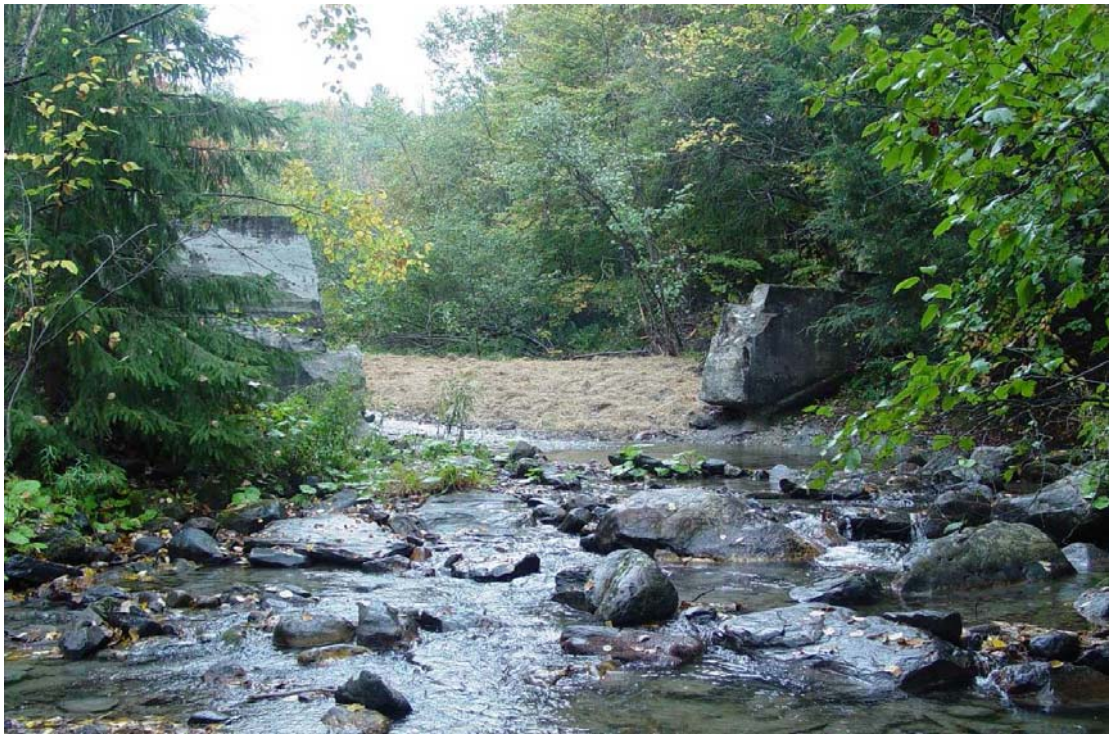
User's Guide to Vermont Dam Removals

A Basic Handbook for Project Managers
October 2009



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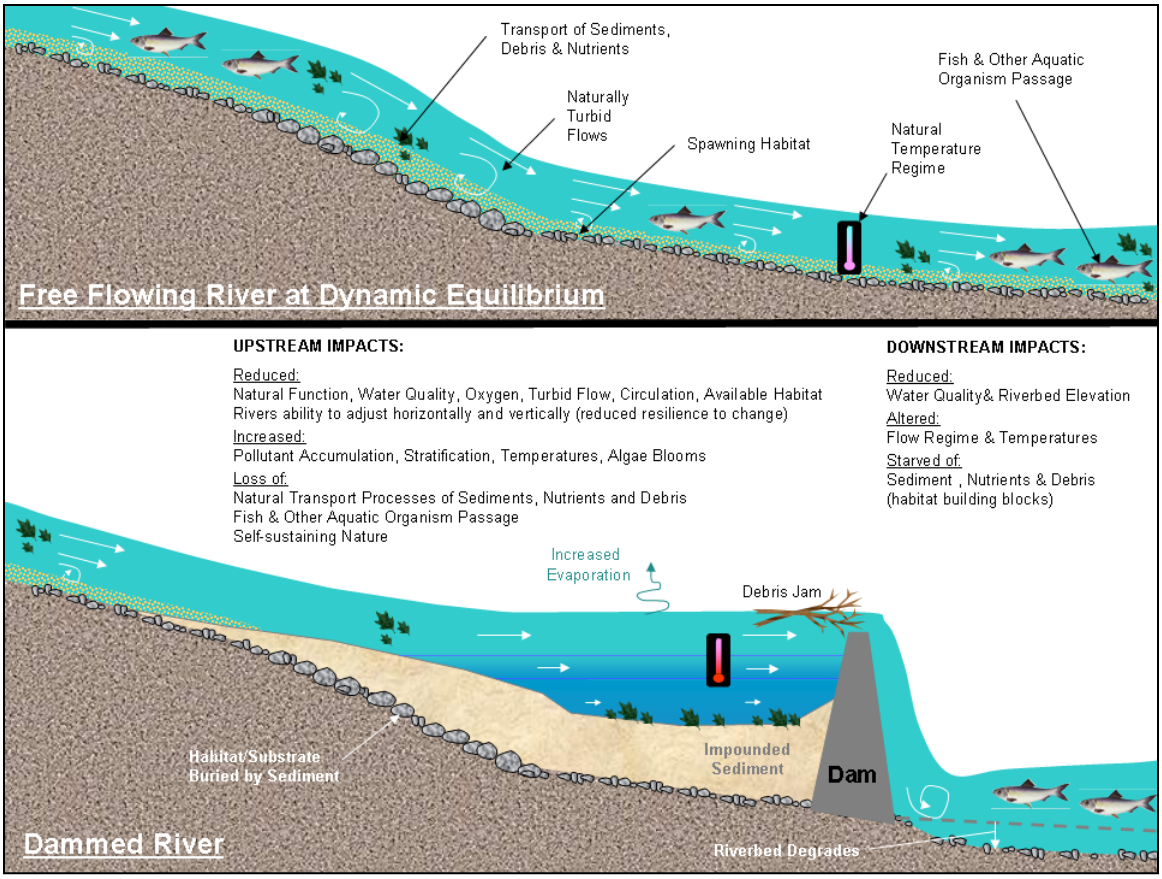
Dam Removal in Vermont

Dam construction began in Vermont in the 18th century and continues to this day. The earliest dams were built to power mills, while later uses include water supply, hydroelectric power, flood control and recreation. Currently, there are at least 1,200 dams in the state, and many no longer serve the purpose for which they were originally designed. Some have been converted to another use, but many serve no useful purpose. They do, however, continue to cause impacts on water quality, aquatic habitat, the ability of fish to move freely upstream and downstream, and the downstream transport of sediment (Figure 1). They also constitute financial and legal liabilities for their owners, and, if they are not properly maintained, potential hazards to public safety.



Graphic courtesy of American Rivers

As awareness of the safety, economic and ecological aspects of dam ownership has increased, dam owners have come to realize that the cost and liability of owning an aging structure outweighs the benefits and are considering removing their structures. If managed well, removing a dam can benefit multiple interests by restoring ecosystem health, improving public safety, providing new recreational opportunities, and relieving a dam owner's economic burden.

