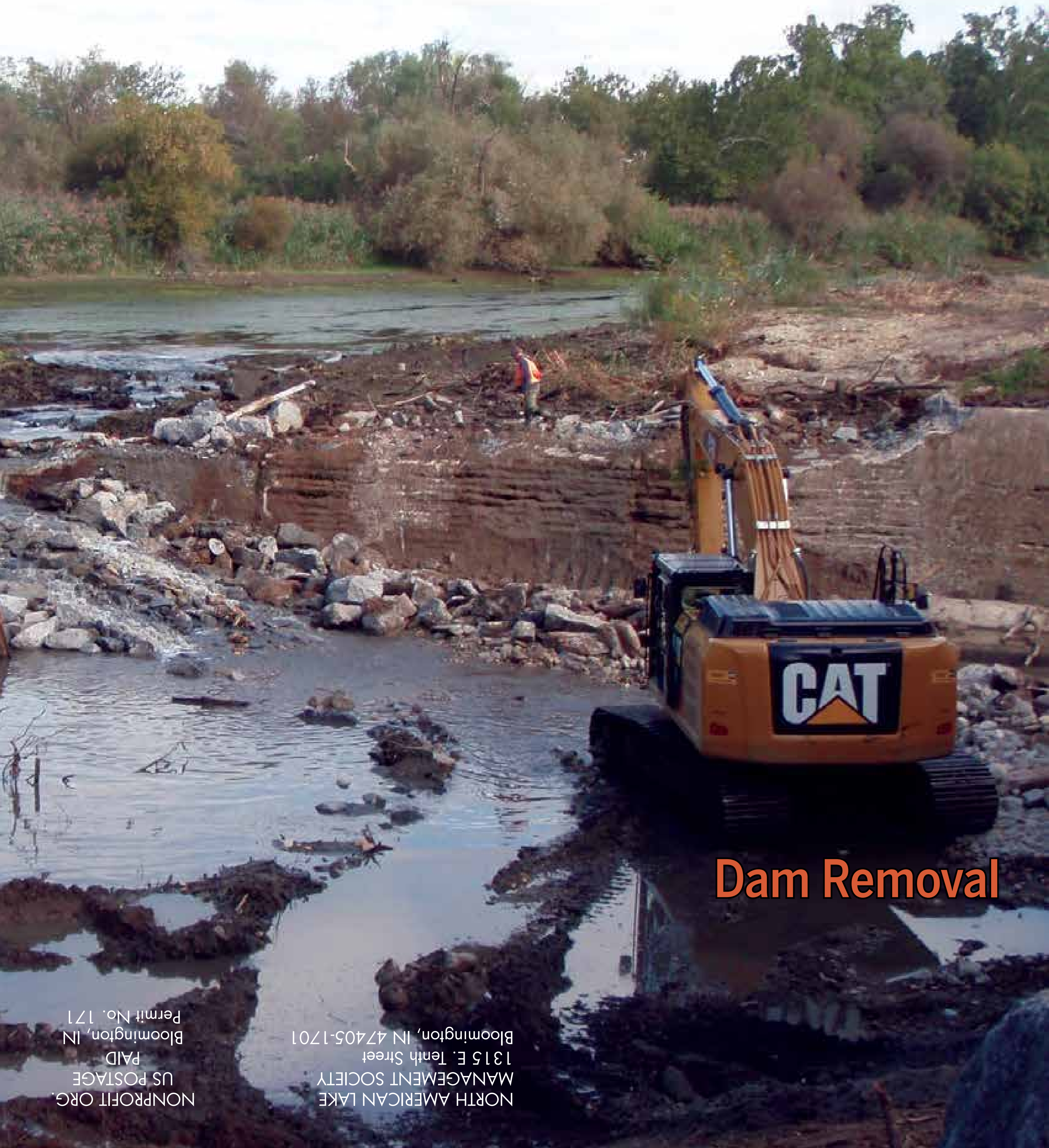
A publication of the North American Lake Management Society

LakeLine

Volume 38, No. 1 • Spring 2018



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Call for Abstracts

38th International Symposium of the North American Lake Management Society

October 30 – November 2, 2018

Duke Energy Convention Center • Cincinnati, Ohio

Photo: Chris Thornton

Now Trending: Innovations in Lake Management

The Ohio Lake Management and Indiana Lakes Management societies are excited to welcome NALMS to the Midwest's "Queen City," Cincinnati, Ohio. On the shores of the mighty Ohio, the river was impounded to serve modern navigation; those impoundments now function like a series of lakes. Cincinnati is also home to a burgeoning craft-brewery industry that is certain to be one focus for conference outings. With Thomas More College's field station, active urban reservoir projects, and Environmental Protection Agency research facilities nearby, we'll find plenty to see, do, learn.

Photo: Hilton Cincinnati Netherland Plaza

Our region is also bordered by the Great Lakes to the north, and our conference theme is well served by recent cutting-edge efforts to understand and mitigate western Lake Erie's press-grabbing eutrophication issues.

Join us at one of the nation's most opulent masterpieces of art-deco architecture, the award-winning Hilton Netherland Plaza, a short walk from sessions at the convention center.

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General Conference, Exhibitor & Sponsorship Information
NALMS Office
608-233-2836 • www.nalms.org

Preliminary Session Topics

We encourage the submission of abstracts for papers or posters on any of the topics listed below, or abstracts that address topics of broad interest to the lake and reservoir management community.

- Monitoring Technologies
- Autonomous Sampling
- Remote Sensing
- Large Data Sets
- Toxins in Source Waters
- Nutrient and Water-quality Management
- Utilizing Citizen Science
- Harmful Algal Blooms
- Great Lakes
- Inter-basin Water Management
- Combating Invasive Species
- Riverine Impoundments as Lakes
- Environmental DNA
- Geospatial Applications

Important Dates

May 11, 2018
Abstracts due.

Late Spring
Registration opens.

August 17, 2018
Registration and payment from presenters of accepted abstracts due.

September 28, 2018
Last day conference hotel rate available.

Visit www.nalms.org/nalms2018 for more information and to submit your abstract.

LAKELINE

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From Amy Smagula the Editor

Hello! I am excited to be the new editor of *LakeLine*. Bill Jones officially retired as *LakeLine* Editor on December 31, 2017, ending his run with the winter 2017 issue that focused on lake management success stories. I officially started as editor on January 1, 2018, and am picking up my first issue as editor with this spring issue that you have before you.

Here is a quick bit about me. I have been a NALMS member since 1998, and have served on various committees and on the Board of Directors for NALMS. I served a term as Region 1 Director, and am now completing my first term as secretary. I am also an associate editor for the NALMS journal. In my day job I am a limnologist with the New Hampshire Department of Environmental Services, Watershed Management Bureau, where I coordinate the Exotic Species Program and conduct varied specialized studies of New Hampshire's lakes and ponds. I look forward to working with the NALMS membership, and beyond, to continue to make *LakeLine* a dynamic and interesting publication. Articles, themes, and other content are welcome. Just reach out to me at LakeLine@nalms.org.

In this issue of *LakeLine*, you will see that dam removal is becoming a more common event, and the projects range from large to small. Most of the projects are expensive and have many intended and unintended consequences. Dam removal projects are occurring globally and they are being done for many reasons, ranging from returning river systems to their natural state, to removing hazard dams, because a dam is no longer needed, or to mitigate negative ecological, physical, and hydrologic impacts that result from the presence of dams. This issue will explore various elements related to dam removal, including ecological, financial, technical and regulatory aspects of such projects. The cover photo used here conveys the messier-looking short-term phase of such projects, but as you will see from the articles contained herein, the results of dam removal are quite restorative and enhancing in the long run.

Larry Oliver, **Wendy Gendron**, **David Olson**, and **Mindy Simmons**, with the United States Army Corps of Engineers, provide an article that gives us a look at the regulatory framework for dam removal projects in the United States, developed with an eye towards ecosystem restoration. They offer an overview on regulatory authority, permits, review and decision-making frameworks, and provide some case studies to exemplify that decision-making process in action, and the outcomes of those projects.

Bill Jones, our former *LakeLine* editor turned *LakeLine* author, examines two significant dam removals on the Elwha River on the Olympic Peninsula of northern Washington. These two dams are among some of the largest removed in the United States, and as such, warrant inclusion in this issue. Bill takes us through the history of the two dams, reasons for removing them, and some of the costs and benefits of removing them.

Next, we hear from **Kate Ebel** with Wildlands Conservancy, a nonprofit organization working in the Lehigh Valley of the mid-Atlantic region. Kate provides a good overview of what it is like to be involved in the various elements of dam removal, from a non-profit perspective. She describes the impacts of dams, the pros and cons of dam removal, and a discussion of the numerous steps and partnerships necessary for the success of dam removal projects. In her article she also highlights some of the notable projects that the Wildlands Conservancy has worked on over the years.

Jerry Sweeten and **Herb Manifold** from Manchester University in Indiana talk about their work in the Eel River and its watershed, from the perspective of professors who are actively engaging their students in studies that capture all aspects of environmental science, including the scientific, economic and political aspects of the subject. Their work was driven by data collected by students at Manchester University, showing differences in upstream and downstream water quality and ecology of the Eel River at low head dams along its reach. Their work led to several dam removals along the river and in the watershed, while addressing factors related to science, public health and safety, history, and politics.

Our fifth article explores restoration of an urban stream in New Hampshire, and restoration and enhancement of a native trout run. **Michele Tremblay** from *naturesource communications* walks us through the removal of several (questionable) structures that impounded McQuesten Brook, including the partnerships, volunteer efforts, financial support, and interesting discoveries made in this now urban oasis.

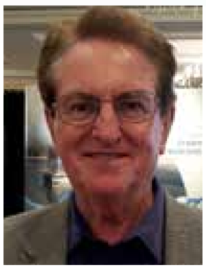
Finally, dams don't just hold back water; they also hold back sediment and other materials. The last article in the issue looks more deeply into the issue of contaminant mobilization that can occur when dams are removed. **Paul Woodworth**, **Laura Wildman**, **Dana Patterson**, and **Chris Mikolajczyk** from Princeton Hydro, delve into the sediments they have found accumulated behind a number of dams they worked with. They share information on disturbing trends in sediment quality and contaminants,

(From the Editor . . . continued on p. 7)

From the President

Frank Browne

Welcome to the spring issue of *LakeLine*. It's great to see life spring up around and in our lakes.



There are also many new and exciting things springing up at NALMS. At the recent mid-term Board of Directors meeting in Boulder City, Nevada, the board approved a new membership category called Early Career: It is a reduced rate category of only $80 per year for young NALMS members in their first five years after graduation. We hope this new category will encourage recent college graduates to join NALMS and enjoy all member benefits. At the mid-term, we also approved a list of NALMS members who will serve as Subject Matter Experts (SMEs) for topics related to lakes and their watersheds. Each of the volunteer experts is a NALMS Certified Lake Manager (CLM) or Certified Lake Professional (CLP). These experts will provide responses to questions NALMS members submit to "Ask the Lake Expert," our new feature on the NALMS website, and also be available as contacts for key specialties they represent.

Our next NALMS Conference will be held in Cincinnati, Ohio, from October 31st to November 2nd. The theme of our conference this year is "Now Trending: Innovations in Lake Management." This year we plan to increase the number of our popular pre-conference workshops, and will also plan to have many of our exhibitors provide demonstrations of their monitoring and lake management products. We are also planning some exciting field trips for the conference. I would personally like to invite students to submit papers and posters for the NALMS conference. Each year we have a student awards program where we present awards for the best student presentation and the best student poster. Cash prizes and certificates of recognition are awarded to the winners.

NALMS continues to be a leader in lake and watershed management and education. We are developing state-of-the- art information on managing toxic blue- green algae. We are developing position papers on timely lake topics. All of this information will be available to NALMS members through our many publications (*LakeLine*, *NALMS Notes & Lake News*, and our professional journal, *Lake and Reservoir Management*) and on our website. Have a great spring!

Frank Browne received his doctorate from the University of Florida. He is president of F. X. Browne, Inc., a civil – environmental engineering consulting firm that performs lake, watershed, and stormwater management projects. Frank is an adjunct professor at Villanova University, where he teaches graduate courses in lake and stream ecology and stormwater management. He is a founding member of NALMS.

(From the Editor . . . continued from p. 6)

and discuss options for how to address these built-up sediments before and after dam removal.

In this issue you will also find a Call for Papers for the 2018 NALMS Symposium, to be held in Cincinnati, Ohio, in October. As part of the conference, we are also including an announcement for the 2018 NALMS Photo Contest.

Happy reading!

Amy Smagula is a limnologist with the New Hampshire Department of Environmental Services, where she coordinates the Exotic Species Program and special studies of the state's lakes and ponds.

Low-Head Dam Removal for Aquatic Ecosystem Restoration in the Corps

Larry Oliver, Wendy Gendron, David Olson, and Mindy Simmons

Introduction

The U.S. Army Corps of Engineers (Corps) has been a partner in the development and management of the nation's water resources since the early 1800s, and its role in constructing and operating dams and other structures for flood risk management is well known. In fact, the Corps operates and maintains approximately 700 dams nationwide that help reduce flood damages to communities, businesses and critical infrastructure, and provide other benefits such as recreation opportunities.

The Corps' role in ecosystem restoration and dam removal in particular is less well known, but since the United States Congress authorized the Corps' first ecosystem restoration authority under the Water Resources Development Act (WRDA) of 1986, the Corps has played an important role in helping to restore the nation's aquatic habitats. The Corps has removed several dams since the start of its ecosystem restoration programs. The Corps also plays a major role in dam removal through its implementation of a regulatory program under Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act (CWA). Section 10 requires prior authorization from the Corps for structures and/or work in or affecting navigable waters of the U.S., and Section 404 regulates the discharge of dredged and fill material into waters of the U.S., and establishes an oversight role for most dam removals.

Ecosystem Restoration Authorities

The Corps has a broad range of programs to meet the water resources needs of states, municipalities, and other organizations. Over the past several decades, ecosystem restoration, including dam removal to restore free-flowing rivers, has been an important component of the Corps' programs. Congress delegated authority for smaller projects to the Corps under a number of authorities collectively referred to as the Continuing Authorities Program (CAP). Two of these authorities are pertinent to dam removal, dam modifications, and river restoration: Section 1135 of WRDA 1986, the Corps' first ecosystem restoration authority, authorizes modifications of Corps projects to improve the environment, and Section 206 of WRDA 1996 authorizes the Corps to carry out aquatic ecosystem restoration projects to improve the quality of the environment on sites unrelated to Corps projects. These programs have been applied to study and implement low-head dam removal, river restoration, and dam modification projects. Removal of large Corps-owned and -operated dams would involve a lengthy decommissioning process that is beyond the scope of this article.

Regulatory Authority

The Corps ensures all of its activities comply with Section 404 and Section 10 requirements and issues permits to other entities for these activities, including dam removal. The Corps issues general permits to provide the regulated public with approval under the CWA and Rivers and Harbors Act of 1899 for categories of projects that result in no more than minimal individual and cumulative adverse environmental effects. Under this approach, the Corps established Nationwide Permit (NWP) 53 for removal of low-head dams.

Nationwide Permit 53 has been used 13 times since it went into effect in March 2017. It has authorized low-head dam removals in Illinois, Ohio, Kentucky, Minnesota, Iowa, Virginia, Oregon, California, and Texas. The permit has been revoked in some Corps districts so project proponents should check with their local Corps office to determine the regulatory requirements for their projects.

Because the removal of low-head dams generally results in a net increase in ecological functions and services provided by the stream, as a general rule, compensatory mitigation is not required for activities authorized by this NWP. However, the district engineer may determine that compensatory mitigation is necessary to ensure the activity does not result in more than minimal adverse environmental effects. The permittee must submit a pre-construction notification to the district engineer prior to commencing the activity. The Corps recognizes the benefits of dam removal and is in the process of developing guidance within the Regulatory Program on how to determine mitigation credits generated by the removal of obsolete dams or other structures.

Dam Removal Decision-Making for Corps Projects

Dams manage and control the flow of water to:

- harness power, either for electricity or to mechanically power equipment in mills;
- reduce flood damages;
- provide water supplies (drinking water, irrigation, fire suppression and others), and
- provide recreation and aesthetic resources.

