the previous two studies. Freeman and others[76] argue that these results underestimate the total economic value of the fishery because they derive from a specific sample size of anglers holding Inland Fishing Licenses.

They also include only *use values*, the benefit received by people who actually use the resource. They do not include *non-use values*, the benefit gained by people who do not use the resource, but who find value knowing it exists. Therefore, one could not use these values to accurately estimate the

Table 15. Citizens Value Kennebec River Restoration

Willingness to pay for removing Edwards Dam, Kennebec River, Maine. Units are annual dollar value per angler holding an inland fishing license.

Type of Angler	Willingness to Pay ($)
Anglers living adjacent to the river	18.11
Other resident anglers	13.71
Nonresident anglers	11.85

Source: Freeman, et al, 1995.[76]

true benefit society receives from a restored fishery through dam removal. Loomis[74] and Gilbert and others[75] studied a sample of the entire population in the previous study discussed, which would include all users and non-users of the fishery.

Freeman states that there is a net benefit to removing the dam despite the undervalued estimates of the fishery. He first assumes that the resource values that would be lost due to the drawdown of the impoundment would be negligible. Therefore, the only indirect cost of removing the dam was referred to as the environmental costs of replacement electricity, which was estimated to be $5,000 to $8,000 per year. On the other hand, the net present value of benefits to recreational anglers would be $36.2 to $48.2 million, indicating that removing Edwards Dam would significantly benefit the community.

Willingness to Pay for a Natural River

Several economic studies have assessed the public's willingness to pay to protect natural environments such as free-flowing rivers.

For example, at one site in California a hydroelectric dam was proposed to provide power and drinking water. A survey was conducted in order to determine willingness to pay to preserve the natural state of a river.

The survey revealed that households were willing to pay $42 to $92 each per year to preserve the natural river. In contrast, the annual benefits received by these households from the project would have been just $2.64 per year. Clearly, it was in the best interest of the community to avoid the hydroelectric development.[66]

In addition, there have been studies done on the value of general protection for natural rivers.

A study done by Sanders, Walsh, and Loomis[78] assessed the use and non-use values of protecting rivers. They found that for rivers in Colorado, the total benefit estimated (use values plus non-use values) was five times more than the estimate generated from only considering use values.

Table 16. Citizens Value River Preservation in Colorado

Willingness to pay per household for river protection, Colorado, 1983. The total value at the bottom of the table represents the total benefit (willingness to pay) each household receives from the preservation of 15 rivers including Poudre, Elk, Colorado, Gunnison, Green, Yampa, Piedra, Los Pinos, Conejos, Dolores, Encampment, Arkansas, Roaring Fork, South Platte, and Rio Grande.

	Annual Household Values ($)
Recreation use value	19.16
Preservation value	
Option value	15.97
Existence value	27.67
Bequest value	36.19
Total preservation value	81.96
TOTAL VALUE	**101.12**

Source: Sanders, et al., 1990.[78]

These results show that residents of Colorado find a significant benefit in preserving their rivers rather than using them for developments like dam projects. Table 16 illustrates the use and non-use values for preserving the 15 rivers included in the study.

From this information, Sanders and others[78] estimated the total net benefit of river protection over 50 years. The present value of total benefit from protecting the 15 rivers was estimated at $1,521 million (equal to $101.12 times the number of households).

The present value of the cost of protecting the rivers would be $69.5 million, which includes the opportunity cost of foregone water development projects, management, and other opportunity costs. Thus, the total net present value of protecting the 15 Colorado rivers was estimated to be the difference, $1,451.5 million.

Appendix III: Glossary of Economic Terms

Benefit-cost analysis: a framework to assess proposed projects that applies value to the benefits and costs that would result from a project, indicating that the project should be undertaken if its benefits exceed its costs.

Bequest value: the value of knowing a resource is preserved for future generations.

Contingent valuation: a method of discovering peoples' willingness to pay (demand) in which people are simply asked how much they would be willing to pay for a certain resource, as opposed to studying peoples' behavior in order to infer their willingness to pay.

Cost-effective: the least expensive way of achieving a given environmental quality; or the way of achieving the greatest improvement in the environment for a given expenditure of resources.

Discount rate: a rate used to compare cost amounts over different time periods. It is used to determine how much a past or future dollar value will be worth today.

Existence values: the value of simply knowing that a resource exists.

Nonmarket: goods/services/resources not bought and sold, so not included in measurement of gross domestic product.

Non-use value: the benefit gained by people from a resource who are not actually using the resource.

Opportunity cost: the benefit lost by not choosing the next best alternative. It is the highest value alternative that is foregone. The lost opportunity is considered a cost of the chosen action.

Option values: the amount a person would be willing to pay to preserve the option of being able to experience the resource in the future.

Present value: money changes in value over time due to inflation; amounts of money at different periods in time cannot be directly compared with each other. Economists often figure out what the value of sums of money from different periods in time would be today - the present value - in order to accurately compare the values.

Use value: the benefit received by people who actually use the resource.

Willingness to pay: the amount a person is willing to pay for an environmental asset; willingness to pay also reflects a person's ability to pay.

Adapted from:

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