Between evaluating infrastructure concerns, fundraising, managing sediment, hiring experts, and wading through the regulatory process, completing a dam removal project can be a daunting task for most would-be river restoration advocates. This guide is intended to help dam removal project proponents understand and begin the process of removing a dam.

Managing a Dam Removal Project

A strong project manager is critical for a successful dam removal project. The project manager's role is to provide leadership and oversee the steps outlined in this manual. Certain tasks may be taken on by project partners or consultants, but the project manager leads the team and provides overall coordination.

A project manager must be flexible and a jack-of-all trades. On any given day, a project manager may promote the project to a potential funder; meet with environmental regulators; oversee or help out with field work; write press releases; coordinate a conference call; or remind a project partner to follow through on a commitment. The project manager serves as the point of contact for partners and the public and often as the "face" of the project.

A project manager should be organized, motivated and patient (a dam removal project can take several years), tactful, and a good communicator. He or she does not need to be a technical expert, but must have common sense and good judgment. He or she should know when to call on experts to help make decisions and be skilled at building partnerships. A sense of humor is helpful as well.

We hope you find this manual useful as you begin to develop your own river restoration projects. We intend to update it periodically. If you have comments or suggestions, please send them to brian.fitzgerald@state.vt.us or bgraber@americanrivers.org.

General Steps for Dam Removal

The following lists the general steps in a dam removal project. These steps are intended to be very general because every dam removal process will have differing site-specific engineering, environmental, and community issues. In some cases, not all of these steps will be necessary. Evaluate each step presented here to determine if it is necessary for your project. Also, these steps do not always conform to a set order. For example, stakeholder and pre-permitting meetings may need to be held earlier in some cases.

While different projects have different timeframes, in general, expect projects to take two-and-one-half to three years from conception to completion. Year one for planning, feasibility, and pre-permitting; year two for engineering design and permitting; year three for implementation.

The following pages describe many of these steps in more detail.

1) Choose a project and conduct initial reconnaissance
- Articulate potential ecological benefits of the project
- Identify other issues that may limit river health besides the dam (i.e. impoundments immediately upstream or downstream; poor water quality resulting from stormwater; channelization)
- Determine dam owner and point of contact
- Determine if dam owner is open to the possibility of dam removal
- Determine current uses of the dam and impoundment
- Assess land ownership around the impoundment and the dam structure
- Identify potential infrastructure impacts: utilities, roads, bridges, etc.
- Determine if the dam, impoundment, or adjacent land are in rare species habitat based on Nongame and Natural Heritage Program maps

- Determine potential "hooks" for funding possibilities – particularly, will the dam removal restore passage and habitat for anadromous species or for sport fish
- Initial assessment of sediment quality
- Assess potential community interests/concerns – flooding, recreation, historic, habitat

2) Site Visit and Planning Meeting
- Conduct a site visit with project proponent, dam owner, and state agencies to plan next steps
- Identify potential partners

3) Fundraising
- Develop a fundraising strategy and a list of potential grant sources
- Gather letters of support
- Apply for funding

4) Preliminary Design – assess scientific and engineering challenges and conceptual approaches
- Collect existing data
- Survey and map the site
- Assess sediment quantity, quality, and mobility
- Assess hydrology and hydraulics
- Develop conceptual plans for:
    - removal of structures
    - sediment management
    - channel and riparian habitat restoration
- Analyze other site-specific issues such as utilities, infrastructure, wetland impacts
- Determine which federal, state, and local permits will be required and complete calculations necessary for those permits
- Pre-project monitoring
    - Gather and measure pre-project information on water quality, geomorphology, and ecology
    - Photograph the site extensively
- Develop cost estimates
- Develop conceptual drawings of proposed project approaches

5) Stakeholder/community meeting(s)
- Meet with abutters and other stakeholders
- Community visioning and planning

6) Pre-permitting meeting(s)
- Meet with local, state, federal environmental regulators, dam safety officials, and historic preservation representatives to clarify and confirm regulatory requirements

7) Engineering and Restoration Design
- Develop engineering design plans of both dam removal and stream restoration
- Develop Project Specifications that specify necessary construction equipment, material specifications and quantities, project sequencing, staging areas, and site access
- Provide an Engineer's Cost Estimate for construction

8) Permitting
- File all regulatory permits
- Attend public hearings

9) Project Implementation
- Hire contractor
- Drawdown impoundment
- Remove dam structure
- Stream channel restoration
- Impoundment revegetation

10) Post-project monitoring

Initial Reconnaissance

The first and most important step in a dam removal project is choosing a project that will be successful and meet its ecological objectives. The initial reconnaissance phase is intended to determine the overall breadth of the project and the likely project challenges. At this phase, you will determine whether the project is simple and straightforward; or very complex, requiring such things as extensive community outreach, contaminated sediment remediation, and comprehensive environmental impact studies. Consider how each of the issues below will affect the cost and scale of the project.

Ecological Benefits

- Summarize the expected ecological benefits of the project, as they will become selling points for funders, regulators, and the public. What will you achieve by removing the dam? You may (for example) reconnect a coldwater trout stream to the mainstem of a river. You may open up key spawning or rearing habitat for herring, salmon, trout, or smelt. Removing the dam may provide a certain number of miles of habitat for insects, mussels, and riparian wildlife species.
- An ideal dam removal project is one where the dam is the primary factor limiting the ecological health of the river. If there are other major problems in the watershed such as excessive urban runoff, pollution, or excessive water withdrawals, you may need to address those problems first, as removing a dam will not fully restore river health in these conditions.

Community Benefits

- Consider the additional benefits that dam removal may provide the community such as eliminating a flood hazard, eliminating a drowning hazard, improving boating or fishing, Consider also additional amenities that river restoration could serve as a catalyst for, such as riverside walking trails or parks. Projects such as this can build unique coalitions including local businesses, town planning commissions, conservation commissions, etc. Diverse coalitions have the ability to mobilize a greater range of project supporters and funders and will make public outreach and communication more effective.

Dam and Land Ownership

- If the dam owner is not the project proponent, determine the dam owner and, if necessary, a point of contact for the dam owner. This may sound like a simple step, but in some cases dams have been abandoned for decades or land owners do not realize that they own dams.
- A dam owner who is committed to dam removal is essential to the success of the project. Many dam owners will express interest in dam removal due to economic, liability, or even environmental reasons. Some simply no longer want the long-term hassle of repairing and maintaining their structure. You may need to meet with an owner several times to explore options before he or she is ready to express interest. You should refrain from spending large amounts of money on the project until the dam owner is willing to commit to it.
- Preliminarily assess land ownership around the impoundment and the dam structure. Dam impoundments with abutting residential backyards, public beaches, and motorboats on them will be much more challenging community outreach efforts than dam impoundments entirely under the ownership of one entity who is interested in removal.

