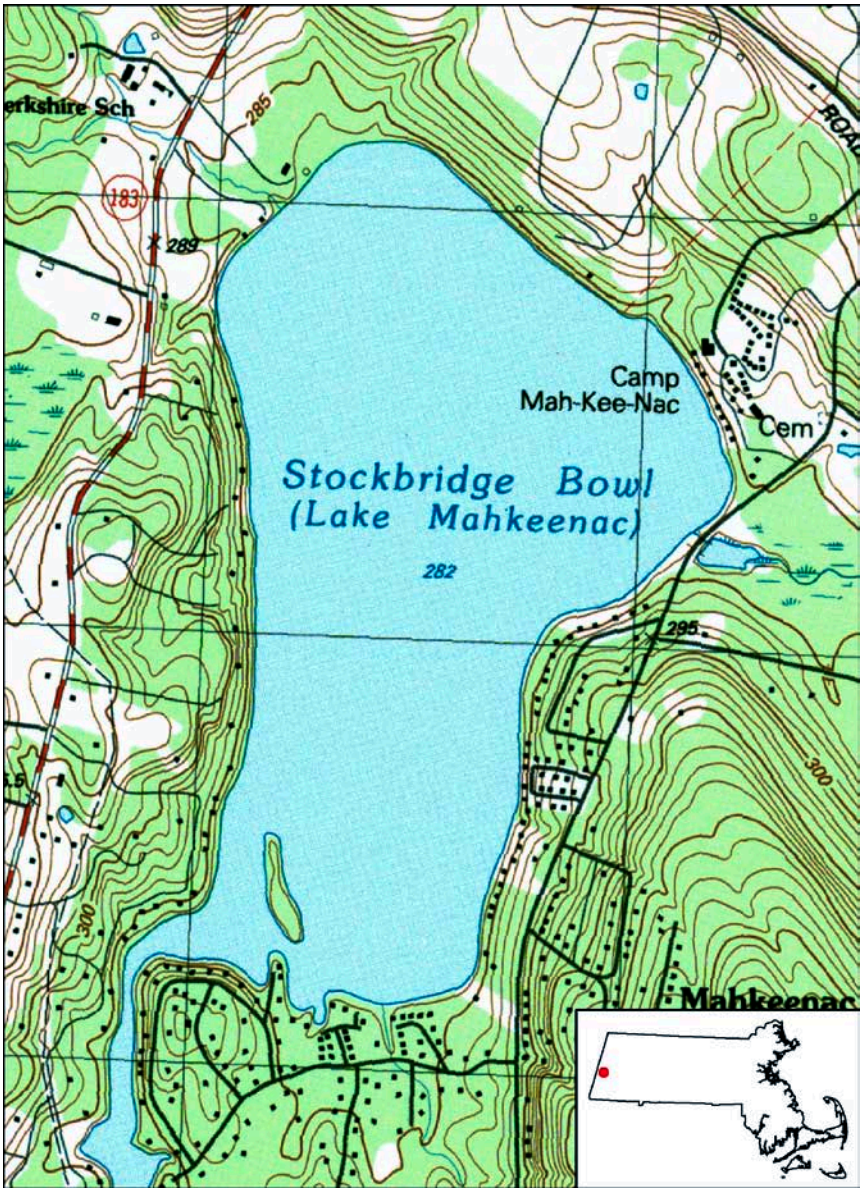
Stockbridge Bowl Watershed Survey



Conducted by the BRPC, SBA and Town of Stockbridge

June 2012

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Table of Contents

Background

Stockbridge Bowl, also known as Lake Mah-kee-nac, is a Great Pond located in Berkshire County, Massachusetts. The area of the lake is approximately 370 acres, with shoreline length of approximately 18,000 feet (3.4 miles). The mean depth of the water is 22'4", with a maximum depth of 48' in the upper middle of the lake. The near shore area of the lake is covered in shallow waters, with 8,047,500 square feet (185 acres), or 48% of the lake, with water depths of 0'-8' (Fugro, 1996) These shallow waters provide warm-water habitat and are distributed around the perimeter of the lake and in the outlet area. The deeper waters in the center of the lake offer a limited area of cold water habitat for species. There are five main contributing tributaries to the lake, two of which are perennial (Shadow Brook and Lily Brook) and three of which are intermittent.

As described in the 1991 Diagnostic / Feasibility Study and as seen in map on the following page, the topography within the Stockbridge Bowl watershed varies dramatically, with moderately sloped land (8-15%) on all side except for the southeastern portion (the Beachwood section) of the lake. The western and northern outer boundaries of the watershed drain steeply eastward toward the lake from West Stockbridge and Lenox mountains, while Rattlesnake Hill drains steeply westward toward the lake. The lake receives surface water runoff from five major tributary streams and from a sixth smaller unnamed stream flowing off of Rattlesnake Hill (refer to Map 1 for stream locations). The watershed is generally covered by glacially-derived till, which consists of unsorted clay, sit, sand gravel and boulders deposited directly atop bedrock. Because these soils are poorly transmissive, recharge of the lake occurs largely through surface flow via tributaries and overland flow. Wetland soils of organic matter, silt and sand are found in large wetland complexes in the northern and southern portions of the Lily Brook subwatershed, and in the smaller wetlands in the Mahican and Shadow Brook subwatersheds.

Stockbridge Bowl was listed as a 4c water body impaired by Exotic Species on the 303(d) *2008 Integrated List of Waters*. Invasive aquatic growth, low dissolved oxygen (DO) and algae blooms were identified as the main water quality problems in Stockbridge Bowl in various studies and management plans completed since 1991. Oxygen levels can become depleted during the summer thermal stratification, stressing aquatic organisms, particularly those with high-oxygen requirements such as trout. Anoxic conditions can lead to higher phosphorus levels as the nutrient is released from lake bottom sediments (Lycott, 1991).

Exotic aquatic plant growth alters the ecosystem within the lake and inhibits boating, swimming and fishing uses of it. The deposits of sandy and organic materials along the shallow waters of the lake provide the perfect medium for aquatic plant growth: sun, warm water and substrate, and nutrients. To control aquatic plant growth, primarily that of Eurasian water milfoil (*M. spicatum,* the 1996 Watershed Management Plan reiterated the in-lake recommendations of the D&F Plan to1) increase the level of winter drawdown (to freeze and kill plant root systems), 2) install a diversion pipe in the outlet to achieve a greater level of drawdown, and 3) to dredge a few key areas around the lake to counteract sediment deposition. Areas specifically called out for dredging activities were Lily and Shadow Brook inlets, the area between the outlet and the island, and the outlet channel (Fugro, 1996). The Stockbridge Bowl Association (SBA) and the Town of Stockbridge (the Town) jointly support the recommendations of drawdown, diversion pipe and dredging, which have been termed as the "3-D Program."

