

Crafting a Lake Protection Ordinance

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Introduction

Lake protection ordinances are an essential tool for protecting the quality of the 41 million acres of lakes and reservoirs in the United States that are under increasing development pressure. This article describes how to craft an ordinance to protect and maintain the quality of lakes from the pressures of both shoreline and watershed development. An effective lake protection ordinance extends over four major zones: the actual shoreline, a forested buffer extending landward, a shoreland protection area that extends further, and finally, a watershed-wide zone used to control pollutant loadings to the lake or reservoir as a whole.

A lake protection ordinance (LPO) is particularly critical around urban lakes, to guide how and where new development will occur. Historically, there has been limited guidance on how to craft an effective LPO that protects lake resources, maintains the quality of the recreational experience, and accommodates the property rights of landowners. Traditionally, most LPOs have primarily focused on a relatively narrow ring of land around the shoreline where development is most visible. However, given that lakes are so strongly influenced by runoff from their watersheds, they often need to be managed from a watershed perspective.

Key Factors to Consider in Lake Protection

Techniques for protecting lakes are markedly different from those used to protect streams. A watershed manager must account for nine factors that are unique to the ecology of lakes and the nature of development that occurs around them:

Shoreline development is a unique form of development.

Lake shorelines are a valuable piece of real estate, and command premium land prices. Purchasers often use these lots to build summer homes or cottages, and seek both good access to the water and an unobstructed view of the lake. Consequently, individual homes are oriented toward the lake. Over time, a ring of development is formed around the lake, with the greatest density of homes within 500 feet of the lake, and less density further away (Figure 1).

Lake shorelines also tend to be developed incrementally over time. It is rare that the lakefront is developed as a single subdivision (which would be much easier to regulate). Rather, shoreline development often happens on a “lot-by-lot” basis, whereby individual lakefront lots are sold and subdivided to build second homes or cottages, often on a custom basis. In addition, each home and its accessory structures tend to be continuously “improved” or expanded by successive owners, to meet their changing tastes and recreational needs. Consequently, an LPO should be written to provide continuous regulation of the shoreline development process.

Since lakefront property is so desirable, it is quite common to have intense lakefront development in otherwise lightly developed watersheds. This presents a real challenge for protecting lakes in rural areas, since these communities typically have limited staff and development review experience.

Techniques for protecting lakes are markedly different from those used to protect streams.

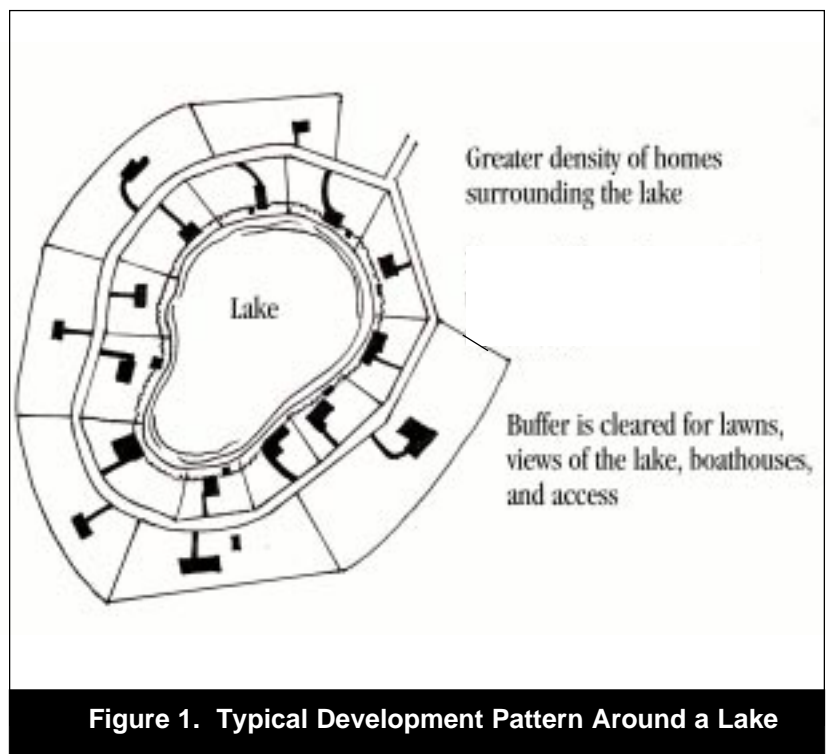


Figure 1. Typical Development Pattern Around a Lake

Lake protection focuses on phosphorus reduction.

An explicit goal of many LPOs is to maintain the trophic state of the lake, which usually means preventing or reducing phosphorus inputs. Most lakes are extremely sensitive to additional phosphorus inputs from future waterfront or watershed development. Consequently, the overall development density in these watersheds should generally be very low.

Shoreline buffers can be justified based on a common economic interest as much as an environmental one.

Lake managers have several tools to reduce phosphorus inputs from new development in a lake watershed. They include limits on the total amount of new development, shoreline and stream buffers, and the use of stormwater treatment practices designed to remove phosphorus from stormwater runoff. In

practice, most managers elect to use all of these tools, and to apply them across the entire watershed draining to the lake. In particular, stormwater treatment practices are often designed to achieve a specific target for phosphorus removal. The LPO often provides very specific instructions to engineers on which stormwater treatment practices to use, how much runoff they need to treat, and how they should be designed to promote greater phosphorus removal. A handful of communities have adopted stormwater performance criteria that call for no increase in phosphorus loading from new development sites (MDEP, 1992; Kitchell, this issue).

Importance of a natural shoreline.

The natural beauty of a lake's shoreline, with its ever-changing panorama of water, light and wildlife, is a prime attraction for lakefront development. Lake property owners as well as lake users consistently report that their primary use of the lake or reason for visiting is to view the scenery (Warbach *et al.*, 1990; Anderson *et al.*, 1998). This is why lakefront properties nearly always command a considerable premium in

terms of land prices. To the extent that a LPO will preserve the natural look of the shorelines, they can maintain or enhance the value of property (CBP, 1998). In one Maine case study, increased water clarity due to the addition of lake buffers increased property values by \$11 to \$200 per foot of shoreline property (Michael *et al.*, 1996). Consequently, shoreline buffers can be justified based on a common economic interest as much as an environmental one.



Direct influence of shoreline vegetation on fish and wildlife.

Natural shoreline vegetation has a direct influence on the ecological integrity of a lake, as it provides shade, leaf litter, woody debris, protection from erosion, and littoral habitat. These benefits are extensively reviewed in Engel and Pederson (1998), and selected research is profiled in Table 1.

Studies in a variety of lake settings have demonstrated a strong relationship between declining fish abundance or diversity and increasing shoreline development, as measured by several indices (Hinch and Collins, 1993; Hinch *et al.*, 1994; Bryan and Scarnecchia, 1992; Chick and McIvor, 1994). Fish foraging and spawning have also been shown to decline as a direct function of cottage or home density around the lakeshore (Engel and Pederson, 1998). Most fish species spend at least part of their lifecycle in the littoral zone of the shoreline. Emergent and submergent plants and coarse woody debris are critical habitat elements in the littoral zone, and each of these is highly vulnerable to shoreline development (Christensen *et al.*, 1995).

Many birds, such as eagles, loons and songbirds, tend to avoid developed lakes, and several researchers have noted that they depart at a relatively low rate of cottage development (Johnson and Brown, 1990; Voight and Broadfoot, 1995; Heimberger *et al.*, 1983). In some cases, the avoidance is due to a loss of nesting sites or perches to spot prey, while in others it reflects a lack of tolerance for noise or disturbance within or along the lakeshore. In contrast, some bird species favor a densely developed shoreline, such as mallards, geese and gulls.