Dam Uses

- Determine if the dam and impoundment are currently serving any purpose that will necessitate replacement. Most dams in Vermont no longer serve the purpose for which they were designed, but many do provide important functions. For example, dams that provide water supply, hydropower, or flood control are much less viable dam removal projects than those structures that do not provide these services. In some cases, these purposes can be replaced by other means.
- Determine if there is any local interest in developing hydroelectric power at the site. The increased interest in renewable energy from local sources has led to an erroneous assumption that most dams are suitable for redevelopment as small hydroelectric projects. While the economics of most of these projects are marginal, even with various economic incentives, it can be challenging to convince community members that hydroelectric development is not economically feasible and that the benefits of dam removal outweigh the value of any energy likely to be produced.

Infrastructure

- Identify any potential infrastructure that could be impacted by dam removal. For example, if bridges cross any portion of the impoundment, an assessment will need to be made of potential scour during the feasibility study. In some places, water and sewer pipes cross through dams or through the impoundment and alternatives will need to be assessed for protecting or moving them. Some dams are attached to mill buildings or retaining walls, requiring a stability assessment prior to completing the design.

Rare Species

- Determine if the dam, impoundment, or adjacent land are in an area that provides habitat for rare species, based on maps published by the Nongame and Natural Heritage Program (http://maps.vermont.gov/imf/sites/ANR_NATRESViewer/jsp/launch.jsp). If these habitats are present, projects can only proceed through close consultation with state and federal biologists. In some cases, the dam removal project will provide significant new habitat for these species. In other cases, construction must be carried out in certain ways to minimize impacts to species or habitat.

Sediment Quality

- The need for contaminant cleanup can significantly increase project complexity and cost. Assess the potential for contaminants trapped behind the dam by considering current and past upstream land uses

such as industrial activity and road density. Information on water and sediment quality in the river may also be available from past environmental studies.

- The Vermont Department of Environmental Conservation maintains the Waste Management Interactive Database, an on-line resource containing information on contaminated groundwater sites, hazardous materials spills, and regulated underground storage tank facilities. It may be useful for you to look at this list in order to determine potential contaminants at or upstream of the dam: http://www.anr.state.vt.us/dec/wastediv/sms/wmid_intro.htm.
- Analyzing a sediment sample may even be useful at this reconnaissance phase, to understand the breadth of the project if other assessments are insufficient to determine the probability of contamination. A core sample should be taken from the fine-grained portion of the impounded sediment and analyzed at a lab for heavy metals and organic constituents. Sediment screening guidelines are available from the Agency of Natural Resources Hydrology Program.

Community Concerns

- Assess potential community interests and concerns. Is the impoundment currently used for recreation? Is the dam structure an important historic resource?

Funding Possibilities

- Determine potential "hooks" for funding possibilities. Foundations and agencies that provide grants for river restoration and dam removal have different interests. Some provide funds for projects that help anadromous fish such as herring or salmon or for other sport fish such as trout. Others will provide funds for private landowners working to improve habitat on their land. Based on these "hooks" some projects can be almost entirely funded by outside sources, while others will receive very little outside funding. With overall project costs typically in the hundred thousands, this is a critical first step.
- The owner of the dam should expect to cover some of the cost of the dam removal project, particularly if the dam is failing and the removal is removing a significant expense and liability from the owner. Contributions to the project can include in-kind services or cash.

The ANR Hydrology Program and American Rivers can help provide technical assistance for evaluating site-specific reconnaissance issues.

Dam Removal Initial Reconnaissance Checklist

Dam name	Location
Dam owner	Land ownership around impoundment
Ecological benefits	Community benefits
Existing dam uses	Infrastructure issues
Rare species	Sediment quality
Community concerns	Funding possibilities

Funding Sources for Dam Removal

Dam removal projects often require a combination of different funding sources to piece together all of the necessary funding. Funders are more likely to fund projects with multiple partners, strong state or local support, general regulator support and effectively completed initial assessments. Each funding source has different interests and project proponents need to determine which funding sources best fits your project's goals. Also, project proponents should carefully consider funding deadlines relative to the project schedule, as many funders have a time limit on using their funds.

Dam owners should not enter into a project with the expectation that the project will be free to them through the available funding sources. Most funders require matching contributions and are more likely to fund projects with a contributing owner. Recent dam removal projects in Vermont have ranged from about $30,000 to $50,000 for the actual deconstruction, with all other work (i.e., design and project management) provided in-kind by the project partners. These were small dams, so deconstruction costs for larger dams are expected to be significantly higher. In addition, state and federal agencies have limited capacity to provide technical services so it is likely that consultants will be needed to perform the engineering and other technical work, driving up costs considerably.

National Sources

NOAA Funding Opportunities
http://www.nmfs.noaa.gov/habitat/restoration/funding_opportunities/funding_ner.html
The National Oceanic and Atmospheric Administration (NOAA) Restoration Center provides funding through several national and regional programs that support restoration of coastal and riverine habitats. of NOAA programs focus on migratory fish, so projects would have to benefit species such as Atlantic salmon, American shad and American eel, limiting the geographic scope to the Connecticut River watershed. Funding range: $25,000-$250,000, depending on the program.

U.S. Fish and Wildlife Service – National Fish Passage Program
http://www.fws.gov/fisheries/fwco/fishpassage/
The U.S. Fish and Wildlife Service's National Fish Passage Program is a non-regulatory program that provides funding and technical assistance toward removing or bypassing barriers to fish movement.
Contact: Chris Smith, 802.872.0629, chris_e_smith@fws.gov

U.S. Fish and Wildlife Service – Partners for Fish and Wildlife Program
http://www.fws.gov/partners/
The U.S. Fish and Wildlife Service's Partners for Fish and Wildlife program offers technical and financial assistance to private (non-federal) landowners to voluntarily restore wetlands and other fish and wildlife habitats on their land. Restoration projects include reestablishing fish passage for migratory fish by removing barriers (dams) to movement.

Eastern Brook Trout Joint Venture
http://www.easternbrooktrout.org/index.aspx
The EBTJV is a partnership operating under the National Fish Habitat Action Plan. The long-term goals of the EBTJV are to implement a comprehensive conservation strategy to improve aquatic habitat, raise public awareness, and prioritize the use of federal, state and local funds for brook trout conservation.

National Fish and Wildlife Foundation
http://www.nfwf.org/
The National Fish and Wildlife Foundation operates a grants program that awards matching grants to projects that: address priority actions promoting fish and wildlife conservation and the habitats on which they depend; work proactively to involve other conservation and community interests; leverage available funding; and evaluate project outcomes. Funding Range: $10,000-$150,000.

Natural Resources Conservation Service – Wildlife Habitat Improvement Program
http://www.nrcs.usda.gov/programs/whip/
WHIP funding is awarded to projects that work to establish and improve fish and wildlife habitat.
Contact: Toby Alexander, 802.951.6796 x 229, toby.alexander@vt.usda.gov

U.S. Army Corps of Engineers – Aquatic Ecosystem Restoration
http://www.nae.usace.army.mil/pservices/206.htm
Section 206 of the Water Resources Development Act of 1996 authorized the Corps to plan, design and build projects to restore aquatic ecosystems for fish and wildlife. Funds from this program can be utilized to remove low head dams as a way to improve water quality and fish and wildlife habitat.