Map 1. Topographic Map of the Stockbridge Bowl Watershed

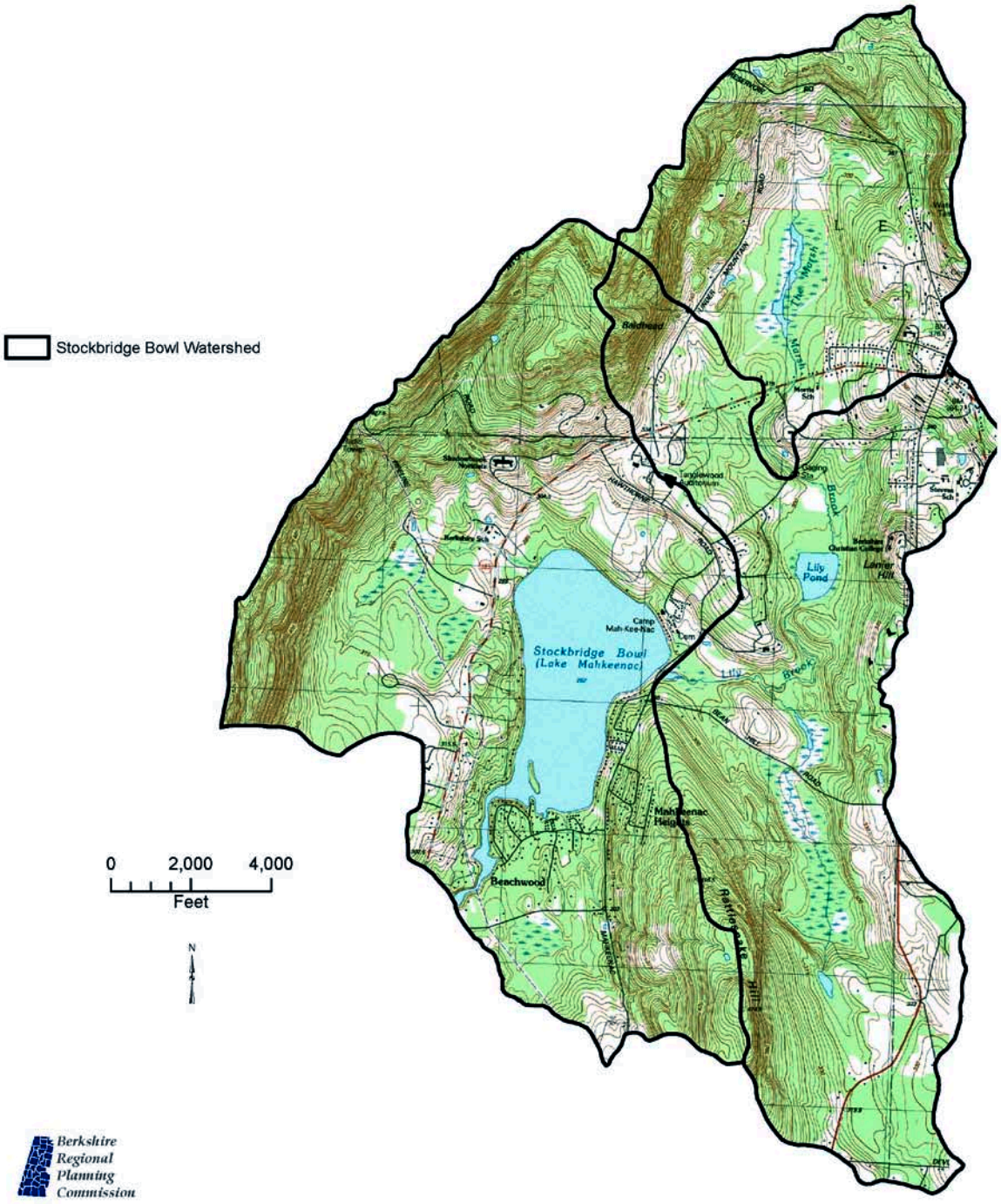
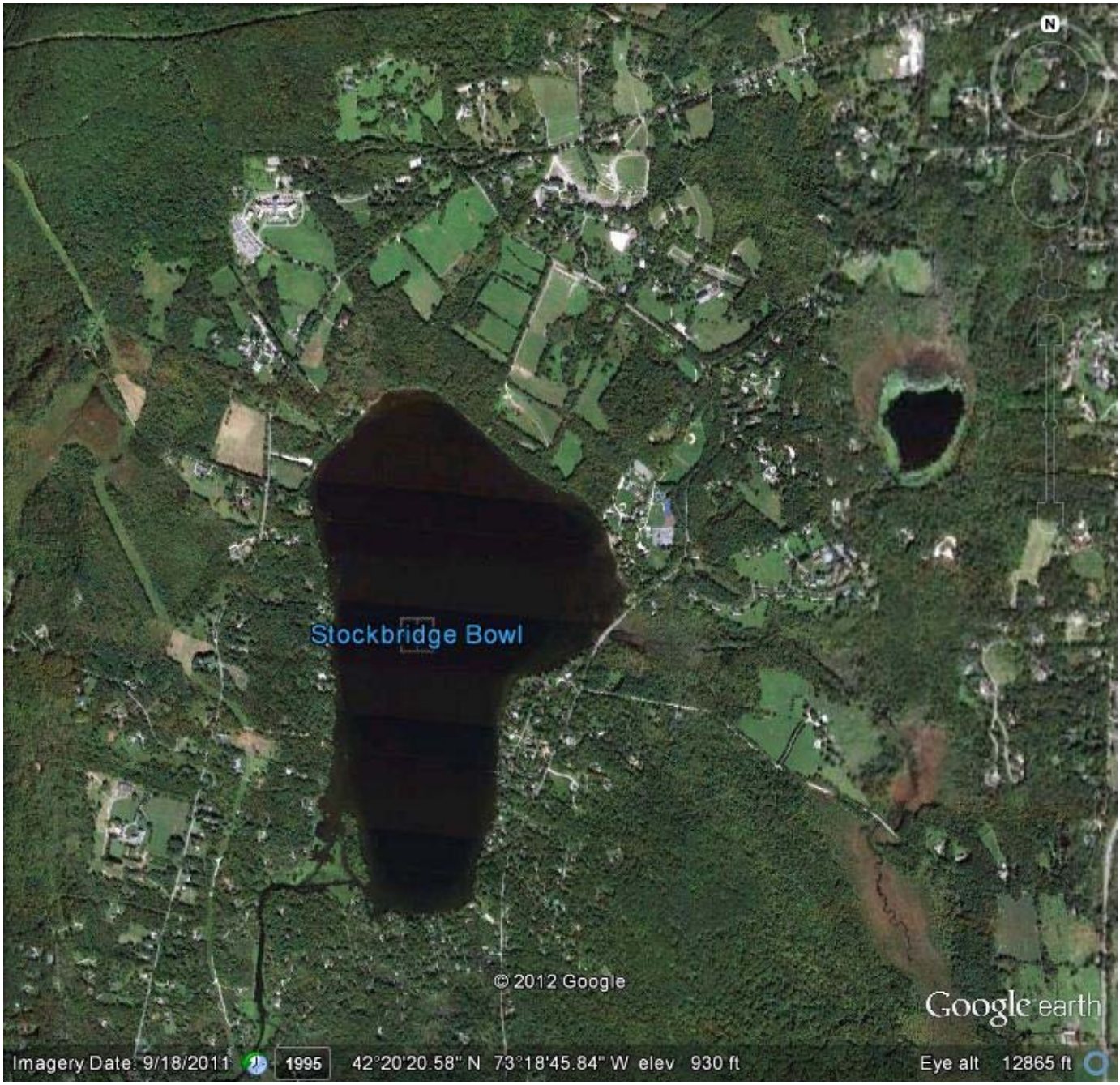


Fig. 1. Aerial view of Stockbridge Bowl and surrounding land uses



In 2009 the Town of Stockbridge was awarded a s.319 Nonpoint Source Pollution Grant to begin implementing the 3-D plan to control aquatic plant growth. The main work conducted under this grant project included:

- Final design and installation of the outlet diversion pipe
- Continuing the plant harvesting program
- Identifying potential nonpoint pollution sources (NPS) within the lake's watershed
- Designing best management practices to reduce NPS at a high-priority site
- Conducting a public outreach program to address identified and potential nonpoint sources of pollution

This watershed plan has been developed as part of the effort to identify and address NPS in the Stockbridge Bowl Watershed.

Land Use in the Watershed

As illustrated in Map 2, Stockbridge Bowl Land Use , major development clusters within the Stockbridge Bowl watershed occur along the eastern and southern shorelines of the lake and in the northeastern portion of the watershed in Lenox. Scattered residential development of found along the major roadways in both Stockbridge and Lenox. Residential land use along the shoreline of the lake is illustrated on the map as Medium Density (1/4 – ½ acre lots), located primarily along the eastern and southern shoreline, and Low Density (1/2 – 1 acre lots), located along the western shore. Camp Mahkeenac on the northeastern corner of the lake is categorized as Participation Recreation and included in the Residential land use category in Figure 2. The acreage of the lake itself is not included in these figures.