In addition, dams create impounded resources that provide habitat for waterfowl, including fringing wetlands that form around the perimeter of impoundments. Fish and other biota benefit from the quiescent, and/or deep waters of a lakelike environment. People are well aware of the human benefits of sitting by a lake, fishing, swimming, boating, and other recreation activities. Waterfront properties are highly desirable and property value is often correlated with water views and water clarity. In the Northeast, many dam structures are considered historic because they played a large role in our Industrial Revolution, powering mills in the mid-1700s through 1900.

Unfortunately, there are also negative consequences associated with dams. They slow the flow of water, which may increase water temperatures, nutrient concentrations, primary productivity, and turbidity, and decrease oxygen concentrations and water clarity. During initial construction, dams may flood important wetland habitats. Dams are physical barriers that reduce river connectivity, isolate biota, impede fish migration, and prevent the natural transport of sediment.

With respect to dam removal decision-making, these environmental, economic, and social benefits must be considered in relation to the benefits of removal. The intent of the Corps' ecosystem restoration policy is to encourage projects that partially or fully reestablish the attributes of natural, functioning, and self-regulating systems. The Corps follows the *Economic and Environmental Principles for Water and Related Land Resources Implementation Studies* (the Principles and Guidelines for short, or P&G) established in 1983 for planning and evaluating civil works projects by federal agencies. The P&G prescribe evaluating effects of each plan using four accounts: national economic development, environmental quality, regional and economic development, and other social effects.

The goal of Corps ecosystem restoration projects is to return an ecosystem to a close approximation of its condition prior to disturbance. In many cases, full restoration is not feasible and partial restoration becomes the objective, settling for a less degraded, more natural future condition. In the case of dam removal, river restoration, and fish passage projects, the Corps takes into consideration the value, uses, and risks of the existing dam and impoundment, the effects on the environment, and goals of the non-federal project sponsor. Selection of a restoration plan entails trade-offs: choosing more of one thing while simultaneously choosing less of something else.

Alternatives in dam removal/river restoration projects generally include:

- no action (maintaining the dam and impoundment);
- full dam removal, or
- partial restoration through the construction of fish passage structures.

From a restoration standpoint, dam removal provides the greatest benefits for fish passage improvement (Kraft 2013) and other ecosystem processes by restoring the full range of river functions (e.g., upstream and downstream organism passage, hydrologic and sediment continuity, and woody debris transport) (Poff and Hart 2002). In particular, the need for dam removal is paramount where the goal is to restore fish passage due to the cumulative effects of many barriers in series and the consequences of imperfect passage on a watershed scale (Oliver and Gendron 2018). However, in many cases other environmental and social factors often preclude dam removal.

The Corps uses both a trade-off analysis and a procedure called cost effectiveness/incremental cost analysis (CE/ICA) to aid in making decisions among alternative restoration plans, including partial and full restoration. The CE/ICA is a framework for comparing changes in costs and benefits progressing from smaller to larger plans. A team develops estimates of the financial cost of alternative plans and their ecological benefits, which can be represented by acres restored, numbers of fish passed, or some representation of habitat quality. Plans that are not cost effective are eliminated from consideration.

The incremental analysis considers the change in cost relative to the change in benefits for each plan. For instance, a fish ladder may be capable of passing 100,000 fish at a lower cost than dam removal, but dam removal might pass 150,000 fish, and allow the river channel to be restored at a greater cost. The decision on whether to remove the dam is based on an evaluation of the added benefits compared to the added costs as well as other tradeoff considerations (e.g., loss of recreation, conversion of lacustrine to riverine, loss of palustrine habitat). The CE/ICA and trade-off and risk analysis are documented and presented to the public for each plan under consideration. See Figure 1 for an example ICA graph and Figure 2 for an example trade-off analysis. The project team, non-federal sponsor, and stakeholders consider all of the above factors to recommend a plan for implementation.

This process is relatively easy when the dam is no longer performing its intended function, is in disrepair, and the habitat quality is poor. However, it gets more complicated when there are competing resource goals. A rigorous

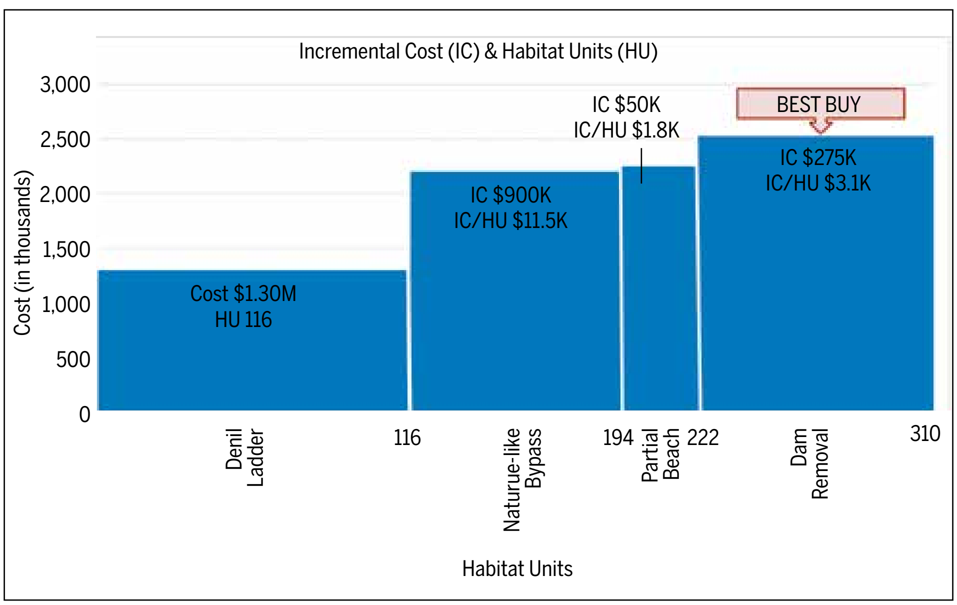


Figure 1. The incremental change in benefits with the change in cost for a typical dam removal project alternative analysis.

	Denil ladder	Nature-like bypass	Partial Breach	Dam Removal
Restore natural balance between coldwater and coolwater species	Partial	Yes	Yes	Yes
Allow movement of woody debris and sediment materials	No	Partial	Yes	Yes
Improves water quality through flushing	No	Partial	Yes	Yes
Provide passage of migrating fish and movement of resident fish/wildlife	Partial	Partial	Partial	Yes
Restores riaparian habitat	No	Partial	Partial	Yes
Prevent passage of invasive species	Partial	No	No	No
Retains small hydropower generation capability	Yes	Yes	No	No
Habitat Units	116	194	222	310
Cost (in thousands)	1,300	2,200	2,250	2,525

* The current small hydroelectric power generation is inactive

Figure 2. Tabular display of the results of a typical trade-off analysis for a dam removal project.

evaluation of trade-offs is required in such instances.

New England Case Studies

Two brief case studies for projects completed by the Corps' New England District highlight some of the challenges experienced during the dam removal decision making process.

The Ten Mile River project in East Providence, RI, evaluated options, including dam removal, to improve fish passage at three dams on the lower Ten Mile River. The three dams blocked fish passage and impaired riverine habitat value. The project team considered the need for river restoration and fish passage against the environmental, economic, and social opportunities and constraints associated with the existing dams and impoundments. The team recommended fish ladders over dam removal because of concerns about contaminated sediment, aesthetics of the impoundment, historic value of one dam, and water supply. The first dam in the series, Omega Pond Dam, was not removed because of concerns about contaminated sediments in the impoundments (too costly to remove and impacts to downstream estuary if released) and public opposition to loss of the impoundment. The second dam in the series, Hunts Mill Dam (Figure 3) is a feature in a historic park site listed on the National Register of Historic Places, eliminating the possibility of removing the dam. The third dam in the series, Turner Reservoir Dam, also impounds contaminated sediment, serves as a significant recreational resource and provides a backup water supply for the city of East Providence and therefore, could not be removed. In this case, the Corps constructed Denil fish ladders at each site to partially restore a portion of the ecological values of the system, while maintaining the values provided by the dams and impoundments.

In contrast, the Corps and its partners selected dam removal as the best alternative for a project on the

Figure 3. Fish ladder on the Hunts Mill Dam in East Providence, Rhode Island. The fish ladder entrance is in the top left of the photo.

Mill River in Stamford, Connecticut, because dam removal provided far greater benefits in terms of river restoration, fish passage and recreation. The existing mill pond dam provided little functional or aesthetic value and impeded passage of anadromous river herring to their upstream spawning habitats (Figure 4). Removal of the dam provided an opportunity to fully restore fish passage and habitat within the former channel and create an urban park that is a centerpiece of downtown Stamford (Figure 5 and Figure 6).

Figure 4. Mill Pond Dam, Stamford, Connecticut.

Conclusion

With any major decision to alter the environment, the process to evaluate dam removal must be a collaborative process. Needs of multiple stakeholders must be considered as well as cost, benefits, unintended environmental consequences, social and long-term and cumulative impacts. A transparent trade-off and risk analysis should be conducted for each specific restoration alternative before a plan is implemented. Rarely does everything go perfectly, so having an adaptive management plan in place to address risk and uncertainty will help overcome challenges through the process and increase the probability of achieving desired goals. And of course, don't forget to get your necessary permits from the Corps!

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Figure 5. Mill River Stamford, CT, immediately following dam removal.

Figure 6. Mill River Stamford, CT, two years following dam removal.

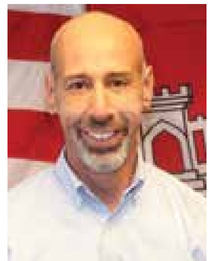
3568(2002)052[0659:HDVAWI]2.0.CO;2.

Detailed information about the case studies are available on the district's website: http://www.nae.usace.army.mil/Missions/Projects-Topics/Ten-Mile-River/

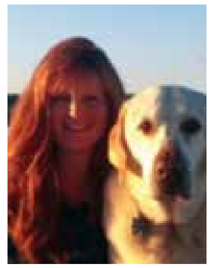
http://www.nae.usace.army.mil/Missions/Projects-Topics/Mill-River/

More information regarding the Corps' ecosystem restoration & regulatory programs are available at: http://www.nae.usace.army.mil/Missions/Public-Services/Ecosystem-Restoration-Authorities/ for more information on these authorities and cost sharing requirements

http://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/Nationwide-Permits/2017_NWP_FinalDD/)



Larry Oliver is a biologist with the New England District of the U.S. Army Corps of Engineers. He is currently the chief of the New England District's Evaluation Branch, which is responsible for providing environmental and economic evaluation and compliance services for Corps of Engineers projects.



Wendy Gendron is a Certified Lake Manager and a past NALMS Region 1 Director. She serves as the chief of the Civil Work & IIS Branch at the U.S. Army Corps of Engineers New England District.

David Olson is a regulatory program manager at the U.S. Army Corps of Engineers. He works on wetland and stream mitigation policies, the Corps' nationwide permit program, and Endangered Species Act compliance.

Mindy Simmons is a senior policy advisor with USACE HQ, where she manages the Aquatic Ecosystem Restoration program, provides guidance on environmental policy and research, and coordinates activities of the Chief of Engineers' Environmental Advisory Board.

Elwha River's
Return to Nature

Bill Jones

The removal of two dams from the Elwha River on the Olympic Peninsula between 2011 and 2014 were the largest dam removals in the world at the time. A project of this magnitude and importance should be included in this issue of *LakeLine* with its theme of "Dam Removal." Unfortunately, we could find no one in multiple federal or state agencies, or in universities willing and able to write this article. Therefore, I have prepared the following based upon previously published materials.

Figure 1. Map of the Elwha River watershed on the north side of the Olympic Peninsula. The vast majority of the watershed lies within Olympic National Park. Courtesy of Olympic National Park (from Sadin et al. 2011).

Setting

The Elwha River is located in the northern half of Washington's Olympic Peninsula (Figure 1). It is only 45 miles long, from its source high in the Olympic Mountains to its mouth on the Strait of Juan de Fuca, but includes over 100 miles of tributaries. The river flows south to north through old growth forests sustained by 60 to 80 inches of rain per year. About 83 percent of the watershed lies within Olympic National Park (Sadin et al. 2011).

The river historically supported a rich and diverse anadromous (fish that spawn in freshwater but live in saltwater) salmonid population. Prior to hydropower development, the Elwha was one of the few rivers in the lower U.S. that supported all the anadromous salmonids native to the Pacific Northwest: spring and summer-fall run Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), chum (*O. keta*), pink (*O. gorbuscha*), and sockeye (*O. nerka*) salmon; summer- and winter-run steelhead (*O. mykiss*); sea-run cutthroat trout (*O. clarkii*), Dolly Varden (*Salvelinus malma*), and bull trout (*S. confluentus*) (Wunderlich et al. 1994). Some chinook salmon exceeded 100 lbs.

The ancestral territory of the Klallam Indian Nation occupied much of the Olympic Peninsula. The Elwha River was at the heart of Klallam culture and life. For thousands of years, the river was a place of power for the Klallam Indians, as it was the source of their creation story and home to one of their most important spirits, Thunderbird. The river empowered the tribe by providing food, recreation, cultural traditions, and a transportation corridor. A permanent Klallam village was located eight miles from the river's mouth (Sadin et al. 2011).

The Dams

In 1911, a private company began construction of the first of two hydroelectric dams on the Elwha River. The Elwha Dam, completed in 1913, was 105 feet tall and created the 2.5- mile-long Lake Aldwell reservoir; A_o = 325 ac, Z_{max} = 100 ft. (Figure 2). The dam sits 4.9 miles upstream from the mouth of the river. The 210-foot-tall Glines Canyon Dam was completed in 1927 and sits more than eight miles farther upstream at river mile 13.4. It created Lake Mills reservoir; A_o = 490 ac, Z_{max} = 150 ft. (Figure 3; Bureau of Reclamation 2011). There were no fish passages built into the dams. At this time in American history, there was a public fascination with feats of construction and engineering, best exemplified by suspension bridges and hydropower dams that "tamed" the ancient power of rivers, revealing humankind's superiority over nature. City officials, newspaper editors, and community members in Port Angeles and other Olympic Peninsula towns gave the dam construction their enthusiastic support (Sadin et al. 2011).

Originally, the two dams generated about 20 megawatts (MW) of electricity that served numerous residential communities and industries on the Olympic Peninsula. This spurred the growth of the City of Port Angeles. Pulp and paper mills built between 1918 and 1929 gave the city a core industry that became the basis for future economic growth. However, since the 1940s, the Elwha River dams' power has gone to a single customer, the former Crown Zellerbach pulp and paper mill in Port Angeles (Sadin et al. 2011).

This "progress" came at a cost for the Elwha River ecosystem. The river's fisheries produced some 400,000 fish

Figure 2. Aerial photo of Elwha Dam and powerhouse, 1995. Source: U.S. Library of Congress. Photo by Jet Lowe.

Figure 3. Aerial photo of Glines Canyon Dam and Lake Mills, 1995. Source: U.S. Library of Congress. Photo by Jet Lowe.

per year before the dams. But since the dams blocked the passage of anadromous salmonids from their natural and historic spawning areas upstream, the river only produced about 3,000 fish per year in the 4.9 miles of river downstream of the Elwha Dam (National Park Service 2018). With no salmonids spawning in the upper Elwha, an important food source for wildlife and birds was cut off. The dams also blocked the transport of nutrients, sediments, and woody debris downstream. This has caused the eastern edge of the pre-dam Elwha delta to erode, and the barrier beach at Freshwater Bay, at the west of the mouth, to recede and steepen (DOI 1995). The dams also increase water temperatures in the middle and lower reaches of the Elwha River in late summer (Wunderlich et al. 1994). Finally, the dams flooded the historic homelands and cultural sites of the Lower Elwha Klallam tribe (National Park Service 2018).

The two Elwha River hydroelectric plants operated with little regulation for 50 years until the Federal Power Act required the owner to license the Elwha Dam and relicense the Glines Canyon Dam with the Federal Energy Regulatory Commission (FERC) in the 1970s. Challenges to the legitimacy and safety of the dams began soon thereafter, and led the Lower Elwha Klallam Tribe and several environmental organizations in the mid-1980s to call for the removal of the Elwha River dams (Sadin et al. 2011). The licensing process by the FERC became extremely contentious and drawn out for a variety of reasons, in particular, over the inability to design fish and wildlife mitigation measures capable of meeting federal, state, and tribal resource goals (Wunderlich et al. 1994). Removal of both dams emerged as an alternative. Since costly legal challenges could delay the federal licensing or removal by a decade, Congress offered legislation to solve the problem. On October 26, 1992, President George H.W. Bush signed the Elwha River Ecosystem and Fisheries Restoration Act into law. The act authorized federal purchase of the two dams on the Elwha from the timber companies that owned them and authorized the Secretary of the Interior to develop a report to identify the alternative that would result in "full restoration" of the Elwha River ecosystem and native anadromous fisheries (Wunderlich et al. 1994).

