Reflecting on Lakes

A Guide For Watershed Partnerships

Streams, lakes and other bodies of water are affected by what happens within a watershed—the land that drains to them. More and more people are working together, learning about their watershed, sharing information with their neighbors, and developing action plans to improve and protect Pennsylvania's waters. This guide is for people who value lakes, have a desire to preserve or improve lake quality, and wish to partner with other individuals or organizations to address watershed issues that impact lakes. The ideas and processes outlined in the following pages can be used as a guide for developing a lake management plan. Because the characteristics of each watershed are unique, you may find certain portions of this booklet to be more applicable than others. Regardless of your own particular area of interest, keep in mind that a long-term, integrated approach, based on a systematic, scientific assessment, is key to the success of any project.

What makes your lake special?

Lakes have different meanings to different people. Some lakes provide millions, and in some cases, billions of dollars worth of food, tourism, transportation, recreation and other opportunities. How do you or others benefit from your lake? Perhaps the lake provides…

- Recreational opportunities involving skiing, boating or fishing.
- Drinking water to area residents.
- Flood protection for downstream residents.
- Abundant wildlife habitat.
- Irrigation for crops, golf courses, and lawns.

- Power generation.
- Tourism (restaurants, shops, hotels, entertainment, marinas).
- A place for reflection or solitude from the hectic pace of today's world.

A high quality lake, valued for its water supply, recreation and aesthetic appeal, can benefit all watershed residents and nonresidents alike by providing a healthy place to play or enjoy a quiet sunset. For many people, a high quality lake improves overall life within a community.

Watershed residents, even those located a long distance from the lake, can benefit if the lake serves as a drinking water supply. A healthy lake can help lower the cost of drinking water treatment, providing savings for present and future customers. Property values, not only on the lake-shore, but throughout the watershed community, can benefit from a desirable lake. Economic development resulting from increased tourism and industrial development can increase the tax base for watershed communities. This could improve schools, roads and police protection.

Well-maintained and protected wildlife habitat areas attract birds and animals that add to the appeal of the lake and its watershed. The good news is that if you and your partners have come to consensus on the ways lake users value your lake, you're already well on your way toward devel-oping an action plan for preserving and improving lake water quality.

Six keys to protecting lakes

- Identify lake values
- Understand the link between the lake and its watershed
- Understand in-lake processes
- Recognize and prevent threats to lake quality
- Form partnerships with lake-watershed members
- Know where to go for help

The lake-watershed link

You are probably able to identify several reasons why your lake is special. It is now important for you to understand the characteristics of your particular lake and its associated watershed. This knowledge will become the basis for developing appropriate and effective management strategies to achieve your group's lake management goals.

A lake is the reflection of its watershed (the land area that drains into it) and the everyday actions that take place in the watershed. The importance of the relationship between a lake and its watershed cannot be over emphasized. The lake-watershed system is a functioning unit with interacting biological, physical, chemical and human components. If a lake suffers from problems such as extensive weed growth, algae scum, fish kills, or

filling in with sediments, often the cause of the problem can be linked to a pollution source or sources within the watershed.

The characteristics of lake-watershed interaction depend on a number of variables. Some variables include the ratio of drainage area to lake area, how the land is used, the climate, soils and geography, as well as existing conservation measures.

The interplay between these and other variables varies from region to region and even from lake to lake. That's why each lake and its watershed are a unique system.

Sizes and shapes. The origin of a lake often determines the size and other characteristics of the lake.

Natural lakes are those that were formed by geological processes, such as receding glaciers (kettle lakes), volcanoes and earthquakes, eroding limestone (solution lakes) and river activity (ox-bow lakes). Lake Erie and Conneaut Lake in northwestern Pennsylvania are examples of natural lakes. Pennsylvania has over 200 natural lakes across the northern tier.

