BY JOHN M. PECKENHAM, CATHERINE V. SCHMITT, JEFFREY L. MCNELLY, AND ANDREWS L. TOLMAN

LINKING WATER QUALITY TO THE WATERSHED:

Developing Tools for Source Water Protection

ALTHOUGH MAINE IS NOT AS HEAVILY DEVELOPED AS MANY AREAS IN THE NORTHEAST, INTERESTED PARTIES CAME TOGETHER TO CRAFT A COMPREHENSIVE SOURCE WATER PROTECTION PROGRAM THAT HAS THE STATE'S WATER INDUSTRY WELL-POSITIONED TO PROTECT ITS SOURCES INTO THE FUTURE.

Watersheds are well recognized as the most effective management unit for the protection of water resources (Robbins et al, 1991; USEPA, 1997; USEPA, 1999; NRC, 1999; NRC, 2000). The current focus on source water protection, stimulated by the 1996 amendments to the Safe Drinking Water Act (SDWA), parallels the watershed approach to clean water taken by federal agencies and the broader scientific community. Watershed management has been called the "key to the future" by the US Environmental Protection Agency (USEPA, 1997), so it is no surprise that safe drinking water programs should require coordination within watersheds to improve water quality.

The most recent amendments to the SDWA require states to assess public water supply susceptibility to contamination. In response to this mandate, the Maine Source Water Assessment Program (SWAP), completed in 2003, evaluated threats to water quality in the watersheds of all public water supplies. Although groundwater supplies were already being evaluated as part of the previously mandated Wellhead Protection Program, no analogous surface water protection policy was in existence in Maine, and therefore SWAP placed considerable emphasis on surface-water supplies.

Maine has approximately 60 community water systems that serve a majority of the population and use surface water (Figure 1). The five largest community surface-water supplies together serve more than 200,000 people, one sixth of the state's population. Many of these supplies are natural lakes, ponds, or streams, including several located in relatively undeveloped watersheds that have exceptional water quality. Although Maine is less developed than most of the Northeast, land development is increasing, placing more demands on Maine's water resources. Encroaching land uses and changing land-management policies make the future quantity and quality of water supply uncertain, especially in the coastal zone and other areas experiencing marked population and development pressures.

Maine has approximately 60 community water systems that serve a majority of the population. Pictured here is Upper Narrows Pond, the water supply for Winthrop, Maine, an area that has seen significant residential development over the past 30 years.

As part of the Maine SWAP, each public surface water supply received a risk assessment. However, communicating the risks to the public and initiating the transformation from assessment to protection has been the responsibility of the water supplier. A few of the larger systems in Maine have well-established watershed programs and watershed protection professionals on staff (Lamie & Crovo, 1996). In contrast are the smaller, and usually rural, water suppliers who have limited financial and human resources with which to comply with new and expected drinking water regulations (Trax, 1999; Phoenix, 2002). The leap from assessment to protection is especially challenging for small public water supplies faced with multiple supply-management issues (Peckenham et al, 2002).

Smaller, and usually rural, water suppliers have limited financial and human resources with which to comply with new and expected drinking water regulations.

Realizing that the ability of water suppliers to address the risks identified by the source water assessment program is severely constrained and likely inadequate, the Maine Drinking Water Program developed a source protection–implementation project in partnership with the Senator George J. Mitchell Center for Environmental and Watershed Research and the Maine Water Utilities Association. The goals of this project were

(1) to help small water suppliers understand the factors affecting the quality of the source water and