Dam Removal

The National Park Service had the lead in preparing an environmental impact statement (EIS) (DOI 1005). Five options were reviewed: (1) removal of both dams, (2) dam retention with fish passages installed on both, (3) removal of Elwha Dam, (4) removal of Glines Canyon Dam, and (5) no action. The EIS determined that the only way to insure full restoration was to remove both dams.

Removal work on the Glines Canyon Dam began September 15, 2011 and at Elwha Dam on September 19, 2011. Different demolition methods were used at the two dams because of their unique structural requirements. You can view videos documenting the dam demolition and river basin restoration at: https://www.nps.gov/olym/learn/nature/elwha-ecosystem-restoration.htm. It took just six months to remove the Elwha Dam (Figures 4 and 5).

The larger Glines Canyon Dam wasn't completely removed until 2014. With some 20 million cubic yards of sediment trapped behind the Glines Canyon Dam, one-half of which was fine sediment that could suffocate downstream fish and their eggs if released at once, contractors had to be more careful. They employed a notch-and-release method where for every 15 ft. of dam removed, they paused two weeks before proceeding. The river did the work in removing the sediments gradually (National Park Service 2018).

Results of Dam Removal

The $26.9 million dam removal contract was part of a $324.7 million total restoration cost. This included purchase of the two dams and hydroelectric plants, construction of two water treatment plants to protect local water supplies, construction of flood protection facilities, and a new, larger fish hatchery for the Lower Elwha Klallam tribe (National Park Service 2018). A project of this magnitude had many cooperating partners, including the National Park Service, Bureau of Reclamation, U.S. EPA, U.S. Fish & Wildlife Service, U.S. Geological Survey, NOAA, Washington State Department of Fish & Wildlife, and the Lower Elwha Klallam tribe.

The ecosystem benefits of dam removal far outweighed the few detriments. On the detriment side, the two reservoirs were water supplies and recreational resources to flat-water boaters and anglers, as well as winter habitat for trumpeter swan (DOI 1995). These benefits were lost with the dam removals. The higher water levels in the river resulting from sediment accumulation caused floodwaters to rise higher than normal, causing two campgrounds and a road to be washed out.

Millions of cubic yards of sediments trapped behind the dams washed downstream, rebuilding riverbanks and gravel bars in and around the river's mouth, creating 70 acres of new beach and riverside estuary habitat for Dungeness crabs, sand lance, surf smelt, clams, and other species (Nijhuis 2014) (Figure 6). The Lower Elwha Klallam tribe once again has access to their historic homelands inundated by the dam impoundments.

Within a week of the last blast at Glines Canyon Dam, fisheries biologists confirmed that two radio-tagged bull trout had migrated through Glines Canyon and were upstream of former Lake Mills in Rica Canyon. A snorkel survey confirmed that naturally migrating Chinook had spawned above Glines Canyon Dam for the first time in over 100 years.

Dam removal is finished, but this is just the beginning of Elwha River Restoration.

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Figure 4. Elwha Dam early in the deconstruction process. Water has been diverted to the spillway on the right to lower the Lake Aldwell. Source: Creative Commons. Photo by Ben Cody.

Figure 5. After removal of Elwha Dam with river back in its original channel. Source: Creative Commons. Photo by Zandcee.

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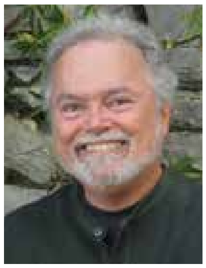

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Figure 6. Elwha River delta in July 2015 showing development of significant bars and beaches. Source: Creative Commons. Photo by Ian Miller.

Dam Removal
as an Ecosystem Restoration Tool

Kate Ebel

Wildlands Conservancy, a nonprofit land trust in eastern Pennsylvania, has been tackling environmental issues since its creation in 1973. For the past 45 years, Wildlands Conservancy has been working to restore degraded stream and wildlife habitat, protect valuable land from development, create trail connections for recreation, educate and engage local communities in environmental issues, and improve water quality. A staff of 23 dedicated full-time professionals work to achieve Wildlands' mission to "Protect and restore critical natural areas and waterways, and educate the community to create a legacy of a healthy, sustainable environment for future generations." Wildlands envisions a Lehigh Valley and Lehigh River watershed that contain expansive natural areas, connected green spaces, healthy waterways, and an enlightened community where people embrace conservation and sustainability.

Wildlands Conservancy works primarily in the Lehigh Valley and Lehigh River watershed, a 1,345 square mile drainage area that eventually flows into the Delaware River. In this area, Wildlands owns and maintains nine nature preserves that have permanently protected more than 2,600 acres of dense forestland, glacial wetlands, coldwater streams and native meadows. The Conservancy also does extensive conservation work with other property owners, connecting green spaces through trails and greenways, permanently protecting large areas of wildlife habitat, restoring degraded stream and floodplain habitats, and reestablishing rare habitats like grasslands and meadows. This work includes removing obsolete dams that are degrading watershed streams; Wildlands has been at the forefront of this emerging stream restoration initiative. There are thousands of dams in Pennsylvania, including eight on the main stem of the Lehigh River and at least one on each of its major tributaries (Figure 1). Many of these structures that no longer serve a purpose are degrading the stream ecosystems, and need to be removed.

The Problem with Dams

Dams convert lotic (moving water) environments into lentic (standing water) ones. Impairments to water quality, including high temperatures, low dissolved oxygen levels, and an accumulation of silt and sediment, characterize the lentic environment within a dam's impoundment. Native coldwater fish species have evolved in lotic environments, and are typically unable to survive in the impounded water behind dams. The stagnant water disorients them while excess sediment and particles can damage their gills and blanket the stream substrates they rely on for spawning. Dams also prevent the free transfer of nutrients and sediment, creating nutrient- and sediment-laden areas upstream and sediment-starved areas downstream.

In addition to ecological concerns, dams pose a major threat to public safety. These structures cause streambank erosion and instability, create a downstream boil which poses a drowning risk, and often have jagged metal or concrete edges. Many are located in public spaces, and signage must be installed to warn people of the dangers associated with recreation in the vicinity.

Wildlands Conservancy worked with Moravian College for a number of years to study the effects of dams on instream macroinvertebrate communities. At the sampled sites, the results of an Index of Biological Integrity, which is used to determine the health of aquatic communities based on the number of pollution-tolerant and -intolerant species, consistently ranged from fair to poor. Aquatic worms, midges, black fly larvae, and other pollution-tolerant species were common at the sites. Additionally, many of the species are more typically associated with slow-moving water or even pond ecosystems. Dams radically alter the local ecosystem, creating stream sections that are uninhabitable for desirable native species.

The Benefits of Removing Dams

The removal of obsolete, deteriorating dams has the power to transform a local stream ecosystem. It converts an often-forgotten section of stream that is degraded from decades of impoundment into a healthy, thriving stream system. Removing dams allows the ecosystem to recover, restoring free-flowing conditions and the natural stream structure, clearing out accumulated sediment, and connecting stream systems to allow for diverse recreational opportunities. The stream once again becomes wild and free, as if the dam had never been there in the first place.

The ecological and community benefits of dam removal are numerous and lasting. It uncovers buried gravel and cobble that provide structural and spawning habitat for macroinvertebrates and fish. Water quality improves as dissolved oxygen levels rise and temperatures fall. These benefits to the ecology of the stream lead to benefits for local communities as well. The improvements to water quality and habitat increase fishing opportunities for anglers. Removal decreases flooding; dams keep the stream channel at maximum capacity, which causes excess water from storm

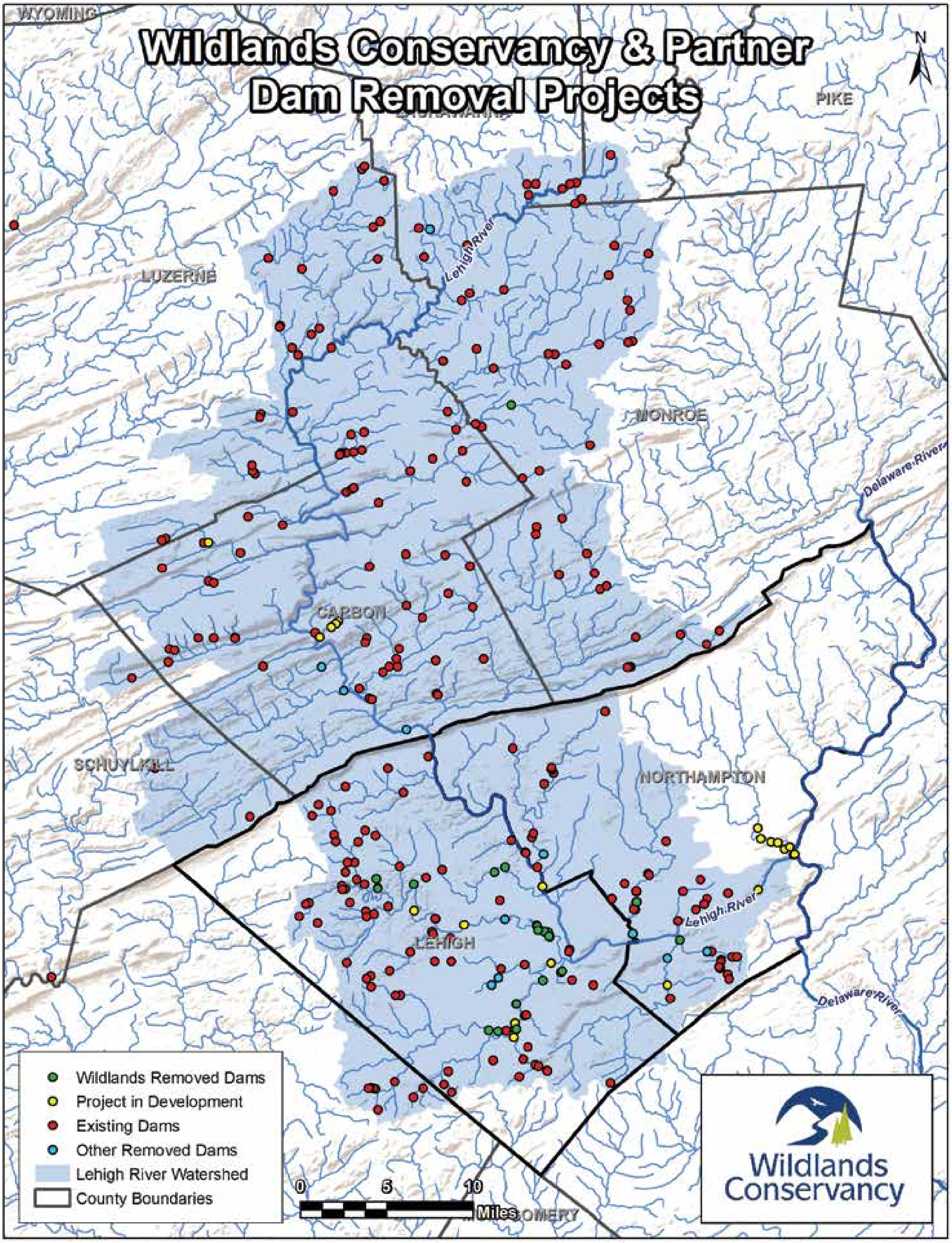

Figure 1. Watershed map showing Wildlands Conservancy (and partners) dam removals in Pennsylvania.

events to be diverted around the structure. Restoration of free-flowing conditions opens up waterways for canoeing and kayaking. The removal of dams from waterways eliminates a significant public safety hazard, as explained by the Pennsylvania Fish and Boat Commission, "Of all the things you may encounter on a river or stream, the low-head dam is one of the most dangerous. In fact, if an engineer designed an efficient, unattended, self-operated drowning machine, it would be hard to come up with anything more effective than a low-head dam."

The stream ecosystem begins to come back to life as soon as a dam is removed. Almost immediately, the unnaturally high water level in the former impoundment begins to drop and riffles that have long been buried reappear. From this point, it will take many more months for the stream to form and settle into a narrower, deeper and cooler channel. The diversity of native aquatic life returns once a normal flow regime and habitat structure has been restored. Soon enough, a wild, free-flowing stream sits in place of the previously stagnant, sediment-choked impoundment and deteriorating concrete structure.

A dam removal project typically provides the opportunity for a holistic approach to restoring a stream. Several stream and floodplain restoration strategies may be combined to improve wildlife and stream habitat. Once the dam is removed, the streambanks are stabilized and regraded if needed, which allows for improvements to the surrounding habitat. Dams create an area of disturbance that often degrades the nearby riparian zone, but removal of the structure and stabilization of the streambanks allows for riparian buffer restoration. A healthy, intact riparian buffer will further stabilize the streambanks, shade the stream, and provide cover and nutrients for aquatic and terrestrial species. This holistic approach provides an opportunity to engage the public in the project through streambank planting events.

The Dam Removal Process

Wildlands Conservancy has worked with many partners to remove 20 dams in the Lehigh River watershed. Each project requires extensive planning and comes with its own unique challenges and benefits. It can be a long process to get from project inception to the actual removal. The first step is to obtain landowner permission, followed by creation and submission of project designs to the relevant permitting agencies such as the Department of Environmental Protection, the local conservation district, the Fish and Boat Commission, and the Army Corps of Engineers. Meanwhile, there are several grant programs from state and federal agencies, private foundations, and counties that provide potential project funds. Both the permitting and funding cycles take about a year. With funding and permits acquired, a contractor must be secured to remove the dam. The entire process tends to take two to three years all told. The costs to complete this process depend on the size and complexity of the project. Completing the designs, permitting, and construction may range from $15,000 for a smaller project to hundreds of thousands of dollars for a larger project.

Many challenges may arise during this process, often in the earlier project planning stages. It can be difficult to approach a landowner to start the conversation about dam removal. Several attempts at outreach and education may be needed to develop a project. Sometimes surrounding infrastructure complicates the project designs if it is in close proximity to a dam. The designer may have to take into account things like nearby bridges or utility lines. It can be difficult to obtain enough funding to complete a project, and often a series of small funds from different sources gets strung together to complete the removal on a tight budget. However, by far the most challenging aspect of dam removal is public opposition.

When public opposition to a dam removal does arise, it can become an impediment to the success of that project. Dam removal is supported by an endless list of environmental organizations, but there are also some vocal critics. These critics often value the aesthetics of the dam, believe these structures prevent flooding, believe they improve fishing opportunities by confining stocked fish, value the history of the structure, or have an image of the dam from before years of deterioration and channel degradation. Wildlands Conservancy is no stranger to public opposition, having faced it on numerous projects. It has occasionally been the reason a removal did not move forward as municipalities faced pressure from vocal opposition. However, momentum for dam removal, as well as the list of partners, is growing. The best way to combat public opposition is through community education and outreach to showcase local successes and the benefits to the stream.

Coordination with various state agencies is necessary to obtain authorization under Chapter 105 of the Pennsylvania Code for a dam removal project. This includes attaining clearances from agencies such as the Pennsylvania Historical and Museum Commission and the Pennsylvania Natural Diversity Index, sending notification letters to the relevant municipalities and planning commission, and obtaining a Drawdown Permit from the Pennsylvania Fish and Boat Commission. These are sent to the Pennsylvania Department of Environmental Protection along with maps and design drawings, an Erosion and Sediment Control Plan, and permitting forms. Specific restrictions and requirements for construction are listed in the permit authorization when it is granted. For example, no instream work can be conducted between October 1st and December 31st in streams supporting naturally reproducing trout in order to protect the wild population.

