Total Maximum Daily Load of Phosphorus for Leesville Pond

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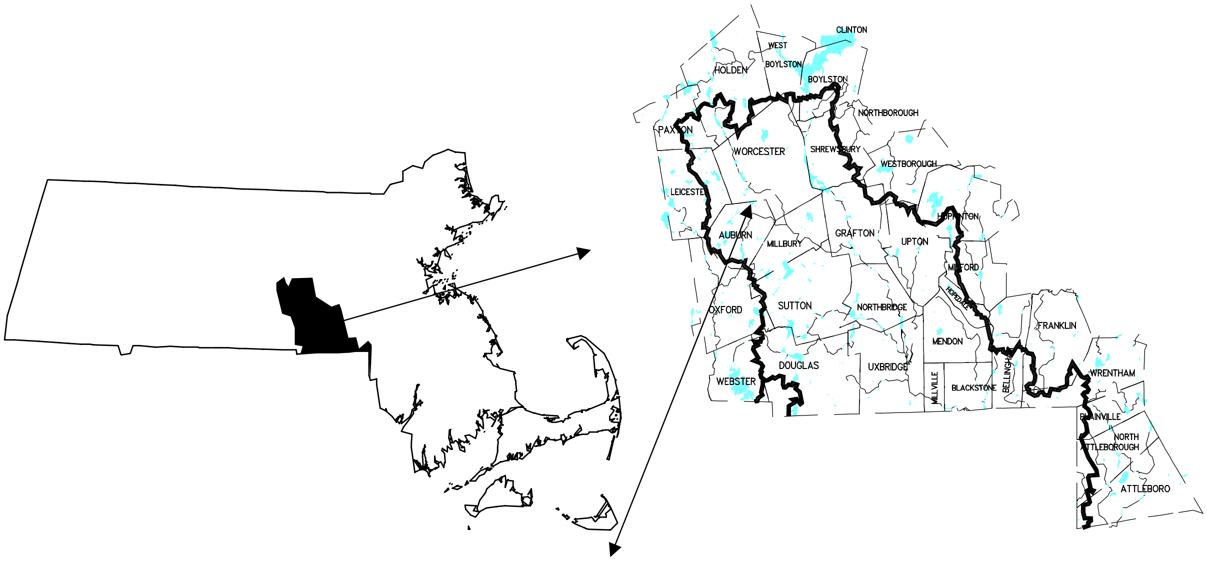
Front Cover
Photograph of Leesville Pond in Auburn and Worcester.

Total Maximum Daily Load of Phosphorus for Leesville Pond, Auburn-Worcester, MA. (MA51087)

DEP, DWM TMDL Report MA51087-2002-011 CN 117 May 14, 2002



Location of Blackstone Basin, and Leesville Pond in Massachusetts.

Key Feature: Phosphorus TMDL assessment of a shallow reservoir.

Location: Auburn and Worcester, MA - EPA Region 1; 42^{o}13’40” 71^{o}48’42”

Scope/ Size: Watershed 6358 Ha (24.5 mi^{2}, Surface area 20.4. Ha (50.5 ac)

Land Uses: Wooded 32.7%, Urban 39.3% Rural 16.8%, Agriculture 11.3%

303d listing: Nutrients (Code 0900); Organic enrichment and Low Dissolved Oxygen (Code 1200)

Data Sources: D/F Study Ganzon and Sutt, 1990. BSC and DEQE data.

Data Mechanisms: NPSLAKE Model, Best Professional Judgment

Monitoring Plan: Massachusetts Watershed Initiative Five-year cycle.

Control Measures: Watershed BMPs; improved flushing of south basin, macrophyte management

Executive Summary

The Massachusetts Department of Environmental Protection (DEP) is responsible for monitoring the waters of the Commonwealth, identifying those waters that are impaired, and developing a plan to bring them back into compliance with the Massachusetts Water Quality Standards. The list of impaired waters, better known as the "303d list" identifies river, lake, and coastal waters and the reason for impairment.

Once a water body is identified as impaired, DEP is required by the Federal Clean Water Act to essentially develop a "pollution budget" designed to restore the health of the impaired body of water. The process of developing this budget, generally referred to as a Total Maximum Daily Load (TMDL), includes identifying the source(s) of the pollutant from direct discharges (point sources) and indirect discharges (non-point sources), determining the maximum amount of the pollutant that can be discharged to a specific water body to meet water quality standards, and developing a plan to meet that goal.

This report represents a TMDL for Leesville Pond in the Blackstone River Watershed. Leesville Pond is a reservoir formed by damming Kettle Brook, and is located in the headwaters of the Blackstone River Watershed. The lower sections of the watershed are somewhat urbanized while the headwaters are largely forested. The goal for the pond is to achieve Class B water [314 CMR 4.05(3)b]. Leesville Pond is listed on the Massachusetts 303d list for Nutrients as well as Organic enrichment/Low Dissolved oxygen that are associated with high phosphorus loadings. These pollutants and stressors are indicators of nutrient enriched system, better known as the process of eutrophication. In freshwater systems the primary nutrient known to accelerate eutrophication is phosphorus. Therefore, in order to prevent further degradation in water quality and to ensure that the pond meets state water quality standards, the TMDL establishes a phosphorus limit for the pond and outlines corrective actions to achieve that goal.

The proposed Total Maximum Daily load (TMDL) is based on the Diagnostic/Feasibility (D/F) of Ganzon and Sutt (1990); parts of which are reprinted in Appendix 1. Some modifications to the nutrient budget of the original D/F study were made based on landuse modeling using the NPSLAKE model of Mattson and Isaac (1999). Leesville Pond is listed on the Massachusetts 303d list for Nutrients and Organic Enrichment/ Low Dissolved Oxygen. The D/F study concludes that the excessive weed growth and low dissolved oxygen in the pond is due to nutrient enrichment was from the pond's watershed. The D/F study recommends watershed management to control nutrients and sediments, and also recommends water level manipulation and plant harvesting (Appendix I). The south basin should be reconsidered as possible wetland habitat to be preserved. The TMDL focuses on a combination of reducing the phosphorus loading to the lake by a combination of improved watershed management techniques aimed at highway runoff and urban stormwater runoff. In addition proposed management should include consideration of repairing the dam to allow drawdowns and by considering increasing the flow through the southern section of the pond by replacing the existing culvert with a canal or discharge pipe to allow more rapid water replacement in the southern basin. These management techniques should aid in controlling macrophytes and allow increases in dissolved oxygen concentrations and improved water quality. Sediment control is also required in order for the pond to achieve surface water quality standards. Significant improvements in highway maintenance practices and Best Management Practices (BMPs); paving dirt roads; implementing erosion control measures; and educating the public are required to control sediment loading to the pond.

Long-term monitoring of the pond is essential to ensuring that source controls continue to be implemented. This TMDL can be achieved through the cooperation and effort of state and municipal agencies, commercial entities in the watershed, and volunteers.

In most cases, authority to regulate nonpoint source pollution and thus successful implementation of this TMDL is limited to local government entities and will require cooperative support from local volunteers, lake and watershed associations, and local officials in municipal government. Those activities can take the form of expanded education, obtaining and/or providing funding, and possibly local enforcement. Funding support to aid in implementation of this TMDL is available on a competitive basis under various state programs including the Section 319 Grant Program, the State Revolving Fund Program (SRF), and the Department of Environmental Management's Lakes and Pond Small Grants Program.

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Introduction

Section 303(d) of the Federal Clean Water Act requires each state to (1) identify waters for which effluent limitations normally required are not stringent enough to attain water quality standards and (2) to establish Total Maximum Daily Loads (TMDLs) for such waters for the pollutant of concern. TMDLs may also be applied to waters threatened by excessive pollutant loadings. The TMDL establishes the allowable pollutant loading from all contributing sources at a level necessary to achieve the applicable water quality standards. The TMDLs must account for seasonal variability and include a margin of safety (MOS) to account for uncertainty of how pollutant loadings may impact the receiving water's quality. This report and attached documents are submitted to the USEPA as a TMDL under Section 303d of the Federal Clean Water Act, 40 CFR 130.7. After public comment and final approval by the EPA, the TMDL will be incorporated into the watershed action plan to be developed by the Executive Office of Environmental Affairs Basin Team (see below) and serve as a guide for future implementation activities. In some cases, TMDLs will be used by DEP to set appropriate limits in permits for wastewater and other discharges. Currently, no point source discharges are permitted in the watershed with the exception of the Phase I stormwater permit for the City of Worcester. The stormwater from Worcester and other areas may be considered as a combination of point and nonpoint sources.