Wildlife Restoration Act (Pittman-Robertson Act) Dept. of Interior-Fish and Wildlife Service
http://wsfrprograms.fws.gov/home.html
The purpose of this Act was to provide funding for the selection, restoration, rehabilitation and improvement of wildlife habitat, wildlife management research, and the distribution of information produced by the projects.

State Sources

Interested proponents should consult with the ANR Hydrology Program. There is no dedicated state funding source for dam removal, but some projects may be eligible for state funds appropriated for river and watershed restoration. Staff also may be able to provide limited technical assistance.

Supplemental Environmental Projects are another potential source of funding. These are funds resulting from the settlement of environmental enforcement cases brought by the state, and are contributed by the violator in lieu of a penalty. While not an option for every project, this funding source may be able to support studies and design as well as construction. Contact the Hydrology Program to determine if such funding is available. Amounts vary, but typically do not exceed $20,000.

Local Sources

The most likely source of local funds is money that has been allocated by a town to address structural and safety problems with a specific, town-owned dam. Such funding is usually only available if it is approved by a town vote at a regular or special town meeting.

Private Sources

Upper Connecticut River Mitigation and Enhancement Fund
http://www.nhcf.org/page10003442.cfm
The M&E fund supports projects in the Connecticut River watershed north of White River Junction. The goals are protection, restoration and enhancement of river, wetland and shoreland resources. Funding is available for project planning and design as well as construction.

Many private foundations exist that provide funding for environmental restoration projects. These sources have not yet been utilized for dam removals in Vermont. In addition, groups like Trout Unlimited, The Nature Conservancy, and American Rivers may have access to funding sources or have good relationships with potential funders.

Additional References

American Rivers' Paying for Dam Removal: A Guide to Selected Funding Sources
http://www.americanrivers.org/site/docserver/pdr-color.pdf?docid=727

EPA Catalog of Funding Sources for Watershed Protection
http://www.epa.gov/owow/funding.html

Wisconsin River Alliance's list of resources (scroll down to view Private funders):
http://www.wisconsinrivers.org/index.php?page=content&mode=view&id=8

The River Network list of Funding Sources
http://www.rivernetwork.org/library/index.cfm?doc_id=114

The ANR Hydrology Program and American Rivers can provide assistance with determining which funding possibilities may apply to your project.

Data Collection for Preliminary or Final Design

Often, a project proponent will initiate the project by collecting enough information to inform key decisions about the project. This process provides concept-level or preliminary designs and quantitative information on environmental and engineering feasibility necessary to make final decisions on the project approach. Key decisions include construction methods; approaches to managing sediment trapped behind the dam; how best to protect nearby infrastructure; and approaches to restoring the formerly impounded area.

In some cases, this work is part of the final design process. In other cases, this work is done in a separate Preliminary Design Phase so that project partners and the dam owner can make decisions about the project's approach before proceeding to final design.

Depending on the size and complexity of the project, design studies can cost anywhere from approximately $10,000 to in excess of $100,000. In the simplest cases, projects have proceeded directly to final engineering design without a separate study.

Selecting Effective Consultants

Typically preliminary design studies are conducted by environmental consultants, and the choice of the consulting team is critical to project success. Because dams are in dynamic riverine environments and multidisciplinary issues such as sediment management, habitat restoration, and infrastructure protection must be addressed, a multidisciplinary consulting team is needed. There is always much more to a dam removal project than just removing a concrete structure. At a minimum, the consulting team must have expertise in engineering, ecology, and fluvial geomorphology. This combination of skills is very rare in traditional engineering firms. *Therefore, traditional engineering firms that lack some of these skills should expect to subcontract with a firm with specific river restoration experience*. An effective consulting team can greatly smooth the process, as regulators expect to see an understanding of all of these multidisciplinary issues in the analysis and design. The ANR Hydrology Program and American Rivers both have lists of consultants and consultant teams that fit these criteria.

Scoping the Study

The preliminary design study typically includes analyses necessary to develop alternatives for removing the structure, protecting infrastructure, restoring instream and riparian habitat, and managing sediment. While every case is site-specific, below are some general items that are frequently included in the scope of work. Note that *not every step is necessary for every project* and a site-specific evaluation must be completed:

1) **Data Collection.** Collect and synthesize all available existing data on the dam, the river, and the surrounding landscape. This could include existing maps and plans, past dam inspections, FEMA flood mapping, air photos, historic maps, fisheries data, planning department reports, and utilities mapping.

2) **Survey and Base Mapping.** A site survey is usually necessary to create a base map and provide information necessary to assess hydraulics and sediment management. In order to completely survey the site, the surveying team must get in the water! The surveying should include:

a. cross sections of the river and adjacent land in the impoundment, downstream, and upstream

b. a survey of the deepest part of the stream through the impoundment, downstream, and upstream (longitudinal profile)

c. a survey of the impoundment bottom and the depth of soft sediment throughout the impoundment (bathymetry and depth of refusal)

d. delineate and survey the resource areas that will be affected as required in the Army Corps of Engineers regulations, including wetland boundaries and ordinary high and low water lines.

3) **Sediment Management Plan.** Quantitatively assess sediment quality and quantity. Complete a due diligence study to identify potential contaminants; use this to inform a sediment sampling and testing plan. Develop a conceptual plan to manage sediment movement and any contaminated sediments. Fundamental to this analysis is determining what portion of the sediment will transport downstream as a result of different management approaches. The consulting team must know how to complete this type of analysis and it is integral in the decision of who to hire for the work.

4) **Hydrology and Hydraulics Assessment**. Hydrology involves assessing the volume and frequency of flows in the river. Hydraulics involves assessing the velocity, scour potential, and depths of these flows. Assessing both is necessary to determining how effectively the dam removal will allow for

aquatic species passage; to assess potential flood impacts; and to assess potential impacts to surrounding infrastructure.

5) **Channel and Riparian Restoration Plan**. Assess alternatives for the structure and habitat within the stream channel and on exposed land in the former impoundment. This may include assessing whether the site will provide fish passage and should provide alternatives for habitat improvements.

6) **Preliminary Structure Removal Plan**. The final approach for removing the structure will be completed during the engineering design, but several issues should be considered during the study phase as they can have a significant effect on the scope of the design. These include:

a. the condition of the dam structure for safety concerns, potential demolition approaches, and whether there are usable gates or removable boards that can be used during the dam removal
b. access to the site for construction equipment and staging areas
c. site limitations, such as utilities or topographic constraints

7) **Pre-Project Monitoring.** The analysis done during the feasibility study should provide the baseline for project monitoring once the dam has been removed. See the section on 'project monitoring' for more information.