Fig. 2. Land Use in the Stockbridge Bowl Watershed, 2005

Land Use*	**Acres**	**Percent of Total Watershed**
Forest (forest, forested wetland)	4,954	70%
Residential (5 residential types, commercial, industrial, participation recreation, urban public/institutional, water-based recreation)	880	13%
Open Land (brushland, cemetery, open land, powerline, transitional)	435	6%
Agricultural (cropland, pasture)	336	5%
Wetlands (nonforested wetlands, water)	462	6%
Totals	7,068	100%

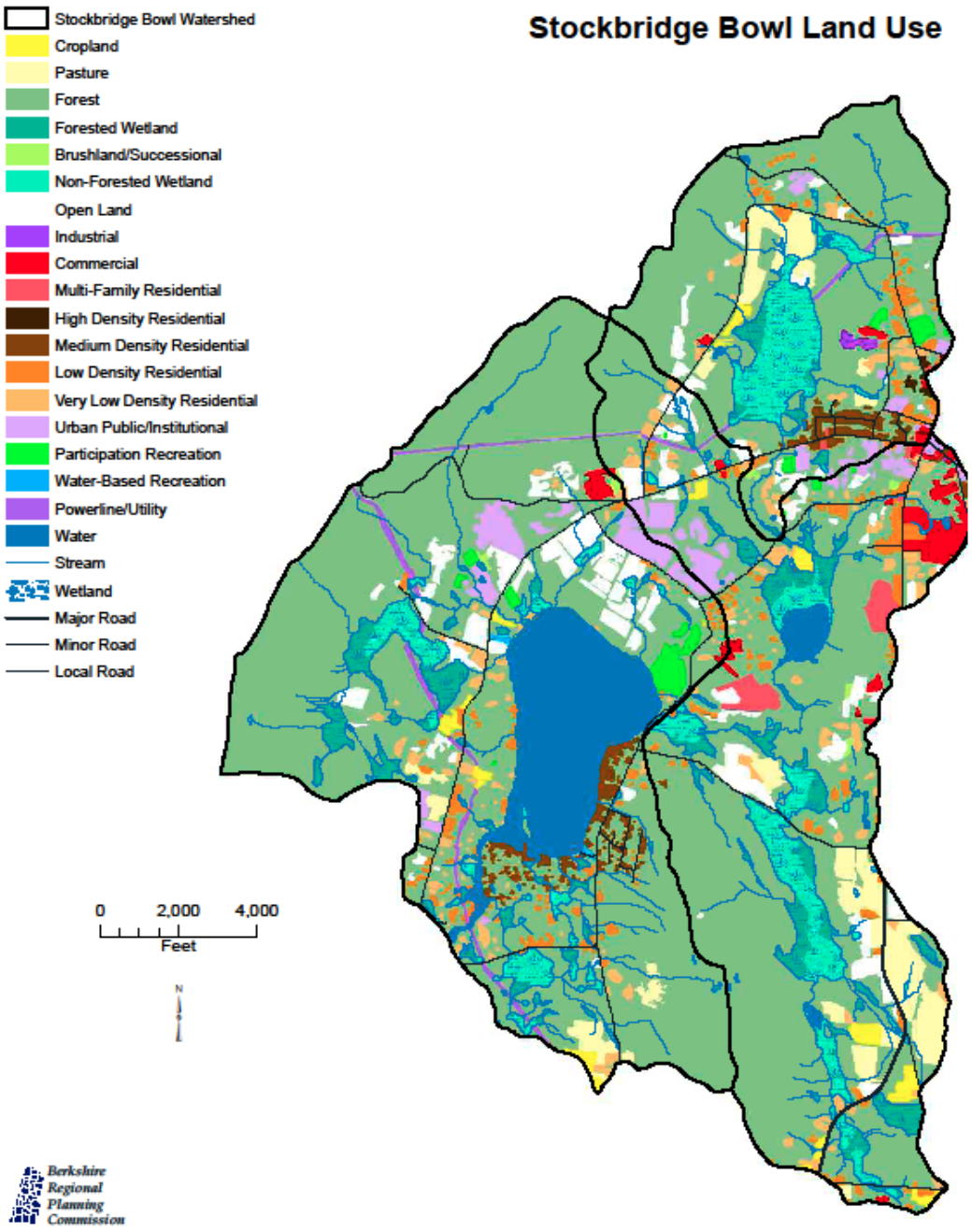
**21 MassGIS land use categories have been aggregated (listed in parentheses) and listed in the five major land use categories cited in the 1991 D&F. Figures should be used only for broad comparison, as mapping methodologies used in 1991 and 2005 are not comparable.*
Source: MassGIS, BRPC.

The SBA and the Town also recognize that land use activities within the watershed and along the shoreline of the lake and its tributaries also affect the levels of sediment and nutrients that are deposited into the lake. Several scientific studies have demonstrated that increased levels

of phosphorus follow residential development. Creating as little as 10-20% impervious surface area on a residential property can double the rate of surface runoff from the site. As cited in the *Massachusetts Buffer Manual*, studies indicate that 80-90% of phosphorus reaches waterways adhered to sediment particles traveling in runoff. One study in Maine found that even careful development of forest into two-acre house lots caused a 2-10 fold increase in phosphorus concentrations in stormwater runoff (BRPC, 2003).

Noting that development and other land uses can accelerates sediment and nutrient accumulation, the SBA and the Town conducted this watershed survey to identify land uses that potentially contribute to sediment and nutrient deposition into Stockbridge Bowl.

Map 2. Land Use in the Stockbridge Bowl Watershed



Scope of the Watershed Survey

Stockbridge Bowl has a watershed of approximately 7,068 acres, which is a ratio of more than 19:1, a relatively large contributing watershed. The Lily Brook watershed is the largest subwatershed, 4,063 acres (57% of total) and involving a wide variety of land uses and habitats (MassGIS, 2005). This watershed is also the single largest contributor of sediment into Stockbridge Bowl. To properly conduct a survey in a subwatershed of this importance would involve extensive field analysis and the cooperation of municipal public works departments, conservation commissioners and a host of private landowners. The focused watershed survey and sediment abatement assessment that should be conducted on Lily Brook was simply beyond the capabilities of the project partners. This, the decision was made to focus on conducting a shoreline survey of the lake and to investigate potential pollution sources in watersheds other than Lily Brook.

Stockbridge Bowl Field Work

The SBA, with the technical assistance of the Berkshire Regional Planning Commission (BRPC), has developed this Stockbridge Bowl Watershed Survey to further engage local residents and property owners in identifying potential sources of nonpoint pollution in the lake's watershed. To develop this watershed survey SBA volunteers and BRPC staff gathered data, conducted field work and outlined a strategy to address potential sources of nonpoint pollution.

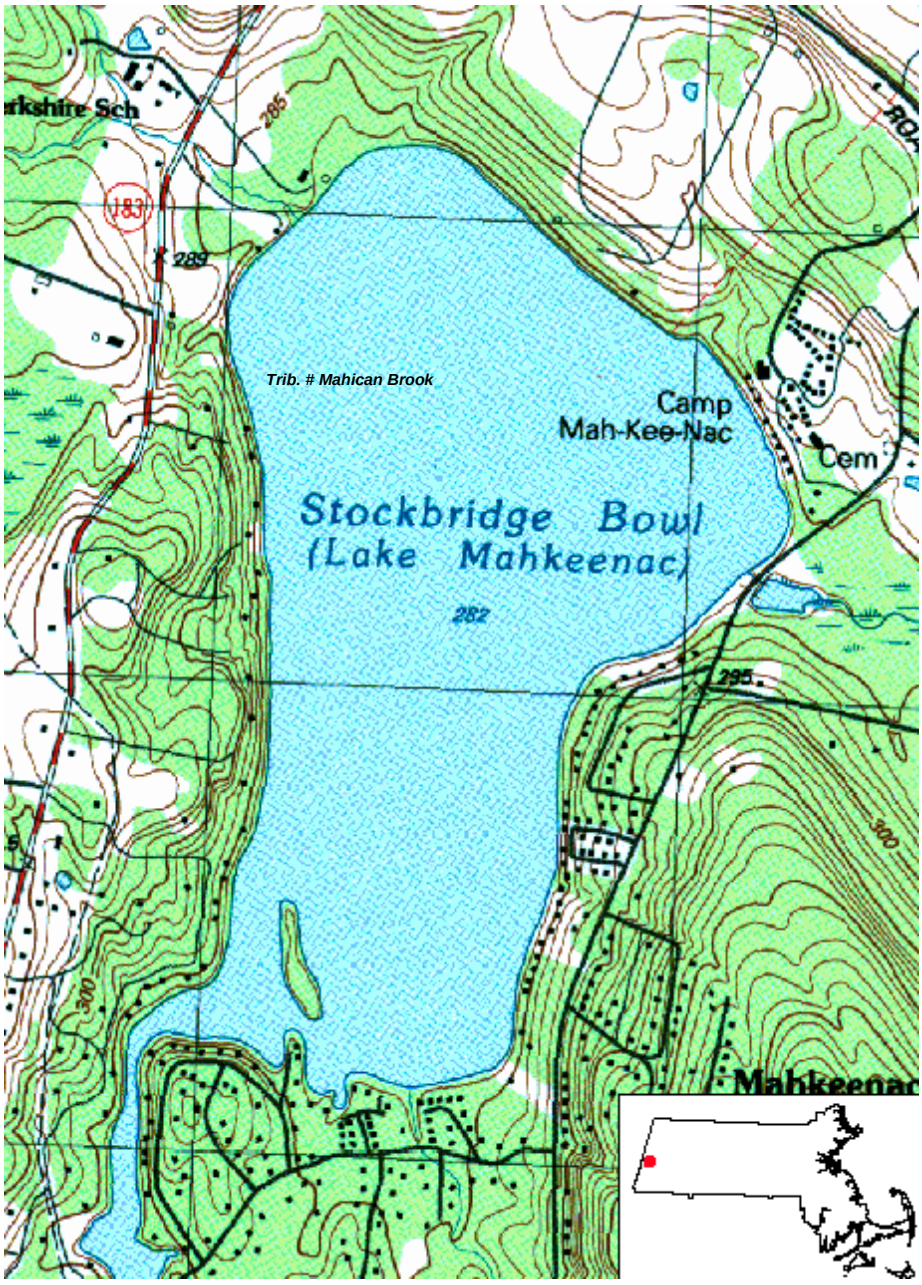
Field work was conducted in 2010 and in 2012. Work in 2010 was primarily a shoreline survey, conducted by boating around the shoreline of the lake and noting (and photographing where possible) potential pollution sources on shore. The survey included the shoreline of the lake and its outlet channel. Field work was conducted by SBA volunteers Gary Kleinerman, Cris Raymond, George Shippey, and BRPC staff Lauren Gaherty and Kim Klosterman. One result of this survey was the determination that the Stockbridge Town Beach was a significant source of runoff to the lower portion of the lake and should be prioritized for remediation.