The Massachusetts Watershed Initiative is a new structure in state government that focuses all branches of government within each watershed to manage environmental issues. The Executive Office of Environmental Affairs (EOEA) has set up Watershed Teams with a Team Leader within each watershed in Massachusetts. The Teams represent state and federal agencies and local community partners. Within each watershed will be created a Watershed Community Council that may consist of watershed associations, business councils, regional planning agencies and other groups. Stream Teams may be created to assess environmental quality, identify local problems and recommend solutions. Stream Teams may include watershed associations, municipal government and business representatives. Additional information and contact information on the Watershed Teams is available on the web at http://www.state.ma.us/envir/watershd.htm.

The proposed Total Maximum Daily Load (TMDL) for Leesville Pond is based on a Diagnostic/Feasibility (D/F) Study conducted by Ganzon and Sutt (1990) and funded under the Massachusetts Clean Lakes Program. (Parts of the D/F are reproduced in Appendix 1). Leesville Pond is listed on the Massachusetts 303d list for Nuisance Aquatic Plants, Organic Enrichment/Low DO. D/F study concludes that the excessive weed growth and low dissolved oxygen in the pond is due to nutrient enrichment was from the pond's watershed. The D/F study recommends watershed management to control nutrients and sedimentation and also recommended increased flushing of the South Basin (Appendix I). The proposed control effort is predicted to reduce total phosphorus concentrations from 0.060mg/l to 0.040 mg/l. In many cases the State has limited authority to regulate nonpoint source pollution and thus successful implementation of this TMDL will require cooperative support from the public including lake and watershed associations, local officials and municipal governments in the form of education, funding and local enforcement. Additional funding support is available under various state programs including section 319 and the State Revolving Fund Program (SRF) and the Department of Environmental Management's Lakes and Pond Grant Program.

General Background and Rationale

Nutrient Enrichment: Nutrients are a requirement of life, but in excess can create problems. Lakes are ephemeral features of the landscape and over geological time most tend to fill with sediments and associated nutrients as they make a transition from lake to marsh to dry land. However, this natural successional ("aging") process can be and often is accelerated through the activities of humans—especially through development in the watershed. For highly productive lakes with developed watersheds, it is not easy to separate natural succession from "culturally induced " effects. Nonetheless, all feasible steps should be taken to reduce the impacts from cultural activities. The following discussion summarizes the current understanding of how nutrients influence the growth of algae and macrophytes, the time scale used in the studies, the type of models applied and the data collection methods used to create a nutrient budget. A brief description of the rationale for choosing a target load (the TMDL) as well as a brief discussion of implementation and management options is presented.

A detailed description of the current understanding of limnology (the study of lakes and freshwaters) and management of lakes and reservoirs can be found in Wetzel (1983) and Cooke et al., (1993). To prevent cultural enrichment it is important to examine the nutrients required for growth of phytoplankton (algae) and macrophytes. The limiting nutrient is typically the one in shortest supply relative to the nutrient requirements of the plants. The ratio of nitrogen (N) to phosphorus (P) in both algae and macrophyte biomass is typically about 7 by weight or 16 by atomic ratio (Vallentyne, 1974). Examination of relatively high N/P ratios in water suggests P is most often limiting and careful reviews of numerous experimental studies have concluded that phosphorus is a limiting nutrient in most freshwater lakes (Likens, 1972; Schindler and Fee, 1974). Most diagnostic/feasibility studies of Massachusetts lakes also indicate phosphorus as the limiting nutrient. Even in cases where nitrogen may be limiting, previous experience has shown that it is easier, more cost-effective and more ecologically sound to control phosphorus than nitrogen. The reasons include the fact that phosphorus is related to terrestrial sources and does not have a significant atmospheric source as does nitrogen (e.g., nitrates in precipitation). Thus, non-point sources of phosphorus can be managed more effectively by best management practices (BMPs). In addition, phosphorus is relatively easy to control in point source discharges. Finally, phosphorus does not have a gaseous phase, while the atmosphere is a nearly limitless source of nitrogen gas which can be fixed by some types of phytoplankton (the blue-greens, or cyanobacteria) even in the absence of other sources of nitrogen. For all of the reasons noted above, phosphorus is chosen as the critical element to control freshwater eutrophication, particularly for algal dominated lakes or in lakes threatened with excessive nutrient loading.

There is a direct link between phosphorus loading and algal biomass (expressed as chlorophyll a) in algae dominated lakes (Vollenweider, 1976). The situation is more complex in macrophyte dominated lakes where the rooted aquatic macrophytes may obtain most of the required nutrients from the sediments. In organic, nutrient rich sediments, the plants may be limited more by light or physical constraints such as water movement than by nutrients. In such cases, it is difficult to separate the effects of sediment deposition, which reduce depth and extend the littoral zone, from the effects of increased nutrients, especially phosphorus, associated with the sediments. In Massachusetts, high densities of aquatic macrophytes are typically limited to depths less than ten feet and to lakes where organic rich sediments are found (Mattson et al., 1998). Thus, the response of rooted macrophytes to reductions in nutrients in the overlying water will be much weaker and much slower than the response of algae or non-rooted macrophytes, which rely on the water for their nutrients. In algal or non-rooted macrophyte dominated systems nutrient reduction in the water column can be expected to control growth with a lag time related to the hydraulic flushing rate of the system. In lakes dominated by rooted macrophytes, additional, direct control measures such as harvesting, herbicides or drawdowns will be required to realize reductions in plant biomass on a reasonably short time scale. In both cases, however, nutrient control is essential since any reduction in one component (either rooted macrophytes or phytoplankton) may result in a proportionate increase in the other due to the relaxation of competition for light and nutrients. In addition, it is critical to establish a Total Maximum Daily Load so that future development around the lake will not impair water quality. It is far easier to prevent nutrients from causing eutrophication than to attempt to restore a eutrophic lake. The first step in nutrient control is to calculate the current nutrient loading rate or nutrient budget for the lake.

Nutrient budgets: Nutrient budgets and loading rates in lakes are determined on a yearly basis because lakes tend to accumulate nutrients as well as algal and macrophyte biomass over long time periods compared to rivers, which constantly flush components downstream. Nutrients in lakes can be released from the sediments into the bottom waters during the winter and summer and circulated to the surface during mixing events (typically fall and spring in deep lakes and also during the summer in shallow lakes). Nutrients stored in shallow lake sediments can also be directly used by rooted macrophytes during the growing season. In Massachusetts lakes, peak algal production, or blooms may begin in the spring and continue during the summer and fall while macrophyte biomass peaks in late summer. The impairment of uses is usually not severe until summer when macrophyte biomass reaches the surface of the water interfering with boating and swimming. Also, at this time of year the high daytime primary production and high nighttime respiration can cause large changes in dissolved oxygen. In addition, oxygen is less soluble in warm water of summer as compared to other times of the year. The combination of these factors can drive oxygen to low levels during the summer and may cause fish kills. For these reasons the critical period for use impairment is during the summer, yet the modeling is done on a yearly basis.

There are three basic approaches to estimating current nutrient loading rates: the measured mass balance approach and the landuse export approach and modeling the observed in-lake concentration. The measured mass balance approach requires frequent measurements of all fluvial inputs to the lake in terms of flow rates and phosphorus concentrations. The yearly loading is the product of flow (liters per year) times concentration (mg/l), summed over all sources (i.e., all streams and other inputs) and expressed as kg/year. The landuse export approach assumes phosphorus is exported from various land areas at a rate dependent on the type of landuse. The yearly loading is the sum of the product of landuse area (Ha) times the export coefficient (in kg/Ha/yr). Using a model of in-lake phosphorus concentrations is a indirect method of estimating loading and does not provide information on the sources of input but can be used in conjunction with other methods to validate results. The mass balance method is generally considered to be more accurate, but also more time consuming and more costly due to the field sampling and analysis. For this reason, the mass balance results are used whenever possible. If a previous diagnostic/ feasibility study or mass balance budget is not available, then a landuse export model, such as Reckhow et al., (1980) or the NPSLAKE model (Mattson and Isaac, 1999) can be used to estimate nutrient loading.

Target Load: Once the current nutrient loading rate is established, a new, lower rate of nutrient loading must be established which will restore water quality. This target load or TMDL, can be set in a variety of ways. Usually a target concentration in the lake is established and the new load must be reduced to achieve the lower concentration. This target nutrient concentration may be established by a water quality model that relates phosphorus concentrations to water quality required to maintain designated uses or specific water quality standards, such as the four-foot transparency criterion at Massachusetts swimming beaches. Alternatively, the target concentration may be set based on concentrations observed in background reference lakes for similar lake types or from concentration ranges found in lakes within the same ecological region (ecoregions). Various models (equations) have been used for predicting productivity or lake total phosphorus concentrations in lakes from analysis of phosphorus loads. These models typically take into consideration the waterbody's hydraulic loading rate and some factor to account for settling and storage of phosphorus in the lake sediments. Among the more well known metrics are those of Vollenweider (1975), Dillon-Rigler (1974) and Reckhow (1979). The TMDL must account for the uncertainty in the estimates of the phosphorus loads from the sources identified above by including a margin of safety. This margin of safety can be specifically included, and/or included in the selection of a conservative target, and/or included as part of conservative assumptions used to develop the TMDL.