8) **Site-Specific Issues.** There are many additional site-specific issues that may need to be evaluated during the feasibility study on a case-by-case basis. These could include:

a. Fish and wildlife habitat studies and wetland impact assessment
b. Infrastructure protection plan – consider potential effects on utilities, bridges, culverts, retaining walls, wells, withdrawal pipes, etc.
c. Assessment of replacing the current uses of the dam and impoundment
d. Historic/archaeological assessment of the dam and surrounding area
e. Photo renderings of project alternatives if desired for community work (see section on community issues)
f. Recreation plan for parks, river walks, boating/fishing access

9) **Permit Identification.** Determine which federal, state, and local permits will be required by assessing whether the project approach will exceed permitting thresholds. Complete the calculations necessary to fill out those permits.

10) **Technical Memorandum**. A Technical Memorandum should describe the above analysis; describe approaches to removing the dam, protecting surrounding infrastructure, and protecting and restoring wetland, riverine, and riparian habitat; and provide a recommended approach.

11) **Conceptual Drawings**. Develop concept-level drawings of design alternatives for removing structures and restoring the site. These concept-level drawings are often referred to as "10%" or "30%" design drawings.

12) **Cost Estimate.** – Develop cost estimates to bring the recommended approach to completion, including costs of final design, permitting, construction and construction oversight. At this point in the process until the engineering design has been finalized, the cost estimate will be considered a 'probable cost' based on the consulting team's best judgment and past experience.

The ANR Hydrology Program and American Rivers can provide sample scopes of work for dam removal feasibility studies and can assist with identifying issues to assess in your feasibility study.

Working with the Community

Many Vermont villages developed around sites that provided waterpower for mills, so dams have been a central part of these communities since their earliest days. Some are historic and scenic structures, and decisions surrounding dams often raise strong feelings of sense of place, connection to the landscape, and nostalgia for the way things have always been. Many impoundments are used for recreation or simply provide a pleasing view for adjacent landowners. In some cases, communities will strongly oppose the notion of dam removal. In other cases, the community will have no interest in the dam at all. In still other cases, the surrounding community may support improved water quality and the return of fish runs and riverine recreational opportunities. Whatever the case, the importance of working with the local community should not be underestimated.

Community interest in the site should be assessed in the early stages of project conception. Based on this initial assessment, project proponents should develop a plan for community presentations and participation.

Public Participation

There are two primary ways to involve the community in dam removal projects: through mandatory regulatory hearings and through proactive public participation. If the community has an interest in the dam, then proactive approaches are critical to help the community through the change that is occurring in the landscape. Having community members as active proponents of a dam removal will help ease the fear of change, will help create new community norms, and will smooth local decision making.

In towns with a conservation commission, reaching out to that body can be a good first step to engage the local community. Ideally, members of the conservation commission can serve as members of the project team by participating in planning meetings and other aspects of the project. The commission can also host public meetings in the local community, serving as a bridge between project proponents and local residents.

Public Visioning

A sense of loss is inherent in the notion of dam removal: an object is being removed. But dam removal projects can also bring a great deal of gain in terms of new recreation opportunities, restored ecosystem health, and a renewed connection to a free-flowing river. With some creative community visioning, the fear of loss can be turned into a sense of gain.

Renderings. Renderings can take the form of drawings or digitally-altered photographs showing "before" and "after" images of the site. They can help the community gain a better vision for how the restored river will look when a dam is removed. Renderings have been successfully used in situations where there is apprehension about the "look" of the restored river or where different removal options are being considered.

Framing Effective Messages. While many river advocates care deeply about the river and the fish and wildlife it supports, for others these are small concerns. The perception of an idea such as dam removal is more important than the actual science that backs it up. It is important to think about the perceived

benefits of dam removal for your audience. For many communities, public safety and the financial burden of failing infrastructure present a strong economic argument, while in other places social or recreational interests may be important. It is also important that community visioning is led by someone from the community and not by state or federal agency staff who will be perceived as outsiders. Agency partners can provide valuable scientific backup and support, including producing renderings and talking about alternatives, but local decisions should be made by those who will be affected by the outcome.

A good initial exercise in planning a community outreach strategy is to write down perceived benefits and barriers as viewed by the community so that they can be adequately addressed. Barriers might include the perceived loss of property values, the loss of a pond and recreational amenity, or simply fear of change. With every loss, there can be a real or perceived gain, such as increased fishing opportunities or increased recreational opportunities in the form of a new walking trail through the old impoundment. Using examples and case studies from other Vermont communities or from other states can also help spread the knowledge that dam removal is becoming a community norm.

Below are some good resources to use when planning community outreach:

Taking a Second Look: Communities and Dam Removal – video produced by Trout Unlimited and American Rivers (2000)

Relics and Rivers: Dismantling Dams in. New England – video produced by the National Oceanic and Atmospheric Administration

Dam Removal: A Citizen's Guide to Restoring Rivers, Rivers Alliance of Wisconsin and Trout Unlimited

Dam Removal Success Stories: Restoring Rivers Through Selective Removal of Dams that Don't Make Sense, 1999, American Rivers, Friends of the Earth and Trout Unlimited. Available at http://www.americanrivers.org/library/reports-publications/

Permitting Dam Removal

Local, state, and federal agencies have authority over dams, dam removal, and ecological restoration. As a result, multiple permits are often required to remove a dam. Each permit has a regulatory threshold that specifies whether it is required for a specific project. Not all permits may be required at all dam removals depending on site-specific actions. Timing for each permit varies. Usually the more thoroughly prepared the design and permit application the less time it takes to receive approval. In some cases, regulators may require additional analysis during the permitting process.

Project permitting costs vary widely depending on project complexity. If the work is entirely completed by consultants (including completing paperwork, filing forms, and attending hearings, meetings, and site visits, permitting can cost between $4,000 and $80,000 depending on site-specific permit requirements. The proponent can realize significant cost savings by handling the filings and any hearings.

Removal of operating hydroelectric dams that are regulated by the Federal Energy Regulatory Commission (FERC) is a more complex subject. The proponent's best course of action is to contact the ANR Hydrology Program while the project is still in the conceptual stage to ascertain the regulatory status and requirements .

Some recommendations:

- Consult with and work cooperatively with regulatory agencies
- Invite state and federal agency personnel to the site prior to beginning the permitting process
- Plan sufficient time to complete all the necessary consultations and regulatory processes, expect delays and the process to take longer than you expect

The ANR Hydrology Program can provide more detail on the dam removal permitting process.

Local Permits

Depending on the local zoning regulations, a zoning permit may be required. In addition, towns that participate in the FEMA National Flood Insurance Program are responsible to permit projects in a mapped Special Flood Hazard Area. The effects of dam removal on published flood elevations and mapped flood hazard areas will need to be analyzed and documented. The local zoning administrator should be consulted early in the process to determine what the local regulatory requirements may be for both zoning and floodplain management.