Follow up field work was conducted in 2012, primarily consisting of on-land investigations to identify land use and drainage patterns that might explain why some of the lake's tributaries were depositing accelerated amounts of sediment within the past few years (2005-10). BRPC staff walked tributary stream corridors in the northern portion of the lake and identified road drainage patterns along the road systems around the lake.

The watershed area of the lake is quite vast, reaching as far out as West Stockbridge and Lenox Mountains to the west, to Parson's Marsh and the western half of Lenox center to the northeast, and to the farm field of High Lawn Farm to the southeast. For the purpose of conducting field work and general analyses, Stockbridge Bowl was divided up into five broad areas: 1) the Northern Shore, 2) Lily Pond Brook, 3) the East Shoreline, 4) Beachwood and 5) the West Shoreline. These areas were determined because each shared common land use patterns and densities, and contained common soil types and slopes. As a result, field work, analysis and recommendations for action will be discussed and categorized using these four areas. The exception to these general commonalities is the Northern Shore, which has disparate land use patterns and soil types. The commonality that exists within this area is that it contains five of the seven sites where in-lake fluvial deposition is clearly evident.

The most comprehensive investigative work about Stockbridge Bowl is the *Diagnostic/Feasibility Study, Stockbridge Bowl, Stockbridge Massachusetts* (the D&F), completed by Lycott Environmental Research, Inc. in 1991. Subsequent management plans and engineering studies often refer back to the original data found in the D&F. To maintain consistency with this strategy, the Stockbridge Bowl Watershed Survey adopted the sub-basins and major tributaries identified in the D&F.

Map 3. Topography and general land use along Stockbridge Bowl shoreline

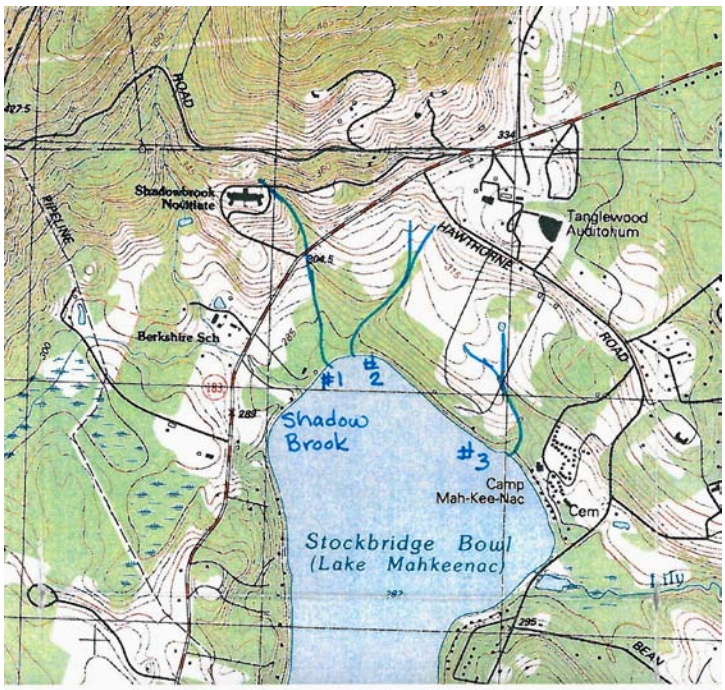


Source: USGS, 1:25,000, 1987.

1. The Northern Shore

Description:

The Northern Shore is bounded on the west by and includes the public boat launch and bounded on the east by Lily Pond Brook, and includes the D&F sub-basins 7, 8A, and 8B. The shoreline here consists of unconsolidated till, with the lake substrate consisting of a mix of gravely and silty loams. A small wetland area lies between Shadow Brook and the unnamed tributary to its northeast. Water depths here drop off moderately to moderately quickly. This shoreline is largely undeveloped; with the major development being Camp Mahkeenac, which has several buildings near the shore, along with a large beach and boat dock area. Tanglewood and the Kripalu Center for Yoga and Health maintain small beach areas that include small out buildings. Land uses beyond the shoreline are a mix of forest, open fields and large lawn areas. Tanglewood maintains large open areas, with its main concert areas north of Hawthorne Street maintained as lawn and its outlying parking areas south of Hawthorne Street and north of West Street as grassy field. Kripalu also maintains large expanses of lawn and open fields.



Shadow Brook (sub-basin 7) is the second largest sub-basin and tributary to the lake. The headwaters of Shadow Brook begin more than 2.5 miles away in the higher elevations of Lenox Mountain, tumbling down steep ravines until it reaches the pond at Kripalu, after which it continues a moderately steep descent into the lake. Kripalu and Berkshire Country Day School are the major developments within this watershed.

Three unnamed tributaries drain lands that begin in the meadow parking lots maintained by Tanglewood and continue to the lake through forest land. The first tributary to the north of Shadow Brook begins in steep terrain at Kripalu and flows through moderately steep terrain before

entering an emergent wetland and then the lake. The second tributary begins in Tanglewood meadows and enters the lake after flowing in a moderately steep channel. The third tributary begins in the meadow parking lots of Tanglewood and then flows in a steep channel through Bullards Woods.

Attempts were made to identify potential causes of sedimentation within the watersheds of the streams in the Northern Shore. Survey volunteers and BRPC staff hiked up along the streams, but no clear causes were found. The sub-basins are largely undeveloped. Segments of all the streams flow down steep slopes within ravines that are clearly eroding during severe storm events. Impervious surface areas that might contribute to peak flows were investigated. Lenox Road (Rt 183) runoff occurs as sheet flow into surrounding vegetation and streams. The road does not collect and discharge runoff through storm drain systems, but runoff does flow into streams and drainage channels that cross Lenox Road and drain towards the lake. No signs of erosion or channeled runoff from developed areas in the area were identified.

Runoff patterns in roadside vegetation and in the forest duff along the stream corridor clearly indicates that road runoff during spring melt and severe rain events from Lenox Road does flow into Shadow Brook, near Berkshire Country Day School. Runoff from the road washes down into the narrow floodplain area along the stream below the roadway. It also appears that the box culvert is slightly undersized and is a point of construction. The stream bank width appears slightly larger up- and down-stream of the road.