After the target TMDL has been established, the allowed loading of nutrients is apportioned to various sources which may include point sources as well as private septic systems and various land uses within the watershed. In Massachusetts, few, if any, lakes receive direct point source discharges of nutrients. River impoundments often have upstream point sources, but these will be addressed as part of the appropriate river system. The nutrient source analysis generally will be related to landuse that reflects the extent of development in the watershed. This effort can be facilitated by the use of geographic information systems (GIS) digital maps of the area that can summarize landuse categories within the watershed. The targeted reductions must be reasonable given the reductions possible with the best available technology and Best Management Practices. The first scenario for allocating loads will be based on what is practicable and feasible for each activity and/or landuse to make the effort as equitable as possible.

Although the landuse approach gives an estimate of the magnitude of typical phosphorus export from various landuses, it is important to recognize that nonpoint phosphorus pollution comes from many discrete sources within the watershed. Perhaps the most common sources in rural areas are leaching from failed or inadequate septic systems and phosphorus associated with soil erosion. Soils tend to erode most rapidly following soil disturbances such as construction, gravel pit operations, tilling of agricultural lands, overgrazing, and trampling by animals or vehicles. A common problem with erosion in rural areas is erosion from unpaved roads. Soils may also erode rapidly where runoff water concentrates into channels and erodes the channel bottom. This may occur where impervious surfaces such as parking lots direct large volumes of water into ditches which begin to erode and may also result from excessive water drainage from roadways with poorly designed ditches and culverts. Any unvegetated drainage way is a likely source of soil erosion.

Discrete sources of nonpoint phosphorus in urban, commercial and industrial areas include a variety of sources that are lumped together as 'urban runoff' or 'stormwater'. As many of these urban sources are difficult to identify the most common methods to control such sources include reduction of impervious surfaces, street sweeping and other best management practices as well as treatment of stormwater runoff in detention ponds or other structural controls.

Other sources of phosphorus include phosphorus based lawn fertilizers used in residential areas, parks, cemeteries and golf courses and fertilizers used by agriculture. Manure from animals, especially dairies and other confined animal feeding areas is high in phosphorus. In some cases the manure is inappropriately spread or piled on frozen ground during winter months and the phosphorus can leach into nearby surface waters. Over a period of repeated applications of manure to local agricultural fields, the phosphorus in the manure can saturate the ability of the soil to bind phosphorus, resulting in phosphorus export to surface waters. In some cases, cows and other animals including wildlife such as flocks of ducks and geese may have access to surface waters and cause both erosion and direct deposition of feces to streams and lakes. Perhaps the most difficult source of phosphorus to account for is the phosphorus recycled within the lake from the lake sediments. Phosphorus release from shallow lake sediments may be a significant input for several reasons. These reasons include higher microbial activity in shallow warmer waters that can lead to sediment anoxia and the resultant release of iron and associated phosphorus. Phosphorus release may also occur during temporary mixing events such as wind or powerboat caused turbulence or bottom feeding fish, which can resuspend phosphorus rich sediments. Phosphorus can also be released from nutrient 'pumping' by rooted aquatic macrophytes as they extract phosphorus from the sediments and excrete phosphorus to the water during seasonal growth and senescence (Cooke et al., 1993; Horne and Goldman, 1994). Shallow lakes also have less water to dilute the phosphorus released from sediment sources and thus the impact on lake water concentrations is higher than in deeper lakes.

Implementation: The implementation plan or watershed management plan to achieve the TMDL will vary from lake to lake depending on the type and degree of development. While the impacts from development can not be completely eliminated, they can be minimized by prudent "good housekeeping" practices, known more formally as best management practices (BMPs). Among these BMPs are control of runoff and erosion, well-maintained subsurface wastewater disposal systems and reductions in the use of fertilizers. Activities close to the waterbody and its tributaries merit special attention for following good land management practices. In addition, there are some statewide efforts that provide part of an overall framework. These include the legislation that curbed the phosphorus content of many cleaning agents, revisions to regulations that encourage better maintenance of subsurface disposal systems (Title 5 Septic systems), and the Rivers Act that provides for greater protection of land bordering waterbodies. In addition, there is the public's concern about the environment that is being harnessed to implement remediation and protection plans through efforts associated with the Massachusetts Watershed Initiative and the Basin Teams. In some cases, structural controls, such as detention ponds, may be used to reduce pollution loads to surface waters.

The most important factor controlling macrophyte growth appears to be light (Cooke et al., 1994). Due to the typically large mass of nutrients stored in lake sediments, reductions in nutrient loadings by themselves are not expected to reduce macrophyte growth in many macrophyte-dominated lakes, at least not in the short-term. In such cases additional in-lake control methods are generally recommended to directly reduce macrophyte biomass. Lake management techniques for both nutrient control and macrophyte control have been reviewed by a Draft Generic Environmental Impact Report (Mattson et al., 1998). The Massachusetts Department of Environmental Protection will endorse in-lake remediation efforts that meet all environmental concerns, however, instituting such measures will rest with communities and the Clean Lakes Program now administered by EPA and, in Massachusetts, the Department of Environmental Management.

Financial support for implementation is potentially available on a competitive basis through both the non-point source (319) grants and the state revolving fund (SRF) loan program. The 319 grants require a 40 percent non-federal match of the total project cost although the local match can be through in-kind services such as volunteer efforts. Other sources of funding include the 604b Water Quality Management Planning Grant Program, the Community Septic Management Loan Program and the DEM Lake and Pond Grant Program. Information on these programs are available in a pamphlet "Grant and Loan Programs – Opportunities for Watershed Protection, Planning and Implementation" through the Massachusetts Department of Environmental Protection, Bureau of Resource Protection and the Massachusetts Department of Environmental Management (for the Lake and Pond Grant Program).

Since the lake restoration and improvements can take a long period of time to be realized, follow-up monitoring will be essential. This can be accomplished through a variety of mechanisms including volunteer efforts. Recommended monitoring will include Secchi disk readings, lake total phosphorus, macrophyte mapping of species distribution and density, visual inspection of any structural BMPs, coordination with Conservation Commission and Board of Health activities and continued education efforts for citizens in the watershed.

Waterbody Descriptions and Problem Assessment

Description: Leesville Pond, (MA51087) is a 50.5 acre (20.4 ha) pond located in the Blackstone River Watershed Basin at approximately 42°17’50” N, 71°48’45” W which is in the town of Auburn with a portion of the pond extending into Worcester Massachusetts (Fig 1). The lake was originally called Trowbridgeville Pond and was formed by damming Kettle Brook around 1830. The current dam is 220 feet long and 15 feet high with two currently inoperable sluice gates. The dam is in the City of Worcester but lake management is handled by the town of Auburn. At one time, the lake was larger but fill was added to connect an island to the shore and create a peninsula where a cemetery now sits. In addition, U.S. Interstate 290 was constructed with additional fill and bisected the lake. There is some disagreement as to the current size of the lake (the Ganzon and Sutt (1990) study quote 34 acres for the two main basins) but for modeling purposes we will include the section east of interstate 290, giving a pond area of 50.5 acres (20.4 ha). The pond consists of an eastern section on the east side of Interstate 290 where Kettle Brook enters, the water passes under Interstate 290 and then the pond is split by the peninsula. Most of the flow goes into the north basin and is discharged at the outlet dam, while the south basin is essentially stagnant with only a small 24 inch diameter (restricted to 15 inches at one end) culvert, about 320 feet long connecting the west end of the basin to the north basin near the outlet.

After runoff from a hurricane in 1955 flooded part of the City of Worcester the US Army Corps of Engineers created the Worcester Diversion in 1959 at the inlet of Kettle Brook to the pond on the east side of Interstate 290. The Diversion consists of a semi-circular weir (ogee spillway) which diverts flood waters into a tunnel and canal system and discharges the flood waters to the Blackstone River about 3.5 miles downstream (see Fig. 1). In high water conditions water flows through this diversion, but additional water can be diverted by closing one or both control gates in a small control dam just downstream of the diversion. With both gates open it is estimated that about 175 cfs flows downstream through the gates as water levels rise to the lip of the diversion weir. Although no records are available, it is roughly estimated that less than 10% of the normal yearly flow is diverted.

The pond has been the focus of several monitoring programs by various agencies. In 1987, the BSC Group of Boston began a Diagnostic Feasibility study on the pond as part of the Clean Lakes Program, however the project was halted in mid-July of 1988 due to funding cutbacks. The Massachusetts Department of Environmental Protection (then the Division of Environmental Quality Engineering) continued water quality studies for the remainder of the year and both data sets were analyzed by two students at Worcester Polytechnic Institute and summarized as the D/F study for Leesville Pond (Ganzon and Sutt, 1990).