The construction phase of a dam removal project is the fruition of years of planning and preparation. After careful planning, a dam is often removed in a matter of days or weeks. To remove the structure from the stream, Wildlands Conservancy works with a contractor who has the experience and equipment needed to break up and remove the concrete and rebar. The contractor will make an initial breach in the center of the dam and let the water level slowly adjust, rather than unleashing the impounded water all at once. Once the water level is drawn down sufficiently, the remainder of the dam can be removed and the streambanks stabilized. While the typical dam consists of concrete or stone and rebar, there are occasionally some unexpected components; an entire 12-inch auger bit was imbedded as fill in one of Wildlands' dam removal projects on Coplay Creek. Wildlands conducts oversight through the removal process to ensure the designs, permit requirements, and erosion and sediment controls are correctly implemented.

Notable Projects in the Lehigh River Watershed

A great local example of overcoming adversity and completing a successful dam removal project is Atlas Dam on Hokendauqua Creek, a tributary to the Lehigh River. This structure was over 600 feet long and ranged from 8 to 15 feet high, impounding Hokendauqua Creek for more than 4,000 feet. Most of this impoundment had filled up with sediment and stagnant water. The Hokendauqua Chapter of Trout Unlimited obtained permission from the landowner and began the process of planning for the dam removal. However, what was supposed to be a two-year process got stretched out closer to ten. Trout Unlimited, and later the Martins-Jacoby Watershed Association, faced numerous obstacles including outspoken public opposition, unexpected costs, and hurdles in permitting. After years of perseverance, the dam was successfully removed in 2014 and replaced with a free-flowing stream and stabilized, planted streambanks.

Wildlands Conservancy's first dam removal, on Little Lehigh Creek which is a tributary to the Lehigh River, was one of the early dam removal projects in Pennsylvania. This dam was located at Wildlands' Pool Wildlife Sanctuary, the base of operations for the organization. Since that first project, Wildlands began building partnerships with local watershed organizations to work with other landowners on dam removals. The Conservancy assessed the existing dams in the watershed, identified the highest priority dam removal projects, and began working through the list to restore streams in the watershed. This led to a large-scale restoration project on the Little Lehigh and Jordan Creeks, in which six dams were removed in summer of 2013, restoring fish passage to more than 15 miles of stream habitat. In 2017, Wildlands circled back around to practice what they preach by removing a dam on Tunkhannock Creek on the Conservancy-owned Maple Tract Preserve.

Much of Wildlands' focus has been on removing dams on public land. The Conservancy has partnered with numerous municipalities and state agencies, such as the Pennsylvania Game Commission and the Pennsylvania Fish and Boat Commission, to remove dams in public parks and on state land. A strong partnership with permitting agencies has made the dam removal process in Pennsylvania efficient and cost-effective, allowing for many successful projects. These partnerships have helped leverage resources to remove dams on public open space. Removing dams on public lands facilitates outreach by giving communities the opportunity to enjoy the benefits of safe park conditions, successful fish passage, and healthy streams. Wildlands removed a dam on Coplay Creek in 2015, which facilitated an ongoing opportunity for public outreach. The dam, located along a local rail trail, was causing flooding and erosion on the trail, and degrading instream habitat. After the removal, Wildlands held a public event to educate local citizens about the project and plant a native riparian buffer along the newly restored stream. Interpretive signage now sits at the project site to continue educating trail users about streamside best management practices.

Looking Ahead

Wildlands Conservancy is a growing organization with an ever-expanding presence in the Lehigh River watershed and surrounding areas. The main strategic goals for the Conservancy are to continue protecting, restoring and enhancing regional waterways, increase our educational programming, continue connecting people to nature, expand our nature preserves, and increase public awareness of our organization. This means the organization will continue building partnerships to restore streams, protect high quality land, educate local communities, build trails to connect public spaces, and restore wildlife habitat.

Wildlands Conservancy will continue focusing on removing obsolete dams to restore the health of watershed streams and their inhabitants. There are seven dam removal projects slated to take place in the next three years, with an additional nine targeted for project development. A notable upcoming project has Wildlands partnering with state and federal agencies, municipalities, private landowners, local watershed organizations, and a local college to remove four dams on Bushkill Creek. This project will restore fish passage and habitat along a significant section of this High Quality – Coldwater Fishery. A local trail makes this area publicly accessible, so the project will also increase public safety and recreational opportunities for local communities. This and other future projects will allow Wildlands to continue leading dam removal efforts to restore stream ecosystems in the Lehigh River watershed.

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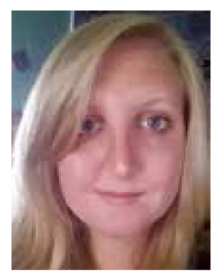

Kate Ebel is the senior environmental scientist at Wildlands Conservancy where she works on such projects as large-scale stream and floodplain restoration, dam removal, riparian buffer restoration, invasive species management, and naturalization of open space. She has been working for the last four years to build partnerships and restore stream health throughout the Lehigh River watershed and surrounding areas.

Next Issue – Summer 2018
National LAke Assessment Data

At the NALMS Symposium in Colorado in 2017, several sessions were offered to showcase work that was done using data derived from the National Lake Assessment (NLA). Many of the talks that were given at that symposium will be highlighted in the summer issue of *LakeLine*, though additional articles related to utilization of NLA data are welcome.

It's a "Dam Opportunity"

Jerry Sweeten and Herb Manifold

A fish was swimming upstream and swam into a concrete wall and said "dam." This is one of the oldest "dam" jokes in the "dam" world. All jokes aside, humans have been ingenious in their ability to place concrete and earthen barriers in stream channels of all shapes and sizes. In fact, we are so good at the trade that it has been referred to as the "beaver syndrome." The rationale for why dams have been built is as diverse as the number of dams across the globe. In Indiana, dams hold up aging glacial lakes, store drinking water, displace floodwaters, and even aid in generating carbon free electricity. Some of these rationales may benefit humans, but to our brethren who live full-time in streams and have no voice in the matter, these structures have dramatic negative ecological consequences.

We Have a Dam Problem

I arrived at Manchester College (now Manchester University) in 2004, to teach biology and direct the environmental studies program. It quickly became evident there was a need to engage young people in academics that captured the science, economics and politics associated with environmental challenges through experiential learning. Some of this early engagement with undergraduates included an examination of nonpoint source pollutants in the Eel River that flows in the backyard of the college. We have examined hundreds, no thousands, of bottles of river water for nutrients and suspended sediment (mud in the water), and how these affected the ecological integrity of the stream with an emphasis on smallmouth bass.

Our first awakening from this data was that there are a lot of nutrients and mud in the water moving down the Eel River racing toward the Gulf of Mexico. In fact, the concentrations and loads in the Eel River are so large that the river was designated as one of 41 priority watersheds in the Mississippi River basin. We quickly realized nonpoint source pollution was of catastrophic proportions. Concentrations and loads of mud in the water are particularly alarming. Perhaps the best analogy is that we are in the midst of an "aquatic dust bowl." What if all this sediment was blowing in the air rather than rushing to the Gulf of Mexico? Perhaps we would have a new perspective.

Our second research discovery was in regards to the ecological effect of two low-head dams near campus. We examined stream habitat and fish indices in four 500-meter sections of the river above each of the two dams and 500 meters below each dam. Much to our surprise, both the habitat score and the fish index score was the lowest in the 500-meter section of the river just upstream of the dams and increased almost in a linear fashion in sections of the river away from the dams. This discovery led to a more in-depth examination of other dams in the Eel River. We discovered that at one time there were 14 dams scattered throughout the basin. In 2009, when this research started to gain traction, there were only 6 of the 14 original dams remaining. Nature removed eight dams with no permits from state and/or federal agencies.

Figure 1 illustrates the locations of dams along the Eel River, and provides

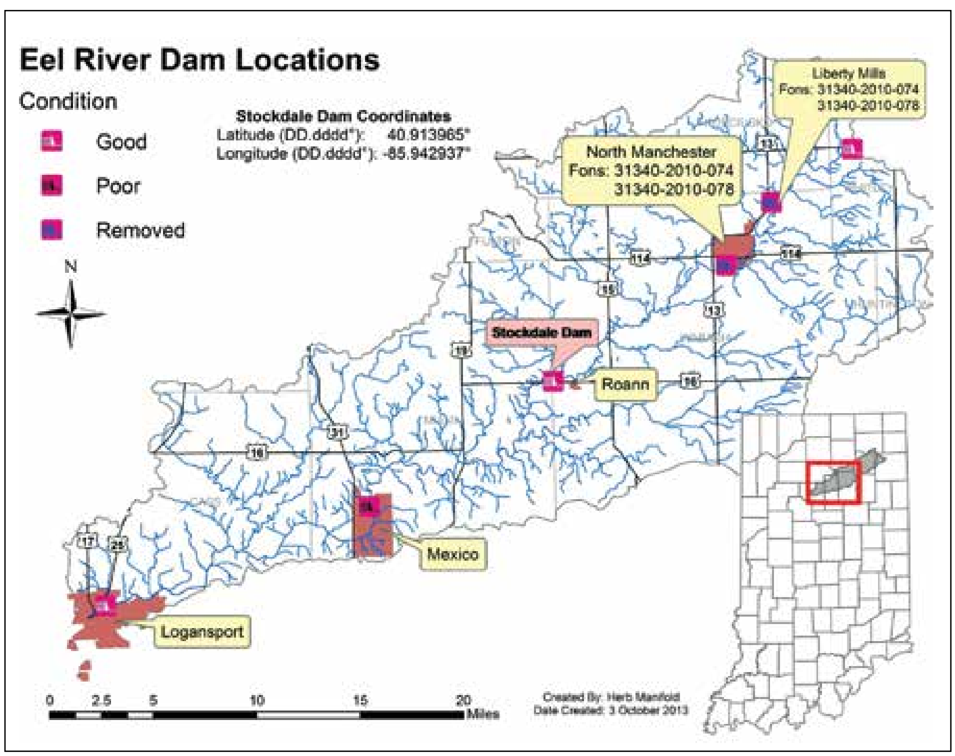

Figure 1. Map showing the Eel River watershed and the location and condition of dams.

an indication of condition for each dam. The most downstream dam still in existence is in Logansport and just upstream of the confluence of the Eel with the Wabash River. The most upstream dam is located in the small village of Collamer about 70 stream miles upstream from the Logansport dam. The two in our neighborhood were in North Manchester and in Liberty Mills about 6 miles or so upstream from the North Manchester dam.

Dam Removals

North Manchester sits in the middle of the Eel basin. Most Eel River dams, like many other dams in Indiana, were built in the middle of the nineteenth century as wooden crib dams. Over time, as the wood cribs deteriorated, these dams were capped with concrete. Their uses varied from grist mills, sawmills, breweries, and even some of the very first attempts to produce electricity. These old dams are now antiquated and serve no particular purpose to humans other than there is this interesting tendency that people enjoy watching water fall over a concrete wall. Being a stream ecologist I must have missed receiving the genetic trait responsible for this aesthetic appreciation. Perhaps people enjoy watching the water because these dams represent some of the most dramatic topographic change in elevation in a landscape that is so flat we can watch our dog run away for three days.

Through some of the most remarkable serendipitous events in my professional life we were able to partner with a group of innovative biologists from the Ohio River Basin Fish Habitat Partnership (ORBFHP) through the United States Fish and Wildlife Service. This relationship increased our knowledge about old low-head dams and a second issue in regards to these old dams came to light. Besides compromising the ecological integrity of the stream, dams can kill people. Wow! What a discovery. It turns out that these old dams are extremely dangerous to humans because of the recirculating nature of the hydrologic currents at the toe (lower portion) of the dam. Nearly every year, someone in Indiana dies after becoming entrained in this powerful recirculation.

Now armed with two critical pieces of information, we received a grant in 2010 to remove the dam at North Manchester and Liberty Mills. The dam at North Manchester was only about three feet tall. This was half the original height and according to local anecdotal history, there was a law enforcement person in North Manchester who attempted to blow a hole in the dam with dynamite. While there was no verification of this story, the dam was severely compromised, but our data illustrated the ecological effect one mile upstream of the dam and the old structure remained dangerous to people. The Liberty Mills dam was about six feet tall and mostly intact except for a six-foot breach on one end.

It took nearly two years to navigate the permitting process to remove these old dams and only one week in October 2012 for the contractor to complete the deconstruction and haul the concrete to a recycling plant. The results were nothing short of remarkable. At North Manchester (Figure 2), three new riffle/pool areas appeared and two similar riffle/pool areas appeared behind the dam at Liberty Mills. Our calculations suggested that by removal of these two dams, nearly 200 stream miles (this includes the mainstem and all tributaries) were reconnected. These were the first two dams to be removed from an Indiana stream with ORBFHP financial resources.

What a fantastic living laboratory for students to document the ecological changes of these two areas of the Eel River. The data from our surveys in the summer of 2013 were dramatically clear, and showed a 25-percent increase in stream habitat scores and a 25-percent increase in fish community scores Figure 3a and 3b). Removal of these dams gave the river new life.

Since removal of the North Manchester dam and the Liberty Mills dam, we removed a third dam from the Eel River in the fall of 2016. This was a dam near the small town of Mexico. The Mexico Dam was built in 1910 and was the first concrete dam built in Indiana (Figure 4a and 4b). It was formidable concrete and had replaced an older milldam in the same location. This particular dam was about 30 miles downstream of North Manchester and about 25 miles upstream of the confluence. No surprise in regards to the pre- and post-removal data; another positive response ecologically and safe passage for humans.

Workarounds

Removal of three dams resulted in reconnection of over 300 stream miles of the Eel River! All this occurred over four years, with many great conservation

Figure 2. Eel River at the location of dam removal in North Manchester.

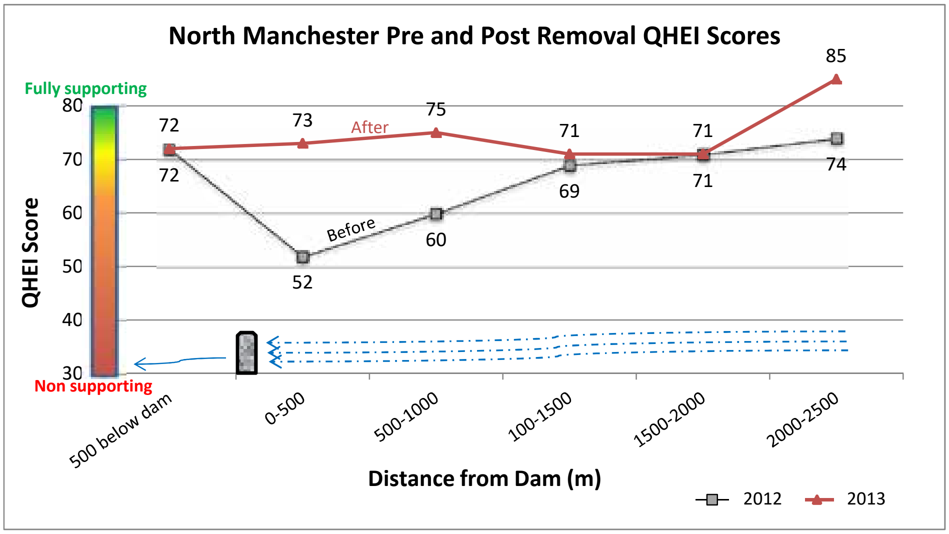

Figure 3a. Pre- and post-dam removal QHEI scores for North Manchester.

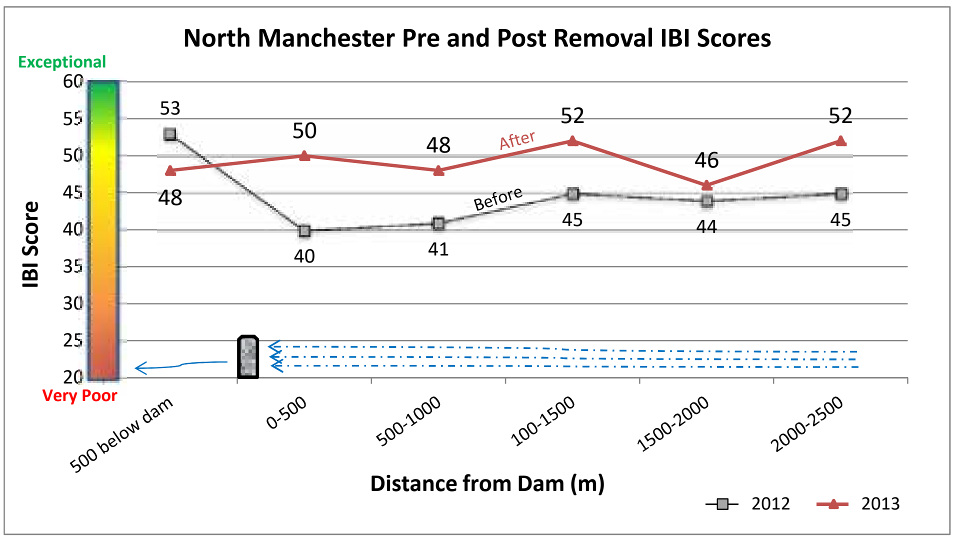

Figure 3b. Pre- and post-dam removal IBI scores for North Manchester.

partners and a number of willing undergraduate environmental studies students. Not too bad. However, a new challenge was at our doorstep. There is an operational dam near Roann at the Stockdale Mill about 30 miles upstream of the Wabash confluence and between the Mexico dam and the North Manchester and Liberty Mills dams. A group dedicated to the preservation of the mill and the dam maintain the site. In fact, this group raised a significant amount of money to renovate the old mill into working condition. The mill is fascinating technology and a visit to this operational mill is a trip worthy of anyone's time. This opportunity is where tradition meets innovation.

