Protection of Lakes and Reservoirs as **Drinking Water Supply Sources**

Chi Ho Sham

Challenges and Solutions

What is source water protection?

Source water protection (SWP) is often referenced as the front-line barrier in the multiple barrier approach to protect drinking water (Morgan et al. 2019). Spatial variabilities associated with geography, history, ecosystem dynamic, land use, and policy make SWP a highly site-specific process that reflects the inherent diversity of natural waters and the areas from which they are derived, along with other drivers that affect source water quality.

American water utilities spend millions of dollars each year on SWP and related measurements. They understand the importance of SWP for maintaining a reliable water supply of optimal quality. They also appreciate that, by dedicating resources to SWP, they are in turn saving resources that would otherwise have to be spent on water treatment or using alternative, more expensive, and less convenient supplies.

According to the U.S. Census Bureau (2011), 70 percent of Americans are served by community water systems using surface waters as their source for raw water. These sources include rivers, streams, lakes and reservoirs. Because of the need to protect drinking water sources, water utilities are a valuable partner for local surface water management programs. Local utilities may be a direct source of funding for lake protection efforts, but more importantly, public support for protection efforts can be greatly enhanced by placing emphasis on drinking water protection. An opinion poll conducted by the Trust for Public Land in 2004 showed overwhelming support for conservation of land that protects drinking water (TPL 2004).

Drinking water sources are subject to a variety of sources of pollution. SWP programs help maintain, safeguard, and/or improve the quality of a given source water. Benefits of SWP programs include reduced water treatment costs, increased public health protection, improved environmental conditions, and other social benefits such as improved relations with stakeholders. Furthermore, SWP provides a way to respond to uncertainties presented by unknown or unregulated microbiological and chemical contaminants (i.e., preventing contamination that treatment may not remove), avoiding costs for monitoring and remediating contamination, and greater likelihood of complying with drinking water regulations.

Pollution prevention is preferable to remediating or treating contaminated source water. SWP programs provide a means toward a more sustainable and resilient future for source water. Many people are aware of the recent concerns about Poly- and Perfluoroalkyl Substances (PFAS) in source water across the U.S., which made headlines at the national and state levels in the last couple of years (see https://www.epa.gov/pfas/basic-information-pfas). The problems posed by these substances will cost billions of dollars to remediate. In other words, it is logical to prevent the introduction of any actual or potential contaminants into source water. Furthermore, certain contaminants can trigger biogeochemical activities that degrade source water and introduce serious public health risks. Contaminant sources that challenge SWP programs are wide ranging. This article will cover issues associated with stormwater runoff and agricultural practices on surface water supply sources.

Types of contaminants

Urban Stormwater

The collective impacts of rooftops, sidewalks, roadways, and other impervious surfaces on surface water bodies can be divided into two categories, those attributed to changes in hydrologic response and water quality impacts resulting from human activities. The hydrologic response of an urban area changes when drainage areas become increasingly impervious, causing stormwater runoff volumes, flows, and velocities to increase while base groundwater flows decrease. Small annual storm events that would ideally be captured by vegetation and soils of an undeveloped landscape are instead delivered quickly and efficiently through the receiving pipe network to surface water bodies. Human activities in the city, such as heavy automobile traffic and chemical uses, generate increased pollutant loads to receiving waters. During dry weather, locally generated pollutants and atmospheric deposition of pollutants from remote locations accumulate on impervious surfaces where rain and snow-melt events would mobilize them into surface water bodies.

Pollutants found in stormwater runoff from urban, industrial, and commercial land uses can have diverse adverse effects on a water supply; examples include:

- **Eutrophication** – Stormwater runoff from virtually every category of land use affected by human activities (as well as under some natural conditions) often contains elevated concentrations of nitrogen and phosphorus, which can accelerate eutrophication (excessive growth of phytoplankton and algae), leading to a host of problems including taste and odor, disinfection byproducts formation, plant operation, and health risks

- **Elevated turbidity and sediment** – Stormwater runoff from construction sites, unvegetated open space, and unprotected areas often has high turbidity and sediment load, which can pose problems for water treatment and affect finished water turbidity, appearance, and, potentially, chemistry, depending on which pollutants are associated with sediment inflows.
- **Synthetic Organic Compounds** – This broad category of pollutants includes compounds such as pesticides, solvents, oil and gas-production related chemicals, hydraulic fluids, and others, which are often found in stormwater runoff and periodically reach water supply intakes via spills. This class of chemicals poses concerns related to public health because basic water treatment facilities are not equipped to handle them.
- **Bacteria** – Concentrations of bacteria in stormwater runoff from various sources (e.g., pet waste, bird dropping, and sewer overflow can be elevated and pose concern for public health.
- **Metals** – High concentration of metals in certain categories of stormwater discharges, such as from some industrial sites, may cause public health concerns and treatment concerns. Many metals are regulated under the Safe Drinking Water Act (SDWA) because of their potential adverse health effects.