Due to the high phosphorus loading from the watershed the lake is experiencing nuisance algae blooms, excessive macrophyte growth and growth of Lemna (duckweed) which often cover the surface, particularly in the south basin. The pond was listed on the 1998 Massachusetts 303d list for Nuisance Aquatic Plants and for organic enrichment and low dissolved oxygen (DEP, 1998). The overall goal is thus to restore the pond to meet the standards for primary and secondary contact recreation by reducing the blooms of nuisance algae, duckweed and by reducing macrophyte growth.

Pollutant Sources and Background

The Ganzon and Sutt (1990) D/F study concluded that phosphorus is most likely the limiting nutrient. It should be noted that light may also limit macrophyte growth in deep water. The typical total phosphorus concentrations average about 0.05 mg/l in the north basin but are higher in the south basin (Ganzon and Sutt, 1990). The best estimate is an average concentration of 0.06 mg/l or 60 ppb. The nutrient budget of Ganzon and Sutt (1990) was calculated in two ways, the first of which used landuse area multiplied by phosphorus export coefficients of Reckhow et al. (1980) and the second used flow-averaged phosphorus concentrations multiplied by annual flow. In their landuse analysis, Ganzon and Sutt did not consider that about seven square miles of watershed area are actually diverted from the basin as a water supply, thus reducing both water and nutrient loadings. The landuse method used by Ganzon and Sutt (1990) grossly overestimated phosphorus loading (4089.7 kg/yr) compared to the latter method (1520 kg/yr) which is generally considered more accurate. The study took the average of these two (2804 kg/yr) or 20.156 g/m^2/yr as current loading and proposed a reduction to 4 g/m^2/yr or 556.6 kg/yr. This proposed target is so low as to be unreasonable. In fact, by their own estimates of loading (see loading table in Appendix) the phosphorus export from forested areas alone exceed the proposed target by nearly a factor of two. In addition, Ganzon and Sutt report the hydraulic residence time to be 61 days on page 5 Ganzon and Sutt (1990). Our estimate of the average residence time of the North and South Basins (area 34 acres, mean depth 1.06 m and yearly flow of 43.0 cfs) is closer to 2 days. During the summer period when flows average about 15 cfs the residence time is estimated to be about 6 days, however, due to short-circuiting, the North Basin is actually much faster flushing while the South Basin is slower. We recalculated the landuse loading estimate based on the reduced area of the watershed with the NPSLAKE model developed by Mattson and Isaac (1999).

Thus, nutrient sources were estimated based on land use modeling within the DEP's NPSLAKE model as discussed below (Mattson and Isaac, 1999). The NPSLAKE model of Mattson and Isaac (1999) was designed to estimate watershed loading rates of phosphorus to lakes. The phosphorus loading estimates from the model are used with estimates of water runoff and these are used as inputs into a water quality model of Reckhow (1979). A brief description of the NPSLAKE model and data inputs are given here. MassGIS digital maps of land use within the watershed were used to calculate areas of landuse within three major types: Forest, rural and urban landuse. This model takes the area in hectares of land use within each of three categories and applies an export coefficient to each to predict the annual external loading of phosphorus to the lake from the watershed. Because much of the landuse data is based on old (1985) aerial photographs, the current landuses may have changed as development occurs and as pastures are abandoned. For most rural areas, the changes due to development of housing is often changes in open or agricultural lands being converted to low density housing, in which case, the export coefficients of the NPSLAKE model are the same and no change in loading is predicted to occur. In cases where development changes forests or rural land uses to urban land uses loading are predicted to increase. In some cases, loadings are predicted to decrease as additional agricultural land is abandoned and forest regrowth occurs. To account for this uncertainty a conservative target is chosen (see below). The MassGIS landuse maps are scheduled to be updated with current aerial photos and the TMDL can be modified as additional information is obtained.

Other phosphorus sources, such as septic system inputs of phosphorus, are estimated from an export coefficient multiplied by the number of homes within 100 meters of the lake. Point sources are estimated manually based on discharge information and site specific information for uptake and storage. Other sources such as atmospheric deposition to lakes was determined to be small and not significant in the NPSLAKE model, perhaps because lakes tend to be sinks rather than sources of phosphorus (Mattson and Isaac, 1999). For similar reasons wetlands were also not considered to be significant sources of phosphorus following (see discussion and references in Mattson and Isaac, 1999). Other, non-landuse sources of phosphorus such as inputs from waterfowl were not included, but can be added as additional information becomes available. If large numbers of waterfowl are using the lake the total phosphorus budget may be an underestimate, and control measures should be considered.

Internal sources (recycling) of phosphorus is normally not included because it is not considered as a net external load to the lake, but rather a seasonal recycling of phosphorus already present in the lake. In cases where this internal source is large it may result in surface concentrations higher than predicted from landuse loading models and may contribute to water quality violations during the critical summer period. In this case, internal loading was estimated by difference (see below). As additional monitoring data become available, these lakes will be assessed for internal contributions and possibly control of these sources by alum or other means. The major sources according to the land use analysis are shown for each lake in Table 2.

The NPSLAKE model assumes land uses are accurately represented by the MassGIS digital maps and that land use has not changed appreciably since the maps were compiled in 1985. The predicted loading is based on the equation:

$$\text{P Loading (kg/yr)} = 0.5^{*}\ \text{septics} + 0.13^{*}\ \text{forest ha} + 0.3^{*}\ \text{rural ha} + 14^{*}\ (\text{urban ha})^{0.5}$$

The coefficients of the model are based on a combination of values estimated with the aid of multiple regression on a Massachusetts data set and of typical values from previous diagnostic/feasibility studies in Massachusetts. All coefficients fall within the range of values reported in other studies such as Reckhow et al., (1980). Further details on the methods, assumptions, calibration and validation of the NPSLAKE model can be found in Mattson and Isaac (1999). The overall standard error of the model is approximately 172 kg/yr. If not data is available for internal loading a rough estimate of the magnitude of this sources can be estimated from the Reckhow model (see below) by substitution of the in-lake concentration for TP. The difference in predicted loadings from this approach and the landuse approach is the best estimate of internal loading.

The NPSLAKE model also generates predictions of estimated yearly average water runoff to the lake based on total watershed area and runoff maps of Massachusetts (see Mattson and Isaac, 1999). Other estimates of nitrogen and total suspended solid (TSS) loading rates are estimates based on Reckhow et al.(1980) and EPA (1983) respectively, and are provided here for informational and comparison purposes only.

Because of the general nature of the landuse loading approach, natural background is included in land use based export coefficients. Natural background can be estimated based on the forest export coefficient of 0.13 kg/ha/yr multiplied by the hectares of the watershed assuming the watershed to be entirely forested. Without site specific information regarding soil phosphorus and natural erosion rates the accuracy of this estimate would be uncertain and would add little value to the analysis.

The results (rounded to the nearest kg) of 1327. kg/yr as shown in Table 1 were modified by adding an additional 259 kg/yr from internal recycling, waterfowl or other souces to get a final total of 1586 kg/yr in order to agree with the estimated loading based on average yearly flow times concentration as described below. Because of the better agreement of modeled vs. measured phosphorus, the NPSLAKE model results will be used as the basis of phosphorus loading in this TMDL. Population (census) data and estimated growth rates are from projections provided on the internet (www.umass.edu/miser/) by the Massachusetts Institute for Social and Economic Research (MISER) at the University of Massachusetts, Amherst. The population in Auburn ranged between 14,845 and 15,005 from 1980 to the 1990 census. Miser predictions on growth are 15,926 for the year 2000 and 16,094 for the year 2010 with an estimated 20 year growth rate of about 7.26 percent. Thus, the landuse estimates of nutrient loading probably have not changed significantly. The data are considered valid for this analysis as there are no reports of significant change in the watershed in the past ten years and no significant lake management has been conducted.

Table 1. Results of NPSLAKE model for Leesville Pond.