Man-made lakes, often called impoundments or reservoirs, are those that were formed by damming a drainageway, stream or river. Manmade lakes can range in size and shape from the smallest farm pond to large "run-of the-river" reservoirs such as Conowingo Pond formed by the Conowingo Dam on the Lower Susquehanna River, or Pinchot Lake in central Pennsylvania. (For simplicity we refer to both manmade and natural lakes as "lakes.")

Lake-watershed size relationship. If a lake is small relative to the size of its watershed, the potential is greater for the lake to fill in with sediment or be affected by nutrients tied to the soil particles, much more so than a large lake with a relatively small watershed. Also, in general, the smaller the water-shed, the easier it is to control the pollutants entering the lake.

Climate and soils. Lakes in areas with more rainfall and steep, erosion-prone, nutrient-rich soils will have greater potential for algae blooms and plant growth than those in dry climates with infertile soils.

Topography. If the slope of the land in the lake's watershed is steep, the potential for pollutants to reach the lake is greater.

Wetlands. Wetlands within the watershed often filter out pollutants before they enter a lake, improving the water quality of the lake. Wetlands also provide habitat for plants and animals.

The in-lake environment

Understanding the relationship between the lake and its watershed is just the beginning. In order to carry out appropriate actions for lake protection, it is also important to understand key in-lake processes.

The in-lake environment is determined by a variety of factors including:

- Volume of water flow into and out of the lake (lake hydrology);
- Hydraulic residence time;
- Lake turnover;
- Internal cycling of lake nutrients (particularly phosphorus and nitrogen);
- Lake habitat for plants and animals.

Lake Hydrology. Watershed features have a great influence on lake hydrology. The volume and rate of water entering the lake via precipitation, groundwater flows, land surface runoff, and streams, compared to the water exiting the lake via evaporation, uptake by plants (transpiration), groundwater seepage, and surface streams, influences the concentration of nutrients, sediments and other potential pollutants within the lake.

Hydraulic Residence Time. The average period of time required to completely renew a lake's water volume is called the hydraulic residence time. For example, if the lake volume is relatively small and the flow of water is relatively high, the hydraulic residence time will be short. This can cause nutrients — which may lead to algae blooms – to be quickly washed out of the lake. On the other hand, if the lake has a long hydraulic residence time, algae have more of a chance to grow, bloom, and flourish given adequate nutrient input and sunlight.

Lake Turnover. Most lakes are stratified in summer, meaning that there is a separation of the warm surface and cool bottom water layers. Seasonal temperature changes during spring and fall cause the water to "turnover" or mix from top to bottom. In some lakes, turnover can be caused by wind mixing the lake. The significance of this phenomenon is that plant nutrients – commonly stored in sediment on the lake bottom – can be stirred up and become fertilizer for algae blooms and aquatic plant growth.

Internal Cycling. Nutrients can "cycle" in a lake when, during warm seasons, a lack of oxygen (i.e."anoxic" conditions) at the bottom creates conditions that allow phosphorus to be released from the sediment. This can stimulate algae and aquatic plant growth when the lake layers remix.

Lake Habitat. Lakes provide important habitat for many plants, fish and waterfowl. Many species depend upon the lake to complete their life cycles. Lakes are often viewed only as places of recreation for many people, but to wildlife and fish, lakes are essential for survival. Often the lake habitat includes significant wetlands along the edge and near the shore as well as open water habitats.

Lake productivity stages

In-lake factors, combined with the lake-watershed relationship, determine how "productive" a lake will be. The biological productivity of a lake is based on the availability of plant nutrients and is referred to as the lake's "trophic" condition. Extremely high or low productivity usually limits aquatic life. High productivity leads to lots of algae and other aquatic plants. Low productivity results in very little aquatic life. Either condition can limit the fishery of the lake.

The trophic condition of lakes ranges from the least productive (oligotrophic), to moderately productive (mesotrophic), to highly productive (eutrophic). Hypereutrophic lakes are the most productive of all, often with obviously abun-dant plant and animal life.