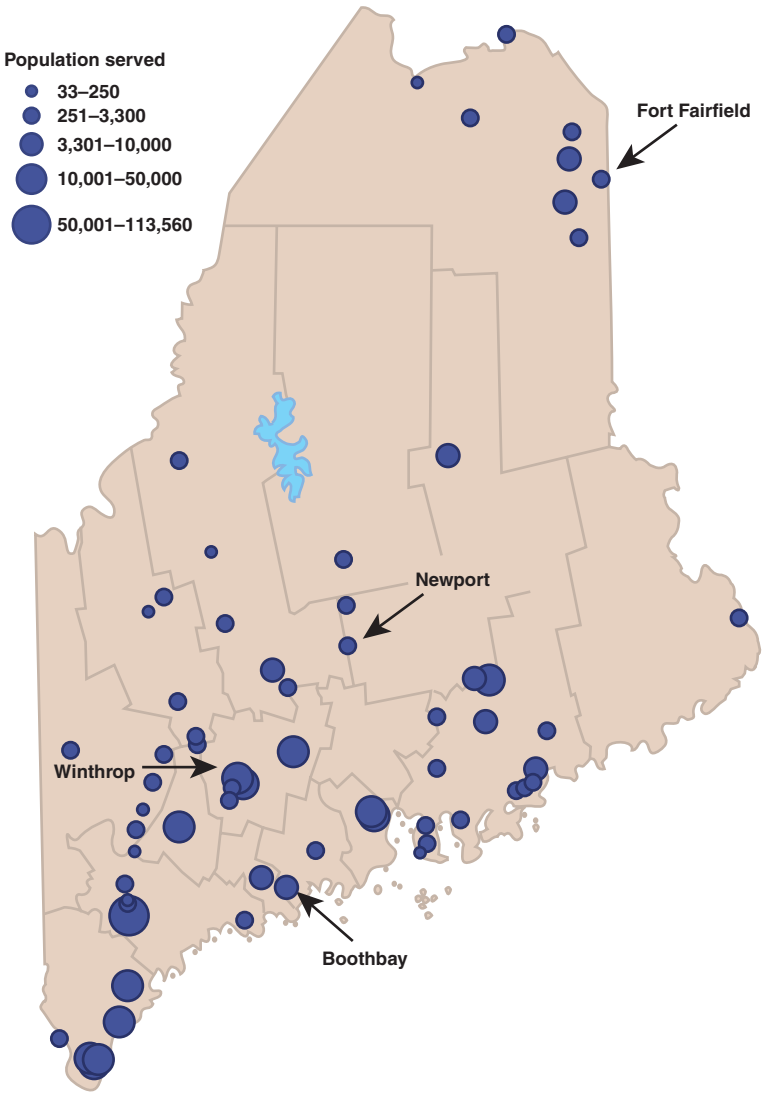
(2) to evaluate the risks posed to water quality within the source watershed.

This effort was driven by the desire to give a greater value to the assessment process by teaming it with an effort to implement and maintain effective source-protection programs. It is much easier and less costly to protect water quality than it is to restore water quality. Enhancing the ability of a water supplier to act on the information collected as part of the SWAP studies was the primary objective.

Underlying the project was this fundamental premise: The protection of drinking water supplies must happen at the local level. In order to be successful, stakeholders in the watershed must work toward common water quality goals. Moreover, because many people have reservations about the merits of regulatory controls, the common goals are more likely to be met through a voluntary program guided by experts outside of state government. Cooperative effort of this type is believed to be an effective method to assure compliance with local, state, and federal environmental regulations.

Public water systems are expected to provide safe water to their customers. In Maine, part of this expectation is met by legislative acts that grant water rights to surface water sources of supply. These acts include a mandate, or obligation, to supply the inhabitants of the served communities with safe water for domestic and municipal purposes. The Source Water Protection process now extends this legal obligation by inference into the watershed, even though a utility may have no given authority

FIGURE 1 Locations of public surface-water supplies in Maine and in four pilot-study sites



Source: Maine Drinking Water Program and other agencies, 2004

or ownership of its watershed. The result is that public water systems are compelled to start self-directed source water protection or risk future regulatory consequences. Mandates such as this, real or implied, place additional stress on water systems, especially small systems.

METHODS

Phase 1: Laying the groundwork. A series of eight regional information meetings were held in early 2001 to introduce the concept of source protection to water suppliers and to review current and forthcoming regulatory mandates. These educational sessions covered several topics, including:

- an overview of the hydrodynamics of water supply sources and watersheds;
- the link between water quality and public health;
- the identification and control of threats to water quality;
- the effect of changing drinking water regulations; and
- the economic connection between source water quality, capital investments, and operating costs.