Similar relationships have been discovered for amphibians and reptiles, which utilize the lakeshore to bask, feed, nest and overwinter (Engel and Pederson, 1998). Natural lakeshore habitat has also been found to be important for deer and other mammals (Buehler *et al.*, 1991). Conversely, many species suffer from increased predation and harassment by pets along more developed shorelines.

Intense pressures for shoreline improvement and clearing.

A lake shoreline is unique in that it remains under continuous pressure for shoreline "improvements" well after the initial development has been completed. Many lakefront property owners install docks, piers, stairs, gazebos, boathouses, boat ramps, bulkheads and other structures on or near the shoreline. At the same time, the forest buffer is under relentless pressure to be converted into a tidier lawn or an unobstructed view.

Figures 2 and 3 are examples of shoreline lots with unregulated and regulated “improvements.”

While the individual effect of each of these improvements is relatively minor, their cumulative impact on the integrity and attractiveness of a shoreline buffer can be severe. For example, a survey of users in a Minnesota lake found that a majority of the respondents felt that multiple shoreline structures and lawns had a negative impact on the lake (Warbach *et al.*, 1990).

When a person is on a lake, he wants to see a natural shoreline. Yet, when the same person is on the shore, he wants to see a lake. This can create a lot of pressure on the buffer, as property owners clear trees and remove vegetation to promote a better view of the lake. However, one individual’s quest for a better view of the lake diminishes the quality of the view for another. Thus, all property owners share a common interest in limiting clearing along the shoreline to screen their neighbors, while still getting at least a decent glimpse of the lake

themselves. Consequently, an LPO needs to carefully prescribe how and where view corridors can be created, and include realistic measures to inform land owners on what uses, structures and activities are restricted or prohibited in the shoreline buffer zone.

Recreational issues are paramount management concern.

Lakes that are actively used for fishing, boating, swimming and other forms of recreation require direct access to the shoreline and across the buffer. While some lakes do have public access and central facilities (such as boat ramps, swimming beaches, etc.), many do not. In these lakes, each waterfront owner creates his or her own recreational access. This can create an inherent conflict between the property owners and outside users of the lakes. Therefore, although the shoreline buffer usually remains in private ownership, it is important to address issues of both public and private recreational access in an LPO.

Table 1. Recent Research Documenting Ecological Benefits of Shoreline Buffers

Key Finding	Reference	Location
Coarse woody debris positively correlated with riparian tree density and negatively correlated with lakeshore cabin density	Christensen <i>et al.</i> , 1996	17 north temperate lakes in northern Wisconsin and the Upper Peninsula of Michigan
Less fish activity, less fish feeding, and increased wave disturbance in fringe zones adjacent to lawns versus undeveloped shorelines	Collins <i>et al.</i> , no date	2 sites on Lake Rosseau, Ontario, an oligotrophic lake
Increase in development and decrease in vegetative cover is correlated with decrease in lakeside populations of white-tailed deer	Voight and Broadfoot, 1995	Lake Muskoka, Ontario
Increase in development and decrease in vegetative cover is correlated with decrease in shoreline populations of nesting bald eagles	Buehler <i>et al.</i> , 1991	Chesapeake Bay Shorelines
Increase in development and decrease in vegetative cover is correlated with decrease in lakeside populations of loons	Heimberger <i>et al.</i> , 1983	Northern Ontario lake
Increase in development and decrease in vegetative cover is correlated with decrease in lakeside populations of songbirds	Johnson and Brown, 1990	Eastern Maine lake
Species richness and abundance of fish were greater along undeveloped shorelines versus developed shorelines in nearshore and intermediate depth zones	Bryan and Scarnecchia, 1992	Spirit Lake, Iowa 2266 hectare glacial lake
Decrease in plant cover from human activity is correlated with a decrease in fish abundance	Chick and McIvor, 1994	Lake Okeechobee, Florida
Decrease in plant cover from human activity is correlated with a decrease in fish abundance	Hinch and Collins, 1993	Ontario



Figure 2. Typical Shoreline With Unregulated "Improvements" (PZC, 1992)

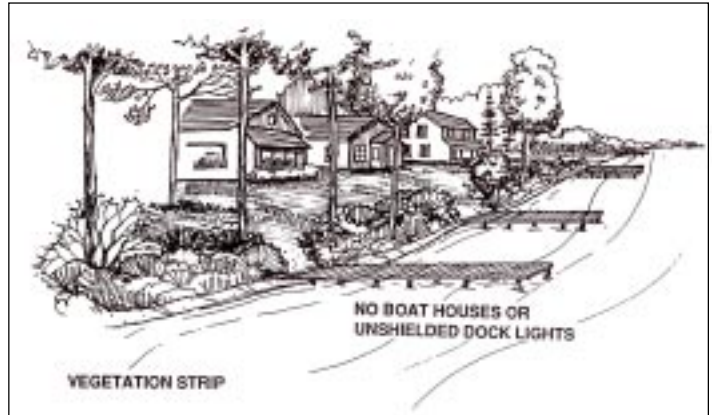


Figure 3. A Shoreline With Limited "Improvements" Is More Attractive and Ecologically Beneficial (PZC, 1992)

Recreational conflicts are not only confined to the shoreline buffer, but often extend into the lake itself. A recurring conflict involves whether or not motorized water craft will be allowed on the lake, either because of concerns over noise, safety, wakes or potential pollutant sources. Many water utilities restrict or prohibit motorized watercraft on water supply lakes, since two-stroke engines can be a significant source of hydrocarbons, lead and phosphorus to the lake. In recent years, conflicts have erupted over the noise, wakes and safety of personal watercraft, such as jet skis. Figure 4 is an example of how conflicts over lake recreational use can be managed by designating specific areas of the lake to each activity. Consequently, residents or local agencies may want to address these issues as part of the LPO or a lake management plan.

Prominence of septic systems.

Lakefront developments are often serviced by septic systems because of their seasonal use or distance from wastewater treatment plants. Because of their proximity to the lake, septic systems can become a potential source of subsurface phosphorus seepage to a lake. Indeed, many researchers have identified failing or poorly functioning waterfront septic systems as an important and controllable source of phosphorus and nitrogen in a wide range of lake systems (Harper, 1995; Childs *et al.*, 1974; Gilliam and Patmont, 1983; Grant, no date; Kerfoot and Skinner, 1981; Robertson and Harman, 1999; and Arnade, 1999). One of the primary functions of the shoreline buffer is to create distance from the leach field and the shoreline, thereby providing as much soil treatment as possible in such a confined area. Watershed-wide septic system regulations may also be a key element of an LPO, particularly in watersheds that have potentially high septic system density or unsuitable soils. More information about septic system impacts on lakes can be found in Swann (this issue).

Lake associations available for enforcement or education.

The lake and its shorelines are a classic case example of the "commons," where the actions of one user or owner can diminish the quality of life for another. Often lakefront property owners recognize that they share a common interest in some form of self-regulation. This has led to the formation of hundreds of lake associations across the country to promote better local lake management. In many lakes, these associations are similar to homeowners associations, in that they are self-governing and self-financing. As such, a lake association can play a pivotal role in education and enforcement of the LPO, through legally binding covenants on individual properties. The North American Lake Management Society (NALMS) has excellent materials on its website on how to establish a new lake management association or energize an older one (www.nalms.org). Lake associations are particularly valuable in educating shoreline landowners about LPO provisions that directly affect them.