The natural process of moving from an oligotrophic state to an eutrophic state can take thousands of years, as inflow from the watershed carries nutrients slowly into the lake. However, where impacted by human activity, productivity can dramatically increase over a relatively short period of time. This type of eutrophication—as a result of watershed disturbance by humans — is known as "cultural" eutrophication.

What threatens lakes?

How do watershed activities threaten a lake's health?

MAJOR THREATS TO LAKES
The major threats to lake water quality in the United States are:

An overabundance of nutrients that leads to algae blooms and excessive plant growth, ultimately depleting oxygen supplies for fish and other aquatic life.

Organic wastes that assimilate in the water, robbing the water of oxygen needed for fish and some other aquatic life to survive.

An overabundance of sediments in runoff from the surrounding land can fill lakes and destroy habitat for plants and animals, as well as clog fish gills and smother fish eggs.

Metals and other organic chemicals, such as mercury and polychlorinated biphenyls (PCBs), contaminate sediment, fish and shellfish.

Rapid raising and lowering of water levels for power generation, irrigation and other uses can disrupt the lake's natural ecology, especially along the shore.

POLLUTION SOURCES
Although lakes naturally contain some sediments and nutrients, many sources of pollution can be attributed to the watershed. These include:

Septic systems contribute to lake pollution when they leak into the shallow groundwater. This can increase the load of nutrients, bacteria (including E-coli) and other organic wastes in lake waters.

Runoff from pavement and lawns in urban areas which picks up oil, metals, bacteria (including E-coli), and nutrients, transporting them through the storm sewer system or washing them directly into lakes.

Agricultural management practices which can lead to nitrogen, phosphorous, sediment, pesticides and organic matter entering the lake, via tributaries that run past farms and fields.

Municipal sewage treatment plants which sometimes combine sewage with stormwater, resulting in a Combined Sewer Overflow (CSO). This can cause nutrients, organic wastes, toxic household substances and other pollution to flow into lakes.

Destruction of shoreline vegetation through construction, wave action, draw downs, and other activities, can degrade lake quality, as well as plant and animal habitat.

Atmospheric deposition, or air pollution that is carried to the ground and waterways via rain or snow, is a major threat in some areas of Pennsylvania. Some forms of atmospheric deposition are referred to as "acid rain." Pollutants delivered to the landscape through atmospheric deposition include nitrogen and mercury.

Urbanization of agricultural or forested land increases hard surfaces like roads, parking lots, and rooftops. This increases the velocity and amount of runoff reaching the lake and causes stream- bank erosion, turbidity, and degraded wildlife habitats. Urban runoff also carries oil, bacteria, nutrients, sediment, and metals into lakes.

Activities that threaten lakes

Today, many of the traditional polluting activities such as building and road construction, logging, commercial farming, and factory discharges incorporate environmental requirements and standards. Often, it's the smaller scale activities that can be the most detrimental to a lake's health.

Household Activities

- Leaking septic systems can contribute to nutrients and bacteria getting into nearby waterways, streams and, eventually, the lake. Some nutrients can also be carried through shallow aquifers and reach spring-fed lakes. Either way, the contamination prevents the lake's use for drinking water or recreational activities. It can also cause over-enrichment leading to algae blooms or too many aquatic weeds.
- Using detergents containing phosphorus to wash boats, cars, and pets can lead to wastewater run-off entering and polluting the lake with excess nutrients.
- Over fertilizing your lawn or fertilizing at the lakeshore can also contribute excess nutrients to the lake, potentially affecting drinking water and recreational activities. Remember: a green lawn creates a green lake.
- Clearing vegetation near and on the lakeshore removes a natural buffering system which can help absorb nutrients and sediment runoff.

Boating Activities

- Using powerful outboard motors in shallow areas can churn up nutrient laden sediments to support algae growth and destroy aquatic life.
- Poorly maintained powerboat engines can leak oil and grease into the lake.