Kripalu is a property that is located on steeply sloped terrain and contains a relatively high amount of impervious surface area. The site drains into the watersheds of Shadow Brook and tributary #1. A site visit to Kripalu did not reveal any serious signs stormwater mismanagement or erosion. Much of the building and the new lower parking lot drains into a stormwater basin, which is maintained by facility staff. Much of the expansive grounds of the site have traditionally been maintained as lawn, but staff have begun to replace the turf with wildflower meadows, creating a more diverse landscape for visitors and wildlife.

A new parking lot behind the main building drains into tributary #1, which undoubtedly contributes to accelerated peak flows during storm events. Besides being an intermittent stream channel, this upper reach of the tributary also serves as a landscaped amenity that travels through a wooded area and crosses walking trails. Previous owners of the property lined the stream channel with flat field stones for a rustic yet landscaped look. Evidence of stormwater deposition can be seen in the channel as it flows through the woodlands. Stormwater techniques to capture or redirect runoff from the parking area and driveway away from the stream channel should be pursued.

Tributary #1 crosses Rt 183 and flows through a wetland complex before discharging into the lake just north of the Kripalu beach. Although the accelerated deposition in the Northern Shore of the lake is a concern, the mix and interconnectedness of stream, wetland and lake habitats in this region, combined with the relatively undeveloped nature of the surrounding landscape, likely provides some of the most valuable wildlife habitat in the vicinity of the lake.

<u>Areas of Concern:</u>

a) This shoreline contains fluvial deposits at the mouths of Mahican Brook, Shadow Brook and the three unnamed tributaries. Although there is some development in these sub-basins, the streams flow through largely forested areas. Steep slopes and deeply carved channels characterize these streams. The in-lake deposits consist largely of

sand and gravel, with little muck or organic material. Lake residents have stated that the sediment input has increased exponentially in the past five years or so.

b) Erosion from the area at and near Camp Mahkeenac's beach.
c) Imported limestone gravel was observed in the lower reaches of the Bullard Woods tributary. It appears that this was washed down from a stream crossing culvert on Bullards Woods. Flood waters overwhelmed the culvert and eroded backfill around the culvert. Replacing the undersized culvert with a new crossing that spans the stream should be considered.

2. Lily Pond Brook

Description:
This area is bounded on the north by the White Pines beach and to the south by the woodland area separating the causeway from the first residence, including the D&F sub-basins 1A and 1B. The shoreline of this area is the shortest, encompassing the causeway of Mahkeenac Road as it crossed Lily Pond Brook. The shoreline here is fill and the lake substrate is characterized by deep silt and muck deposits, carried in by Lily Pond Brook. Water depth here is very shallow. This area of the lake is severely impacted by invasive aquatic plants, most particularly Eurasian water milfoil. The causeway is a popular spot for local anglers.

Lily Pond Brook is by far the lake's largest tributary, encompassing the largest sub-basin (approximately 4,029 acres). The northern headwaters of the brook begin in Parson's Marsh and on Baldhead Mountain in Lenox, while also collecting water from the western portion of downtown Lenox and the Shakespeare and Company property. The southern headwaters are a large wetland complex that collects water from the eastern flank of Rattlesnake Hill.

As noted by lifelong Stockbridge residents, sediment deposition at the Lily Brook inlet area on both sides of Mahkeenac Road has severely reduced the water level and detention capacity of this area. In previous decades the town would periodically dredged out the sediment on both sides of the causeway, but this practice was halted in the early 1970s. Older residents remember canoeing up Lily Brook to the pond above, but canoes have not been able to go up the brook for several years now.

The vast majority of the Lily Brook watershed is undeveloped, but there are several areas where development and roads are located near tributary streams and wetland. These are miles away from Stockbridge Bowl and are beyond the scope of this watershed survey. Much of the denser developed areas lie in the upper reaches of the Lily Brook watershed, with water flowing through two large wetland complexes and a pond before it reaches Stockbridge Bowl. Wetlands often act as buffers for peak storm flows and filters for pollutants, trapping sediment and organic materials and processing some nutrient and chemical inputs, so it is perplexing that sediment transport is so acute at the lake.

Areas of Concern:

a) The Lily Brook inlet upstream of the causeway is exponentially filling in with sediment.
b) The Lily Brook inlet on the lake side of the causeway is severely impacted by sediment and resultant invasive aquatic plant growth.

c) The gravel parking areas drain into the lake from both sides of the road.
d) Road sand and salt applied to Mahkeenac Road during winter drain into the lake from both sides of the road with no treatment.

3. The East Shoreline

Description:
The East Shoreline is bounded by the Lily Brook causeway to the north and the Stockbridge Town Beach to the south, and includes the D&F sub-basin 2. Most of the shoreline consists of loam derived from glacial till, with some areas prone to wetness; the lake substrate consisting of a mix of cobbles and gravel, with occasional areas of silt and/or organic matter. Water depths here drop off moderately.

This shoreline is characterized as having medium density residential development (1/4 – ½ acre in size) scattered along its length. This shoreline is more densely developed, with smaller homes being built on smaller lots. Although mature trees are generally maintained between properties, many of the homes have lawns stretching down to the water, lacking shoreline vegetation. Some shorelines have retaining walls. The waterfront properties are accessed from Mahkeenac Terrace behind and upslope from the houses. These roads branch off of Mahkeenac Road.

A common park and beach area for the Mahkeenac Shores neighborhood is located in this area. The Stockbridge Town Beach is located in the southern end of this shoreline area. The Mahkeenac Heights neighborhood is located on the steep western slope of Rattlesnake Hill. Altogether there are more than 100 homes in this sub-basin, with approximately half of these located in the shore area between the lake and Mahkeenac Road, and the other half clustered in Mahkeenac Heights.

The Stockbridge Town Beach is located downslope of Mahkeenac Road and upslope of the lake. Runoff flows off the road, down the parking lot, along the driveway and into the lake. Due to the slope of the site, the runoff erodes the driveway gravel directly into the lake. Beach sand also erodes into the lake. Geese concentrate at the site, creating the potential for bacterial contamination of the water in this area.

There are several drainage ditches that collect runoff from Mahkeenac Road, Rattlesnake Hill and the Mahkeenac Heights neighborhood and discharges it directly into Stockbridge Bowl. Notable drainage ditches are near the beaches at Mahkeenac Shores and Town of Stockbridge.

Areas of Concern:

a) Drainage ditches from the road systems all along this stretch of the lake should be individually assessed.
b) There is a white discharge pipe that should be assessed (see photo for location).
c) Few of the homes have shoreline vegetation.
d) Mahkeenac Shores park supports very little vegetation. What is there is compacted and stressed from use.
e) The drainage ditch next to Mahkeenac Shores beach is significant sediment deposition.
f) The northern stretch of Mahkeenac Road has a road drainage system that concentrates and discharges runoff into ditches that flow into the lake untreated.
g) The construction site cross from the Town Beach driveway was discharging sediment-ladened into the road stormdrain system in the spring of 2012.
h) Runoff from the Town Beach parking lot and driveway is carving gullies and carrying the sediment-laden flow into the lake unimpeded.
i) Beach sand from the Town Beach is eroding into the lake. (NOTE: New England Environmental, Inc. designed a plan to control stormwater runoff at the Town Beach as part of the s.319 NPS grant project).

4. Beachwood

Description:
The Beachwood neighborhood is bound on the east by Mahkeenac Road and on the west by the lake outlet channel, and includes the D&F sub-basins of 3A and 3B. The Beachwood Drive, Birch Lane and Lakeview Drive and all roads that shoot out from these are included in this shoreline section. Most of the shoreline consists of loam derived from glacial till, with many areas prone to wetness. Water depths are shallow here and drop of moderately. This shoreline is characterized as having medium density residential development (1/4 – ½ acre) along its length. Like the East Shore, the homes in this area tend to be smaller homes on shall lots. The land here is level, with little slope. Duck Pond Brook flows off of the steep slopes of Rattlesnake Hill and flow through this area in a relatively shallow channel.

Homes located on the western loop of Lakeview Drive Road are located on steeply sloped land along the outlet channel. The character of the outlet channel resembles a slow moving river. Sun bathing mud turtles, ducks and great blue herons were observed in the cove etched into the channel. A large mature snapping turtle was also seen swimming in the channel.