Lake protection ordinances must be customized for unique lake conditions and water quality goals.

While this article presents an overall framework for crafting an LPO, it is important to keep in mind that the actual details of each ordinance will differ for every lake. For example, more stringent criteria are often applied to lakes that are a primary water supply, as compared to a reservoir used for recreation or flood control. Similarly, managers will usually adopt more stringent criteria in order to maintain the character of a phosphorus-sensitive lake in a wilderness setting, as compared to a highly eutrophic lake in a more urban setting. In some lakes, the LPO is primarily used to regulate competing recreational or shoreline interests, while others may be driven more by the need to reduce phosphorus loads.

In nearly all lakes, the ability to achieve management goals for a lake is heavily influenced by the amount and type of prior development along the shoreline or within the watershed. Thus, lake managers should engage both lake users and watershed residents to set realistic goals for lake protection very early in the ordinance process. In addition, communities that have many lakes and reservoirs may want to classify them in order to manage them better. An example is the state of Minnesota's lake classification system shown in Table 2.

The Four Zones of Lake Protection

The four primary zones of lake protection are the shoreline, shoreline buffer, shoreland protection area, and the lake's contributing watershed (see Figure 5). The development criteria within each of the four zones are often different and include the following:

1. Zone geometry
2. Vegetative target
3. Allowable uses
4. Restricted uses
5. Septic system siting
6. Stormwater treatment practice design
7. Residential lot design requirements
8. Zoning
9. Enforcement
10. Education

The key development criteria for the four zones of an LPO are compared in a condensed fashion in Table 3.

In general, the four-zone approach to lake protection is most restrictive at the shoreline, and is more flexible as one progresses further up into the watershed. Greater detail on the key criteria for a lake protection ordinance is provided in the following pages.

Zone 1: Shoreline

The shoreline begins as the point where the mean high water mark meets the land. Given the importance of the shoreline to lake ecology and screening, it is essential that this zone be retained in a natural state, with minimal disturbance of native vegetation. A common approach to manage the shoreline is to require shoreline permits for any activity that modifies, alters, clears or otherwise disturbs the natural shoreline. Permits, which can be required by a local or state agency, place limits on tree clearing, bulkheading and rip-rapping. Exceptions may be granted to clear small

Table 2. Example of Lake Classification System (Bernthal and Jones, 1998)

Lake Class	acres water per shoreline mile	# homes per shoreline mile	lake depth
Natural Environment	< 60	< 3	<15 feet
Recreational Development	60 - 225	3 - 25	> 15 feet
General Development	> 225	> 25	> 15 feet

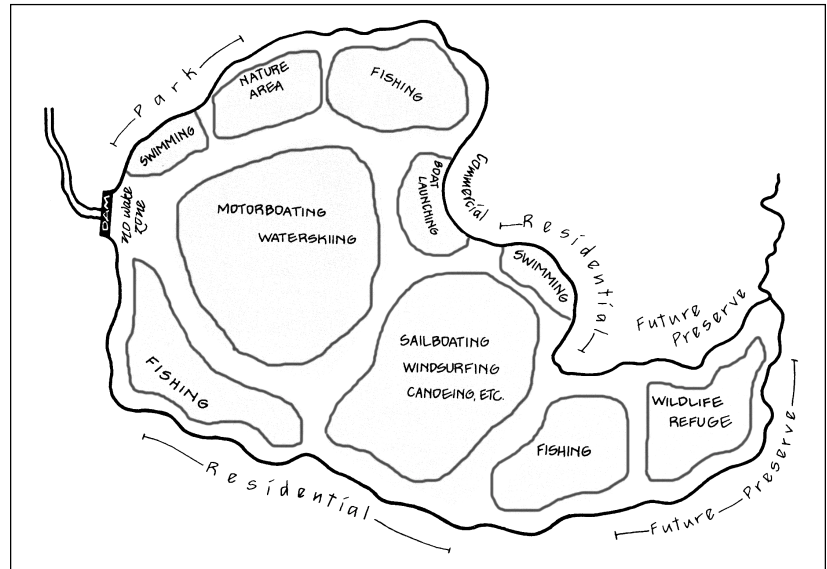


Figure 4. A Lake Use Plan Can Resolve Conflict Over Recreational Use (NIPC, 1995)

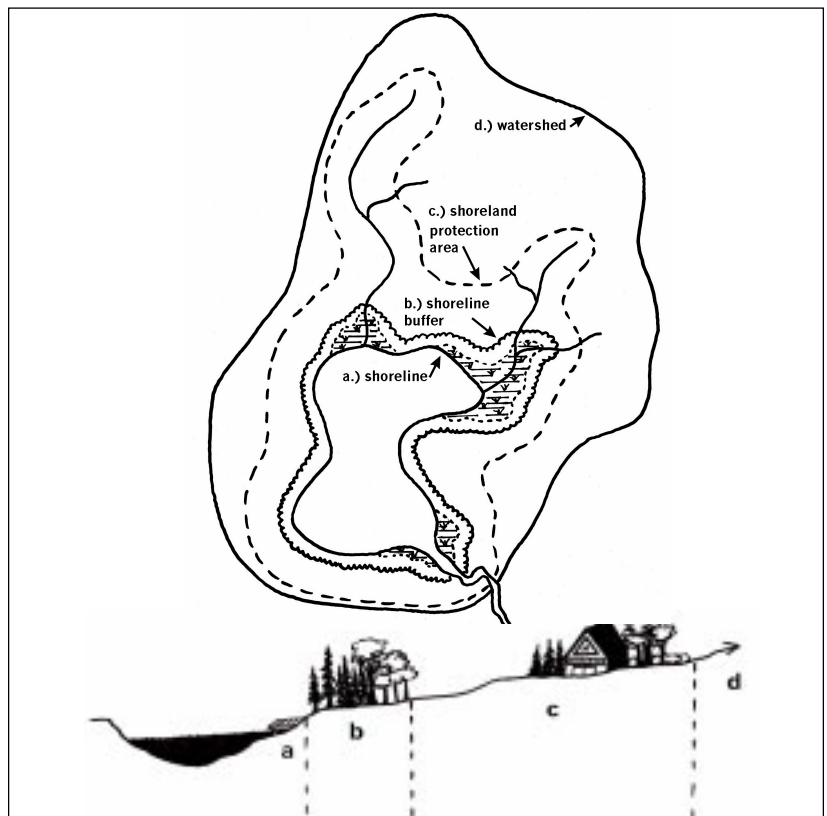


Figure 5. The Four Zones of Lake Protection

areas for allowable uses, as defined later. The permit process should require the applicant to demonstrate that natural methods of shoreline stabilization, such as bioengineering, are not feasible before retaining walls, riprap or bulkheads are allowed to stabilize the shoreline. Some communities may also specify low or no wake areas, set boat speed limits and exclude motorized watercraft in their LPOs in order to prevent shoreline erosion (Standing *et al.*, 1997).