In the fall of 2017, we completed installation of a prototype fish ladder at the Stockdale Mill dam (Figure 5). This is a collaborative research project of an innovative fish passageway biologist from Massachusetts, the ORBFHP, the Stockdale Mill foundation, an ingenious structural engineer, and little old Manchester University Environmental Studies Program. However, we were uncertain about the ability or memory of fish to use the ladder after being blocked by the dam for more than 160 years.

There are 52 species of fish in the Eel River, and we had documented many of them at the toe of the dam during our fish surveys, but this fish ladder had only been tested in a laboratory in Massachusetts. We were all quite surprised and excited to see thousands of individual fish, some as small as three inches, move through the ladder and around the dam. As scientists, we often are interested in boiling the world to numbers. Because of our geekiness, our research includes sophisticated electronics to evaluate use of the ladder. We have 2,000 fish swimming above and below the dam with microchips and three antennas in strategic locations to track the fish. Of those 52 species that live in the Eel River, we have documented 15 species moving through the ladder! Some of these include bluntnose minnows, rosyface shiners, common shiners, stonerollers, and northern hogsuckers. Perhaps they have found their way home. The ecological response fish and even freshwater mussels to the fish ladder may take decades to understand. We are operating on nature's time and not on a fiscal calendar.

In the case of the Eel River, we have removed three dams and installed one fish ladder. This has reconnected over 700 miles of the Eel basin. Ecologically, we may never understand all of the salient secrets of nature we have unlocked, but we know the river is safer for humans, and we have learned that nature is resilient if we will only listen and understand natural systems. Moreover, no human will lose their life in the deadly recirculation of these dams, and fish can swim upstream without swimming into a wall of concrete and saying "dam."

Future Work

There is one remaining dam in the Eel River that should be removed. This dam is near the small town of Collamer, about 70 river miles upstream of the confluence of the Eel River with the Wabash River. We have had sufficient financial resources from a private donation to remove this antiquated dam since 2015, but in this case the property owner will not allow the dam to be removed.

Unfortunately, this past summer of 2017 a young person lost their life at this dam and a second young person nearly drowned trying to rescue the first person. It is unspeakably sad and after talking to the mother of this young person who died, my heart ached! This dam could have been removed.

The Collamer Dam moves us quickly from the world of science, where most scientists are comfortable, and into the world of politics. There are many conversations underway in regards to the very old and outdated laws about who owns a dam in a public waterway and who should pay to have them removed. Dam removal is one of the simplest and most profound improvements we can do to improve Indiana streams.

Figure 4a. Mexico Dam before removal.

Figure 4b. Location of Mexico Dam after removal.

Figure 5. Fish ladder at Stockdale Mill Dam.

Jerry Sweeten, Ph.D., is a professor of biology at Manchester University and Principal Investigator for dam removals and fish passageway in the Eel Basin.

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The authors have recently started a new environmental consulting business with the goal of education, and ecological restoration, Ecosystems Connections Institute, LLC.

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Tell us what you think of *LakeLine.*
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What would you like to see in *LakeLine*?

Send comments by letter or e-mail to editor Amy Smagula (see page 5 for contact information).

To Restore or Not to Restore; **That is the McQuestion**

Michele Tremblay

When is a pond not a pond? When it struggles to be six inches deep with increasing sediment and decreasing oxygen? When it is on the 303d list of impaired waters as failing to meet designated uses supporting aquatic life and primary contact recreation? When there is no boat access or enough water for boats or swimming? When the local citizen science group gives up its urban pond monitoring because the water is so shallow and the temperatures are so high? When the primary substrate structures are shopping carts and shipping pallets? When your high school senior environmental science job shadow is so grossed out by the smell of the over eight-foot-long sediment cores that he decides to enroll in art college instead?

A pond by any other name might still smell of methane. A lot of people had given up on the McQuesten watershed and turned their attention to other urban waters.

To the New Hampshire Rivers Council (Council) came a heart-wrenching plea: When an eight year-old girl comes to you with wild, native eastern brook trout and asks why they died, there *is* no McQuestion about restoration of the McQuesten watershed.

What began as the Council's annual watershed clean-up in partnership with employees from Anheuser-Busch observing World Environment Day, grew into a comprehensive watershed restoration and management plan that was implemented with stunning on-the-ground results and nearly immediate water quality improvements.

The Council, in partnership with the New Hampshire Department of Environmental Services, New Hampshire Fish and Game Department, City of Manchester, Town of Bedford, nonprofits, and local businesses, galvanized the planning efforts to restore the McQuesten watershed – a third of which is covered by impervious surfaces (Figure 1a-c).

McQuesten Brook and its tributary in Manchester and Bedford, New Hampshire, were obstructed by four dams (three on an unnamed tributary forming the McQuesten Ponds and one on the mainstem) created in the early 1950s and squeezed through two undersized culverts. Downstream in the Town of Bedford, McQuesten was subjected to further torture as it passed under a collapsed historical stone culvert and two more undersized culverts before reaching the Merrimack River via a perched culvert under Interstate 293.

The story of McQuesten Pond or, more accurately "ponds," has nothing to do with the brook and everything to do with an urban planning vision. Early on, the City of Manchester envisioned the land along the tributary as a residential area. "Paper roads" were created on maps. Piles of rocks, concrete, and granite curb fragments were brought to the area as placeholders and became three causeways across the tributary, which were functioning as dams and creating a series of ponds. On the brook's mainstem, an impressive do-it-yourself dam was built with cinder blocks and stuccoed with concrete at the outlet of a nearly 8,000-foot long culvert carrying the brook underneath neighborhoods. The dam impounded not only water but an array of debris. It was there that the eastern native brook trout were trapped and died (Figure 2). It was dubbed the "fish killer dam," and everyone agreed its days were numbered.

Development in the commercial and residential areas brought with it decades of runoff that accumulated as over a dozen feet of sediment in the impoundments. The tree canopy that once shaded the tributary withered and died in the impoundments. Water temperatures rose, oxygen plummeted, and the pond became shallow and choked with algae (Figure 3). While some area residents cared about the pond area, others treated it as a dumping ground. Snow was plowed from the "riparian" parking lots taking with it dumpster overflow, shopping carts, shipping pallets, bottles, cans, and an amazing array of discarded items including construction waste, furniture, a coffin wagon, and a four-foot-tall stuffed crab. For over a decade, leading up to the dams de-construction and culvert removals in the summer of 2016, McQuesten Pond failed to meet designated uses supporting aquatic life and primary contact recreation. The impoundments were always full and did not allow for flood storage. Businesses and area residents were flooded regularly during even small storms. McQuesten Brook had lost its way.

With funding from New Hampshire Department of Environmental Services Watershed Assistance Grants, New Hampshire Fish and Game Department, Samuel P. Hunt Foundation, and Council member dues, partners contracted with Comprehensive Environmental, Inc., to study the watershed and draft a plan with specific recommendations and priorities to improve watershed quality. The Council contracted with Inter-Fluve Inc. to design the dams removal project in Manchester while the Town of Bedford worked with their engineering team on the three culverts downstream. The on-the-ground work was funded through New Hampshire Department of Environmental Services Watershed Assistance Grants and Aquatic Resource Mitigation Programs, and

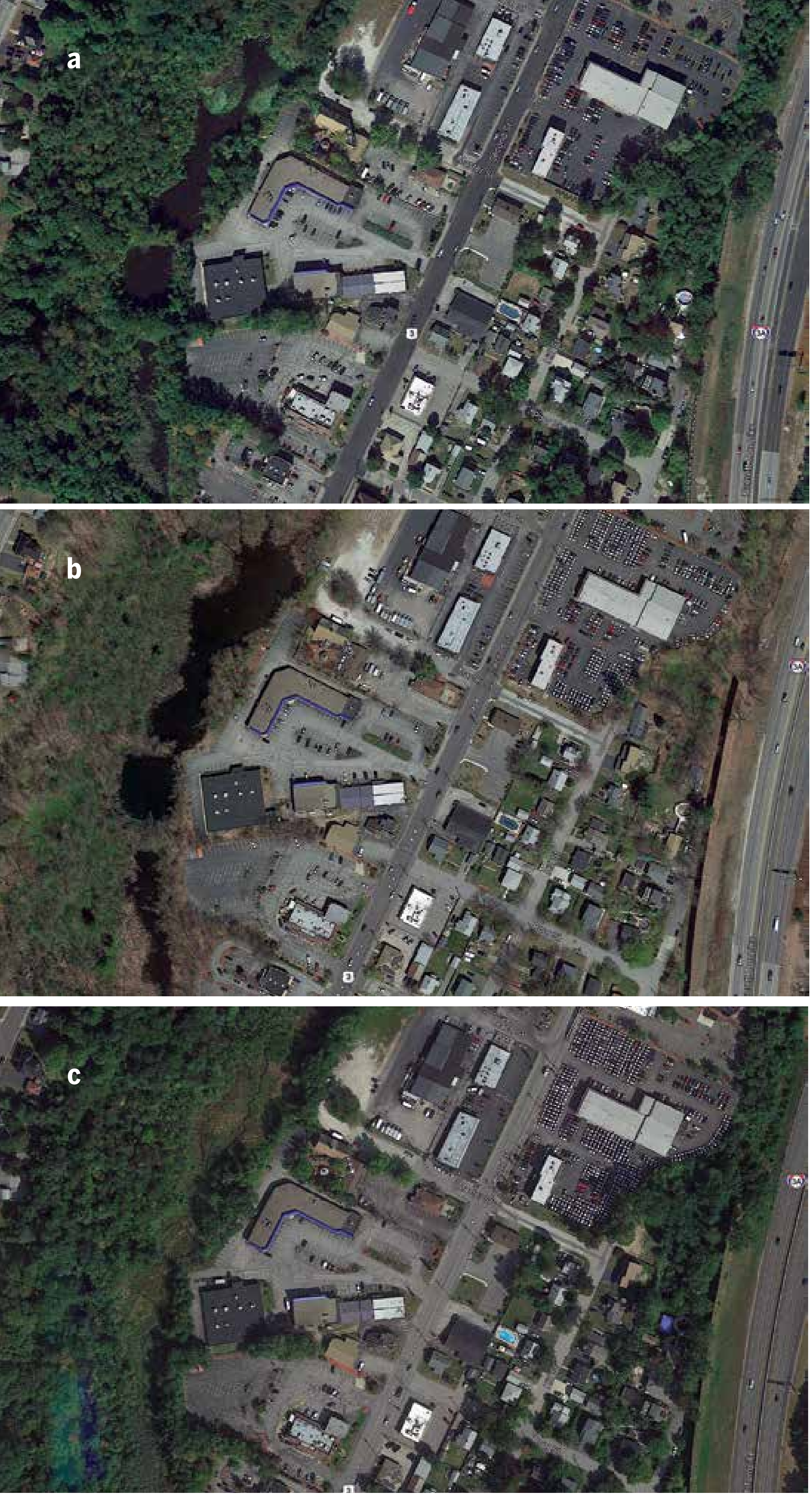

Figure 1 a-c. Google Earth images of McQuesten Ponds over time.

Figure 2. Eastern brook trout were found dead behind the impoundment on the main tributary to McQuesten Brook.

matched with Council membership dues. The City of Manchester Department of Public Works donated equipment, labor, and the hauling and disposal of materials from dam removal sites. The Town of Bedford provided match through their capital improvement program, including engineering and construction costs.

The City's Department of Public Works crews gathered one morning in 2016 with volunteers in the heat of high summer to remove the Fish Killer Dam. Area homeowners provided access to the steep site through their backyards to allow for compressed air hoses to snake down the steep banks from generators. With two jackhammers and hand tools, the dam was removed just after midday. Several volunteers were dispatched to Taco Bell for take-away food while others continued to clean up the first site. City crews left the site to deploy heavy equipment to the three tributary dams. Within a week, all of the dams were removed (Figure 4).

Carefully coordinated with the Manchester city crews' work on the three tributary dams, the Town of Bedford was removing three culverts downstream. It replaced one with a full spanning bridge over McQuesten Brook. The collapsed road crossing under which the brook disappeared was removed. The third culvert was removed completely and the road discontinued, with the purchase and demolition of a house on the other side of the culvert. The purchase and demolition was less expensive than replacing a

Figure 3. The uppermost and main McQuesten Pond was choked with algae for most of the year.

Figure 4. A member of the Manchester Department of Public Works removing the obstruction that formed the main McQuesten Pond

culvert or building a second bridge to keep the road open. The cost to the Town of Bedford to purchase the property was used as non-federal match to leverage federal grant funding for the project.

The City of Manchester Department of Public Works was not a stranger to recognizing when change was needed. Staff had previously played a major role in the removal of a dam in the northern part of the city where a pond was also on the 303d list and flooding was becoming more common and affecting businesses, residents, and infrastructure.

The final McQuestion: What about that perched culvert at the Merrimack River? The McQuesten plan (and conventional wisdom) cited it as a barrier to aquatic organism passage. However, it is keeping large fish from the Merrimack from entering McQuesten Brook, which protects the eastern native brook trout from predation. For now, the culvert remains. While we are on the culvert topic, the Council will not be pressing to daylight the portion of McQuesten Brook that flows through that 8,000-foot culvert. The brook mainstem flows through a highly developed part of Manchester and Bedford. Perversely, the passage through darkness is keeping the water clear, cold, swift, and full of oxygen where it daylights into a surprisingly wooded area. Standing and looking downstream, one can see the meanders of a recovering habitat and forget that this is one of the most urban and highly developed areas of the largest city in New Hampshire. These two features could be a Shakespearian tragedy for most watersheds but for now, they benefit McQuesten Brook.

The eastern native brook trout size and population density in this urban area has rivaled that of those found in pristine mountain streams in New Hampshire. The dam and debris that trapped and killed the fish is removed and they now move freely through the cool waters of the mainstem and tributary. They thrive and reproduce naturally with no stocking intervention (Figure 5).

On the first morning after the dam removals, night herons, ducks, songbirds, deer, raccoons, native trout, and other fish and wildlife were exploring the newly restored habitat. They found rich sources of food; clear, cool water; and other benefits within the restoration area. Their tracks are evidence of the amazing diversity supported by this newly restored urban oasis. Workers at nearby stores and offices come to the area throughout the year to park and sit in their cars to enjoy a midday meal.

The New Hampshire Rivers Council and its partners plan to continue intensive monitoring at all the restoration sites for at least five years including monumented photo points, electrofishing, particle counts, habitat assessments, and ambient sampling that the Council and partners conducted before and

Figure 5. Mature, healthy eastern native brook trout.

during the restoration. So far, the post-restoration dissolved oxygen monitoring is promising. Data loggers deployed in the restored reaches of McQuesten Brook during the summer of 2017 monitored dissolved oxygen concentration and saturation every 15 minutes. Once the data were analyzed by the NHDES, they informed the Council that McQuesten Brook was consistently meeting the designated uses of aquatic life with dissolved oxygen concentration and saturation well above the state standard. Confirmation monitoring will continue in 2018 for primary contact designated uses as chlorophyll-*a* concentrations are measured in the former impounded reach of McQuesten Pond. It is anticipated that McQuesten Brook and the area of the former ponds will be removed from the 303(d) list for both impaired designated uses during the 2018 and 2020 assessment cycles.