Areas of Concern:

a) Many of the properties maintain lawn right to the water's edge, lacking shoreline vegetation.
b) There is a home on Lakeview Drive, on the eastern shoreline of the outlet that contains several areas of exposed along a path on a steep slope.
c) There is a white PVC drain pipe on a property on Lakeview Drive.
d) A house that sits high on a hill on the southern end of the outlet channel has a very large lawn with little shoreline vegetation.

5. The West Shoreline

Description:
The West Shoreline is bounded on the south by the lake outlet and to the north by Mahican Brook, and includes the D&F sub-basins 5, 6A, 6B.

Like the East Shoreline, most of the West Shoreline consists of unconsolidated till, with the lake substrate consisting of a mix of cobbles and gravel. Water depths here drop off moderately. However, the southern portion of the shoreline, across from the island and following along the outlet channel, consists of loams that tend to be wet. The lake substrate is silts and mucks, with very shallow water depths. The substrate and shallow warm water provide the perfect growth medium for aquatic vegetation, which is abundant in this area of the lake. This shoreline is characterized as having low density residential development (1/2 – 1 acre) scattered along its length. Most properties contain some lawn, but forest cover is fairly well maintained between the houses. Many, but not all of the properties have maintained at least some shoreline vegetation. Some areas contain mature trees that provide shade at the shoreline. The homes are located on Lenox Road (Rt. 183), and are typically accessed by long driveways. The land slopes moderately from the road to the lake. The road does not have a storm drain system; storm runoff drains away from the road as sheet flow into the surrounding area, which is largely undeveloped and vegetated.

The shallow waters in the area between the outlet, the island and the western shoreline is covered in dense stands of lily pads during the growing season. Other aquatic and emergent vegetation flourishes along the shoreline in this area. This dense growth inhibits boating, making it difficult to paddle through and entangling motor propellers. The lake soils in this area are layered with silts and organic matter, making the habitat in this portion of the lake more like a shallow pond or wetland. While the dense plants impact the aesthetic and recreational use of this area of the lake, it serves an ecological function in that it offers cover and refuge for young fish, amphibians and turtles as they hide from predators.

Areas of Concern:

a) Gullies carved in the gravel parking lot of the boat ramp, along with sand on the concrete launch pad, indicate that stormwater runoff is transporting gravel and sediment into the lake at this site.
b) There is prolific lily pad growth in the shallow waters that lie between the island, the Cove Lane peninsula and the outlet channel.
c) A garden hose or pipe is attached to the wooden dock of a property in the outlet channel. This is most likely hooked up to a basement sump pump, but the source is unknown.
d) A property in the outlet channel has collected and stored a pile of leaves on the shoreline. This could be a nutrient source.
e) Several properties along this shoreline, particularly in the southern portion, lack vegetation along the shoreline.
f) Fluvial deposits of sand and gravel create a shallow area at the mouth of Mahican Brook.
g) A stand of phragmites is taking hold at a site in the outlet channel. Control is easiest and most successful when patches are small like these.

Tools at our Disposal

Shoreline Property Owner Survey

In April, 2012, the SBA mailed a survey to waterfront property owners around the lake in an effort to identify common potential sources of NPS from land use patterns and from landscaping practices. The front page of the survey asked respondents about potential NPS on their properties and the back of the survey provided information on NPS and tips on how they might mitigating potential pollution sources on their properties. Identifying potential sources of sediment transport and sources of phosphorus were the main focus areas of the survey. A copy of the survey and survey results are found in Appendix A.

SBA sent out 129 surveys and received 50 responses, for a return rate of 39%. The first five questions of the survey focused on understanding possible sources of sedimentation from residential properties. Thirty-eight percent of responding property owners reported having exposed soils on their property. Forty-four percent 44% reported that runoff from their property or driveway flowed into the lake or a stream. Most respondents (66%) reported that their property does not flow into a drainage ditch or stormdrain system, which correlates with the relatively few road drainage systems around the lake. However, of the 22% of respondents that did say that runoff from their property enters a ditch or drainage system, almost a third of them did not know where the ditch or drainage system emptied in to.

The last two questions focused on understanding common sources of phosphorus. Eighty percent of respondents reported that they washed their cars at a car wash. Of those who washed their cars at home, most washed them on gravel (presumably on their driveways). When asked what they do with their grass clippings after mowing, 62% reported leaving them on their lawns, with a few respondents reporting that they dumped them in brush nearby. A total of 14% reported that they did not know where the clippings went, as they had a lawn care company maintain their lawns.

The results of the survey indicate that NPS outreach to waterfront property owners should focus on identifying and mitigating sediment transport from exposed soils and driveways. This is especially important given that many of the properties on the east and west sides of the lake are located on steeply sloped land, with driveways that extend down from the road towards the lake.

Wetlands Protection Act

The Massachusetts Wetland Protections Act regulates any activity that involves filling, excavating, or otherwise altering the ecological functions of wetland resource areas, including wetland, streams and lakes. Land use activities that have the potential to impact the functions of wetland resources or are within buffer zones (100 feet of banks or bordering vegetated wetlands) or within the 200-foot riverfront area can only be conducted with permission granted under a wetlands permit, issued in Stockbridge by the Stockbridge Conservation Commission. Typical land use activities are those that create permanent buildings or structures, disturb significant amounts of soil or remove significant amounts of natural vegetation. Some waterfront activities are notably exempt from the WPA, such as creating a small pathway from the house to the lake, pruning trees for a vista of the lake, installing a fence (as long as allows small animals to pass underneath or through it), and planting native trees, shrubs and ground cover.

Stockbridge Zoning Bylaws

Lake and Pond Overlay District. In addition to the WPA, the Town of Stockbridge regulates certain land use activities that occur within specific overlay districts. Stockbridge Bowl is one of five lakes that are located within the town's Lake and Pond Overlay District zoning district, governing land use activities along the lakefront area 150 feet back from the high water mark. This is 50 feet beyond the state's buffer zone. The purpose of this zoning district is to:

> *protect and enhance the principal lakefronts of the Town of Stockbridge; to maintain safe, healthful conditions; to prevent and control water pollution; and, to preserve vegetative cover and natural beauty*.

Most land use activities require a special permit, including:

- New non-exempt structures or alteration of existing structures (does not include maintenance or repair of existing)
- Roads and driveways
- Non-exempt removal of vegetation (does not include removal of dead or dying trees & vegetation, pruning of vegetation, gardening that does not involve removal of shrubs or trees)
- Excavation and removal of soil or subsoil
- Stormwater prevention, mitigation or drainage

Activities are expressly prohibited within this area are:

- Applications of fertilizers, pesticides and herbicides
- Storage or dumping of waste, junk or refuse
- The relocation of watercourses and removal of soils and subsoils