Allowable Uses

Most communities allow minor alterations along the shoreline to provide reasonable access and recreational use. For example, most typically allow only one pier or dock on each frontage lot, along with a limitation on its total length and extension into the lake (50 feet is common; Standing *et al.*, 1997). This provision prevents the proliferation of docks from detracting from the scenic character of the natural shoreline. Most communities also permit a single stairway or ramp down to the water, but may restrict its

Table 3. Development Criteria for the Four Zones of an LPO

Criteria:	Shoreline	Shoreline Buffer	Shoreland Protection Area	Watershed
Defined as:	high water mark (HWM)	50 to 150 feet from HWM, 300 feet for source water	250 to 1000 feet from HWM	divide of contributing watershed
Vegetation target for the zone	maintain natural shoreline, no disturbance without permit	forest or native vegetation, maximum view corridor of 30 feet	maximum clearing limits on individual lots of 25 to 50%	forested buffers for tributary streams
Allowable Uses	Bioengineering, 1 pier or dock per frontage, 1 stairway	walkways, boathouses within the view corridor	residential homes, septic systems	most are allowed
Restricted Uses	boathouses and other accessory structures, rip rap, bulkheads	no permanent structures, no impervious cover or other land disturbing activity	commercial or industrial zones, uses with hazmat spill risk	uses with hazmat spill risk
Septic Systems	n/a	not allowed	setback 100 to 200 feet from HWM	design, feasibility or inspection criteria to reduce failure
Stormwater	no new pipe outfalls to lake	no stormwater practices allowed (except for practices at boat launching)	presumed to be achieved by environmentally sensitive site design	stormwater treatment practices required to remove target phosphorus levels
Lot Requirements	n/a	n/a	minimum lot size, minimum frontage, max impervious cover, limit rooftop runoff	open space subdivisions and better site design to reduce impervious cover
Zoning	establish requirements and density in a lake protection overlay district or a comprehensive plan			
Enforcement	local or state permit	local development review process		
Education	lake association and/or resource agency			lake association or watershed organization

width to six feet or less. Normally, pre-existing structures are exempted from the shoreline permit process, but they may not be significantly expanded without one (Bernthal and Jones, 1998).

Restricted Uses

Many communities prohibit tree clearing or grading along the shoreline, although individual trees can be removed for safety purposes. Boathouses and other accessory structures are generally prohibited within the narrow shoreline zone. In addition, no new storm-water outfalls should be allowed that discharge to the shoreline.

Zone 2: Shoreline Buffer

When natural shoreline buffers are maintained, they protect the integrity of the shoreline, provide habitat for wildlife and fish, reduce the likelihood of erosion, and help to reduce runoff and pollutant loads (Engel and Pederson, 1998; Wenger, 1999; Fuller, 1995). In addition, natural shoreline buffers support the aesthetic and recreational values that make lakefront development so desirable and economically attractive. Natural shoreline buffers also protect the physical and ecological integrity of lakes by providing shade, leaf litter, woody debris, erosion protection, and habitat.

A common base width for a shoreline buffer is 75 feet (Heraty, 1993), although widths typically range from 50 to 150 feet. If a lake is used as a source of drinking water or is very pristine, buffer widths of 200 to 300 feet are often used (RICRMC, 1994; Standing *et al.*, 1997; Kitchell, this issue). The base width of a shoreline buffer should be expanded to include steep slopes or wetlands, or contracted when pre-existing

development is located close to the shoreline. Some communities set the base width of the shoreline buffer based on the surface area of the individual lake, and require wider buffers around their larger lakes. Most communities now clearly prescribe how the buffer will be delineated within the LPO. For natural lakes, the natural mean high water level is a good benchmark, whereas the water line at "full pond" is often used for reservoirs.

Vegetation Management

The vegetative target for the shoreline buffer is mature forest or native vegetation. This may involve actively re-vegetating areas or letting them gradually return to their natural state. Depending on the region, the natural state will not always be a forest. The use of native plants within the buffer usually requires less maintenance, and these plants are easier to establish. Some communities set specific restoration goals for the shoreline buffer. For example, New Hampshire requires that a plan be submitted that describes the species, number, and basal area of trees proposed for replanting a natural woodland buffer (Springs, 1999).

Tree clearing for view corridors or access trails is inevitable, so many LPOs do allow for some clearing, or have guidelines for thinning or removing of dead trees. For example, Rhode Island Coastal Zone Buffer Program and Maine Shoreland Protection Standards indicate that shoreline access paths can be no more than six feet wide and follow a winding path that does not promote erosion (see Figure 6).

In addition, clearing for a view corridor is generally limited to no more than 25% of the length of the shoreline for residential lots of two acres or less (RICRMC, 1994). Other communities have opted for a more operational criteria, allowing a single view corridor per lot, and no opening greater than 250 square feet in the forest canopy

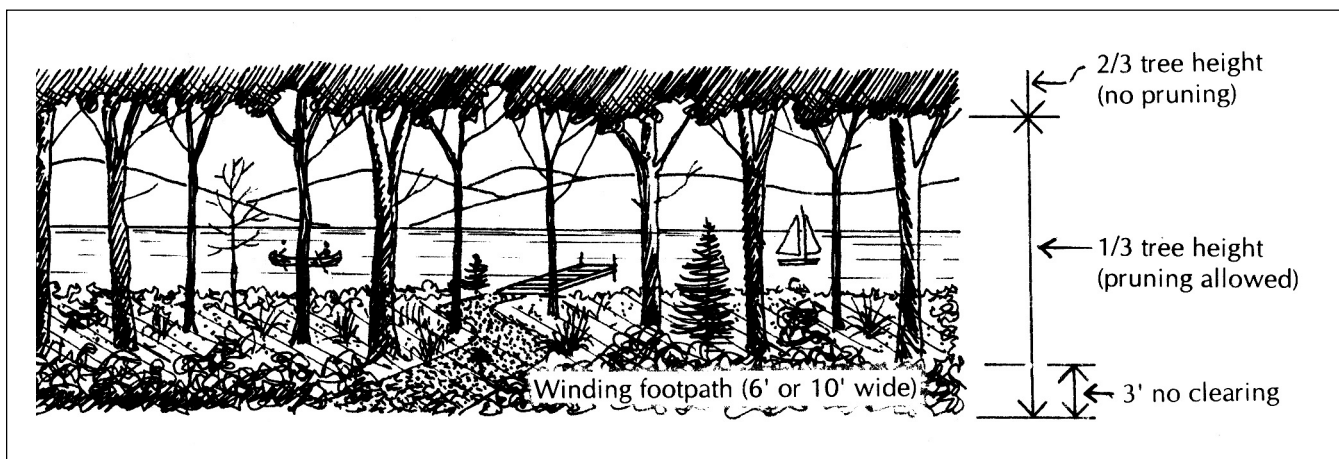


Figure 6. Example of Guidelines for Vegetation Thinning in the Shoreline Buffer for View Corridors and Footpaths (Illustration by Brian Kent)

as measured from the outer limits of the tree crown (MDEP, 1999). Still others allow clearing of no more than 40% of the basal area of trees within 100 feet of the shoreline (Bernthal and Jones, 1998).

Allowable Uses

Allowable uses in the shoreline buffer should be limited to clearing for shoreline access paths and view corridors. Many communities also permit trails and passive recreation within the buffer zone. In addition, boathouses and other accessory structures may be allowed within the buffer, but must be set back at least 25 feet from the shoreline. Some shoreline zoning ordinances also place limits on the number and square foot area of boathouses and other structures

(Bernthal and Jones, 1998). An exemption is usually provided for public recreation facilities such as boat ramps and public beaches. Careful planning is needed to develop public facilities in a manner that minimizes clearing of the shoreline. In some cases, stormwater practices such as perimeter sand filters can be installed to treat direct runoff from boat ramps and associated parking lots.

Restricted Uses

Many land uses and activities are restricted or excluded from the shoreline buffer zone. These include paved surfaces, primary structures, grading, pesticide application, mowing, motorized vehicles, or any other activity that causes soil disturbance or contributes to pollution. In addition, septic tanks and drain fields are excluded from the shoreline buffer, and often must be set back an even greater distance into the shoreland protection zone.