The meetings in phase 1 were also intended to reveal the level of knowledge held by individual water supply managers. Systems in need of assistance with watershed management or SDWA compliance were invited to participate in the second phase of the project. The second phase prepared water utility managers for SWAP while simultaneously placing watershed protection within the context of their operations. This enabled managers to determine how to give watershed protection adequate importance.

The executive director of the Maine Water Utilities Association introduced the phase 1 sessions by explaining why source protection is necessary. A representative of the Maine Drinking Water Program outlined the regulatory setting for source protection, a representative of the Mitchell Center presented information about watershed hydrology and how watersheds affect water quality, and a consulting engineer provided information about successful water quality management strategies. A key part of each session was having a host water utility present information about its source of supply and discuss water quality challenges faced by the organization.

Phase 2: Source water protection pilot-program development. Following the phase 1 workshops, participants were invited to participate in a pilot study. Selection criteria for pilot sites are listed in the sidebar on page 66. Pilot sites were selected on the basis of need, which biased the selection to small systems with immediate or overwhelming risks. Ten surface water utilities served as informational study sites to illustrate the water quality issues and risks faced by small-system managers in Maine. Field visits to these 10 sites were made in Fall 2001 to document existing water quality conditions and watershed issues as well as the effectiveness of source protection efforts. The goal

As part of the Maine Source Water Assessment Program each public surface water supply received a risk assessment. Included was Eagle Lake in Acadia National Park, the water supply for Bar Harbor, Maine.

was to identify utilities that needed assistance with source water protection, as well as those having high risks to water quality. It was important to understand the needs and limits of managers in order to craft a template to help them solve problems.

Four utilities were selected to develop a template for future source water protection assistance to surface water suppliers: Boothbay Harbor Water System, Fort Fairfield Utilities District, Newport Water District, and Winthrop Utilities District (Figure 1). More than just an inventory, work with these sites addressed specific water quality problems and applied watershed-management techniques. These techniques included shoreline surveys, media outreach, introducing monitoring programs with local schools, coordinating with local watershed organizations, and communicating with landowners.

The Boothbay Harbor Water System serves a coastal community with limited freshwater resources. The only source of supply is located in a neighboring town, a 29.5 ha (73 acre) lake (Adams Pond) that has insufficient storage capacity to meet summer demand. A secondary source serves as a backup supply (Knickerbocker Lake). Adams Pond lies within a developed state highway corridor whereas Knickerbocker Lake has seasonal camps and light residential development. A priority at this utility was development of watershed-protection ordinances to protect the quality of its limited quantity of water.

> The Source Water Protection process now extends this legal obligation by inference into the watershed, even though a utility may have no given authority or ownership of its watershed.

The Fort Fairfield Utilities District serves a town situated within an agricultural district. Their source is a stream (Pattee Brook) that suffers from excessive nutrient loading, but the small system had limited knowledge about the sources of nutrients. Part of the watershed extends into New Brunswick, Canada. Although land uses were observed to be similar on both sides of the border, cross-border management is problematic. Fort Fairfield needed assistance to identify and prioritize the problems in its watershed in order to rank importance.

The Newport Water District uses an 80.5 ha (199 acre) surface water supply (Nokomis Pond) with a limited-access, mostly wooded shoreline. There are few residences on the lake, and motorboats are prohibited. Part of this source-control effort was a result of experience gained from phosphorus problems with the former source (Sebasticook Lake). The district was focused on replacing aging infrastructure, and source protection was not a leading priority; Newport needed help in delineating its watershed and identifying immediate risks.

The Winthrop Utilities District uses a 112.9 ha (279 acre) surface water source (Upper Narrows Pond). The Town of Winthrop and the area surrounding the pond have had steady residential development pressure for more than 30 years. Winthrop was concerned about how development was affecting its source and also whether erosion-control practices had been installed and operated properly.

Specific activities were conducted with staff at each pilot utility along with some public awareness efforts, mainly media exposure. In Boothbay the focus was on the needs of a

Pilot Study Site Selection Criteria

(1) Candidates were ranked by degree of watershed stress (quality, quantity, watershed development).

(2) Study sites with past water quantity or quality problems were given preference.

(3) Candidates were ranked by economic need as determined by size of staff and population served.