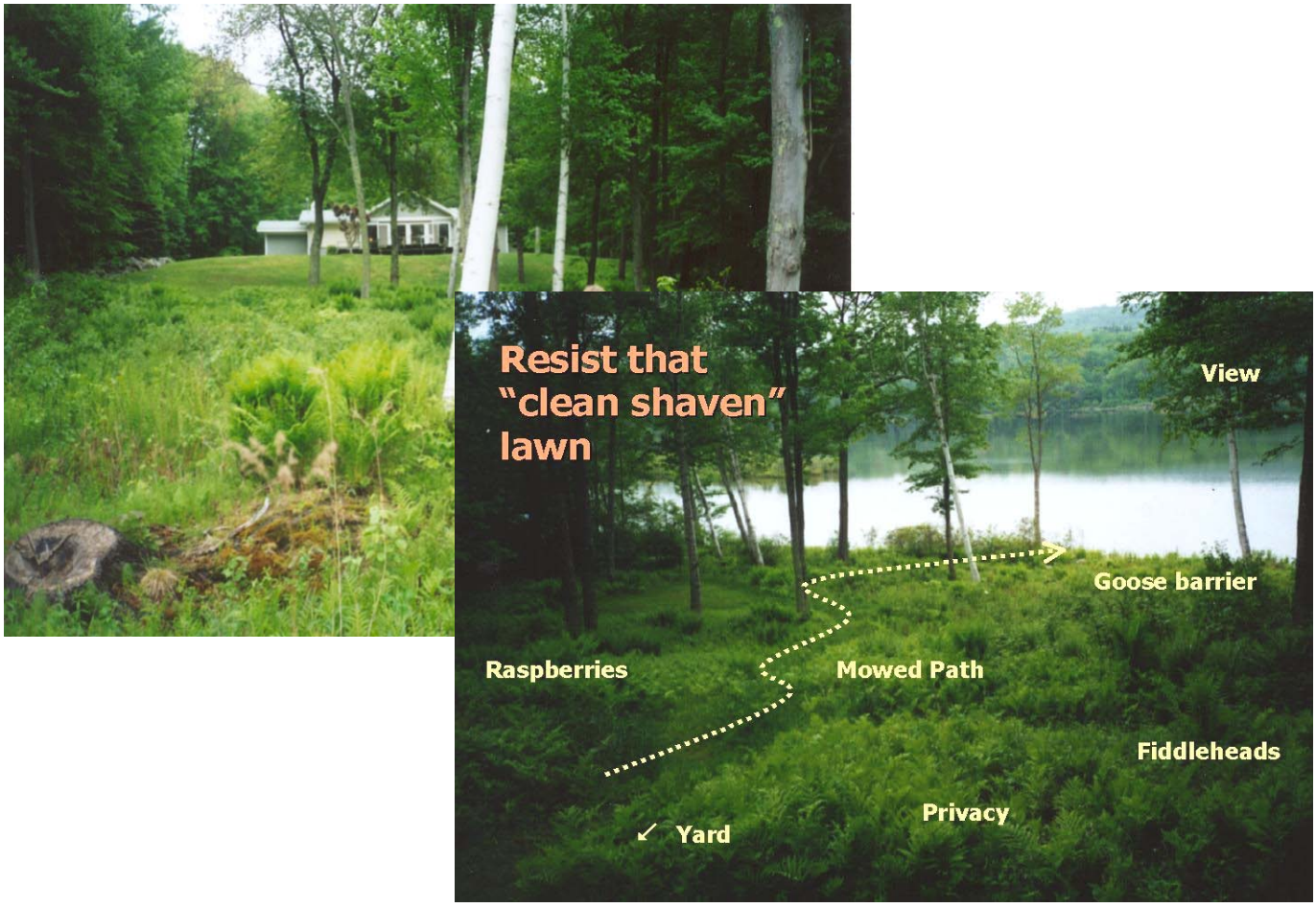
The bylaw goes on to state that vegetation within 35 feet of the high water mark shall be maintained as an undisturbed natural buffer strip. The general exception to this standard allows for the creation of a contiguous clear-cut opening in the buffer strip for lake access, provided it does not exceed 20% percent of the frontage along the water, and not exceeding 35 feet on any individual lot. The cut should be angled across the lot so as to allow for a view and access, but to reduce runoff. Exceptions to this standard may be made with a special application to the Planning Board, with consultation of the Conservation Commission. Driveways and parking areas within the 150' zone must be constructed of permeable material.

Landscaping Tips

Development disturbs the soil, removes natural vegetation and creates imperious surfaces such as building rooftops, roads and driveways. Stormwater runs off these hard surface areas at an accelerated rate, collecting trash, debris, sediment, bacteria, petrochemical and other substances that have accumulated on our terraces, driveways and yards. As a result, an increased amount of runoff delivers an increased amount of pollution to the lake. Residential properties have been documented as contributing 0.5 – 1 pound of phosphorus per acre to the receiving waterway each year. The situation becomes more acute as the land around our lake becomes developed and the runoff is quickly and directly delivered into the lake without the chance of infiltrating and being filtered by the forest soils and microbes.

We can begin to reverse the impacts of developing homes and lawns by identifying problematic areas of erosion and runoff, and by careful landscaping practices. "Lakescaping" is a term that has been coined to describe landscaping techniques that focus on reducing runoff and mimicking the natural processes that capture and filter stormwater. Surface runoff doubles when impervious surfaces such as buildings, driveways and patios cover a mere 10-20% of site. The goal of lakescaping is to reduce the amount of surface runoff and increase the amount of infiltration into the soil.

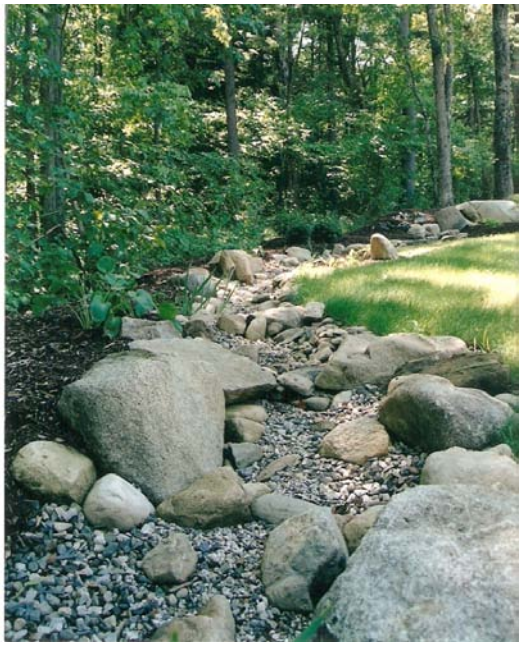
The photos below show a shoreline property on a lake in southern Berkshire County. Looking from the lake towards the house (top photo), we can see that the landowner maintains a small yard around the house. Looking from the house down towards the lake, we see that the view has been maintained with lower branch pruning, lake access has been maintained with a mowed path, and the vegetation offer seasonal delights such as fiddlehead ferns and raspberries. The vegetation deters geese from visiting the lawn. As a bonus, the vegetation provides food, cover and nesting sites for wildlife.



Here are a few lakescaping tips to consider:

- Maintain or replant as many trees, shrubs and forest undergrowth as possible to return your property to a more natural landscape condition, especially along your shoreline. This vegetation filters overland flow from driveways, patios and lawns. Consult a landscape professional for a selection of plants that will provide color throughout the year or for those that will attract birds and butterflies. Consider planting only native plant species, especially choosing those that flower or fruit to provide food and cover for wildlife.
- At a minimum, maintain or plant a buffer of tall vegetation along your shoreline. This buffer will not only filter sediment from runoff, but it will also deter geese from coming onto your lawn to feed. Geese like the comfort of having a clear view and pathway to the water to be able to quickly escape predators. This is especially true of geese that have flightless goslings. So, block their view with shrubs or tall grasses or flowers.
- Consider replacing impervious blacktop or concrete driveways and patios with pervious techniques. Pervious techniques include gravel, stone, grass, flat stones or lattice pavers (see photo right) that allow some rainwater to soak in between the blocks. When replacing impervious surface areas on steep slope, design it carefully so that runoff does erode and wash materials such as gravel or stone downhill into the lake.

- Avoid channeling water directly to the lake. Direct surface runoff to vegetated areas or infiltration trenches of stone (see photo below), and collect roof rain water in a rain barrel, which will provide water for your plant beds.
- Keep grass clippings out of the lake, storm drains, and off streets. Grass brakes down into its nutrient elements quickly, giving the lake an infusion of unwanted phosphorus.
- Wash your car at a car wash. Detergents used to clean cars often contain phosphorus. If you do wash your car at home, be sure soapy runoff water does not directly flow into the lake or tributary stream, because this would give the lake an unwanted infusion of phosphorus.
- Spread the work about Lakescaping to your neighbors and fellow lake association members.



For a more complete list of suggestions and ideas, visit the SBA website.