Stormwater Treatment

The natural vegetation of the shoreline buffer acts to slow down and spread out runoff and promotes infiltration in the soil, thereby reducing the need to treat the quality of stormwater runoff. In this sense, the natural shoreline buffer is the last line of defense for treating stormwater. More importantly, stormwater treatment practices designed to treat stormwater from upland sources should not be located within the buffer. Many communities also prescribe that no new pipes or channels be constructed to convey stormwater across the shoreline buffer (i.e., sheetflow conditions must be maintained).

Enforcement and Education

The LPO should specify who is responsible for enforcing and managing the shoreline buffer during and after construction. A lake association can be a good candidate to perform this role, since the shoreline buffer often falls within the boundaries of most lake associations. In addition, lake associations may have the authority to extend covenants from their members to establish shoreline buffers on existing waterfront lots that otherwise might be grandfathered. The North American Lake Management Society publishes several useful lake management references (www.nalms.org). The Terrene Institute also publishes *The Lake Pocket Book* as a useful guide.

Regardless of whether the shoreline buffer is enforced by a lake association or a local agency, it is important that the LPO contain provisions to notify owners and contractors about the boundaries and restrictions of the buffer. Some useful techniques include marking buffer boundaries with permanent signs that describe allowable uses; clearly delimiting the buffer boundaries on all construction plans, maps, deeds and property surveys; and verifying that new owners are fully informed about uses/limits when waterfront property is sold.

The LPO should contain a series of progressively tougher enforcement actions for owners and contractors who violate the provisions of the buffer, beginning with a notice of violation with time to correct. If these administrative remedies fail, then fines, property liens, stop work orders, restoration liability and other sanctions should be available.

Enforcement measures can and will create needless conflict with many waterfront owners if they are not accompanied by strong and continuous programs to educate residents about the value of shoreline buffers, and the limits that they impose on their land. Lake managers should strive to reach every landowner with a mailing, meeting or visit to ensure they understand the rules. The enforcement agency can directly educate owners during annual buffer walks to check on encroachment, and provide information on how residents can become better stewards through reforestation and shoreline bufferscaping programs. Lake managers should strive to integrate buffer education with other water quality and recreation messages they want to deliver, whether they are boating or fishing regulations, septic system cleanouts or lake management issues. Waterfront owners may also want to know about techniques to slow the spread of invasive species such as zebra mussels and Eurasian water milfoil, which are an increasing problem in many lakes (Klessig *et al.*, 1993). Techniques to prevent the spread of invasive species may include boat cleaning or boat pumpout facilities at centralized locations.

The LPO should specify who is responsible for enforcing and maintaining the shoreline buffer.

Zone 3: Shoreland Protection Area

The shoreland protection area extends beyond the shoreline buffer and is primarily intended to regulate the geometry and nature of development on lots adjacent to a lake. In a way, the shoreland protection area is a special overlay zone for residential development, and includes various setbacks, impervious cover limits and forest conservation requirements.

The width for a shoreland protection area typically ranges from 250 to 1,000 feet, as measured from the shoreline. The state of Minnesota has a similar zone where shoreland standards apply to all land within 1,000 feet of the lake (ILCC, 1996). The actual width depends on the underlying lot size or zoning category in the area. In general, as lot size increases, the width of the shoreland protection area increases. At a minimum, the shoreland protection area should extend at least two lot lengths outward from the lake. Often, the exact boundaries of the shoreland protection area are expanded to account for bluffs, wetlands, steep slopes, erodible soils, or other sensitive natural features around the lake.

Vegetation

Since development will occur in the shoreland protection area, vegetative targets are much less restrictive than along the shoreline or in the shoreline buffer zones. Maximum clearing limits are imposed in this zone to keep the building footprints as small as possible and conserve natural areas. A typical example is prescribed under the Maine Shoreland Zoning guide-

lines, which limit clearing during construction to no more than 25% of total lot area or 10,000 square feet, whichever is less (MDEP, 1999, see Figure 7). In Waupaca County, Wisconsin, no more than 50% of each shoreland lot or 25,000 square feet, whichever is less, may be disturbed for residential or commercial construction (Standing *et al.*, 1997).

Restricted Uses

A primary reason for establishing the shoreland protection area as a zoning district is to exclude or set back uses or activities that have the potential to degrade the water quality of the lake or detract from its scenic character. Consequently, a long list of uses and activities are often excluded from the shoreland protection area.

Examples of land uses that are frequently considered to be non-conforming include livestock operations; facilities that generate, store or dispose of hazardous materials; landfills; junkyards; surface discharges from sewage treatment plants; golf courses (unless they have an approved integrated pest management plan); above or below ground storage tanks; stormwater hotspots (MDE, 2000); and non-residential roads.

In addition, most communities consider the shoreland protection area to be an exclusively residential zone, with exceptions for water-dependent operations (such as boat launching areas, private campgrounds, and the like). Consequently, industrial, commercial, or institutional developments are often excluded from this zone, particularly if the lake is a primary drinking water supply.

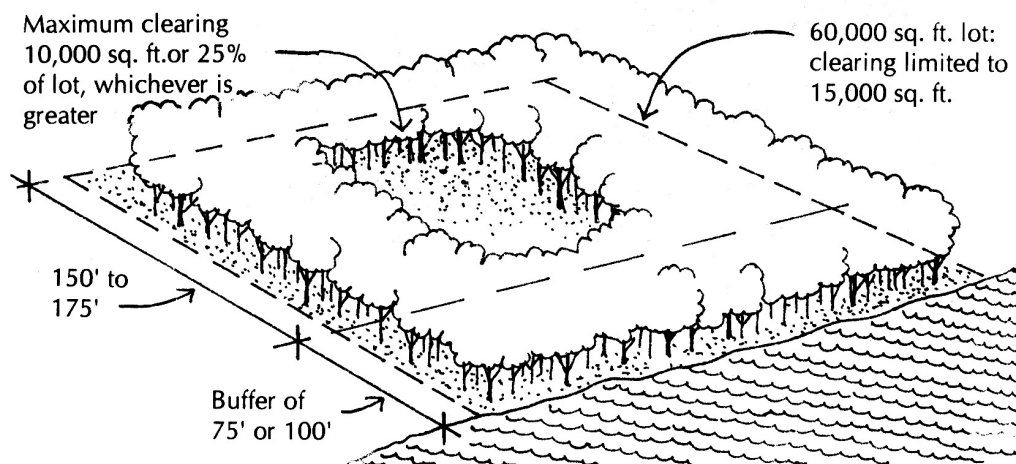


Figure 7. An Example of Limits on Clearing for a Shoreline Lot (Illustration by Brian Kent)

Shoreland protection areas frequently require setbacks, the most common being a 100 to 200 foot setback for septic tanks and drain fields, as measured from the shoreline. From a practical standpoint, this means that septic systems need to be located well beyond the outward boundary of the shoreline buffer. Figure 8 illustrates this concept.

Setbacks for septic systems may vary depending on the lake's use and watershed characteristics. For example, the state of Virginia requires a 100 foot septic system setback from a stream; New Hampshire requires a 125 foot septic system setback for areas with porous soils; the New York City reservoir system has a 300 foot setback for absorption fields, and a 500 foot setback for septic systems; and the state of Maine prohibits septic systems in Resource Protection Districts (CWP, 1995a; Spring, 1999; NRC, 2000; MDEP, 1999).

It is very difficult to effectively treat the quality of stormwater runoff within the shoreland protection area with conventional stormwater practices.