Farm Activities

- "Clean" cropping practices that leave the fields clean in the fall also leave soil vulnerable to erosion by snow, wind and rain. Nutrients and some herbicides attach to the soil particle and are carried with it, and ultimately, to the lake.
- Mixing herbicides near wells or tile lines can leak chemicals into shallow groundwater that ultimately resurface into springs or streams and carry it into the lake.
- Improper manure application can contribute to nutrients and bacteria getting into nearby waterways, streams and lakes. Some nutrients can also be carried through shallow aquifers and reach spring-fed lakes. This contamination can prevent the lake's use for drinking water or recreation. It can also cause over enrichment and algae blooms. Although it may seem that one house, one boat, or one farm alone cannot harm a lake, the cumulative impacts of dozens of boats, homes, and farms can add up to poor lake quality. Every action you take affects the lake!

What you can do

Because lakes and their watersheds are interrelated, watershed management is essential for achieving and maintaining a healthy lake. In many cases, in-lake treatments (like those to treat algae) may also be required to achieve a desirable and balanced system.

Form a partnership among citizens, local and state government agencies and farmers, as well as anyone else with a vested interest in the lake and its watershed. Be sure to involve all key players in the effort at the initial planning stages and continue to seek active

participation through implementation. This helps identify and avert future conflicts and is often the key to success.

Although it is not always possible to avoid conflict in partnerships that involve groups with seemingly divergent interests, finding and building on common goals — a healthy, balanced lake and watershed — will help overcome differences. Clear communication and strong leadership will also help assure a successful lake-watershed partnership.

It is a good idea to enlist an advisory team to assist your group with technical questions, in compiling and analyzing data, and in implementing and evaluating the group's efforts. Some groups bring in professional consultants for this purpose.

WHAT ABOUT EXISTING LAKE ASSOCIATIONS?

Lake associations are volunteer organizations usually comprised of lakeshore property owners. These organizations can often find participation and limited financial commitment from people who do not reside on the lakeshore, but either impact or can be affected by lake quality. This is why it's very important to have a strong lake-watershed partnership.

Other advantages of voluntary organizations include the ability to:

- Detect and begin to address potential stresses to the lake system before they become major problems.
- Represent members' interest to state and local governments.
- Educate decision-makers regarding land use in the watershed and protection of the lake.
- Act as an early warning signal for potential threats to the lake.
- Undertake projects to help protect the lake.
- Educate newcomers and visitors about the value of practicing wise use of the lake and surrounding watershed.

PUTTING TOGETHER YOUR PLAN

- Your group is ready to begin the planning process if:
- Most stakeholders are involved and have been invited to participate.
- Your group has maps and information detailing lake uses, watershed uses, and other factors that will impact your project.
- You have selected a technical advisory team to assist you.
- The group has committed to meet regularly at a neutral location and agreeable time.

While the following section details 12 major tasks in developing a comprehensive lake management plan, it might also be helpful to view the planning process as three stages. The stages, however, do not have to be completed in a specific order:

Stage One includes uncovering concerns, gathering and analyzing information and data, defining challenges and opportunities, developing objectives, and documenting data and decisions.

Stage Two includes developing a game plan for addressing the objectives, selecting the best watershed management alternative(s), listing ways (strategies) for implementing the suggested alternative(s) and determining how to measure progress.

Stage Three includes implementing and evaluating efforts.

Remember, your group's efforts will be based on the best available assessment of your watershed. It's unrealistic to hope to have all of the information you need at the onset. Be sure to recognize and note missing information throughout the planning process.

A comprehensive lake management plan

Proper lake management begins with developing a comprehensive lake management plan. Once developed, the plan will provide your group with a well thought out "game plan" to improve and protect the water quality of your lake. As mentioned earlier, the best management plans are built upon a thorough understanding of how the surrounding watershed influences water quality and how physical, chemical and biological interactions in the lake further modify lake quality. Without this understanding, lake associations can make poor, costly management decisions in an attempt to improve the water quality of their lakes.

Generally, 12 major tasks need to be completed in order to develop a logical, cost-effective lake management plan.

1) Identify and prioritize all desirable lake uses, such as swimming, fishing, boating, aesthetics, irrigation, and drinking water supply. Try to be specific in describing each lake use (for example, a cold water trout fishery versus a warm water largemouth bass and bluegill fishery).