Total Estimated Pollution loads based on GIS Landuse and NPSLAKE model (Mattson and Isaac, 1999).

```
_____________________________________________________________________________
Watershed Area=                                        6358.4 Ha (24.5 mi2)
Average Annual Water Load  =                       38760798.7 m3/yr (43.9 cfs)
Average Runoff=                                          61.0 cm/yr (24.0 in/yr)
Lake area=                                               20.4 Ha. (50.4ac)
Areal water loading to lake:  q=                        190.0 m/yr.
Homes with septic systems within 100m of lake.=           0.0
Other P inputs =                                        259.2 kg/yr
 _____________________________________________________________________________

Estimate of annual Nonpoint Source  Pollution Loads by land use
 _____________________________________________________________________________

 Land use            Area             P Load          N Load       TSS Load
                   Ha (%)          kg/yr (%)          kg/yr          kg/yr
 _____________________________________________________________________________
 Forest category
   Forest:         3212.2 (50.5)   417.6 (31.5)         8030.4        77091.8
 Rural category
   Agriculture:     499.3 (7.9)    149.8 (11.3)         5137.1       180454.7
   Open land:       327.3 (5.1)     98.2 (7.4)          1701.7        46493.5
   Residential Low: 414.0 (6.5)    124.2 (9.4)          2276.9       160623.0
 Urban category
   Residential High:988.9 (15.6)   360.9 (27.2)         8293.7       564134.6
   Comm - Ind:      482.8 (7.6)    176.2 (13.3)         4813.4       346633.4
 Other Landuses
   Water:           324.2 (5.1)      0.0 (0.0)             0.0            0.0
   Wetlands:        109.8 (1.7)      0.0 (0.0)             0.0         5818.8

 Subtotal          6358.4         1326.8               30412.1      1383364.1

 Other P inputs:     NA            259.2 (0.0)
 0.0 Septics:        NA              0.0 (0.0)
 _____________________________________________________________________________
 Total             6358.4 (100.0) 1586.0(100)          30412.1      1383364.1
 _____________________________________________________________________________
```

Water Quality Standards Violations

There are two water quality violations listed; Nutrients and Organic enrichment/Low DO. In consideration that the waters listed are a Class B water and warmwater fishery, the data listed above were judged sufficiently well documented to place the lake on the Massachusetts 303d list for 1998 (DEP, 1998) related to impairment of primary and secondary contact recreation and aesthetics. These Water Quality Standards are described in the Code of Massachusetts Regulations under sections:

> 314CMR 4.04 subsection 5:
>
> (5) Control of Eutrophication. From and after the date 314 CMR 4.00 become effective there shall be no new or increased point source discharge of nutrients, primarily phosphorus and nitrogen, directly to lakes

> and ponds. There shall be no new or increased point source discharge to tributaries of lakes or ponds that would encourage cultural eutrophication or the growth of weeds or algae in these lakes or ponds. Any existing point source discharge containing nutrients in concentrations which encourage eutrophication or growth of weeds or algae shall be provided with the highest and best practical treatment to remove such nutrients. Activities which result in the nonpoint source discharge of nutrients to lakes and ponds shall be provided with all reasonable best management practices for nonpoint source control.

and

> 314CMR 4.05 (3) b: "These waters are designated as a habitat for aquatic life, and wildlife, and for primary and secondary contact recreation...These waters shall have consistently good aesthetic value.
>
> 1. Dissolved Oxygen:
>
> a. Shall not be less than 6.0 mg/l in cold water fisheries nor less than 5.0 mg/l in warm water fisheries unless background conditions are lower;
>
> b. natural seasonal and daily variations above this level shall be maintained…

and

> 314CMR 4.05 (5) a: All surface waters shall be free from pollutants ......or produce undesirable or nuisance species of aquatic life".

Section 314 CMR 4.40(3) subsection 6 also states:

> 6. Color and Turbidity - These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this class.

In addition, the Minimum Standards for Bathing Beaches established by the Massachusetts Department of Public Health which state that swimming and bathing are not permitted at public beaches when:

> 105CMR 445.10 (2b) A black disk, six inches in diameter, on a white field placed at a depth of at least 4 feet of water is not readily visible from the surface of the water; or when, under normal usage, such disk is not readily visible from the surface of the water when placed on the bottom where the water depth is less than four feet….

The Ganzon and Sutt (1990) study concluded nutrient inputs of phosphorus from the watershed to be the primary cause of the nuisance plant growth and the organic enrichment/ low DO conditions.

TMDL Analysis

Identification of Target: There is no loading capacity *per se* for nuisance aquatic plants. As the term implies, TMDLs are often expressed as maximum daily loads. However, as specified in 40 CFR 130.2(I), TMDLs may be expressed in other terms when appropriate. For this case, the TMDL is expressed in terms of allowable annual loadings of phosphorus because the growth of phytoplankton and macrophytes responds to changes in annual rather than daily loadings of nutrients. The target in-lake total phosphorus concentration chosen is based on consideration of the typical concentrations expected in lakes in the region. The phosphorus ecoregion map of Griffith et al. (1994) indicates the lake is in an ecoregion with concentrations of 15-19 ppb, based on spring/fall concentrations, while the phosphorus ecoregion map of Rohm et al., (1995) suggests that typical lakes in this ecoregion would have concentrations between 30 and 50 ppb, based on summer concentrations. As noted above, for most lakes nutrient budgets are calculated on an annual basis, as it is generally believed that they respond slowly to changes in nutrient loadings due to the long residence time. Leesville Pond, however, has a very short residence time of about 2 days (not 61 days as calculated by Ganzon and Sutt, 1990) due to the shallow mean depth of 1.06 m and this residence time is probably even shorter in the north basin and somewhat longer in the south basin. Considering that Leesville Pond is more of a 'run of the river' impoundment with a very fast flushing time much of the algae and unattached macrophytes are expected to be flushed downstream before growing to levels otherwise expected from the TP concentrations. Thus, DEP is justified in this case to set the target TP concentration at a relatively high level of 40 ppb. Note that according to the Carlson Trophic State analysis (Carlson,1977) a lake should have total phosphorus concentrations of about 40 ppb to meet the 4-foot transparency requirement for swimming beaches in

Massachusetts. Normally the target should be set lower than this to allow for a margin of safety, but fast flushing reservoirs are not as sensitive to phosphorus loadings and the target can be set higher than in lakes. The lowered phosphorus concentrations will lessen the chance of nuisance algal blooms, which may occur as macrophyte biomass is reduced by direct controls.

The shallow water sediments offer an ideal habitat for natural growth of aquatic macrophytes, which provide habitat for fish and wildlife and as such complete elimination of macrophytes is neither possible nor desired. To some extent, the proliferation of aquatic macrophytes in the pond is a natural condition resulting from the availability of shallow, nutrient rich sediments being flooded when the lake was created by a dam. Some consideration should be given to reclassifying portions of the lake (particularly the south basin) as a wetland habitat area to be protected. Thus reducing the supply of external phosphorus may not meet the goals of the TMDL without additional management in the lake as discussed below. The lower phosphorus concentrations will lessen the chance of nuisance algal blooms, which may occur as macrophyte biomass is reduced by direct controls.

Due to the fast flushing rate normal modeling equations do not apply (e.g. the Pond exceeds the hydrologic loading of the range of lakes used to calibrate the Reckhow et al. 1979 model). The U.S.E.P.A. has used a hydraulic residence time of 14 days as distinguishing river pools from lakes. In this case, a simple average concentration times average yearly flow (Equation 1, below) is used to relate to the annual load. Using the hydrologic areal water load to the lake of 190 m/yr estimated from the NPSLAKE model and the lake area of 139,123 m^2 from Ganzon and Sutt (1990) we estimate a total yearly flow of 26,433,000 m^3. Based on the estimated 60 ppb total phosphorus in the pond we estimate a loading of 1,586 kg/yr of Total Phosphorus.

$$\textbf{Annual load TP (kg/yr) = TP (mg/m}^{3}\textbf{)* Annual water load (m}^{3}\textbf{/yr) /1,000,000 mg/kg} \qquad \textbf{(1)}$$

Loading Capacity

The 40 ppb target represents a 33 percent reduction from the current total phosphorus concentration of 60 ppb in the North Basin. For purposes of modeling, only the North Basin Concentrations are used, as the higher concentrations in the stagnant South Basin are assumed to be due to recycling from the sediments. Again, based on the simple flow times concentration equation, the target concentration of 40 ppb the loading is estimated to be attained with an annual total phosphorus load of about 1,060 kg/yr.

Wasteload Allocations, Load Allocations and Margin of Safety:

DEP chose an additional margin of safety of 5 percent of the total TMDL. In this case, the margin of safety is 1060 kg/yr*.05 or 53 kg/yr. Much of the runoff from urban landuses (High density housing and commercial industrial landuse) may be considered as point sources, but also include some nonpoint sources. In this report, such loads are included in the waste load allocation of 271 kg/yr, which leaves 736 kg/yr for the load allocation to nonpoint sources as indicated in the right side of Table 2. This will require a reduction of 579kg/yr from the annual load. Loading allocations are based on the NPSLAKE (Mattson and Isaac, 1999) landuse modeled phosphorus budget. Phosphorus loading allocations for each landuse category are shown (rounded to the nearest kg/yr) in Table 2. No reduction in forest loading is targeted, because other than logging operations, which are relatively small in scale and already have BMPs in place, this source is unlikely to be reduced by additional BMPs. The remaining load reductions are allocated as a proportional phosphorus loading reduction of about 49 percent.

The reductions in TP loading will be accomplished by a watershed management source reduction program. Improvements in water quality are also expected if flushing rates can be increased in the south basin.

Table 2. TMDL Load Allocations.