A few LPOs regulate the use of fertilizer or pesticides in the shoreland protection area. For example, the New Hampshire Comprehensive Shoreline Protection Act limits the use of any fertilizer in protected areas, and limits fertilizer use outside these areas to low phosphate, slow release nitrogen fertilizer or limestone (Springs, 1999). In other watersheds, the use of pesticides is prohibited in this zone. For example, the herbicide atrazine may not be applied within 200 feet of natural lakes or reservoirs in the New York City reservoir watersheds (NRC, 2000). While these restrictions are admirable from an environmental standpoint, they are often difficult or impossible to enforce with individual property owners.

Environmentally-Sensitive Shoreland Design

In practice, it is very difficult to effectively treat the quality of stormwater runoff generated by development within the shoreland protection area with conventional stormwater practices such as ponds, wetlands, or filters. Constraints such as the proximity to the lake, small

drainage area, poor conveyance and the need to stay out of the shoreline buffer make it a major challenge to engineer treatment practices in the zone. Therefore, the stormwater strategy in the shoreland protection area is to minimize the creation and concentration of stormwater runoff through environmentally sensitive shoreland development techniques. These development techniques include site fingerprinting, impervious cover limits, minimum lot sizes and natural conveyance. As a practical matter, then, stormwater treatment is achieved through site design requirements within the shoreland protection area. Lots that meet the design requirements are presumed to automatically comply with any stormwater requirements. Figure 9 illustrates how environmentally sensitive shoreland design can be applied in a typical lakefront residential lot.

Environmentally sensitive shoreland design techniques for residential lots include the following:

Minimum Lot Sizes and Minimum Shoreline Frontages

Since the shoreline is a finite resource, many communities have sought to limit the intensity of lakefront development through minimum lot sizes and shoreline frontage distances. Minimum lot sizes tend to range from slightly less than one acre to five acres or more. For Maine lakes, minimum lot size for residential development in the shoreland zone is 60,000 square feet, with a corresponding minimum shoreline frontage of 300 feet (MDEP, 1999), while Minnesota lots adjacent to Natural Environment lakes have a minimum lot size of 80,000 square feet (Bernthal and Jones, 1998). Once again, lakes or reservoirs that are a primary source of drinking water or undeveloped lakes that are being protected because of their natural beauty tend to use very large lot zoning typically greater than five acres (Standing, 1997; Kitchell, 2001, this issue).

A Maximum Limit for Impervious Cover on the Lot

The LPO often specifies a maximum amount of imperviousness for the shoreland zone. We generally recommend a 10 to 15% as an impervious cover limit

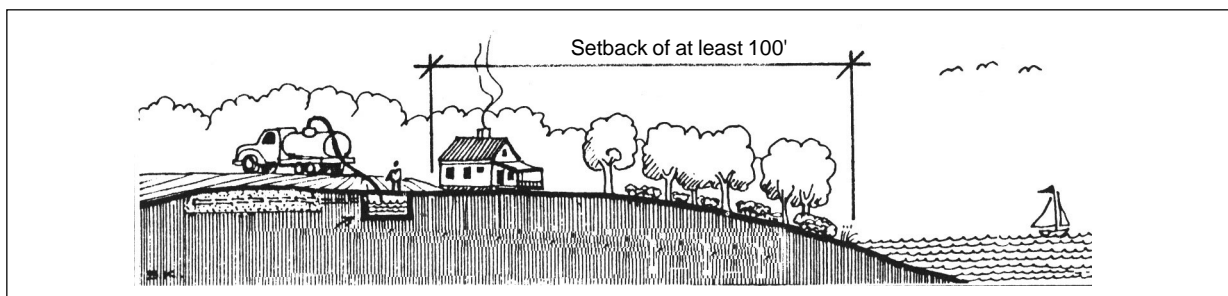


Figure 8. A Septic System Setback in Relation to the Shoreline Buffer (Illustration by Brian Kent)

for residential lots in the shoreland protection area. However, this percentage can vary depending on land use, lot size, and the desired level of development around a lake. For example, Shawano County, Wisconsin has a limit of 8% impervious cover on lots within 300 feet of the lake's ordinary high water mark (Standing, 1997), while the state of New Hampshire has a 20% impervious cover limit for alternative developments such as PUDs, which incorporate residential and commercial areas in a planned community (Bernthal and Jones, 1998).

Site Fingerprinting

Many communities specify that a minimum fraction of the lot be conserved in natural cover, and mandate that the lot cannot be cleared or otherwise disturbed during site construction, nor converted to lawn afterwards. Normally, area that must be conserved includes the shoreline buffer and additional areas within the shoreland protection area. For the lot as a whole, the target for natural cover conservation will vary according to zoning category, but typically ranges from 40% to 75%. Figures 10 and 11 contrast conventional and alternative techniques for clearing a site for development.

Grading Limits

Any grading at the site should promote sheetflow, and avoid concentrating runoff. Often, driveways comprise much of the grading in the shoreland protection zone. In this respect, driveways should be graded to follow contours and avoid the need for ditches. Otherwise, driveways should be constructed of more permeable material, such as river rock, blue stone, gravel or grass pavers. If the lot has a slope greater than 10%, or is less than one acre in size, berms, depressions or terraces may be required to capture runoff and encourage infiltration at the outer boundary of the shoreline buffer.

Rooftop Disconnection

Residential rooftop runoff can be easily disconnected and conveyed as sheetflow across vegetated areas or into the buffer. In practical terms, this means that downspouts should not be connected to any conveyance system. If soils are not suitable, then dry wells,

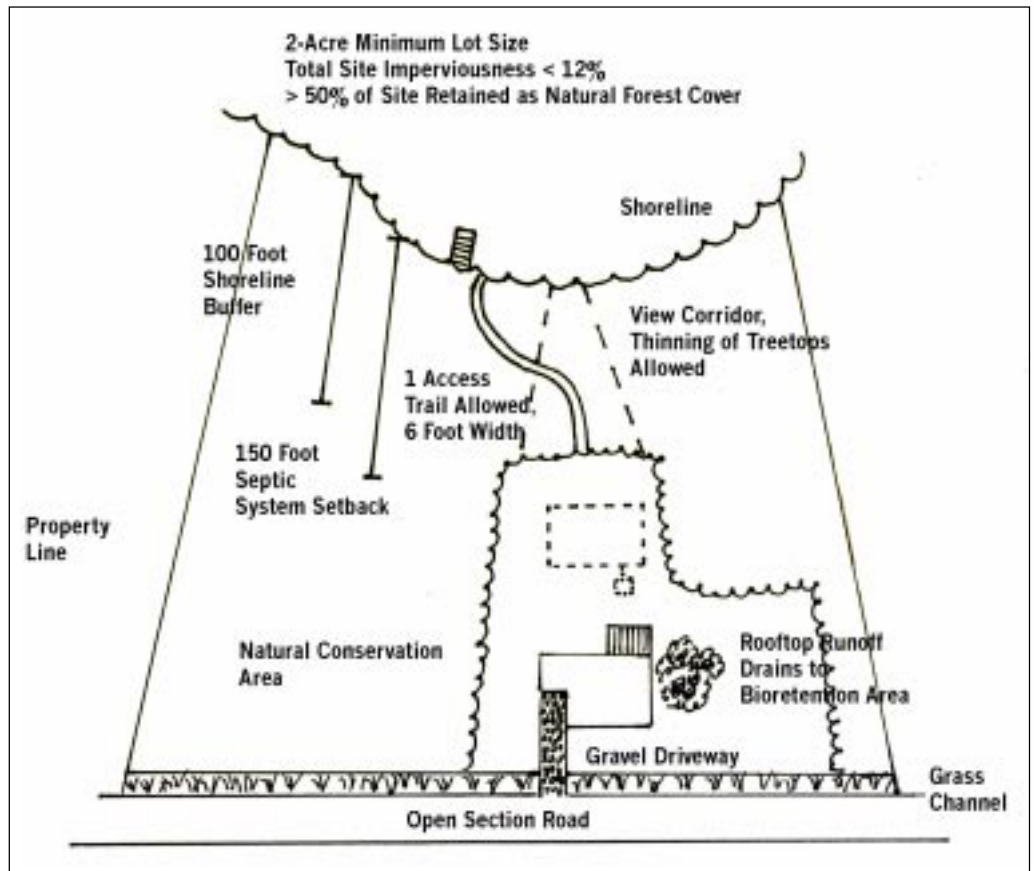


Figure 9. Example of Environmentally Sensitive Design for a Residential Shoreline Lot

french drains or rain barrels can be used to store rooftop runoff. Figure 12 illustrates how to use a rain barrel to store rooftop runoff.