2) Determine which desirable lake uses are currently impaired. Be sure to list which lake problems are causing the impairments. Shoreline fishing and swimming, for example, may be impaired due to the presence of dense aquatic vegetation.

3) Gather and evaluate past lake and watershed water quality data. Reliable historical data can be extremely useful when compared to more recently collected data.

4) Gather and evaluate information about the watershed's existing characteristics (i.e. geology, soil types, groundwater resources, topography, land uses). This information provides valuable insight on how the surrounding watershed influences lake water quality.

5) Determine the morphological characteristics of the lake (i.e. surface area, water volume, or hydraulic residence time). This information is critical in evaluating in-lake restoration alternatives.

6) Perform lake water quality monitoring to assess existing lake conditions and to determine cause and effect relationships for any observed lake problem.

7) Perform watershed water quality monitoring to determine which portions of the watershed contribute the highest quantities of pollutants (namely nutrients and sediments) to the lake. Once identified, these portions of the watershed can be targeted for future implementation of watershed management alternatives to reduce incoming pollutants to the lake.

8) Analyze and evaluate data to assess changes in lake water quality over time, existing lake conditions, determine the causes of observed lake problems and identify problematic areas within the watershed.

9) Determine water and pollutant (nutrient and sediment) "budgets" for the lake. This provides a detailed summary of all major sources of water and pollutants to the lake. This information is essential in selecting and prioritizing in-lake and watershed management alternatives for future implementation.

10) Determine pollutant reductions that are necessary to improve lake water quality. If these reductions are too high to achieve, your lake association may have to re-prioritize its list of desirable lake uses.

11) Evaluate and select applicable in-lake and watershed management alternatives to improve and further protect lake water quality.

12) Prioritize recommended in-lake and watershed management alternatives for future implementation to achieve lake water quality objectives for desirable uses.

By addressing these major tasks, lake management associations will be adequately equipped to make difficult lake management decisions to improve and further protect the water quality of their lakes. **Some of the tasks, such as Tasks 1 through 4, may be completed by the association members or other interested partners. As for the remaining, it is recommended that the lake association seek outside assistance from federal, state, or local agencies, and/or a qualified consultant with experience in lake and watershed management.**

Set a realistic goal

As your group becomes more familiar with the lake, its link with the watershed, and the desires of those who use the lake and live in the watershed, you and the group should reevaluate the goals.

Let's assume your lake is highly productive due to a combination of natural factors that occur even without human presence, such as a warm climate, a shallow bottom, and highly productive soils. In this situation, a plan that has a goal of returning the lake to an oligotrophic, pristine clear water condition would be impossible.

Setting realistic goals based on existing conditions, in addition to social and economic considerations, is a key to success.

Where to go for help

For more information, visit the Pennsylvania Department of Environmental Protection's website at http://www.depweb.state.pa.us DEP Keyword "DEP Watershed Management" or call the (DEP) Bureau of Watershed Management at 717-787-5259. Your county conservation district or extension office may also provide you with assistance or additional resources.

ADDITIONAL SOURCES OF INFORMATION

Pennsylvania Lake Management Society
P.O. Box 425, Lansdale, PA 19446
www.palakes.org

North American Lake Management Society
P.O. Box 5443, 4513 Vernon Blvd., Suite 100, Madison, WI 53705
608-233-2836
www.nalms.org

Pennsylvania Fish and Boat Commission
P.O. Box 67000, Harrisburg, PA 17106-7000
717-705-7800
www.fish.state.pa.us

U.S. Environmental Protection Agency, Region 3
1650 Arch Street, Phildelphia, PA 19103
www.epa.gov/owow

YOU MAY ALSO FIND THESE PUBLICATIONS HEPFUL

Lake Notes, a series of publications produced by the Pennsylvania Association of Conservation Districts, Inc.. Visit www.pacd.org or phone 717-238-7223.

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