McQuesten Brook is finding its way again with cool and oxygenated water from feeder streams and underground springs. Native tree, shrub, grass, and wildflower seeds buried under water for nearly seventy years are sprouting and growing lushly in the rich bottom sediments of former ponds (Figure 6a and 6b).

To restore or not to restore? If you ask local businesses, residents, native eastern brook trout, and the other wildlife flourishing there today, me thinks there is no question.

See the plan and learn more at NHRivers.org.

Figure 6a. The former uppermost and main McQuesten Pond during the autumn after the dam removals. The brook is meandering with feeder stream and springs through the former impoundment areas.

Figure 6b. McQuesten Brook finding its way again. The vegetation is sprouted from seeds buried under the impoundments for decades. Woody material was left on the site to provide natural habitat and stream flow regimes.

Michele L. Tremblay serves as the president of the board of directors of the New Hampshire Rivers Council. She is principal of *naturesource communications*, helping nonprofits and government groups with their communications, outreach, capacity building, and water quality programs. Michele serves the people of New Hampshire and the northeast United States and Canada in a variety of pro bono and volunteer capacities. She lives on a small pond and has no immediate plans to remove its dam.

Sediment Trends Observed in 40+ **Dam Removals in the Northeastern U.S.**

Paul Woodworth, Laura Wildman, Dana Patterson, and Christopher Mikolajczyk

Management Implications

The United States is a country of dam builders. In the Northeast, we started building dams very soon after landing on Plymouth Rock, with documented construction in the Massachusetts Bay Colony dating as far back as the early 1600s (Jansen 1980; Walter and Merritts 2008). However, as the dams in our country age, we face difficult and complicated decisions. Should we continue to repair and maintain dams or should we remove them?

An excellent example of a community with multiple dams who faced complex decision making and balancing stakeholder concerns is Plymouth, Massachusetts. In an effort to restore the Town Brook, they removed multiple abandoned mill dams that no longer served economic purposes and constructed a fishway around the historic Plymouth Grist Mill Dam. Additionally, they implemented stormwater remediation projects to further improve water quality in the Billington Sea, the furthest upstream impoundment. This decision for dam owners and communities often comes down to several factors: current use, cost, and the potential environmental impacts and/or ecological benefits of removal.

All Dams Accumulate Sediment

When the decision is made to remove a dam, one key component to dam removal is sediment transport. Dams by design interrupt sediment transport, so over years, sediment accumulates behind the dam, which not only impacts the impoundment but also deprives downstream reaches of sediment, exerting geomorphic and ecological impacts downstream. From a geomorphological point of view, the greatest impact to downstream ecosystems is the sediment trapping. Kondolf's "Hungry Water" theory explains that when the passive flow of sediment and woody debris is interrupted by dams, the "hungry water," starved of sediment, will scour the sediment from the downstream banks and channel bed to rebalance its power. This can lead to further erosion and downcutting of the channel (Kondolf 1997). From an ecological point of view, dams directly impact ecosystems by interrupting the movement of aquatic organisms and degrading water quality.

Upon removal, the natural flow of the river will return, eventually rebalancing the stream's sediment budget. However, if sediment accumulations are significant, the initial release of impounded sediment can temporarily increase turbidity, impact downstream habitats, or expose aquatic organisms to contamination. So, how do you manage the sediment when removing a dam? Typical approaches involve passive release or active removal, or some combination of the two.

We reviewed data from over 40 dam removals that Princeton Hydro worked on in the Mid-Atlantic and New England Regions (all but nine had been removed between 2006 and 2015) to look for patterns in sediment management. We believe that this set of dam removals is a representative sample of the greater collection of dam removals occurring throughout the region and, to some degree, across the country. Our analysis compared and contrasted the impoundment types, sediment accumulation, and sediment contamination in seven states over the last decade, and our results are of interest to both those removing dams and those maintaining dams.

We posed a variety of questions to begin to understand the volume and type of sediment that has accumulated behind a dam:

- How effectively does the dam trap sediment?
- How many years of accumulation have occurred?
- Is it still accumulating sediment?
- Is the impounded sediment bedload (as seen in the natural channel) or suspended load, too (i.e., fine size classes like silts and clays)?
- Would the release of sediment result in deposition to such a degree that habitat or infrastructure would be adversely impacted?

Quantifying Sediment Behind the Dam

Sediment quantity may best be defined relative to the transport capacity of the natural channel and sediment loading to the site. However, we have found that two simple metrics help to ascertain the relative volume of impounded sediment behind a dam and the likely complexity of the response to sediment release:

- the width of the impoundment relative to the width of the natural (i.e., bankfull) channel, and
- the depth of impounded sediment relative to the depth of the natural channel.

Considering the first metric, we classified our project sites into two broad categories: narrow or broad. Narrow impoundments are riverine, as wide as the natural channel, not more than twice the width of the natural channel. Wide impoundments are two times as wide as, or wider, than the natural channel. Considering the second metric, we classified our project sites in three broad categories: low, moderate, or high. Low corresponded to sediment depths less than twice the depth of the natural channel. High corresponded to sediment depths four or more times the depth of the natural channel. We recognize that these broad categories are simplistic; a more robust approach would quantify these metrics precisely and represent the full range of ratios, which likely exhibit a gradation rather than distinct groups.

Through our analysis, we found that the majority (74 percent) of sites had a narrow impoundment width relative to the channel width (Figure 1), not too surprising considering many wider impoundments with abutting lakeside residents are not commonly considered for dam removal, and 67 percent had low impounded sediment depth relative to channel depth. Our results showed that 71 percent of the dams retained a low sediment quantity relative to the sediment transport capacity of the channel and the estimated sediment loading to the site. But more importantly, of that volume, what is likely to be mobilized following dam removal and the re-formation of a natural channel?

Our data shows that mobile quantity is typically high, for example, in narrow impoundments, where the total volume is low (Figure 2). Wide impoundments may contain a high total volume; however, the portion of that sediment that is actually mobilized (upon dam removal) is often much lower. This makes sense in that when a dam creating a wide impoundment is removed, a relatively narrow meandering stream reforms, leaving much of the impounded sediment untouched to dewater and revegetate. It's only the few cases, where the actual mobile quantity is moderate or high, that deserve more attention than the others. These dams tend to be high, relative to the natural channel depth, with impounded sediment depths multiple times greater than the natural channel depth, after years of accumulation.

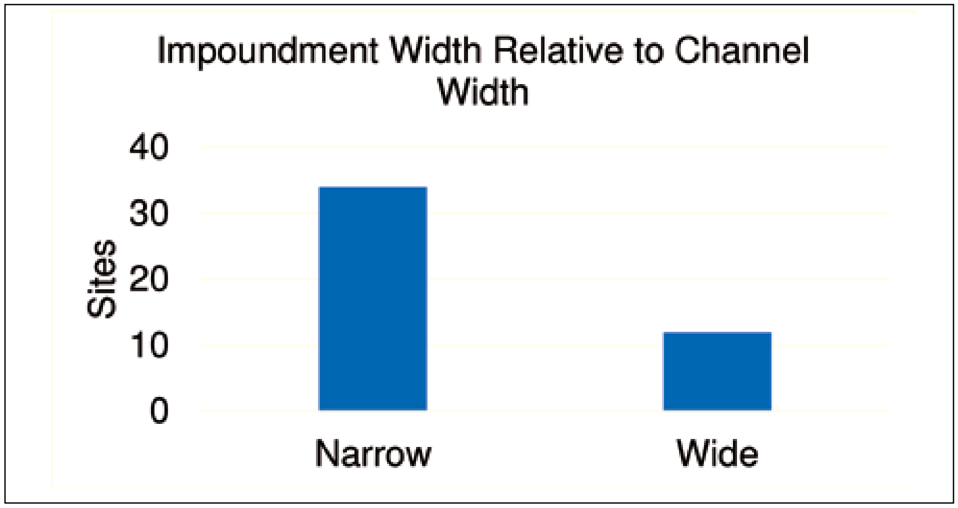

Figure 1. The majority of dams removed have narrow riverine impoundments.

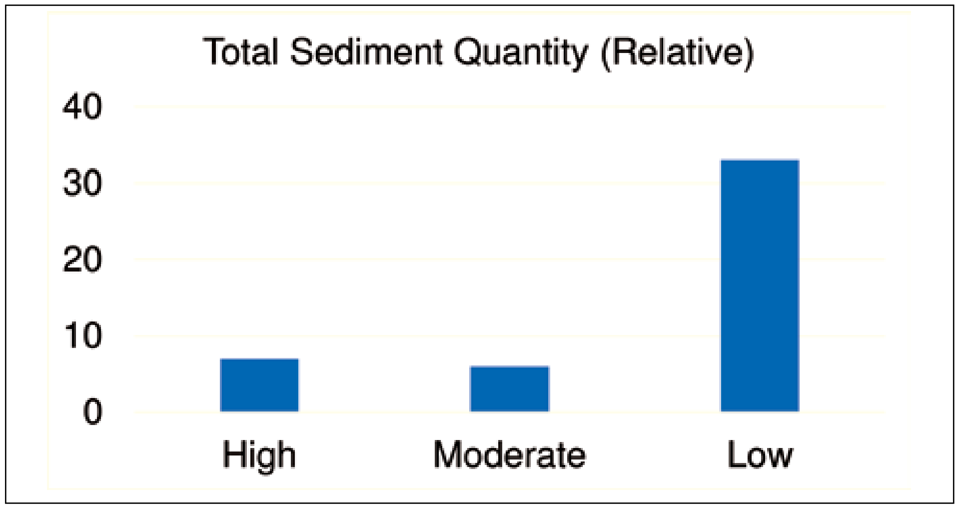

Figure 2. The majority of dams removed have low relative sediment quantity.

Contaminant Trends in Sediment Analyses

In conjunction with quantifying sediment, what about assessing the quality of sediment? Sampling and laboratory analysis of impoundment sediment was completed for 78 percent of dam removal projects. Sediment sampling and analysis were not conducted for a minority of projects where the impounded sediment was recognized as (a) low mobile volume, (b) very coarse-grained (gravel, cobble, or boulder) reflective of natural bedload, and/or (c) a due diligence investigation confirmed very low probability of contamination. Due diligence investigations involve research of geospatial datasets, historic maps, aerial photography, land use history, toxic release inventory database, and other records to rule out the likelihood of point source and nonpoint source pollutant sources on site or in the contributing watershed. Most of the dam removals occurred in developed areas with mixed land use and decades of potential pollutant sources, which necessitated sediment sampling and laboratory analysis. Analysis included grain size, organic content, VOCs, cyanide, chromium, PCBs, pesticides, herbicides, hydrocarbons, metals, and PAHs. To provide context within the watershed, samples of in-stream sediment were also taken upstream and downstream of the impoundments. Samples of in-stream sediments had to be intentionally biased toward the finest grain sizes available as contaminants bind preferentially to fine grain sizes.

The most interesting part of our analysis was the trend in types of contamination present in the samples. For the 36 dam removals where lab analysis was conducted, data showed that volatiles, cyanide, chromium, and PCBs were rarely detected. Agricultural chemicals were more likely to be present if agricultural activities were dominant in the surrounding watershed. However, PAHs and, to a lesser extent, metals were detected most often. As reported in Metre and Mahler's article in the special edition on PAHs in the spring 2017 *LakeLine* publication, PAHs have been increasing in lake and stream bed sediments from a variety of sources. Our data verifies their findings: (a) PAHs are the most common contaminant in dam sediments and (b) PAHs are found ubiquitously upstream and downstream of dams.

Looking further into the PAHs, we found that there are eight usual suspects: Benzo[b]fluoranthene, Benzo[a] anthracene, Benzo[a]pyrene, Chrysene, Dibenz[a,h]anthracene, Fluoranthene, Phenanthrene, and Pyrene. These PAHs often exceeded the respective ecological screening levels (sometimes exceeding both tiers: lower threshold and probable), and importantly were commonly found both upstream and downstream. Ecological screening levels have been developed in two tiers: threshold effect concentrations and probable effect concentrations. Most states reference the ecological screening criteria compiled by NOAA in the Sediment Quality Quick Reference Tables, while a minority of states have established their own criteria. All of them rely mainly on the "development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems" set forth by MacDonald et al. in 2007.

Managing Sediment: Passively or Actively?

Now that we've identified the level of contamination for each project, how do we determine what sediment management technique will be used for removal? Using an active approach, the sediment could be stabilized onsite, or excavated and hauled offsite. Conversely, a passive approach would allow for mobilization and downstream transport of impounded sediment, re-formation of a natural channel in the impoundment, and minimization of the construction period needed. Despite the fact that ecological screening levels were exceeded at most sites, we were able to passively manage the sediment in 32 of 46 dams. Only 10 dam removals used a strictly active approach, and four used a combination of active and passive techniques (Figure 3 and Figure 4).

So, why was passive management possible despite exceedances? In most of these stream systems, PAHs are ubiquitous throughout, both upstream and downstream. While it is unfortunate that this low-level contamination is abundant in streams, risk assessments show that the release of the accrued sediment with the slight exceedances will likely not have an increased negative ecological effect on the downstream ecosystem or further contaminate a downstream area. For many of the passive dam removal projects, we proposed a passive solution that was approved by project partners including environmental groups as well as the regulatory agencies.

Dam removals are often costly projects, and many owners may be leery of removal due to the potential unknown levels of contamination found in the sediment. Even when contamination issues are known, it is important to look into the feasibility of using a passive management method. It allows for the minimization of construction related impacts while setting the river on a path to restore itself, helping to ensure that the final result is the restoration of a fully functional dynamic river system. In addition, it can bode well for the bottom line of the total dam removal project, saving excavation and capping costs (Figure 5).

The results of our analysis help to inform dam owners who are actively maintaining their dams to serve a wide variety of valuable purposes such as water supply, recreation, hydroelectric, navigation, irrigation, and flood control. And, even more importantly, on a broader watershed level, these PAH trends that we uncovered in 40+ dam removals are important to consider when making future lake management decisions. Because PAHs have become one of our biggest contaminant problems, as recognized in the *LakeLine* special issue that

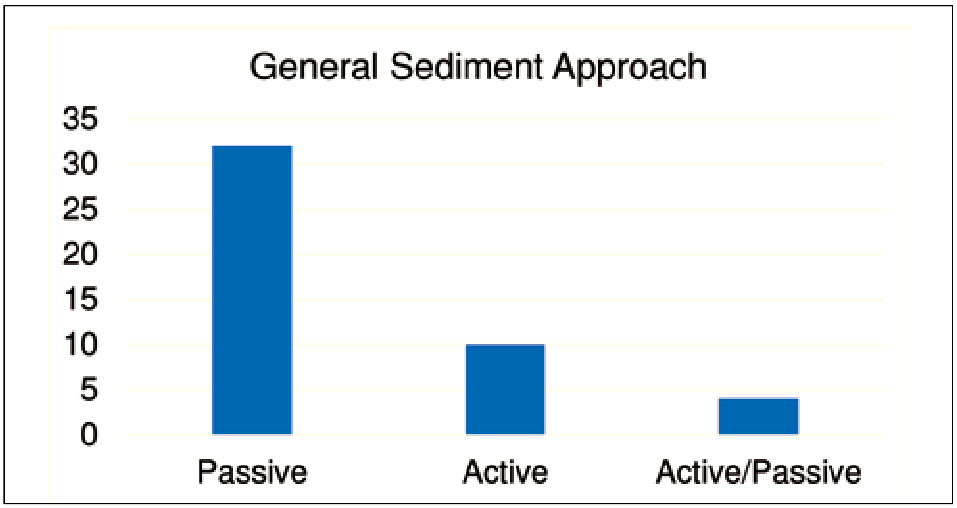

Figure 3, The majority of dams removed have been done with a passive sediment management approach.