Source	*Current TP Loading (kg/yr)*	*Target TP Load Allocation (kg/yr)*
Load Allocation:		
Forest	418	418
Agriculture	150	76
Open Land	98	49
Residential (Low den.)	124	62
Septic System	0	0
Internal recycling	259	131
Waste Load Allocation:		
Residential (High den.)	361	182
Comm. Indust.	176	89
Total Inputs	1586	1007

The TMDL is the sum of the wasteload allocations (WLA) from point sources (e.g., sewage treatment plants) plus load allocations (LA) from nonpoint sources (e.g., landuse sources) plus a margin of safety (MOS). In this case the TMDL is:

TMDL = WLA + LA + MOS = 271 kg/yr + 736 kg/yr + 53 kg/yr = 1060. kg/yr.

Modeling Assumptions, Key Input, Calibration and Validation: No models currently exist to predict a reduction of nuisance aquatic macrophytes as a result of phosphorus controls, therefore, no macrophyte models were used. Control of nuisance aquatic macrophytes is based on established literature and best professional judgment. As noted above, due to the fast flushing rate normal lake modeling equations do not apply to such a fast flushing reservoir and instead we have modeled it as a simple batch reactor with Total Phosphorus assumed to be conservative. The concentrations used we based on the North Basin, which is assumed to better represent the phosphorus loading of the system. The South Basin, as noted previously, is largely stagnant and does not represent average loading concentrations. The hydraulic loading was estimated from the NPSLAKE model described in Mattson and Isaac (1999), which assumes in this case that 24 inches of runoff occur in the watershed each year. Annual flow was estimated by multiplying watershed area by annual runoff and annual Phosphorus loads were estimated from average concentrations of the North Basin multiplied by annual flow as noted above.

Seasonality: As the term implies, TMDLs are often expressed as maximum daily loads. However, as specified in 40 CFR 130.2(I), TMDLs may be expressed in other terms when appropriate. For this case, the TMDL is expressed in terms of allowable annual loadings of phosphorus. Although critical conditions occur during the summer season when weed growth is more likely to interfere with uses, water quality in many lakes is generally not sensitive to daily or short term loading, but is more a function of loadings that occur over longer periods of time (e.g. annually). Therefore, seasonal variation is taken into account with the estimation of annual loads. In addition, evaluating the effectiveness of nonpoint source controls can be more easily accomplished on an annual basis rather than a daily basis.

For most lakes, it is appropriate and justifiable to express a nutrient TMDL in terms of allowable annual loadings. The annual load should inherently account for seasonal variations by being protective of the most sensitive time of year. The most sensitive time of year in most lakes occurs during summer, when the frequency and occurrence of nuisance algal blooms and macrophyte growth are usually greatest. Therefore, because the Leesville Pond phosphorus TMDL was established to be protective of the most environmentally sensitive period (i.e., the summer season), it will also be protective of water quality during all other seasons. Additionally, the targeted reduction in annual phosphorus load to Leesville Pond will result in the application of phosphorus controls that also address seasonal variation. For example, certain control practices such as stabilizing eroding drainage ways or maintaining septic systems will be in place throughout the year while others will be in effect during the times the sources are active (e.g., application of lawn fertilizer).

Implementation

First and foremost the towns subject to Phase II stormwater regulations (Auburn, Paxton, Leicester, and Millbury) as well as MassHighways should begin the stormwater management plans required under Phase II to reduce discharge of pollutants to the “maximum extent practicable”.

MassHighway, which maintains the Interstate Highways including I-290 as well as other state roads, will also be required to apply for the EPA Phase II General Stormwater NPDES Permit by March 10 of 2003. MassHighways does have a draft Stormwater Handbook (MassHighways 2000) which details BMP installation and maintenance on new construction. It is DEP’s understanding that these BMPs have not been fully implemented yet in this and other regions.

To reduce loadings of sediments and associated nutrients to the target level this TMDL will require the following additional minimal, performance standards for roadways within the watershed area of the TMDL (see map in Appendix I). :

1)Visually inspect the roads monthly and sweep as needed. Any solids or "visible roadway accumulation" (debris, sand, dust, etc.) on paved roads must be removed. At a minimum, roads must be swept a least twice a year as soon after snowmelt as possible or by April 1st of each year and again in the fall. It is recommended that future purchases of sweepers should be of the high efficiency design.
2)Inspect catch basins at least twice a year and any other settling or detention basins once a year to measure depth of solids. If solids are one half or more of design volume for solids, then completely remove all solids.
3)Inspect and maintain all structural components of stormwater system on a yearly basis.

The implementation plan has several additional components: maintenance and repair of the dam if the town decides to keep the pond. A watershed survey should be conducted to identify major sources of Nonpoint source pollution and target those for Best Management Practices (BMPs) to reduce sources of phosphorus. Funding must be found to implement the targeted BMPs and finally, continued monitoring of water quality should be conducted to determine effectiveness of the BMPs. The Ganzon and Sutt (1990) diagnostic study identified some watershed management programs that could be implemented, it is DEP’s understanding that these measures have not been undertaken..

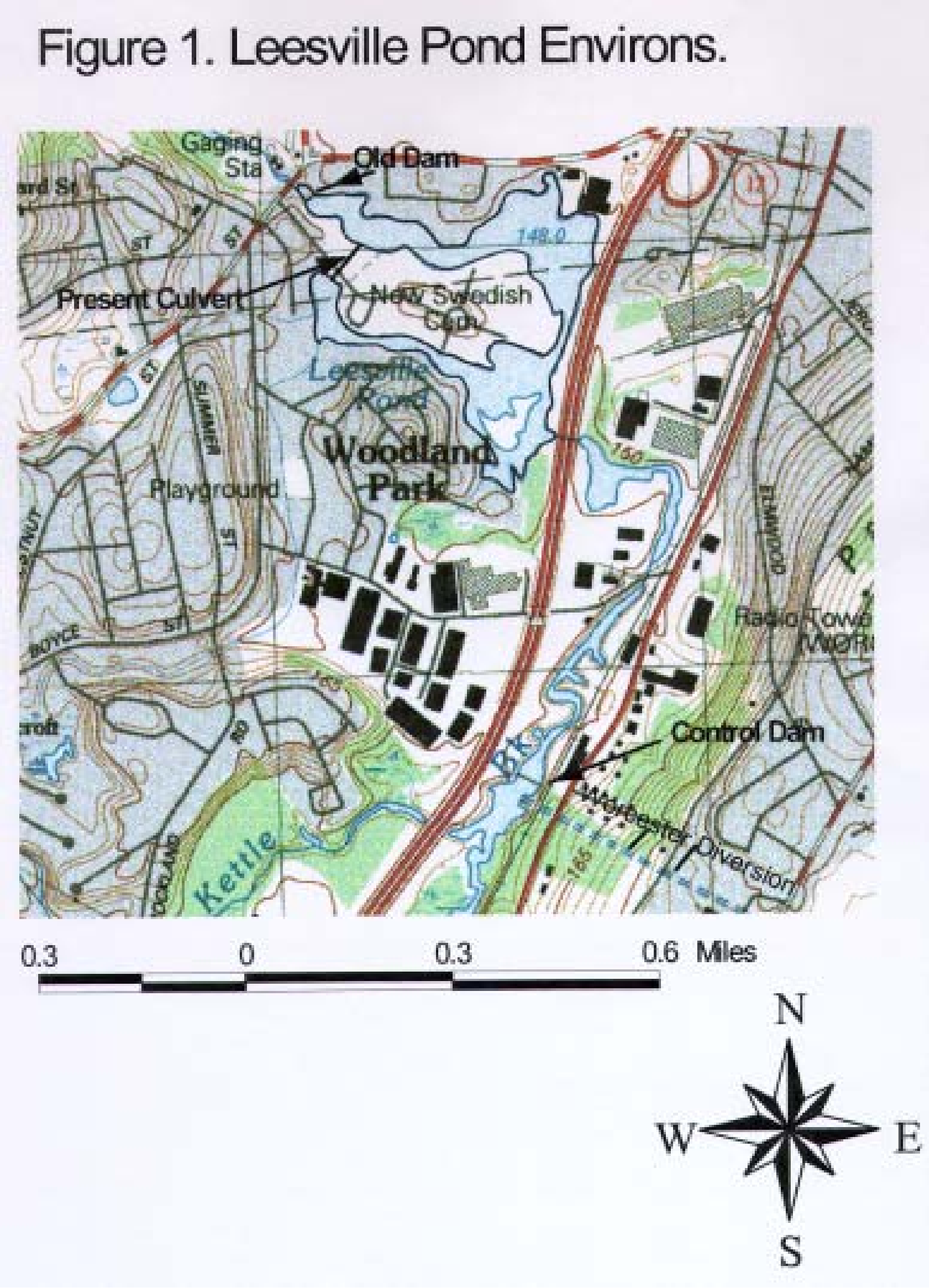

Figure 1. Leesville Pond Environs.