In 1972, the Federal Water Pollution Control Act, also known as the Clean Water Act (CWA), was amended to make illegal the discharge of any pollutant as a point source to any water body in the U.S. without authorization by a National Pollutant Discharge Elimination System (NPDES) permit. Pollution control measures were first implemented in industrial wastewater operations and municipal sewerage systems; however, it became apparent that more regulations were needed to include the identification of stormwater drainage systems as a point source. In 1987, the CWA was amended to implement a two-phase approach to the reduction of stormwater discharges.

The first phase was aimed at large and medium municipal separate stormwater systems (typically systems serving populations of 100,000 or more), industrial activities, and construction activities that disturbed five acres or more of land. The Phase I part of the program was implemented on November 5, 1990. The Phase I permitting process required these larger cities to develop and implement a stormwater management program, and to address stormwater management at specific municipal facilities at which "industrial" activity took place. It also required certain industries as well as any construction project greater than five acres to obtain NPDES permit coverage through the development and implementation of stormwater pollution prevention plans that would control erosion and sedimentation as well as pollutant discharges.

On December 8, 1999, the NPDES Phase II Stormwater Rule was published in the Federal Register by EPA. The NPDES Phase II Stormwater requirements focused on small Municipal Separate Storm Sewer Systems (MS4s) (usually cities with populations of less than 100,000) and small construction activities (construction activity that disrupts one or more acres of land). The basis of this Phase II approach was to design a stormwater management program that focused on six minimum control measures that include:

- Public Education and Outreach
- Public Participation and Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Runoff Control
- Post-Construction Site Runoff Control
- Pollution Prevention and Good Housekeeping at Municipal Operations

The NPDES Phase II program requires the development of best management practices (BMPs) for each of the minimum control measures and the development of an implementation schedule and measurable goals throughout the five-year permitting period. Regulated entities are required to submit progress reports annually and are subject to enforcement action as described in the CWA if they fail to implement the selected BMPs.

States are providing funds under Section 319 of the CWA for the assessment, design, and construction of stormwater BMPs, along with education and outreach of stakeholders and the public. In addition, funds from Section 604b of the CWA are available to conduct water quality assessment and watershed management planning, BMP design, and development of stormwater utilities. Furthermore, Clean Water State Revolving Fund (CWSRF) loans are available to communities for stormwater management planning, BMP design and construction, and formation of stormwater utilities. Additional state and local funding sources are available to communities to manage and control stormwater runoff.

Agriculture Practices

The advancements of food product systems have led to the increasing reliance of agrichemicals and scale of production to enhance crop yields and low prices. A variety of chemicals, ranging from phosphorus, nitrogen, and pesticides have been used intensively across the agriculture landscape.

As mentioned earlier, the increasing levels of nutrients (e.g., phosphorus and nitrogen) in surface water bodies, coupling with higher temperature and residence time, can lead to increased primary productivity (eutrophication) and natural organic matter that are precursors of disinfection byproducts in typical surface water treatment plants. When water is chlorinated to make it safer for consumption, the chlorine can react with organic material and form potentially harmful disinfection byproducts, such as trihalomethanes and haloacetic acids, which may he carcinogenic. In addition, more eutrophic waterbodies are also associated with cyanobacterial blooms like the one on Lake Eerie shown in Figure 1 (commonly referred to as harmful algal blooms) that are linked to the releases of cyanotoxins (such as microcystins and cylindrospermospsin) affecting the nervous system (neurotoxins), the liver (hepatotoxins), and the skin (dermatoxins).

Pesticide runoff from agricultural lands can enter and has the potential to contaminate surface waters. Depending on the toxicity and concentration of specific pesticides, along with the exposure of the population to these pesticides, many pesticides are regulated under SDWA. Along with the states and tribes, EPA sets

Figure 1. Harmful Algal Bloom in Lake Erie (source: NOAA; https://oceanservice.noaa.gov/news/weeklynews/july13/lake-erie-habs.html.

and implements regulations that protect our drinking water from source to tap. National Primary Drinking Water Regulations (NPDWRs) for numerous pesticides can be found at https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations to protect public health by limiting the levels of pesticides and pesticide residuals in treated drinking water. It should be noted that treatment technologies to remove pesticides to meet various regulatory standards can be expensive (e.g., the use of activated carbon and nanofiltration).