Limitations on Back Lot Development

Lake managers constantly struggle with the issue of backlot development, which drives up the overall density of shoreline development. Backlot development allows off-water lots to share a narrow strip of waterfront land that provides access to the water. This often results in over-development of the lakeshore to accommodate docks and access points for a large number of people. Several zoning techniques can limit backlot development. First, zoning regulations can prohibit the development of shore lots with more than one owner or establish limits on the number of off-water lots served by one access lot (Standing, 1997). Alternatively, minimum lot sizes can be established for off-water lots by extending the width of the shoreland protection area further from the lake. Figure 13 illustrates the backlot or "keyhole" development concept.

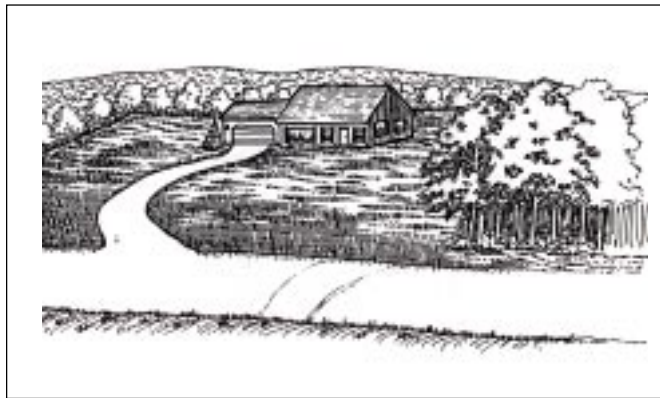


Figure 10. Conventional Clearing and Grading Techniques Leave the Majority of This Residential Lot Bare (PZC, 1992)



Figure 11. Site Fingerprinting Was Used on This Residential Lot to Reduce Clearing and Preserve Trees (PZC, 1992)

Zone 4: Watershed

Establishing shoreline buffer zones may not always be enough to protect a lake from the impact of land development, particularly if it is sensitive to increased phosphorus inputs. If significant land development is expected in a lake watershed, the LPO must be designed to create a fourth management zone that encompasses the watershed as a whole.

From a watershed perspective, it may be necessary to control all sources of phosphorus to the lake in order to meet water quality goals. In this case, the LPO should define how and where the eight tools of watershed protection should be applied (CWP, 1998). Often, this may require a watershed plan that estimates current and future impervious cover, and investigates major (and controllable) phosphorus sources. Still, some generalizations can be made on how the eight tools can be applied to protect lakes, as discussed in the following paragraphs.

Watershed Zoning/Land Use Planning

Given the current limits of stormwater treatment described by Caraco (this issue), it is evident that the water quality of many lakes can only be maintained if limits are set on the cumulative amount of watershed development. While the exact development threshold often depends on the combined geometry of each individual lake and its watershed, most lakes can sustain only a rather low density of development, as measured by indicators such as impervious cover or lot size. The notion that a carrying capacity for development exists for many lakes has long been advanced by many limnologists (Wetzel, 1975; Wetzel, 1990; Vollenweider, 1968 and 1975).

Consequently, one of the first tasks of a lake manager is to compute current and future phosphorus budgets for the watershed as a whole. These budgets help determine how much extra phosphorus load can be expected in the future, and how much this load can be reduced by stormwater treatment practices in the watershed. If the budget indicates that phosphorus loads will still exceed desired targets even if stormwater treatment practices are widely applied across the watershed, then additional land use controls may be needed. Lake managers have typically relied on three complementary land use strategies to minimize development density in lake watersheds.

Large-lot Zoning

Residential land in the watershed is often zoned for large-lot development, with minimum lot sizes of one, two, five or even 20 acres. The basic reasoning is that large lots have comparatively low impervious cover, even if it spreads development over a potentially greater area than would otherwise occur. In addition, communities may allow developers the option to cluster development within these large lot zones, if shared septic systems are allowed.

Land Use Exclusion

Commercial and industrial zones are often minimized or excluded from the watershed in order to minimize spill risk, and to reduce impervious cover. Often these zones are not feasible for development if a community elects not to extend sewer into the watershed, given the larger volumes of wastewater that they generate.

Reliance on Septic Systems

Communities often choose to rely on septic systems for wastewater disposal within lake watersheds for two reasons. First, most communities find that it is not economical to service large lot development with sewers. Second, the presence of sewers can often induce more development density than originally intended. Therefore, a lack of sewer capacity acts as a secondary growth control, and can reduce pressures to rezone land to a higher density in the future.

While these land use strategies have been widely applied, they may not be appropriate for every lake watershed. For example, it may not be desirable to extend large lot zoning or exclude commercial development when a lake has a very large watershed, or has already experienced a great deal of past development. The strategy can also backfire if unsuitable soils or site conditions make widespread septic system failure likely, or if the community has no capacity to inspect and manage septic systems over time. These situations call for a more sophisticated land use strategy that may involve down-zoning, transferable development rights, or watershed-based zoning (CWP, 1998).

Another important component of zoning is a careful assessment of existing water pollution hazards in the watershed, with a strong emphasis on land uses or activities that may pose a risk of spills or accidental discharges. In particular, the potential risk of spills from existing or planned roadways should be assessed, and contingency response plans prepared.

Land Conservation

Land conservation is a critical tool for limiting where land development takes place in a lake watershed. Many communities have secured easements or acquired land in the watershed for the express purpose of lake protection. Generally, shorelines, shoreline buffers, and tributary streams are the key land acquisition priorities, although large wetlands and public access areas may also be preferred.

Stream Buffers

Stream buffers are an integral part of any watershed protection strategy, and an LPO should strongly recommend establishing them throughout the watershed. The buffer should apply to all perennial streams that drain to the lake. The basic design of stream buffers is described in Schueler (1995), and model ordinances can be found at the Stormwater Manager's Resource Center (www.stormwatercenter.net). In some cases, stream buffers in lake watersheds have a variable width depending on the distance of the stream from the primary water intake. A good example of this concept

can be found in Georgia's reservoir protection standards, which require a 150 foot buffer around the reservoir, a 100 foot buffer along streams within a seven mile radius of the reservoir, and a 50 foot buffer along streams outside the seven mile radius for watersheds less than 100 square miles (Burnett and Ashley, 1992).

Better Site Design

Communities may also want to encourage open space designs for residential subdivisions located outside of the shoreland protection area, since clustering has been shown to reduce the phosphorus loadings (Zielinski, 2000). Narrower road standards and the use of roadside swales are also particularly appropriate in most lake watersheds.