(4) Preference was given to watersheds on the Maine Department of Environmental Protection 305b threatened list.

(5) Candidate utilities needed to be able to contribute to the project through a combination of personnel, logistical, or administrative support.

watershed stewards group and watershed-protection ordinances. Additional work was conducted with students studying water and conservation. A watershed survey was conducted in Fort Fairfield to identify major nutrient sources. Newport needed some basic information on the source, a delineation of the watershed, and a shoreline survey to identify areas where human contact was likely. The size of the watershed was questioned, and subtle topographical changes had to be field-checked because the SWAP boundaries were derived from topographical maps with insufficient resolution. In Winthrop, a shoreline and road survey were conducted to inventory the use and condition of erosion-control measures in developed areas. The inventory of water quality problems, watershed activities, and management needs were combined with lessons learned from applying watershed solutions to lay the foundation for the third phase of the project. The pilot sites provided a clearer picture of the watershed-protection tools that managers needed and was the basis for a source-protection handbook.

Phase 3: Creation of a source water protection reference publication. A source water protection reference guide for Maine surface water systems was developed based on information collected from the pilot-study sites. The guide was intended as a source water protection tool for water system managers and other stakeholders in drinking water protection. The goal was to give utility managers a tool to be used in conjunction with their SWAP report to initiate source-protection actions.

A key part of each session was having a host water utility present information about its source of supply and discuss water quality challenges faced by the organization.

RESULTS AND DISCUSSION

Water utilities' need for assistance was obvious, but because it was physically impossible to do all of the legwork for water utilities, a tool was needed to leverage time and effort. Manager requests for technical assistance led to development of a reference document. *Source Water Protection: Linking Water Quality to the Watershed* (Schmitt, 2003) was designed to help water suppliers implement source water protection plans. The content of the guide was based on discoveries from the first two phases of the project and on risks identified by the source water assessment process. The goal was to make it easier for water suppliers to follow assessment with protection activities. The guide was distributed free to all of Maine's public surface water suppliers, drinking water protection specialists, regional planning agencies, and other appropriate stakeholders.

The fundamental premise of the guide is that water suppliers are confronting common water quality problems or watershed activities that pose a threat to water quality. The guide is sometimes referred to as the "cookbook" because it is designed so that public water suppliers can take the relevant "ingredients" (e.g., water quality and land uses) from their systems and create customized solutions on a watershed scale. Sample pages are shown as sidebars on pages 67, 68, and 69. The complete document can be viewed on-line at www.umaine.edu/WaterResearch/research/pdfs/Source%20Water%20Protection.pdf.

The guide is organized so that each section is cross-referenced with the others. If water suppliers are having a specific water quality problem, they can go directly to a topic page to find out about the problem and specific short-term solutions and treatment options. Also listed on each topic page are both the larger watershed-scale activities that can cause the various water quality impairments and suggested long-term solutions.

Many of Maine's surface water supplies have natural characteristics that create challenges during treatment and distribution. For example,

Example page from the Maine Source Water Protection guide addressing the water quality problem of turbidity

Turbidity

Turbidity is a measure of the transparency of water, or how light is scattered or absorbed by particles in the water. As turbidity increases, less light penetrates the water. Turbidity can be caused by eroded sediment and stormwater runoff from the watershed or shoreline and by organic matter within the water body. Turbidity is used as an indirect indicator of water quality, for example, nutrient levels or filtration effectiveness. Higher turbidity levels may be associated with higher levels of disease-causing microorganisms. Turbidity interferes with disinfection, requiring an increase in filtration and disinfectant use.

Turbidity is a problem that is often intermittent or seasonal, and requires **monitoring.** In addition to measuring turbidity with a meter at the treatment plant or by sending water samples to a laboratory, water clarity can also be measured with a Secchi disk. Weekly Secchi disk readings or turbidity measurements can help track transparency trends and identify potential sources of high turbidity.

Watershed Sources

Intensive **forestry** and **agriculture** can be sources of eroded sediment.

Wildlife (especially beaver) activity can erode sediment.

Sediment is carried by runoff from **residential and urban development,** construction sites, camp roads, and impervious surfaces.