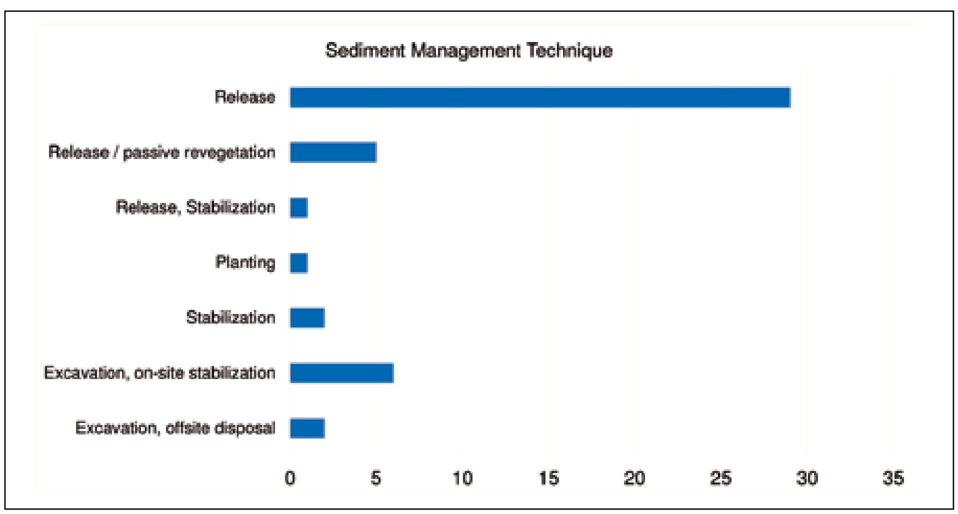

Figure 4. While the majority of dam removals have utilized passive sediment management approaches, a variety of other combinations with active approaches have also been employed.

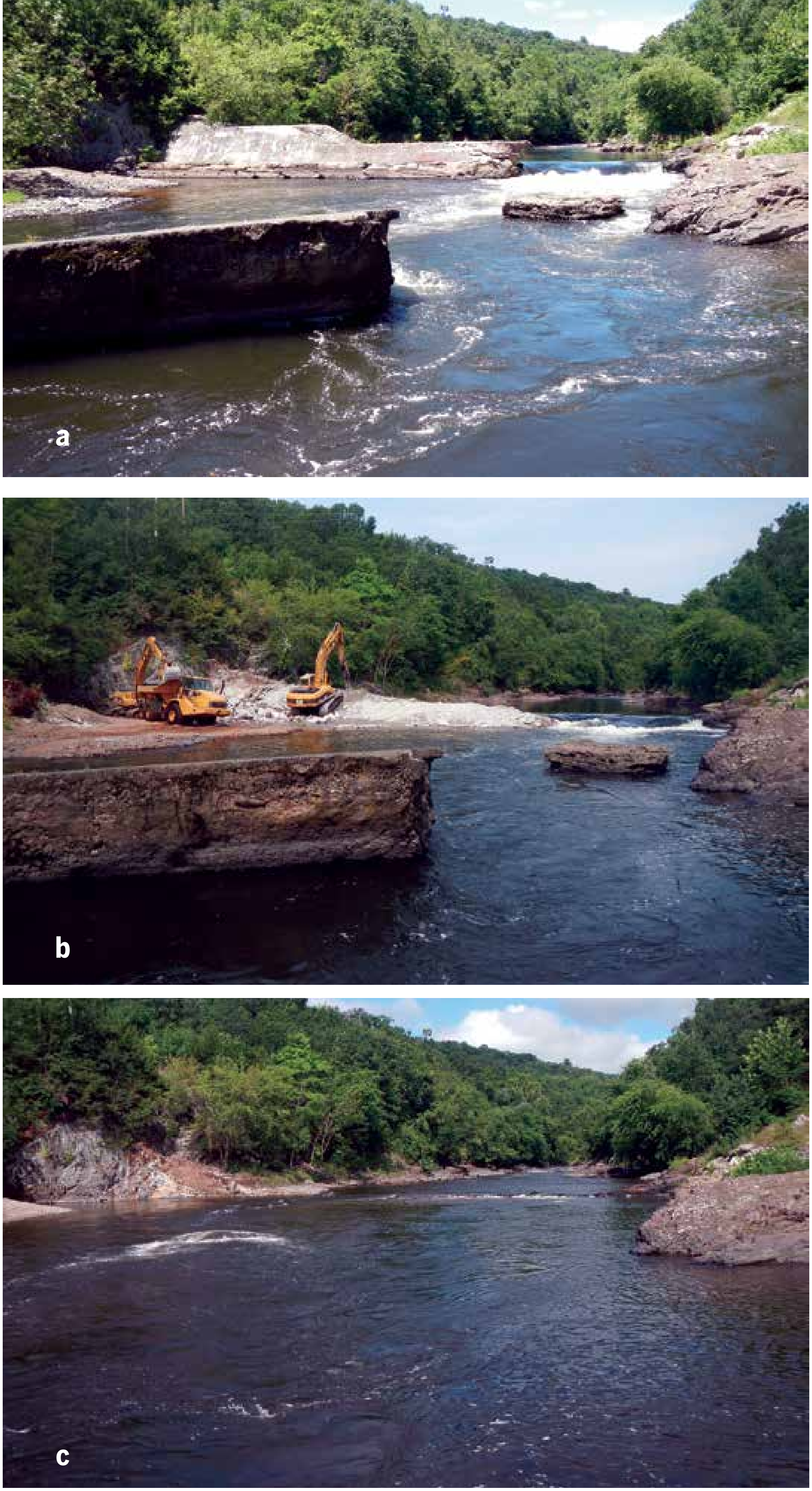

Figure 5. Spoonville Dam: (a) before removal, (b) during construction, and (c) after removal.

Passive Sediment Management at Tannery Brook Dam

Using passive sediment management during dam removal can create a flourishing natural area with a stream meandering through a wet meadow, in the footprint of a former pond that through plant succession can transition to scrub shrub and riparian forest communities. The Tannery Brook Dam in Boscawen, New Hampshire, is a 30-year-old, over 20-foot-high earthen dam with a wide impoundment, shallow sediment, and limited mobile portion. While this was a relatively large dam with a 23-acre lake, Princeton Hydro used a simple design-build approach for removal. It resulted in a successful passive release of sediment and stabilization at the dam breach, with a re-formation of channel. Overall, this approach allowed the brook to reestablish itself by utilizing the existing habitat building blocks (i.e., root wads, large woody debris, and pre-dam substrate) that had been previously submerged. This process enabled the brook to convert back to its original channel form, and minimized the cost for removing the dam (Figure 6 a-c).

highlighted the ubiquitous nature of PAHs in lakebed sediments and their ecological impacts (Metre and Mahler 2017), management of these sediments becomes even more critical for lake managers. Together, lake managers, dam removal experts, and concerned stakeholders must prioritize finding ways to reduce or eliminate the further release of PAHs into our watersheds.

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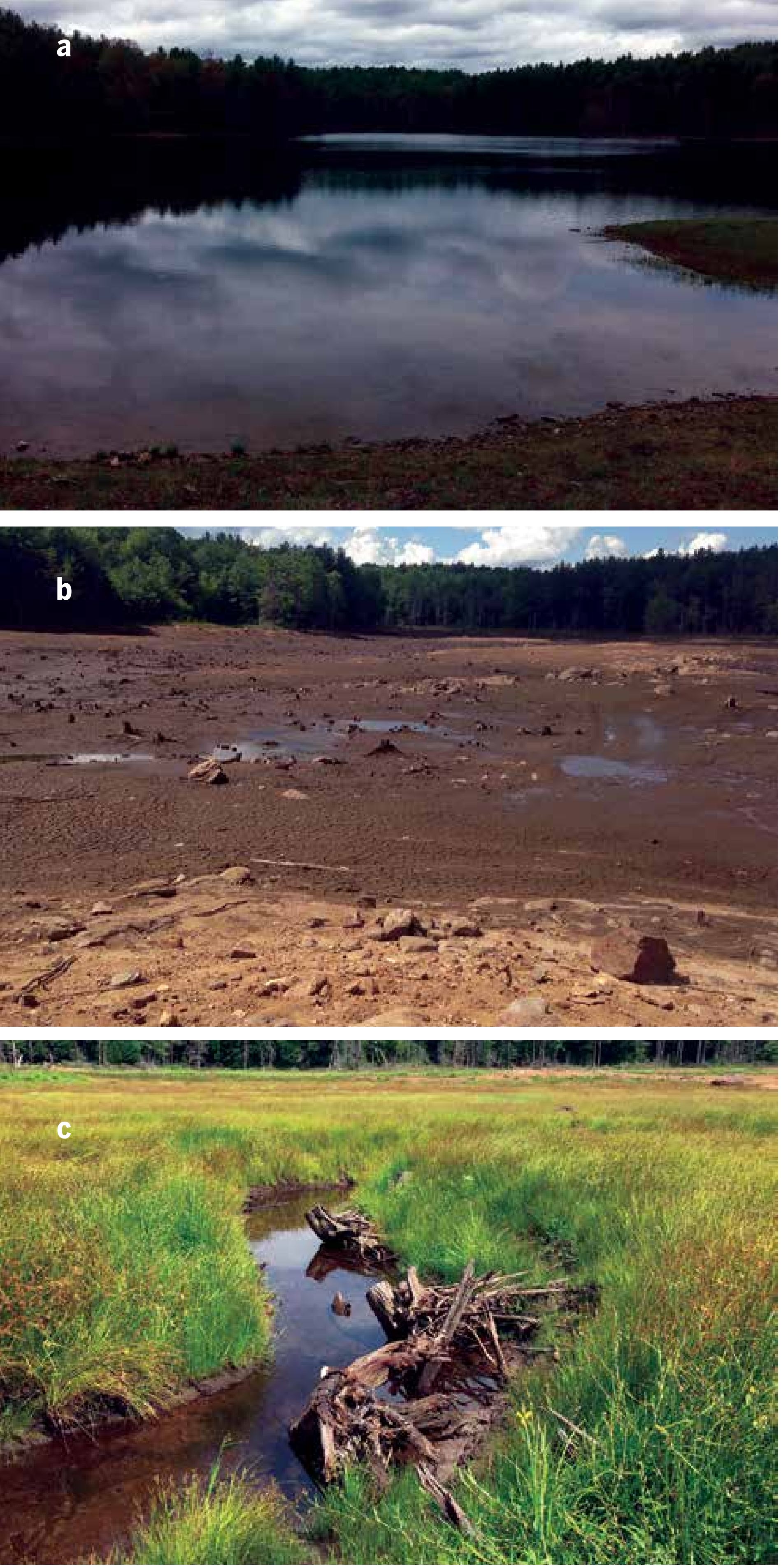

Figure 6. Tannery Dam: (a) before removal, (b) after removal, and (c) one year after removal.

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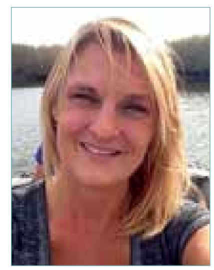
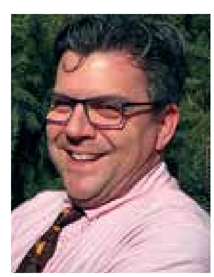


Laura Wildman, PE, is a water resources & fisheries engineer for Princeton Hydro who is passionate about restoring rivers through the reestablishment of natural functions and aquatic connectivity. She is considered one of the nation's foremost experts on dam removal and alternative fish passage, regularly lecturing, instructing, and publishing on these topics.

Dana Patterson is a communications strategist and environmental scientist for Princeton Hydro who brings a strong mix of diverse stakeholder engagement experience, coupled with values-based communication strategy and technical writing. In her previous NGO role, she taught thousands of students about wetlands, wildlife, and watersheds and provided community groups with technical guidance on site remediation.



Christopher Mikolajczyk, CLM, is a senior aquatic scientist and certified lake manager for Princeton Hydro and conducts the management, oversight, and coordination of aquatic ecology and water resource projects in three main areas: aquatic resource restoration and management, aquatic ecosystem sampling and investigations, and stormwater quality modeling and management.

Ryan Elliot

Student Corner

A citizen-based approach to fishery data collection

Monitoring the fisheries in a lake can provide lake associations and stakeholders with information on the species present, the condition of those populations, and what management strategies may or may not be effective. Unfortunately, there are times when limited budgets can impede the study of these important resources in public waterbodies. When resources limit the number of waterbodies that can be surveyed, a citizen-based approach to studying fisheries can be a useful and cost-effective way for supplementing standardized data. Here, I discuss the use of a citizen-based angling program to collect fisheries data and suggest ways to improve these programs for interested lake associations.

Study Site

Lake of the Woods (LOW), New York, is a 172-acre dimictic, oligotrophic lake (Figure 1). It has a limited littoral zone and a maximum depth of 87 feet. The lake supports a two-story fishery, so anglers can catch warmwater species like largemouth bass *(Micropterus salmoides*) and coldwater species like lake trout (*Salvelinus namaycush*). It is also stocked every year by the New York State Department of Environmental Conservation (NYSDEC) with lake trout (*Salvelinus namaycush*) and landlocked Atlantic salmon (*Salmo salar sebago*). The two organizations involved in managing the lake, the LOW Association (LOWA) and the Indian River Lakes Conservancy (IRLC) requested a survey of the fisheries in the lake to provide a contemporary view of their fisheries, when conducting a large-scale survey with nets or electrofishing equipment was not possible. To reconcile this problem, an angler log book program was developed to supplement state fisheries data for LOW. This study relied on local anglers to collect data using a catch and release method, so it did not place any additional stress on the fisheries, was low cost, increased stakeholder engagement,

Figure 1. Beautiful Lake of the Woods, New York, in early autumn.

and reduced sampling burden on the NYSDEC.

Methods

Local anglers were recruited as volunteer participants in this study. For waterbodies smaller than 1,000 acres, a minimum of 5-10 anglers should fish at least 25 times each during the study (Green 1989).

The lake was divided into five parts, each with an offshore area (> 25 ft depth) and two inshore areas (< 25 ft depth), for a total of 15 individual sections (Figure 2). The sections were created using identifiable landmarks so volunteers could easily determine what section they were fishing in.

All anglers were asked to record the total length of their catches so that the proportional size distribution (PSD) of each individual species could be calculated. Proportional size distribution is a measure of how balanced a population is in terms of total length and is expressed as a value between 0 and 100 (Willis et al. 1993). Low PSD values (< 30) represent populations containing primarily small individuals, high values (> 70) indicate populations dominated by large fish, and intermediate values (30-70) are indicative of balanced populations. Anglers were also asked to report their name, species caught, area where the fish was caught, the date, and type of gear they were using so these factors could be used in statistical analyses.

Results

One of the useful things about PSD is that the index has specific interpretations for fish populations and their management. For example, the PSD value from the angler data was 91 for bluegills (*Lepomis macrochirus*) indicating a population dominated by larger individuals. This can be compared to a PSD value of 57 for largemouth bass which indicates a more balanced population of large and small fish.