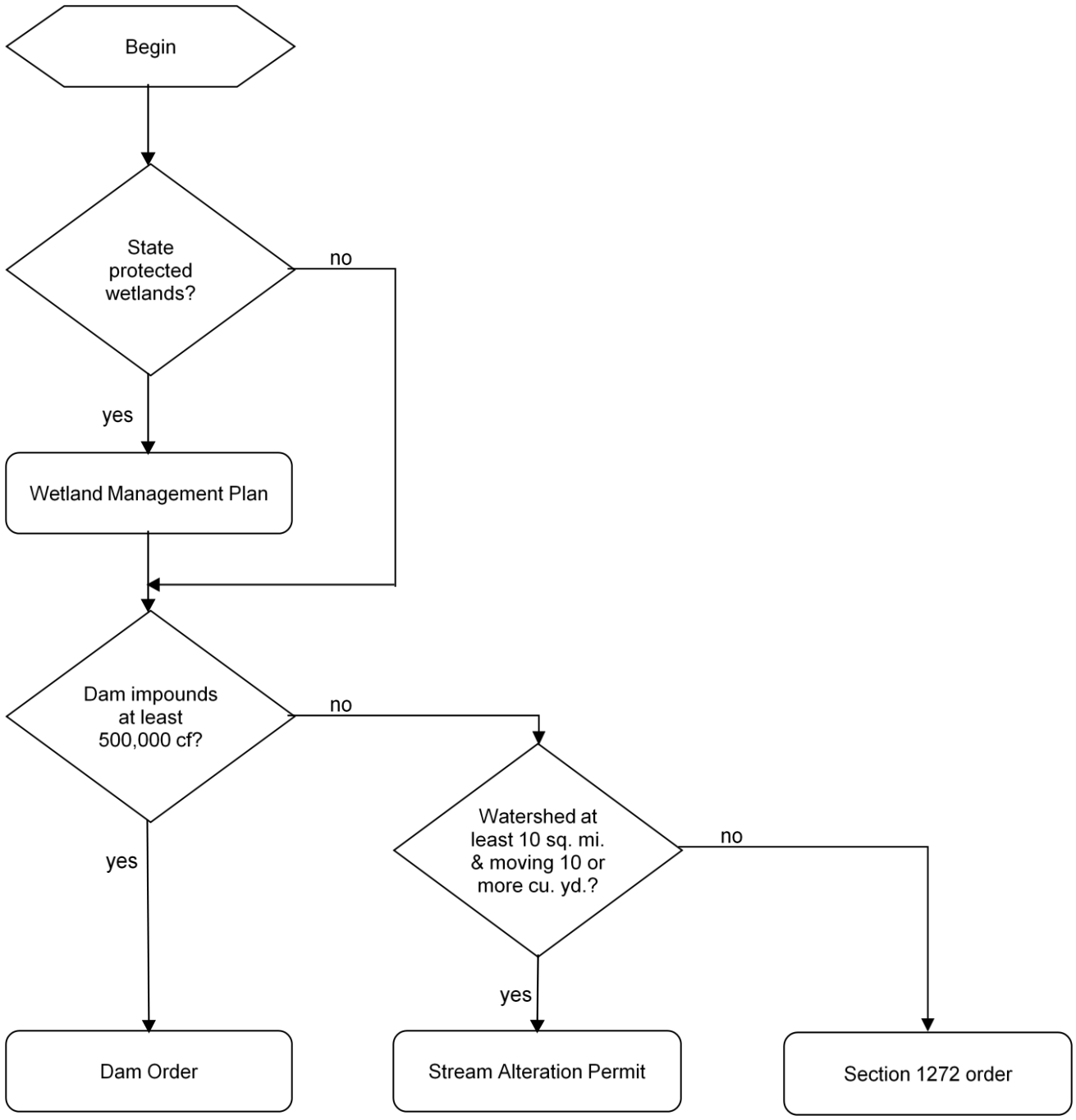
State Permits

Depending upon the size and location of the dam, the State of Vermont may require one or more permits or approvals. The key questions to ask are:

- Does the project affect wetlands protected under the Vermont Wetland Rules?
- How much water or other liquid does the dam impound?
- What is the size of the watershed area upstream of the dam?
- Will removal of the dam involve movement, fill or excavation of more than 10 cubic yards of material?

With answers to those questions, you can use the following diagram to determine the principal state permit that will be required.

State Permit Program Jurisdiction



Wetland Management Plan – DEC Wetlands Program
http://www.anr.state.vt.us/dec/waterq/wetlands.htm
Dam removals and other restoration projects that affect protected state wetlands under the Vermont Wetland Rules require that a plan be submitted to the State Wetlands Coordinator. Contact Alan Quackenbush (802.241.3761 or alan.quackenbush@state.vt.us) for detailed information.

Dam Order – DEC Dam Safety Program
http://www.anr.state.vt.us/dec/fed/damsafety/ds_permits.htm
Dams that impound at least 500,000 cubic feet of water or sediment (or both) require an order prior to any construction, reconstruction or removal.

Stream Alteration Permit – DEC River Management Program
http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_management.htm
Dams that fall below the 500,000 cubic foot threshold for a dam order may require a stream alteration permit.

Section 1272 Order – DEC River Management Program
http://www.anr.state.vt.us/dec/waterq/permits/htm/pm_1272order.htm
Projects that do not require a stream alteration permit will likely be authorized by one of these orders, which focus on prevention or control of a downstream discharge of sediment or other pollutants.

In addition to the approvals described above, there are other approvals and permits that may apply. They are:

Water Quality Certification – DEC Water Quality Division
http://www.anr.state.vt.us/dec/waterq/permits/htm/pm_401.htm
Any project which must obtain a permit from the Army Corps of Engineers must first obtain a Section 401 Water Quality Certification from the state.

Construction Stormwater Permit – DEC Stormwater Management Program
http://www.anr.state.vt.us/dec/waterq/stormwater/htm/sw_permits.htm
Construction projects involving 1 or more acres of land disturbance require a permit for the discharge of stormwater from the construction activities.

Insignificant Waste Management Event Approvals (IWMEA) – DEC Solid Waste Management Program
http://www.anr.state.vt.us/dec/wastediv/solid/permit.htm
An IWMEA is required for one-time, on-site disposal of solid wastes such as untreated wood, masonry, concrete or other inert materials.

Act 250 Permit – Vermont Natural Resources Board
http://www.nrb.state.vt.us/lup/faqs.htm
In certain unusual circumstances, a dam removal project may fall within the jurisdiction of Act 250. Once the project is clearly defined, the DEC Regional Permit Specialist should be contacted to prepare a Project Review Sheet. Information on that form will be reviewed by the Act 250 District Coordinator, who will issue a Jurisdictional Opinion for the project.

Historic Resources Review – Division for Historic Preservation
http://www.historicvermont.org/programs/regulatory.html
Any projects that are subject to state or federal permits can be reviewed by the Division for Historic Preservation to identify potential impacts on historic or archeological resources. Projects that involve a federal permit or that will use federal funding are subject to a more prescribed process mandated by Section 106 of the National Historic Preservation Act. While a separate permit is not involved in either case, it is worthwhile to engage division staff early in the reconnaissance phase.