Solutions

Watershed and shoreline surveys will identify forestry and agricultural practices and roads that might be contributing to erosion.

Participate in **development review** to promote stormwater management, proper road construction, buffers, and the use of erosion control during construction.

ponds that receive drainage from surrounding wetland areas can be naturally highly colored from organic-matter loading. The organic matter can combine with chlorine during treatment to form disinfection byproducts. When water quality problems result from natural characteristics of the supply and are not the result of human activities in the watershed, treatment-based solutions are the most appropriate option, unless another source of supply is available.

However, problems with raw water quality are sometimes the first noticeable sign of potentially damaging activities in the surrounding watershed. Maintaining the highest-quality source water is essential in preventing water quality impairment (Gullick, 2003). Thus, locating and abating threats in the watershed are the most effective and least expensive long-term solutions to protecting water quality. Protecting the source can be an economically efficient process for providing safe water at a low cost. For example, the Surface Water Treatment Rule required filtration of all surface sources unless the water utility could demonstrate attainment of specific site controls and water quality criteria. Source protection efforts are part of a waiver from filtration.

There are some major gaps in protection programs that are nearly universal. Too many water systems lack rigorous raw water quality information except the monitoring required by law. No additional monitoring of raw water quality was required as part of Maine's SWAP, yet such monitoring is the most effective way to detect changes that derive from activities in the watershed and provides information that can be used to identify threats in the watershed. Watershed protection strategies will be ineffective if the watershed and source are not well-understood in terms of biological–chemical interrelationships and dynamics.

Numerous land uses and activities within the watershed of a surface water supply can affect water quality. Even in cases in which water quality is not impaired, a supplier may be concerned about the relative risks of land uses and activities in the watershed. The supplier may wish to be proactive in addressing land use activities to prevent water quality degradation. Factual information on causes and effects is needed to support protection efforts.

The Watershed Sources section of the *Source Water Protection* guide discusses common watershed land uses and activities that can affect water quality and provides references and resources for addressing watershed activities, including agriculture, forestry, residential development, and others. The section also describes various management and outreach approaches that can be included as part of a source water protection plan. It is unlikely that any one system will be able to employ every technique, but a combination of many or several can greatly improve water quality protection efforts.

Underlying the source water protection concept is the fundamental premise that protection of drinking water supplies must happen at the local level. This was evident through all phases of the project, and as a result the guide emphasizes watershed management, outreach, and education over treatment and distribution technologies. All of the watershed solutions require communication with various stakeholders in the water-

Underlying the source water protection concept is the fundamental premise that protection of drinking water supplies must happen at the local level.

Example page from the Maine Source Water Protection guide addressing the activity of forestry and how it affects water quality

Forestry

From a water quantity and quality standpoint, forests are the preferred watershed land cover. Forestland can enhance water quality, provide wildlife habitat, and allow for passive recreation. A forest-management plan that is designed to enhance water quality and increase water yields can include commercial logging. By supplying clean water and generating income through the sale of lumber, forest management is highly beneficial. Income from forest harvesting can subsidize watershed-management programs. Logging and other silvicultural activities are widely recognized as acceptable water supply watershed uses which, when properly managed, will not degrade water quality. [Best management practices] should be applied to protect water quality, soil structure, residual trees, and cultural resources.

Water Quality Problems

When not conducted in accordance with a forest-management plan or when forest is in small privately owned woodlots, logging can contribute to the following water quality problems:

Algae

Turbidity

Pathogens

TOC/disinfection by-products

Pesticides and herbicides

Solutions

Watershed and shoreline surveys can identify areas of erosion.

Conduct **landowner education** for foresters and woodlot owners about BMPs.

Standards for [best management practices] are available from state agencies.

shed: landowners, farmers, foresters, citizens, schools, local governments, and state officials. Often the responsibility for coordinating these parties falls to the public water supplier.

To assist in fulfilling this responsibility, each topic page in the guide contains a list of references and local contacts for more information and assistance, and sections are cross-referenced. For example, under the Solutions heading on the turbidity page (sidebar on page 67), the supplier sees that watershed and shoreline surveys can identify areas of erosion. The guide advises the supplier to take an active role in a development-review process, which can prevent future erosion and turbidity spikes. Suppliers can then turn to the Development Review section of the guide (sidebar on page 69) for solutions to those topics. Additionally, a state-specific directory of contacts and resources is included in the guide.