Another option to entirely divert large stormwater flows to the Worcester diversion was considered and rejected as it was believed that the sources of nutrients could be controlled within the watershed and not simply diverted downstream where additional impacts may occur. Instead, an enhancement of the culvert to improve flushing in the south basin was proposed.

While it is likely that increased flow through the south basin would improve conditions (presumably to mimic conditions of the north basin), simply increasing the culvert size at the west end of the south basin may not accomplish the goal because flowing water will tend to take the path of least resistance and continue to flow through the north basin where the outlet of the pond is located. Instead, it is possible to get increased flushing of the South Basin by running a small diameter (e.g. 10 inch) from the South Basin, through the culvert, along the bottom of the pond to a deep outlet opening in one of the sluice gates of the dam about 900 feet away. Such a pipe could be operated by a valve to draw water directly from the South Basin using the 6.5-foot head drop of the sluice gates. This would leave that gate inoperable, but this is no loss as both gates are presently inoperable in any case. If designed with a continuous slope in the pipe through the culvert area, the design would not require siphon and the inlet could be adjustable to take either surface water (to flush duckweed downstream) or lowered to remove anoxic and/or nutrient rich bottom water, as desired. Such measures would have to be further studied and the condition of the old dam and associated gates reevaluated. If 2 cfs of flow (2*883,000 m^3/yr) were generated it could increase flushing of the estimated 11850 m^3 volume of the South Basin to equal about a 2.5 day flushing time. The diminished flushing of the North Basin would be minimal (about 13 percent less). There would be no net increased flow downstream to the Curtis Ponds, only a change in the path taken by the water to favor flow through the south basin of Leesville. Significant cost savings could be realized with this option if the 10 inch pipe could be threaded through the larger culvert and simply sunk to the bottom of the lake, thus eliminating the need for costly excavation. This option would require further engineering inspections of the dam and a cost/feasibility analysis. The Massachusetts Office of Dam Safety may be able to offer some of these services.

Joan Crowell, the president of the Leesville Pond Association, noted in a phone conversion in January of 1999 that flash boards on the old dam were removed last fall and lake level subsequently lowered about 8 inches, which now interferes with skating due to weeds in ice. Also the sluice gate was temporarily repaired with plywood but it has never been fully repaired as promised.

Because of the uncertainty associated with predictions of water quality improvements due to the proposed flushing project, it is necessary to target the watershed for nutrient reductions through watershed BMP management programs. Because much of the nutrient loading is coming from developed areas (see Table 1) and from Interstate 290, urban and highway runoff should be targeted in particular. The Town of Auburn is included in the newly announced EPA Storm Water Phase II Rule. This rule requires the Town to develop and implement a stormwater management plan for the municipal separate storm sewer system (MS4), under the National Pollutant Discharge Elimination System (NPDES). BMPs for general nonpoint source pollution control are described in a manual by Boutiette and Duerring (1994). The Commonwealth has provided a strong framework to encourage watershed protection by legislation requiring low phosphorus detergents. All of these actions will be emphasized during the outreach efforts of the Watershed Team.

Considering the lack of information on discrete sources of phosphorus to the lake the BMP implementation plan will of necessity include an organizational phase, an information gathering phase, and the actual BMP remedial action phase. Phosphorus sources can not be reduced or eliminated until the sources of phosphorus are identified. Because many of the nutrient sources are not under regulatory control of the state, engagement and cooperation with local citizens groups, landowners, local officials and government organizations will be needed to implement this TMDL. The Massachusetts Department of Environmental Protection will use the Watershed Basin Team as the primary means for obtaining public comment and support for this TMDL. The proposed tasks and responsibilities for implementing the TMDL are shown in Table 3. The next step will be to release this TMDL for public comment to watershed and lake associations, town Conservation Commissions and the interested public. Depending on public response, a public meeting will be held to obtain comments on the report, define goals and to organize groups for implementation. The local citizens within the watershed will be encouraged to participate in the information gathering phase. This phase may include a citizen questionnaire mailed to homeowners within the watershed to obtain information on use of the lake, identify problem areas in the lake and to survey phosphorus use and Best Management Practices in the watershed. The most important part of the information-gathering phase is to conduct a NPS watershed field survey to locate and describe sources of erosion and phosphorus within the watershed following methods described in “Massachusetts Volunteers Guide for Surveying a Lake Watershed and Preparing an Action Plan” (DEP, 2001a). For this survey volunteers are organized and assigned to subwatersheds to specifically identify, describe and locate potential sources of erosion and other phosphorus sources by driving the roads and walking the streams. Once the survey is completed, the Basin Team will be asked to review and compile the data and make recommendations for implementation. Responsibility for remediation of each identified source will vary depending on land ownership, local jurisdiction and expertise as indicated in Table 4. Farmers can apply for money to implement BMPs as part of the NRCS programs in soil conservation. Town public works departments will generally be responsible for reduction of erosion from town roadways and urban runoff. The Conservation Commission will generally be responsible for ensuring the BMPs are being followed to minimize erosion from construction within the town. A description of funding sources for these efforts is provided in the Program Background section, above.

The major implementation effort would take place during the year 2000 as part of a rotating 5-year cycle, but would continue in the “off years” as well. The major components will focus on stage I of Whitman and Howard (1987), which involves septic system inspection, maintenance and upgrades as required under Title 5 with the Board of Health as the lead agency. Additional nutrient and erosion control will focus on enforcement of the wetlands protection act by the local Conservation Commission and various Best Management practices supported by the National Resource Conservation Service (NRCS formerly SCS). Best Management Practices (BMPs) for logging are presented in Kittredge and Parker (1995) and BMPs for general nonpoint source pollution control are described in a manual by Boutiette and Duerring (1994), BMPs for erosion and sediment control are presented in DEP (1997). The Commonwealth has provided a strong framework to encourage watershed management through the recent modifications to on-site septic system regulations under Title 5 and by legislation requiring low phosphorus detergents. All of these actions will be emphasized during the outreach efforts of the Watershed Team.

The Department is recommending that the lake be monitored on a regular basis and if the lake does not meet the water quality standards additional implementation measures may be implemented. As new housing development expands within the watershed, additional measures will be needed to control the associated additional inputs of phosphorus. A proactive approach to protecting the lake may include limiting development, particularly on steep slopes near the river, changes in zoning laws and lot sizes, requirements that new developments and new roadways include BMPs for runoff control and more stringent regulation of septic systems. Examples of town bylaws for zoning and construction, as well as descriptions of BMPs are presented in the Nonpoint Source Management Manual by Boutiette and Duerring (1994), that was distributed to all municipalities in Massachusetts. Other voluntary measures may include encouraging the establishment of a vegetative buffer around the lake and along the river, encouraging the use of non-phosphorus lawn fertilizers and controlling runoff from agriculture and timber harvesting operations. Such actions can be initiated in stages and at low cost. They provide enhancements that residents should find attractive and, therefore, should facilitate voluntary implementation. The National Resource Conservation Service is an ideal agency for such an effort and the residents will be encouraged to pursue NRCS’ aid.

Reducing the supply of nutrients may not in itself result in control of rooted macrophytes and continued macrophyte management is an essential part of the implementation plan. The approach recommended in the Ganzon and Sutt (1990) report is to repair the dam and control gates that will allow a drawdown. Although not proposed here, the town should seek opportunities to get selected areas dredged at reduced cost.

Table 3. Proposed Tasks and Responsibilities

Tasks	**Responsible Group**
TMDL development	DEP
Organization, contacts with Volunteer Groups	Watershed Team
Study the possibility of reclassification of south basin of Leesville Pond as a wetland habitat area to be protected.	DEP
Conduct loading study and develop methodology to calculate loadings from highways	MassHighway
Initiate twice yearly sweeping and catch basin inspection and cleaning program along I-290 and other roadways (see text). Install additional BMPs as needed to address pollutant loadings identified above.	MassHighway, MassPike and towns of Auburn, Leicester, Paxton, and Millbury and City of Worcester.
Prepare stormwater management plan for Phase II.	MassHighways, MassPike and towns of Auburn, Leicester, Paxton, and Millbury.
Organize and implement NPS watershed field survey	Watershed Team and Leesville Pond Association
Compile and prioritize results of NPS watershed surveys	Watershed Team and Leesville Pond Association
Determine if dam is to be repaired or removed.	Town of Auburn
Following decision to repair dam, explore funding sources and begin project.	Town of Auburn with assistance from Watershed Team, and Leesville Pond Association.
Examine feasibility and costs of South Basin flushing,	Watershed Team, Town of Auburn and Leesville Pond Association.
Organize implementation; work with stakeholders and local officials to identify remedial measures and potential funding sources.	Watershed Team and Leesville Pond Association and local Conservation Commission
Write grant and loan funding proposals	Leesville Pond Association, BlackstoneWatershed Associations, Towns, Planning Agencies, NRCS
Organize and implement education, outreach programs	Leesville Pond Association, BlackstoneWatershed Associations,
Implement remedial measures for discrete NPS pollution	See Table 4 below.
Include proposed remedial actions in the Watershed Management Plan	Watershed Team
Provide periodic status reports on implementation of remedial actions to DEP	Watershed Team
Monitoring of lake conditions	DEP (year 2 of cycle) and Leesville Pond Association (annually)