Federal Permits

The U.S. Army Corps of Engineers may have jurisdiction over a dam removal project through two federal laws:

- Clean Water Act – Section 404 requires a permit for discharge of dredge or fill material into all waters of the United States, including wetlands.
- Rivers and Harbors Act of 1899 – Two sections of this act require a permit for work in *navigable* waters of the United States. Section 9 requires a permit for construction of new dams, and Section 10 requires a permit for other structures or work. The extent of navigable waters in Vermont is defined in Corps regulations.

The application and review process is the same regardless of which statute triggers Corps jurisdiction. As noted in the state permits section, any project that requires a federal (Corps) permit under Section 404 of the Clean Water Act will require a Section 401 Water Quality Certification from the state. Projects seeking authorization under Section 404 or Section 10 also require consultation with the Division for Historic Preservation under Section 106.

Projects that meet certain criteria and would result in "minimal impacts" may be eligible for coverage under the Vermont General Permit, resulting in a simpler and faster permitting process.

More information on Corps of Engineers permitting is available at:
http://www.nae.usace.army.mil/reg/index.htm.

The Vermont Project Office in Essex Junction can be reached at 802.872.2893.

Final Engineering Design

The final design plans are the culmination of the preliminary design data collection, project approach decision-making, stakeholder input, and regulator input. Engineering design plans and specifications should be completed in sufficient detail that a contractor could take the plans and complete the work. While that is the goal in terms of the level of detail, the designer should also be present on-site during construction to oversee the process.

Just as with preliminary studies, the design team must be interdisciplinary to appropriately design all aspects of the project (see discussion in the feasibility study section on selecting effective consultants). The design typically includes a set of drawings (the design plan), a set of detailed specifications, and a technical memorandum describing the analysis and approach.

Final engineering design can cost between $10,000 and perhaps $200,000, depending on the size and complexity of the project.

Engineering Design Plan. The design drawings should show both dam removal and stream restoration plans. Plan sheets typically include base maps and drawings of:

- Existing site conditions
- Staging areas and access
- Removal plan
- Dewatering plan (sometimes completed by the contractor)
- Delineation of resource areas
- Proposed plan view
- Proposed cross sections
- Proposed longitudinal profile
- Erosion prevention and sediment control practices
- Infrastructure replacement/protection
- Habitat feature schematics

Project Specifications. The project specifications detail the construction work that will be completed. Typically specifications detail:

- Construction equipment needs
- Material specifications and quantities
- Project sequencing
- Staging area treatment
- Site access
- Dewatering
- Other site-specific details such as planting plans, traffic control, infrastructure protection, etc.

Design plans and specifications are required to be stamped by a licensed Professional Engineer if the dam is considered statutory to the state or if there is infrastructure that could be impacted by the project.

Technical Memorandum. The technical memorandum describes the analysis that went into the design and details the rationale behind the project approach. If a technical memorandum was completed during the feasibility, this document may be nearly identical with revisions that were completed in the final design.

Cost Estimate. The design team should develop an itemized cost estimate based on the design and specifications. At this stage, the cost estimate is considered an Engineer's Opinion of Probable Cost based on the project specifications, until contractors bid on the project.

Construction

Construction is most commonly bid out to qualified contractors. In some cases, town departments of public works or partnering corporations have qualified personnel and the appropriate equipment to complete some or all of the work. Regardless of who is driving the construction equipment, the same team that designed the project should oversee project construction. There are very few contractors that have experience with habitat restoration projects and many of the nuances of infrastructure protection and habitat construction must be relayed on-site during construction.

Construction can cost from about $30,000 upwards.

While this handbook is not intended to guide the scientific and engineering aspects of dam removal, some key points include:

• The entire vertical extent of the dam structure should be removed from the stream. Rivers are dynamic systems and any solid concrete structure that is left in the bed of a river can eventually become a barrier again as river flows cause scour on the downstream side over time.
In some cases, side abutments are left in place to preserve a historical remnant of the structure. In these cases, the hydraulics should be carefully modeled to ensure that the remaining abutments do not create a constriction and ultimately scour and cause high flow velocities.

• To effectively restore habitat, simulate the surrounding stream or other nearby healthy streams to the extent possible. For example, if the stream channel upstream of the impoundment has a slight slope and the channel downstream of the dam has a slight slope, then as a general rule, the restored channel through the removed dam should not have a steep slope. This will allow whatever species that make use of the more natural sections of the stream to also make use of the restored sections.

• Remember, good habitat is messy! Aquatic species need a range of complex habitats at different times in the season and for different life stages. Only be neat and clean where it is necessary for infrastructure protection. Otherwise, vegetate the site extensively and provide varying instream habitats such as by adding wood in the stream and providing variation on the stream bed.

• Slowly draining the impoundment during dam removal:

- Reduces the release of sediment downstream
- Allows the bed of the impoundment and stream to drain and stabilize
- Prevents a "wall of water" from crashing downstream and damaging both infrastructure and habitat

This can be accomplished by gradually removing boards from the control structure; slowly opening a low-level outlet if one exists; or by cutting incremental breaches into the dam structure and letting the water level lower after each increment.

• Carefully consider the need to proactively revegetate land that is exposed by the dam removal. While the Vermont environment is extremely effective at growing vegetation, often the first species that take root in exposed land are non-native or invasive species.

Project Monitoring

Monitoring project results is an important, but often overlooked step in the dam removal process. There are two types of monitoring that occur at dam removals. The first is project evaluation to determine if the engineering design was constructed properly and that the project is performing successfully in terms of infrastructure and public safety concerns. The second is environmental monitoring to determine if the project is meeting habitat goals over the long-term.

Project Evaluation

The contractor and construction manager should complete a project evaluation immediately following project completion. However, the project proponent should also complete regular project inspections of the site. The proponent can develop a checklist of issues to visually inspect with the assistance of the

project design team. The checklist might include a visual assessment of vegetation growth, erosion, and scour around infrastructure, such as pipes, retaining walls, and abutments.

Environmental Monitoring

Environmental monitoring involves evaluating changes in several ecological, hydrologic, and geomorphic parameters to determine if the project is meeting long-term ecological goals. A monitoring plan should be developed during the project development phase, as most monitoring parameters must be pre-measured prior to project implementation in order to establish pre-project baseline conditions. Trained personnel from universities, environmental consulting firms, or scientific staff from various nonprofits can complete environmental monitoring activities. In some cases, state agencies can provide assistance with project monitoring, such as by evaluating fish populations before and after dam removal.

The Gulf of Maine Council has published a Guide to Barrier Removal Monitoring, available at http://www.gulfofmaine.org/streambarrierremoval/. This guide recommends seven critical monitoring parameters and outlines methods for each parameter. It also provides data sheets, equipments lists, etc. It is important to consider the monitoring needs in the context of the size and scope of the project and not develop a monitoring plan that is overly ambitious.