The PSD values (including credible intervals [CRIs]) of these two species were plotted on a grid, where purple boxes (horizontal for bluegills and vertical for largemouth bass) represent balanced populations (Figure 3). When plotted, these two estimates place us in the upper middle portion of the plot, reflecting the unbalanced bluegill fishery and more balanced largemouth bass fishery as specified in the Centrarchid Sampling Manual (Green 1989). In this example, the results can be taken to mean that there is good fishing in LOW for both bluegills and largemouth bass, but both species may be having issues with recruitment considering that there is a lack of shallow water habitat, which these species need for nesting and recruitment. These results indicate that both populations could be susceptible to over-harvesting. Since these two species may have recruitment issues in LOW, the populations will not replenish themselves as quickly as they would if recruitment were more successful. In cases like this, intense angling pressure may remove fish faster than they can reproduce, leading to an overall decline in the quality of the fisheries. Fortunately, most anglers

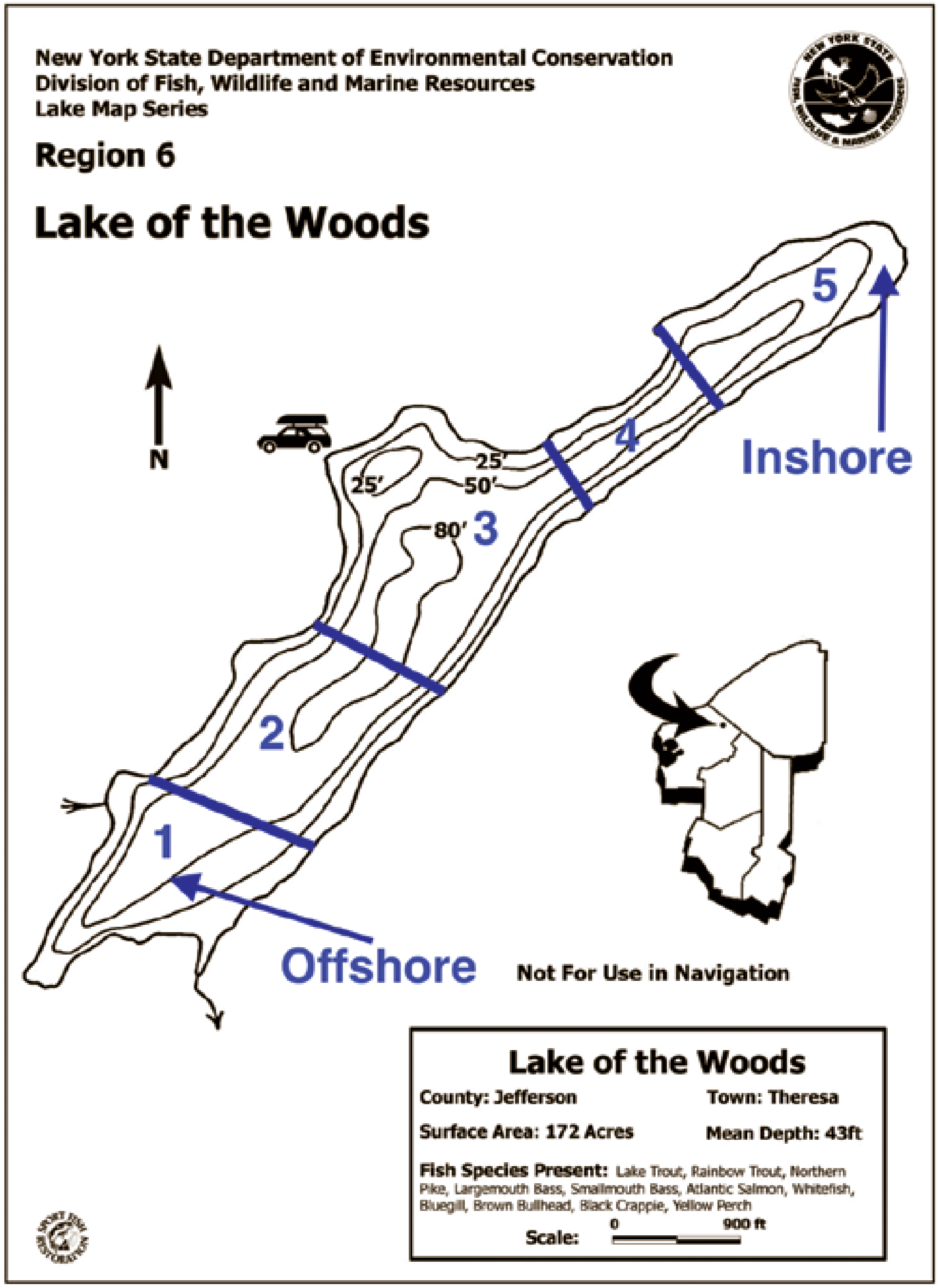


Figure 2. A bathymetric map of LOW. The lake has been separated into five sections, each with an offshore and two inshore areas, giving a total of 15 unique spatial units. These sections were used by angling volunteers to report where they caught each of their fish. Map provided by the NYSDEC.

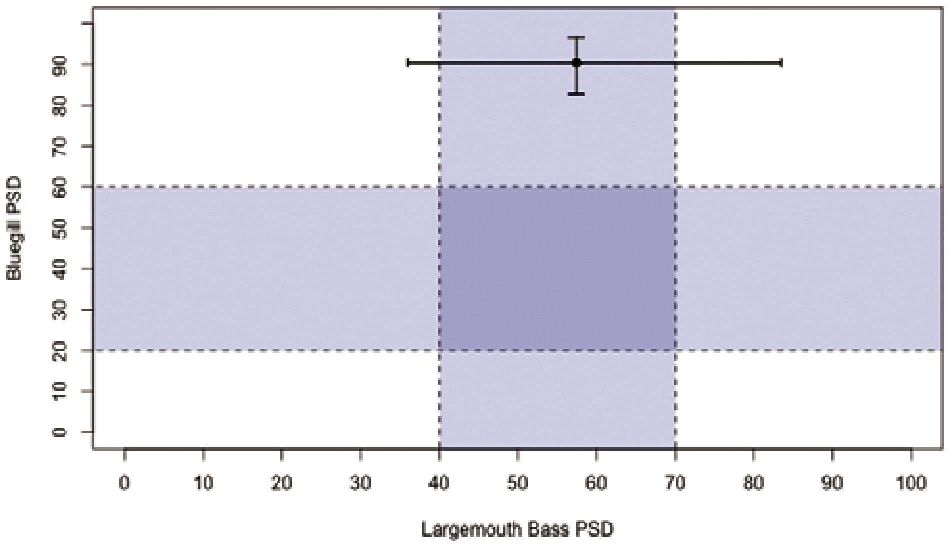


Figure 3. PSD estimates for largemouth bass (M. salmoides) *and bluegills* (L. macrochirus). *The vertical bar represents the PSD estimate and 95 percent credible interval (CRI) for bluegills and the horizontal line represents the same for largemouth bass. This figure was adapted from the* Centrarchid Sampling Manual *(Green 1989).*

Figure 4. A stakeholder, participating in the angler log book program, happy to have just caught a largemouth bass.

on LOW release the fish they catch, so there is not an extreme angling pressure on these populations. However, if behaviors of anglers change or outside traffic to the lake were to increase, there could be negative impacts on both of these populations. For that reason, I will recommend that the anglers on this lake continue to practice catch-and-release fishing.

Room for Improvement

For those considering implementation of an angler log book program on their own lake, begin the study with a training day for volunteers and maintain open communication between volunteers and project organizers. This will allow organizers to convey what is expected of volunteers and it provides an opportunity for feedback. Volunteers should also be provided with standard data sheets, so they always know what information they are responsible for collecting. Additionally, it is recommended that anglers fish as much as they can for each species of fish that you are concerned about collecting data for and request that they report all of their fishing activities during the course of the study. As you collect more data, PSD estimates improve, making it more likely that your findings represent the actual populations in the lake. Finally, managers may wish to use other tools such as catch-per-unit effort (CPUE) or measures of fish condition in addition to PSD estimates to improve the reliability of their recommendations.

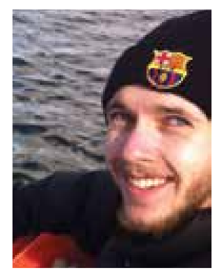
Future Use

This study provided reliable estimates of PSD for warm water species and should have some continued utility on LOW as well as other bodies of water. Cold water species were not heavily targeted by anglers in this study, but citizen-based data collection should also be applicable to these species, if they are targeted to a greater degree. This type of program should not conflict with any state regulations, as it is low impact. Citizen-based monitoring programs can also help lighten the workload for state agencies. Angler log book studies are also beneficial to lake associations, not only because they provide contemporary fisheries data, but because they are low cost and increase local residents' involvement (Figure 4). It is my hope that the LOWA and other associations are able to use monitoring programs such as this to learn more about and better manage the fisheries in their lakes.

References

Green, D.M. 1989. Centrarchid sampling manual, p. i – L-8. In Fish sampling manual. New York State Department of Environmental Conservation.

Willis, D.W., B.R. Murphy and C.S. Guy. 1993. Stock density indices: development, use, and limitations. *Reviews in Fisheries Science* 1(3): 203-222.



Ryan Elliott began his college career as an undergraduate at Binghamton University and earned a BS in environmental studies and a minor in geography. He is currently enrolled in the Master of Science Lake Management program at SUNY Oneonta, with an anticipated graduation date of May 2018. His thesis work focuses on the ecology and management of Lake of the Woods, NY, with a focus on fisheries management and water quality. *Author note: Requests for references can be sent to Ryan's email here: ellirj14@oneonta.edu*

North American Lake Management Society
Call for Nominations

The North American Lake Management Society (NALMS) is seeking nominations for individuals interested in serving on the board, and for individuals, papers and projects that should be recognized at our Annual Symposium in October 2018.

CALL FOR NOMINATIONS FOR BOARD POSITIONS

This year NALMS will be looking to fill vacancies in the following positions:

- President-elect
- Secretary
- A Regional Director for:
  - Region 2: New Jersey, New York, Puerto Rico.
  - Region 6: Arkansas, Louisiana, Mexico, New Mexico, Oklahoma, Texas, and all other areas not in the United States or Canada.
  - Region 10: Alaska, Idaho, Oregon, Washington.
  - Region 12: Alberta, British Columbia, Manitoba, Northwest Territories, Saskatchewan, Yukon Territory.
- Student Director

If you are interested in serving on the NALMS Board, or would like to nominate someone else, please contact George Antoniou by June 1, 2018 at george.antoniou@dnr.iowa.gov.

CALL FOR NOMINATIONS FOR AWARDS

Each year NALMS recognizes individuals, organizations, and programs, corporations and projects that have contributed to the Society and to the science of lake and watershed management. Presented at the annual NALMS Symposium banquet, these awards were established to encourage the advancement of NALMS' goals. These awards recognize outstanding efforts of our colleagues and encourage similar activities and will be presented this year at the Society's 38th Annual Meeting in Cincinnati, Ohio.

Nominations should be sent to NALMS Awards Liaison from these categories:

- **Secchi Disk Award** – for the individual member considered to have contributed the most to the achievement of NALMS' goals. Recipient must be a NALMS member.
- **Jim Flynn Award** – for the organizational member considered to have contributed the most to NALMS's goal. Recipient must be a NALMS Corporate member.
- **Friends of NALMS Award** – awarded to individuals or corporations making major contributions to NALMS. Recipients do not have to be NALMS members, and "contributions" extend beyond monetary donations.
- **Lake Management Success Stories** – Individuals or organizations who have accomplished successful lake or watershed management efforts. Nominees must show demonstrable improvements in lake condition as a result of their efforts. Up to three projects may receive awards each year.
- **Advancements in Lake Management Technologies** – Individuals or organizations, who have refined, developed or discovered new, innovative or improved methods, technologies or processes for achieving lake or watershed management outcomes in manners that are safer, cheaper or more effective. Objective documentation should accompany the nomination. Up to three projects may receive awards each year.

Deadline for Nominations: August 15, 2018 • Send award nominations to Dr. Dana Stephens at stephend@nwfsc.edu.

NALMS Membership Form

Mailing address

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City ST/Prov. Postal Code

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Billing address ❑ check if same as above

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Lake Leader Emeritus *	$64 ❑ ($53 ❑)	$79 ❑ ($68 ❑)
Professional	$144 ❑	$173 ❑
Professional Emeritus *	$122 ❑	$151 ❑
Lifetime	$4,600 ❑	

Organization

Organization	
Affiliate **	$334 ❑
Non-Profit	$334 ❑
Corporate	$662 ❑

* only for those who are retired, over 60, and have been members for 5 years.

** For approved organizations only – call 608.233.2836 before joining as a new member

Do you want to help protect lakes? A donation will help ensure that NALMS' mission to foster the management and protection of lakes continues.

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☐ Charge the amount of US$ _______________ to the following credit card: ☐ VISA ☐ MasterCard | Is this a business card? ☐ Yes ☐ No

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NALMS, PO Box 7276, Boulder, CO 80306-7276

Rev. 1/18

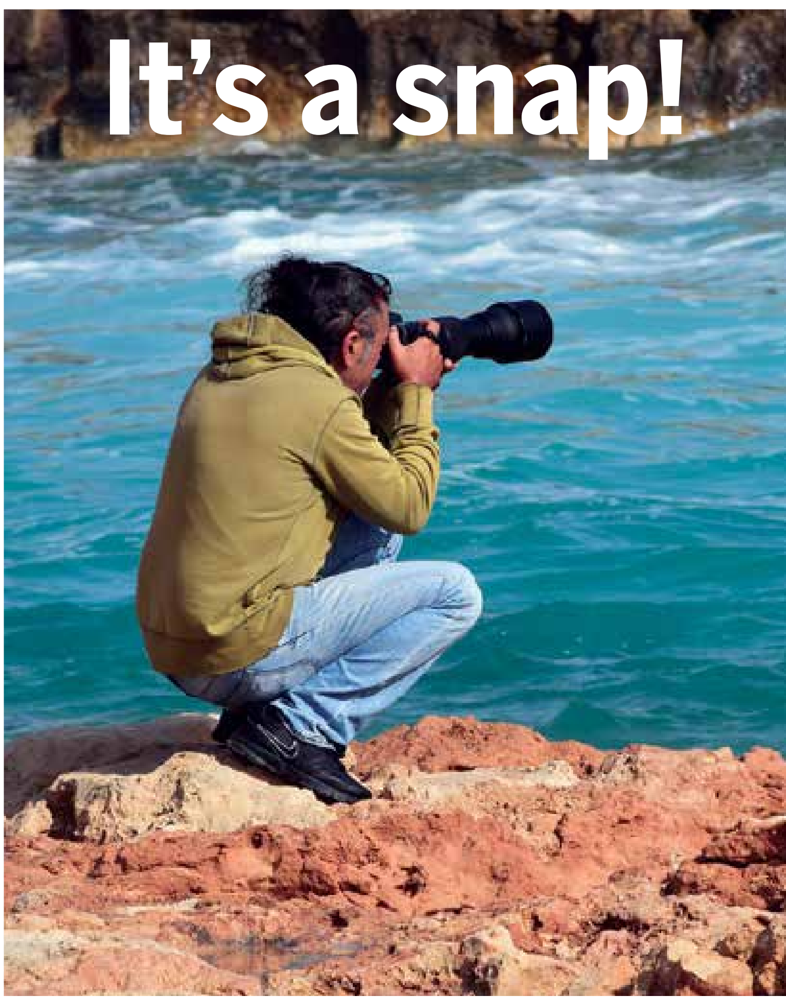
NALMS Mid-Term Board of Directors Meeting Summary

Prepared by Amy P. Smagula, NALMS Secretary

The NALMS Board of Directors met in Boulder City, Nevada, for a mid-term meeting on March 10-11, 2018. Below is a list of topics discussed during the mid-term:

- Review and revision of NALMS membership categories and membership dues for each category of membership (see new membership categories and dues structure on page 39 of this issue of *LakeLine*;
- A review of the NALMS Policy Committee work plan, which includes plans for developing a number of new position statements and white papers;
- Nomination of a new program-lead for the NALMS Certification Program. Kiyoko Yokota (also Region 2 Director) has agreed to take lead on this important certification program, replacing Chris Mikolajczyk who is stepping down. The NALMS board thanks Chris for his many years of service in this capacity;
- Review and acceptance of an updated Strategic Plan for NALMS to follow in the coming years;
- Review and approval of a new Subject Matter Expert (SME) list that is now available on the NALMS website;
- A discussion of future conference planning options for NALMS, including (1) a contract option for conference planning services and (2) an internal conference planning team made up of NALMS members; and,
- Evaluation of NALMS operations in the form of breakout group discussions, including:
  - Evaluation of NALMS programs, and further development and refinement of each, including funding and sustainability of those programs;
  - Review of NALMS publications and future directions for each;
  - Long-Term financial planning for NALMS; and,
  - Member benefits discussion, and how to enhance the benefits of being a NALMS member.

2018 NALMS Board of Directors and NALMS staff at the mid-term meeting held March 10-11, 2018 in Nevada.



YOU could be the winner of the 2018 NALMS Annual Photo Contest.

Two winning images will be selected, a Member's Choice winner selected by Symposium attendees and an Editors' Choice winner selected by the editor and production editor for the entry that will make the best *LakeLine* cover. We have secured sponsorship for the Photo Contest so a *$250 gift card* will be awarded to each winner.

Your favorite lake or reservoir photo could grace a cover of *LakeLine*! Entries will be judged during the 2018 NALMS Symposium . . . in Cincinnati, Ohio!

Only electronic submissions will be accepted. You must be a NALMS member to submit an entry.

Photos should be of sufficient resolution to print from (approximately 300 dpi at 8.5" x 11"). Maximum of one submission per person.

Entries must be received by October 15, 2018.

Send your entry to:
Amy Smagula, Editor, *LakeLine*
LakeLine@nalms.org


Temperature
pH and ORP
Conductivity and Salinity
Dissolved Oxygen
Turbidity
Depth and Level
Blue-Green Algae
Chlorophyll
CDOM/FDOM
Rhodamine
Crude and Refined Oil
Nitrate
Ammonium
Chloride
Total Dissolved Gas
PAR, CO2 and More