Figure 12. Rooftop Runoff is Collected in a Rain Barrel and Stored for Later Use

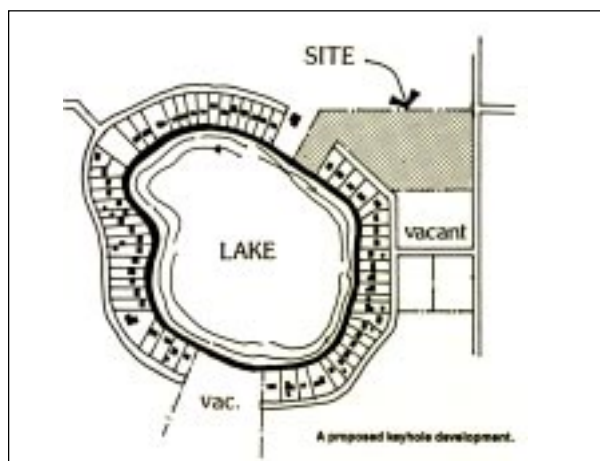


Figure 13. An Example of a "Keyhole" or Backlot Development (Warbach et al., 1990)

Erosion and Sediment Control

Lakes are especially vulnerable to the impacts of sedimentation and turbidity generated from upstream construction sites.

Lakes are especially vulnerable to the impacts of sedimentation and turbidity generated from upstream construction sites. Consequently, erosion and sediment control (ESC) plans are normally required at new development sites in lake watersheds. ESC requirements need to be adjusted to reflect the prevailing development conditions around lakes. For example, if most of

the development will be constructed on large lots or by individual contractors working on a single lot, it may be important to have both a low area threshold for triggering ESC plans, as well as a simple checklist approach for preparing ESC plans for individual lots.

Stormwater Treatment Practices

Stormwater treatment practices in the watershed are often designed to achieve a specific target for phosphorus removal. Local ordinance and design manuals often give very specific instructions to engineers on what stormwater treatment practices to use, how much runoff they need to treat, and how they should be designed to promote greater phosphorus removal. Depending on the phosphorus sensitivity of the lake and the amount of future development forecasted, lake managers may elect to establish specific stormwater phosphorus removal targets in the LPO.

A number of communities have adopted stormwater performance criteria that set forth specific phosphorus load reductions from new development sites. Typically, they require an engineer to calculate the phosphorus load before and after the site is developed, and then design a stormwater treatment system that can eliminate the difference (MDEP, 1992; Kitchell, this issue). Most communities prescribe the Simple Method (Schueler,

1987) to compute post development loads, and provide tables that indicate the estimated phosphorus removal capability associated with each practice (see Caraco, this issue). Depending on the site, the engineer may need to choose a stormwater practice with a higher phosphorus removal capability, reduce the impervious cover of the site, capture a greater volume of stormwater runoff, or install more than one practice on the site. If a designer still cannot meet their phosphorus load reduction target, they may have the option of providing an offset or a fee in-lieu for phosphorus reduction elsewhere in the watershed.

Wastewater Discharges in Lake Watersheds

Communities are often sharply divided on how to manage and dispose of wastewater in lake watersheds, given that treated wastewater is often a major component of a lake's phosphorus budget. Most have adopted one of three broad strategies to manage wastewater, depending on the degree to which they wish to limit development and their confidence in septic systems:

Reliance on Septic Systems

This strategy prohibits any surface discharges of treated wastewater within a lake watershed, and relies instead on septic systems to dispose of wastewater on individual sites. The strategy is frequently employed in drinking water reservoirs and to maintain low residential density in other lake watersheds. The success of this strategy requires effective phosphorus removal by septic systems, which in turn may require stringent requirements throughout the watershed, particularly if the overall density of tanks is high (Swann, this issue). Regulations in the watershed typically establish criteria for soil suitability, minimum lot size and drainfield area and a greater shoreline setback from the lake during initial construction. Of equal importance is the establishment of a management authority to inspect, maintain and rehabilitate septic systems after they are built.

Limited Sewer Relief

Failing septic systems are sometimes found to be a major water quality problem along the shoreline, and a common remedy is to extend a sewer to connect to clusters of failing units. Sewers may also be needed to accommodate denser development elsewhere in the watershed. In either case, while wastewater is collected by sewers, it is pumped out of the lake watershed for subsequent treatment and discharge.



Reliance on Sewer

In some watersheds, communities have had such poor experience with septic systems that they rely instead on sewers to dispose of wastewater. Often, these communities are concerned with bacteria and phosphorus discharges from failing septic systems or package plants, or have large areas of the watershed that are simply not suitable for septic treatment. Some communities pump the sewage out of the watershed for treatment, while others rely on advanced wastewater treatment within the watershed.

In phosphorus-sensitive lakes, it is important to deal with all sources of phosphorus in the watershed. Many developing watersheds still have active agricultural operations that can contribute significant nonpoint phosphorus loads. Consequently, lake managers should carefully evaluate agricultural sources, such as row crops, confined animal feeding operations, dairies, hobby farms and grazing livestock, and cooperate with farmers and ranchers to implement needed best management practices.

Watershed Stewardship

The watershed is often the best scale at which to perform public education and outreach. In lake watersheds, the outreach effort strives to meet two broad objectives. The first objective is to create an awareness among all watershed residents that they are connected to the lake downstream. Once residents become more connected to the lake, the next objective is to educate them about specific ways they can have a positive influence on lake quality through their daily actions. These include activities such as lawn fertilization, car washing, septic cleanouts, fall leaf disposal, and pet waste disposal (CWP, 2000). Indeed, many of the most

progressive watershed education programs have been created for lake watersheds. Examples include Lake Sammamish, Washington, and Lake Harriet, Minnesota (PCP, 1998; MDA, 1998). Figure 14 shows a graphic used on a billboard for the Lake Harriet Watershed Awareness Project.

Lawn care has traditionally been the primary focus of many lake education efforts, which is not surprising given the potential phosphorus inputs from careless fertilization (CWP, 1995b). A handful of communities have gone as far as to place restrictions on the use of fertilizer/pesticide applications throughout the watershed (Springs, 1999; NRC, 2000). Other communities promote fertilizer formulations that do not include phosphorus. Most communities have stressed direct technical assistance to homeowners on how to reduce or eliminate the use of fertilizer and pesticides. Several excellent fact sheets have been developed to educate lake residents about environmentally friendly shoreline landscaping techniques (PWD, 1995; UWEX, 1994).

Summary: The Lake as a Commons

Garret Hardin, in his famous essay on the tragedy of the commons, observed that the quality of a shared resource will always be degraded when everyone has access, but no one has control or ownership. Resource degradation can only be averted, he argued, if the parties agree to some form of self-regulation in order to minimize their collective impact on the resource (Hardin, 1968).

In this sense, a lake is a classic example of a commons. Most of the residents in the watershed use the lake in some way, and all residents influence it directly through their impact on the watershed. The very qualities that attracted current residents to a lake are likely to lure new ones. As a consequence, most lakes will expe-



Figure 14. Graphic used for Lake Harriet Watershed Awareness Project (MDA, 1998)

rience constant growth pressures along their shorelines and in their watersheds. An LPO is an effective framework for regulating the nature of development within the lake "commons."

The quality of a shared resource will always be degraded when everyone has access, but no one has control or ownership.

While lake communities often face tough choices about which precise criteria to apply within each of the four lake protection zones, they possess an inherent advantage when it comes to watershed protection. Most residents already place a high value

on lake quality, whether it means natural scenery, good fishing, pure drinking water or a place to float. These shared values provide a strong foundation to reach a consensus for greater lake protection.

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