The most basic approach to project monitoring is to develop photo stations to photograph the site from the same location repeatedly over time. In addition, there are a number of parameters that can be monitored to track the ecological success of a project, and they fall in some broad categories:

Ecological response

- Evaluate changes in fish, macroinvertebrate, and other aquatic species distributions and abundance.
- Evaluate vegetation regrowth in exposed lands, particularly assessing invasive and exotic species.

River channel response

- Evaluate sediment movement, erosion, and habitat structure by surveying channel structure and analyzing bed material samples.

Water quality response

- Evaluate changes in water quality, including such parameters as water temperature, dissolved oxygen, and suspended solids.

Hydraulic response

- Evaluate changes in flow velocities as it impacts aquatic species movement and recreational boating safety in the river.

Frequently Asked Questions

What will the restored river look like?

The river channel that re-forms or is actively restored after a dam is removed will be a similar size and shape as the river upstream and downstream of the former impoundment. Sometimes the general shape of the old river channel can be seen in underwater patterns if you look at an aerial photograph of the impoundment. Some dams were built to increase the water level in a natural lake or pond and that natural lake will be restored after dam removal. Changes to the landscape will be more or less dramatic depending on the size the structure, its purpose and the size and shape of the impoundment. Renderings

showing what the restored river channel will look like under different removal scenarios can help the community to understand the process and make decisions about removal options.

Will there be an increase in flooding?
Only a small percentage of dams provide flood control benefits and those dams were expressly built for that purpose. Most dams do not significantly affect or control downstream flooding and therefore their removal will not cause a significant change in flooding downstream. In some cases, dam removal can actually decrease flooding upstream of the dam, and can eliminate a downstream hazard by removing the potential for a catastrophic breach of the structure.

Can the dam be used for hydropower production instead of being removed?
Retrofitting existing small dams to generate electricity is usually uneconomic. With few exceptions, the good sites for hydropower development in the state were developed decades ago, so the sites that remain are hampered by limited generating capacity and the cost of development, operation, and maintenance. Even with economic incentives to develop renewable energy sources, the economics of many dam sites remain marginal. The cost of repairs to an existing dam to meet current safety standards can be prohibitive, in addition to the cost of the new infrastructure necessary for energy production. In most cases, the community, public safety, economic and ecological value of removing the dam will outweigh the societal benefits provided by the relatively small amount of renewable energy.

How long will it take the impoundment to revegetate?
Depending on the time of year, revegetation of the sediment behind a dam begins within weeks of exposure to sunlight. It is important to keep an eye on invasive plants such as purple loosestrife and Japanese knotweed during the first growing season, so that native plants can grow and out-compete unwanted species.

What happens to the fish and wildlife that were in the impoundment?
Dams create artificial habitat by impounding water and altering river function. Impoundments trap sediment and create stagnant conditions with warmer water than the rest of the river system. Generally, much of the wildlife that uses an impoundment such as birds and turtles will quickly adapt to restored river conditions. Rivers typically provide more habitat variety and conditions for native species. Fish will be able to move upstream and make use of the full river for their life cycle. The restored river may also help bring back cold water fisheries such as trout, and will allow anadromous fish such as Atlantic salmon to use the river for spawning. While the fishery will certainly change, a greater variety of fish and fishing opportunities is likely to result.

What about all the sediment behind the dam?
One of the first steps in designing a dam removal is to assess the quality and amount of sediment behind a dam. If the sediment is contaminated, precautions will be necessary for removal and disposal or in-situ capping. Dredging of sediment is not always necessary during a dam removal and not all sediment that was trapped by the dam will flush downstream during removal. Typically a combined approach is taken of removing some sediment and stabilizing the rest through active revegetation and bioengineering. Sediment impacts below the dam are generally temporary and the river quickly readjusts to its new configuration. Bioengineering and stream channel reconstruction can help stabilize sediments in the former impoundment.

Will there be wetland impacts?
The wetland habitat behind a dam will change when the dam is removed. Depending on the surrounding topography, deep water marsh may become shallow marsh or wet meadow. Habitats such as red maple

swamp may return. Rivers are also wetlands, and riparian areas have important habitat functions. While the total wetland area may change, the function of the natural ecosystem will be improved. Usually wetlands above a dam are not self-sustaining (they are sustained by a human-made structure that must be maintained) and will gradually fill with sediment over time.

What if the owner just breaches the dam?
A dam owner may be required by the Dam Safety Program to open the gates, breach or lower the dam for safety reasons. This action removes the pressure from impounded water on the dam structure to prevent a catastrophic failure. Many dam owners may not have the financial means to fully remove a structure and will leave the structure in the stream. Open gates can clog with debris and water can re-impound behind the structure creating an unstable habitat and safety concerns.

Breached structures can also continue to be passage barriers to fish, especially at low flows, and do not allow for full channel recovery above the dam. A better option is to fully remove the vertical extent of the structure and fully restore the channel and its banks as a natural system. Citizens should encourage dam owners to proactively deal with their dams before emergency situations arise so that the community has a chance to participate in the decision process.

Who will own the exposed land?
Because many dams were constructed by mill owners centuries ago, sorting out property ownership is not an easy task. A mill owner may have owned a dam and/or mill pond miles from the mill itself, and deeds for the dam may not always be attached to surrounding properties. Deeds and titles for the specific dam and/or legislative acts that provide for creating reservoirs will often show who owns the impoundment and the land under the water, and often this might be the municipality, especially if it is a municipally-owned dam. Whether or not abutters have rights to the newly exposed land is something that would have to be sorted out on a case by case basis.

What about property values?
While the loss of one type of recreational and scenic resource may decrease value to some, to others, the restored river, improved water quality, and added open space increases the value of the site. Preliminary studies are showing that property values in some cases may actually increase long-term following dam removal, but every case is site-specific.

Is the dam historic?
There are over 1,200 dams in Vermont. Some of these dams and their associated mills provide examples of early colonial and industrial development. Some community members will feel a certain amount of attachment to dams for their historic significance, while others will feel that the true history is a free flowing river. The history of these sites can be preserved through interpretive signage and preservation of associated mill buildings or a leaving a component of the dam.

Is there money available to help remove the dam?
There are several sources of federal and other funding available for dam removal, depending on the amount and type of habitat being restored. Rivers are seen as a public resource so there are many parties interested in seeing habitat restoration.

Finding Additional Assistance

The ANR Hydrology Program can provide additional information and assistance on dam removal projects. Contact Brian T. Fitzgerald at 802.241.3468 or brian.fitzgerald@state.vt.us.

American Rivers provides support to dam removal efforts across the country. In the northeast, Brian Graber leads the river restoration program. He can be reached at 413.585.5896 or bgraber@americanrivers.org.

In addition, the national Dam Removal Clearinghouse provides a wealth of additional information and project examples from around the country:
http://www.lib.berkeley.edu/WRCA/CDRI/