Watershed Action Plan

This table summarizes a series of recommended actions to address identified or potential nonpoint pollution sources in the Stockbridge Bowl Watershed. Immediate attention should be paid to High (H) priority items, while Medium (M) priority items should be pursued as soon as feasible. While many action items could be pursued concurrently, there are some instances where a Medium priority action item would logically follow a High priority item. For example, conducting a "lakescaping" program should be done after landowners have conducted Rainy Day Surveys on their properties and identified the problematic areas of runoff that need to be addressed by landscaping and other stormwater management techniques. In the Responsibility column, The Town = the Town of Stockbridge, and the SBA = the Stockbridge Bowl Association

LAKE-WIDE ACTIONS	**PRIORITY**	**RESPONSIBILITY**
Approach the Housatonic Valley Association to see if they would conduct stormwater monitoring at a few select tributary streams and drainage channels to determine sediment, nutrient and bacterial loading. Streams that should be considered are Shadow Brook, Lily Brook and the unnamed streams in the northern portion of the lake.	H	SBA
Work with landowners to minimize runoff from their properties into the lake:		
▪ Hold Rainy Day Survey workshops. First hold a workshop to train landowners how to survey their properties and identify areas of erosion and other potential runoff problems. This workshop could provide instructions and a site plan and survey form to fill out. Hold a second workshop where landowners can bring their completed Rainy Day Surveys and have professional landscaping consultants provide ideas on ways to solve the problems landowners have discovered.	H	SBA
▪ Conduct a "lakescaping" program that informs property owners about techniques such as shoreline vegetated buffers, rain barrels, vegetated swales, rain gardens, infiltration trenches, pervious pavement.	M	SBA
▪ Conduct a Rain Barrel Blitz, whereby a large number of rain barrels are purchased at a bulk rate and distributed to interested landowners. Focus first on distributing the barrels to densely developed areas.	M	SBA

▪ Promote the planting of shoreline vegetation. Educate landowners about the importance of shoreline vegetation by holding a workshop and suggest they refer to the *Massachusetts Buffer Manual.* Provide copies of the manual to each member association of the SBA. Refer to examples of lakefront buffers found in Appendix C.	M	SBA, The Town
▪ If the Rain Barrel Blitz is successful, consider offering a Buffer Bonanza, to purchase a larger amount of vegetation at a bulk rate price. Consider offering the installation of the plants as part of the program to make it easier for landowners who are not capable of doing it themselves.	M	SBA, The Town
▪ Track and promote success stories by highlighting lakescaping projects in the SBA newsletter and on its website. Consider holding contests and giving prizes for the best improvements.	M	SBA
Develop a brochure that reminds landowners of town policies, bylaws and other regulations governing use of their land within 150' of the lake shore, such as restrictions on the removal of shoreline vegetation, the application of fertilizers and pesticides. The brochure also describes the process for importation of new beach sand. The Town could send this brochure would be set in annual tax bills. The notices should include the procedures for replenishing beach sand.	H	SBA, The Town
Conduct pilot studies at several sand beach sites whereby runoff controls (e.g. silt fence, sediment rolls, etc.) are installed along the high water line in the fall to capture eroding sand over the winter and spring melt. Sites where beach erosion is severe should be prioritized. The Conservation Commission could require installation of runoff controls as a condition of allowing landowners of steeply sloped sites to import new sand to replenish their beaches.	H	SBA, The Town
Consider joining the Lakes and Ponds Association of Western Massachusetts (LAPA-West) to avail itself of the educational opportunities that LAPA-West offers. This includes the opportunity to network with neighboring lake groups and learn from their experiences, and to stay apprised of events and educational offerings.	M	SBA

THE NORTHERN SHORE	PRIORITY	RESPONSIBILITY
Kripalu should consider incorporating stormwater control measures to capture or divert flow from the new upper parking lot into tributary #1.	H	Kripalu, SBA
Replace the undersized culvert on the Bullards Crossing trail with a new crossing that spans the stream channel. The existing culvert is undersized and become overwhelmed during peak flows, eroding away fill from around the culvert and sending it downstream towards the lake. Stream channel stabilization in this area may be needed in the vicinity of the crossing.	H	SBA
Hire the services of an engineering firm to investigate potential techniques to capture sediment input from the tributary streams.	M	SBA, The Town
LILY BROOK WATERSHED	**PRIORITY**	**RESPONSIBILITY**
Conduct comprehensive study of the Lily Brook watershed that investigates all land uses and drainage patterns that might contribute to the sediment transport that is occurring into Stockbridge Bowl. This work should provide data that will be valuable in the event that the Town and SBA actively pursue the dredging of materials that have accumulated at the inlet.		
▪ Establish a technical advisory team of representatives from the Town of Stockbridge, SBA, Town of Lenox and major landowners with the watershed to oversee the development of the study.	H	SBA, The Town
▪ Secure funding for conduct the study. Potential sources that should be considered are the 604b Water Quality Assessment Grant Program, the Massachusetts Environmental Trust Fund, Community Preservation funds (both Stockbridge and Lenox have enacted the Community Preservation Act).	H	SBA, The Town
▪ Support SBA's fundraising efforts to conduct lake management activities at the inlet.	M	SBA, The Town

EAST SHORELINE	PRIORITY	RESPONSIBILITY
Implement the improvements to the Stockbridge Town Beach as design by New England Environmental, Inc. Potential funds for final design and construction could include: ▪ Community Preservation Act funds ▪ Town funds: 2013 Annual Town Meeting ▪ s.319 Nonpoint Source Pollution Grant Program: May 2013	H	The Town
Design and construct improvements at the Mahkeenac Shores park and the drainage channel to its north. This would likely involve the services of a design team that would include landscape architects to identify ways to improve vegetative cover at the site and engineering staff to reduce sediment deposition from the drainage channel.	M	SBA
Make extra efforts to incorporate stormwater improvements when construction on Mahkeenac Road are conducted. During the design phase, require that project engineers consider stone lined or vegetated swales along the roadway, install deep sump catch basins to capture sediment, creation of plunging pools to dissipate the erosive powers of storm flows, and sediment basins within easy reach of the road (for easy periodic sediment removal).	M	The Town
Consider armoring around road culverts on Mahkeenac Road where the roadbed is eroding and gravel is washing into the stream or drainage channel.	H	The Town
Work with landowners along Mahkeenac Road to identify ways to reduce runoff from their properties and driveway into the road's drainage system. Offer them ideas on how to lesson runoff from impervious surfaces (rain barrels, pervious pavement) and distribute runoff across their properties for detention (direct runoff into rain gardens, install berms or water bars that redirect runoff into vegetated areas and away from the road).	H	SBA
Investigate the white plastic discharge pipe to assess its discharge (see photo for location).	H	SBA

WEST SHORELINE	PRIORITY	RESPONSIBILITY
Work with the Massachusetts Public Access Board to design and construct stormwater runoff controls at the public boat launch to reduce sediment transport into the lake. This project could be conducted in conjunction with stormwater management improvements at the Town Beach.	H	The Town and MA State Access Bd
Approach the landowners with exposed soils on the shoreline or upslope of it. Offer ideas for mitigating runoff.	H	SBA
Remove the small stand of phragmites that has become established in the outlet channel. Control is easiest and most successful when patches are small like these.	H	SBA, The Town
Investigate the property in the outlet channel with the garden hose extending from the house to the lake, as noted in the shoreline survey section.	M	SBA, The Town

Appendix A

RESULTS OF THE LAKE PROPERTY OWNER SURVEY

Issued April 2012

Question	Answers: Number of responses (percent of total)*				Write-in Comments
1. Do you have any areas of exposed soil on your property?	Yes 19 (38%)	No 31 (62%)			
2. If you answered yes to question #1, why is the soil exposed? (Percent is only of those who responded Yes to question #1)	Dirt driveway / walkway 13 (68%)	Eroding shoreline 3 (16%)	Very shady – hard to grow plants 5 (26%)	Other (please write in why) 5 (26%)	Garden, Road runoff, or Driveway 5
3. Does rain runoff from your driveway or property flow into the lake or stream?	Yes 22 (44%)	No 17 (34%)	Unsure 13 (26%)		Driveway to vegetated area to lake 1
4. Does runoff from your driveway or property flow into a storm drain system or ditch?	Yes 11 (22%)	No 33 (66%)	Unsure 6 (12%)		Driveway to vegetated area to lake 1
5. Where does the runoff go once it enters the storm drain system or ditch?	Treatment Facility 1 (0%)	The lake 6 (12%)	A stream 0 (0%)	Unsure 14 (28%)	Into our wetland or ground 3
6. Where do you wash your car?	Pavement 1 (0%)	Gravel 4 (8%)	Grass 0 (0%)	Car wash 40 (80%)	
7. When you mow your grass, what do you do with the grass clippings?	Leave them in the yard 31 (62%)	Dump them in brush nearby 6 (12%)	Throw them in the garbage 4 (8%)	Blow or rake them into the lake 0 (0%)	Unsure – have landscaper 7

**Note: Percent is percent of total returned surveys (50 respondents) unless noted otherwise. Not all answers had a total of 50 responses, as some respondents left some questions unanswered while other questions received multiple answers.*