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Work at pilot sites participating in the source protection implementation project has seen several tangible results. In Boothbay, watershed surveys were completed, and the utility has participated in development permit reviews and instituted watershed protection ordinances. In Newport, the source watershed was found to be smaller than mapped in SWAP with a reduction in potential risks. In Winthrop, the utility now has the documentation needed to help institute local controls on land uses in its source watershed. Finally, in Fort Fairfield, the utility has worked with the agricultural community to minimize soil loss into its source stream.

CONCLUSIONS

The principle of watershed management as the first line of defense against drinking water contamination is not new. Indeed, watershed protection was well accepted by the late 19th century when the association between human contact with drinking water sources and waterborne disease outbreaks became clear and urban areas switched to more remote, protected supplies (Burdy et al, 1983). It follows then that the general conclusion from the source water protection pilot project was the importance of watershed approaches in assessing and protecting water quality. The following concluding points were derived from the pilot studies and completion of the source water protection reference guide.

- Source water protection will not succeed if the water supplier does not consider it as an important objective. The pilot project demonstrated a need for continual reinforcement on the importance and necessity of source water protection.
- Source water monitoring is a valuable source water management and protection tool. Most water utilities have limited human and financial resources, and a water supplier will reap a great benefit by monitoring the source. Monitoring also provides data that can be used in communications with other stakeholders in the watershed.
- Coordination with local and state government and the public is one of the greatest challenges faced by water suppliers. Supply managers are forced to communicate and educate those in the land use and planning community about the importance of protecting drinking water

quality. The role of communicator and educator is not traditionally played by managers of public water supplies, and resources are needed to help water suppliers fulfill this role.

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ABOUT THE AUTHORS

John M. Peckenham *(to whom correspondence should be addressed)*

is a PhD candidate, senior research scientist and assistant director of the Senator George J. Mitchell Center for Environmental and Watershed Research, Norman Smith Hall, University of Maine, Orono, Maine 04469; e-mail jpeck@maine.edu. Peckenham has worked in the fields of research and consulting on water quality and remediation. He is a member of AWWA, the National Groundwater Association, and the American Geophysical Union and has been published in Environmental Monitoring and Assessment, Journal NEWWA, *and* Journal of Environmental Quality. *Catherine V. Schmitt is a research assistant and science writer at the Senator George J. Mitchell Center for Environmental and Watershed Research and participated in this project as a graduate student. Jeffrey L. McNelly is executive director of the Maine Water Utilities Association. Andrews L. Tolman is the Source Water Assessment Program coordinator in the division of Source Water Protection, Maine Drinking Water Program.*

Example page from Maine's Source Water Protection guide discussing development review, an action designed to protect sources

Development Review

Public Law 761, enacted in 2000, requires that public water suppliers be notified of certain activities being proposed within the source water protection area (direct watershed) of the water supply. Public water suppliers are essentially treated as an abutter in cases in which abutters are notified. This gives you the chance to attend public hearings and comment on proposed development.

Here are some suggestions when reviewing and commenting on development:

- At the very least, introduce yourself at the hearing, and make it clear that you are representing the interests of public health and water supply protection.
- Promote construction best management practices and erosion controls (silt fencing, haybales, covering or seeding stockpiled soil, etc.).
- Request stormwater best management practices in residential and urban development, including deep sump catch basins, grassed swales, buffers, etc. Under Maine's 1997 Stormwater Management Law, a construction project may require a permit from the DEP if the project includes 20,000 square feet [1,858 m^2] or more of impervious area or 5 acres [2 ha] or more of disturbed area and is located in the watershed of a public water supply. Contact the Bureau of Land & Water Quality at 287-3901. Stormwater management regulations are available at www.state.me.us/dep/blwq/stormwtr/index.htm.
- Promote vegetative buffers and other landscape controls on non-point-source pollution.
- Pursue land conservation and easement options on undeveloped portions of lots and subdivisions.

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