SWP and the Safe Drinking Water Act

The SDWA, authorized by Congress in 1974 and amended in 1986 and 1996, seeks to regulate public drinking water for public health protection. While the SDWA does a relatively good job addressing goals related to drinking water quality, it deals very little with the issue of water quantity and source water quality. Issues surrounding water quantity are left largely to state and regional authorities; whereas source water issues are generally addressed at the local level where decisions and actions are needed to ensure the availability of safe, reliable, and sustainable drinking water.

Section 1453 of the 1996 SDWA Amendments required states to develop and implement Source Water Assessment Programs (SWAPs). States were required to identify the sources for all public drinking water supplies, delineate the source water contributing areas, identify potential sources of contamination, determine the susceptibility of the water supplies to contamination, and disseminate the results to the public.

Although most of the source water assessments were completed (U.S. Environmental Protection Agency 2006), apart from a handful of states, SWP activities are generally not required of public drinking water supplies. In other words, SWP is voluntary in nature at the national level. Nevertheless, the information developed under SWAPs has become a useful tool to help local stakeholders develop and implement voluntary SWP programs to protect source water quality.

The 1996 SDWA Amendments recognize the direct connection between watershed protection and safe drinking water, and authorized funds to implement state drinking water programs and help states provide revolving loans to assist public water systems in improving drinking water infrastructure using the Drinking Water State Revolving Fund (DWSRF). States may use up to 10 percent of their annual DWSRF grant for SWP program, or to provide loans to acquire land or conservation easements, and an additional 10 percent of its DWSRF allotment to administer or provide technical assistance through SWP programs.

In addition, EPA's Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) includes a provision whereby a water utility may qualify for a 0.5-log disinfection credit as a result of an effective SWP program (Sham and Morgan 2011).

On July 26, 2019, EPA issued a memorandum in response to an amendment to Section 1452(k) of the Safe Drinking Water Act (SDWA), which is included in the 2018 America's Water Infrastructure Act (AWIA), to expand source water protection-related eligibilities under the Drinking Water State Revolving Fund (DWSRF) program. This expansion includes the use of DWSRF's 15 percent set-aside for additional source water protection activities at the local and state levels, i.e., (1) updates to source water assessments and (2) expenditures to implement source water protection activities (under Section 1452(k)(1)(D)). The availability of these funds can be used to leverage other funding sources such as the Clean Water State Revolving Fund (CWSRF), Clean Water Act (CWA) Section 319 funding, and conservation funds from the Natural Resources Conservation Service (NRCS) as authorized under the Agriculture Improvement Act of 2018.

Finally, drinking water utilities that obtain their source water from relatively pristine surface water supplies may apply to EPA for a Filtration Avoidance Waiver which, if granted, would release them from the filtration treatment requirements of the SDWA and instead require SWP activities. New York, Boston, Syracuse (New York), Seattle, and San Francisco are examples of some of the cities that have Filtration Avoidance Waivers.

Note: The nine minimum elements in watershed-based plans under Section 319 of the Clean Water Act (U.S. Environmental Protection Agency 2013) and the six primary components of successful SWP programs (American Water Works Association 2007) can easily be cross-referenced and they cover essential the same concerns under the watershed or SWP programs.

Selected challenges and solutions associated with surface water source protection

In general, since the 1996 SDWA Amendments, SWP has been discussed and promoted in an *ad hoc* fashion by different organizations at the national, regional, state, and local levels. The site-specific nature of SWP has made these programs bottom-up exercises. A lack of awareness and recognition at the national level and the largely voluntary nature of SWP have made SWP programs a low priority or invisible to the decision makers and general public. The prospect of potentially prioritizing limited resources between treatment and protection activities, along with the sense of helplessness felt by many water utilities that do not control activities and land use in their contributing watersheds, have made SWP a complex and challenging issue. Obstacles to successful SWP typically are not technical, but rather social, political, financial, or regulatory.

In 2018, the Agriculture Improvement Act was signed into law and it directs U.S. Department of Agriculture (USDA)'s Natural Resources Conservation Service (NRCS) to allocate at least 10 percent of their conservation title funds to projects that protect drinking water sources. The allocation total over five years is $4 billion, or roughly $800 million per year. Water utilities can tap into these funds by working with their local conservation districts and NRCS. The next article in this issue includes some helpful guidance and resources to consider. Some of the NRCS programs that are included for source water protection are:

- **Regional Conservation Partnership Program (RCPP)** – including activities associated with other USDA programs such as the Environmental Quality Incentives Program, Conservation Stewardship Program, Agricultural Conservation Easement Program, Healthy Forests Reserve Program, PL 83-566 Watershed Program, and the Conservation Reserve Program. RCPP projects start with an application by an eligible partner (e.g., agricultural or silvicultural producer associations, farmer cooperatives or other groups of producers, state or local governments, American Indian tribes, municipal water treatment entities, water and irrigation districts, conservation-driven non-governmental organizations and institutions of higher education, and conservation districts). Selected partners work alongside NRCS to help agricultural producers and forest landowners implement conservation activities that address natural resource priorities on eligible lands (e.g., any agricultural or non-industrial private forest land, or associated land on which USDA determines an eligible activity would help achieve conservation benefits).
- **National Water Quality Initiative (NWQI) Source Water Protection Area Project** – focusing on addressing specific agriculturally related source water protection needs by channeling NRCS conservation program funding to agricultural producers in identified watersheds to implement practices that help to protect sources of drinking water. Due to the fact that the NWQI contains both an implementation phase and a readiness phase, utilities interested in working with NRCS on an NWQI project do not need to have every detail of a proposed project solidified prior to applying for funding. Identification of source water protection areas and source water concerns related to agriculture is sufficient to get the application processes moving. A State Conservationist can provide information on the requirements for NWQI proposals.

To effectively prioritize and spend these funds for the greatest benefit to utilities and water quality, eligible partners such as water utilities, irrigation districts, and conservation-driven watershed organizations need to be involved. NRCS decisions are made more in the state offices than in the national office. In this decentralized model, water utilities and local partners are the key players to make things happen by:

- Developing a relationship with the NRCS state conservationist, the top official for NRCS in each state. These individuals have considerable authority in prioritizing and focusing conservation programs within their respective states. They are often the focal point of information and ideas. Conservation districts, agricultural groups and many others frequently bring concerns and ideas to them. By getting to know them – organizing a meet-and-greet with utilities, bringing specific concerns to their attention, inviting them to talk at your conference, or otherwise engaging them – you can develop important relationships that will serve your communities. A current list of NRCS state conservationists can be found at: www.nrcs.usda.gov/wps/portal/nrcs/main/national/contact/states/
- Attending and joining the State Technical Committee and applicable local workgroups. The State Technical Committee (STC) is where formal recommendations to the state conservationist are made; whereas local workgroups cover smaller areas and provide more local and specific information to the STC on specific source water protection needs at the water utility and watershed level. Involvement in the STC and/or local workgroups will raise the profile of source water protection and help to assure that local concerns are addressed
- Encouraging utilities with source water concerns to reach out to NRCS to form partnerships. There is a single pathway to implementing a project with NRCS. There are several different conservation programs (such as the NWQI and RCPP) that work differently and are built to address different types of concerns. The state conservationist is an expert in matching concerns to programs. The state conservationist may identify other potential partners such as conservation districts or local producers' associations.

References

AWWA (American Water Works Association). 2014. *ANSI/AWWA Standard G300-14. Source Water Protection*. Denver, Colo.: AWWA.

Morgan, Robert, Jennifer Heymann, Margaret Kearns, and Stephanie Ishii. 2019. "The First Step of Water Treatment: Source Water Protection." *Journal of AWWA*: 111(6): 84-87.

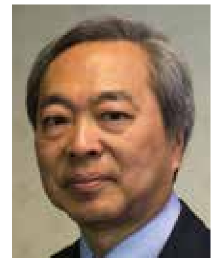
Sham, Chi Ho and Robert Morgan. 2011. Examining the AWWA Standard G300. *LakeLine* 31(3): 12-15.

TPL. 2004. *Source Water Protection Handbook; Using Land Conservation to Protect Drinking Water Supplies*. Trust for Public Land, San Francisco, CA, and the American Water Works Association, Denver, Co.

U.S. Census Bureau, 2011. Historical Census of Housing Tables. Available: ftp://ftp.census.gov/library/publications/2010/compendia/statab/130ed/tables/11s0955.pdf,

U.S. Environmental Protection Agency. 2006. *How-to Manual: Update and Enhance Your Local Source Water Protection Assessments*. D.C.: USEPA Office of Ground Water and Drinking Water. Available: https://www.epa.gov/sites/production/files/2015-09/documents/2006_09_27_sourcewater_update_enhance_assessments.pdf.

U.S. Environmental Protection Agency. 2013. *A QUICK GUIDE to Developing Watershed Plans to Restore and Protect Our Waters*. D.C.: USEPA Office of Wetlands, Oceans, and Watersheds. Available: https://www.epa.gov/sites/production/files/2015-12/documents/watershed_mgmnt_quick_guide.pdf.



Dr. Chi Ho Sham is a vice president and the chief Scientist of Eastern Research Group, Inc. (ERG), leading the drinking water and source water protection practice. He is an active member of the American Water Works Association (AWWA) and is currently the chair of its Technical and Educational Council (TEC). He received his B.A. from the University of Regina in Canada and his M.A. and Ph.D. from the University at Buffalo in New York. Currently, he is an adjunct professor and a senior research fellow at Clark University in Worcester, Massachusetts.