Table 4. Guide to Urban Nonpoint Source Control of Phosphorus and Erosion

Type of NPS Pollution	Whom to Contact	Types of Remedial Actions
Industrial		
Phosphorus Cleaning Agents	Industry Manager	Reuse and reduce or eliminate phosphorus containing cleaning agents.
Floor drains connected to storm sewers	Industry Manager and Regional DEP	Redirect floor drains to sewer system.
Stormdrains	Industry Manager and Regional DEP	Label stormdrains and forbid dumping or washing of chemicals into stormdrains. Add detention/ filtration basins to all stormdrains.
Stormwater runoff	Industry Manager, EPA	Use nonstructural BMPs for reducing stormwater pollution including fertilizer use, street and parking lot sweeping and Pollution Prevention Plans, Multi-sector NPDES permits.
Construction		
Erosion, pollution from development and new construction.	Conservation commission, Town officials, planning boards	Enact bylaws requiring BMPs and slope restrictions for new construction, zoning regulations, strict septic regulations. Enforce Wetlands Protection Act
Erosion at construction sites	Contractors, Conservation commission	Various techniques including seeding, diversion dikes, sediment fences, detention ponds etc.
Stormwater Runoff		
Turf Management	Golf Courses, Parks & Recreation Departments	Use non-phosphorus containing fertilizers. Apply fertilizers only after soil tests.
Urban Runoff from public roads	MassHighway, MassPike, Town or city Dept. Public Works,	Reduce impervious surfaces, institute street sweeping program, catch basin cleaning, install detention basins etc. (see text).
Unpaved Road runoff	Town or city Dept. Public Works	Pave heavily used roads, divert runoff to vegetated areas, install riprap or vegetate eroded ditches.
Residential areas		
Septic Systems	Homeowner, Lake associations, Town Board of Health, Town officials	Establish a septic system inspection program to identify and replace systems in non-compliance with Title 5. Establish a regular septic system inspection program. Discourage garbage disposals in septic systems.
Lawn and Garden fertilizers	Homeowner, Lake associations	Establish an outreach and education program to encourage homeowners to eliminate the use of phosphorus fertilizers on lawns, encourage perennial plantings over lawns.
Runoff from Housing lots	Homeowner, Lake associations	Divert runoff to vegetated areas, plant buffer strips between house and lake
Other stream or lakeside erosion	Landowner, Conservation Commission	Determine cause of problem; install riprap, plant vegetation.

Reasonable Assurances

Reasonable assurances that the TMDL will be implemented include both enforcement of current regulations, availability of financial incentives, and the various local, state and federal program for pollution control. Enforcement of regulations includes enforcement of the permit conditions for point sources under the National Pollutant Discharge Elimination System (NPDES). Enforcement of regulations controlling nonpoint discharges include local enforcement of the states Wetlands Protection Act and Rivers Protection Act; the Title 5 regulations for septic systems and various local regulations including zoning regulations. Financial incentives include Federal monies available under the 319 NPS program and the 604 and 104b programs, which are provided as part of the Performance Partnership Agreement between DEP and the USEPA. Additional financial incentives include state income tax credits for Title 5 upgrades, low interest loans for Title 5 septic system upgrades and cost sharing for agricultural BMPs under the Federal NRCS program. Lake management grants are also provided by the State Department of Environmental Management Lakes and Ponds Program.

Water Quality Standards Attainment Statement

The proposed TMDL, if fully implemented, will result in the attainment of all applicable water quality standards, including designated uses and numeric criteria for each pollutant named in the Water Quality Standards Violations noted above.

Monitoring

A synoptic survey of the lake from a vantagepoint on the shoreline was conducted by DEP in June of 1994 which noted very dense submerged plants (including *Cabomba caroliniana*) and very turbid conditions, but no data were collected. Monitoring will be continued on a five-year watershed cycle with this basin being scheduled to be visited again in 2003, 2008 etc. The extent of monitoring will depend on priority ranking of the sites.

Public Participation

The results of a lake management questionnaire returned by the Leesville Pond Association are available in Appendix II. A preliminary public meeting was held on Nov. 10, 1999 with state and local government representatives and local environmental groups including the Leesville Pond Association at the DEP office in Worcester to discuss an earlier draft of the TMDL. This draft TMDL will be announced in the Environmental Monitor for public review and comment.

The final public meeting was held on November 1, 2001 at 6:30pm at the Knights of Columbus Hall in Auburn with 63 people in attendance (see Appendix III). Invitation letters were sent to town and city officials as well as other environmental groups. A newpaper articles in the Worcester Telegram and Gazette noted the time and place of the meeting.

Public Comment and Reply

During the public meeting much of the discussion focused on repairing the dam and on the responsibilities of MassHighways to control stormwater runoff from I-290, and the Phase II stormwater discharge requirements of the Town of Auburn and MassHighways. It was noted that the City of Worcester already has a Phase I stormwater discharge permit. The following is a summary of written and oral comments (in some cases edited for clarity) which were received during the 30-day comment period. Sections of the draft report were modified as appropriate to respond to the comments.

1 **Comment: The use of the NPSLAKE model is a good tool to estimate pollution loading to a lake, evaluating any specific land use coverages is problematic if the specific map isn't included. Please provide the specific land use data, in GIS map form, used for the NPSLAKE model, so that we can better comment on the results of the load calculations.**

Response: A map is now provided in Appendix IV.

2. **Comment: One source of pollution load for Leesville Pond that isn't specifically identified in your evaluation, but should be looked at as a separate source of NPS is highway runoff. Interstate 290 cuts Leesville Pond and probably discharges a great deal of nutrients along with sediment loads to the Pond. I think segregating out the contribution from I-290 would help evaluate possible BMPs for the highway.**

Response: The NPSLAKE model does not have the capability of estimating runoff from specific highways. We hope to obtain specific data on highway runoff from MassHighways (see comment #15 below).

3. **Comment: The flushing project proposed on page 18 indicates that it might work even with the gates of the dam left inoperable, would not it make more sense to fix the gates, and conduct a drawdown for the Pond to deal with the weeds. This might also increase the movement of water from the South Basin to the dam. Please add dam repairs to the sluice gate and conducting a drawdown to Table 4 as part of the Tasks that will be needed to address the noxious weeds and improve Leesville Pond. Conducting a drawdown was discussed by James Straub, DEM Lakes and Ponds Program, at the Public Hearing, as a necessary first step to helping the Pond.**

Response: If the purpose of management is to conduct a drawdown then the gates should be fixed. The proposed flushing pipe was intended to increase the flow through the south basin during the summer months when uses are impaired, and for this the gates do not need to operate, or as proposed, one could be fix to operate as designed and the other modified to install the flushing discharge pipe. Drawdowns are typically conducted in the winter months and would have no effect on increasing flow in the south basin in the summer . Dam repairs can be added as a suggested Task, and should be done if the dam is to remain in good condition, however, the owner of the dam (Town of Auburn) must decide if they wish to maintain or decommission the dam.

4. **Comment: Will a future TMDL be done for sediment, given the issue of highway runoff and sediment in-fill from the Highway? I think it would be better to fold in these two issues because they co-exist in many instances.**

Response: The pond is not listed as being impaired by sediments and thus a TMDL is not required at this time. Nevertheless, sediments contribute to the problem of nuisance plants and carry additional phosphorus into the pond and therefore sediment controls and additional BMPs on I-290 and surrounding roadways are a necessary part of the current phosphorus TMDL. See also Response to comment #15 below.

5. **Comment: Finally, the tasks in Table 3, as amended by Table 4, are the start of a comprehensive strategy to address the Pond. Given the amount of urbanization and Cemetery expansion, a major discussion and evaluation of restoring the Pond to its previous elevation should be included. From information provided at the Public Hearing, the flashboards used to hold the Pond at a higher level. If the Pond was restored to this level, it would help with weed control, allow for annual drawdown, and allow more water into the South Basin to move to the North Basin and towards the Dam.**

Response: Further evaluation and discussion of runoff from urban areas and the cemetery should be included as part of the proposed lake watershed survey. The restoration of the flash boards would probably help with weed control and drawdown and should be included in the dam restoration plans. Apparently they were removed when some of them broke away and it was found that the concrete keyway had deteriorated. This might be able to be fixed temporarily with a steel keyway to allow new flashboards to be installed to raise the pond water level. Additional depth would probably improve conditions in the south basin as well although it is not clear if increased flushing would take place.

6. **While flushing of the south basin seems logical, I question whether it's appropriate to flush the nutrients and algae downstream. Perhaps a detention basin would help in this situation**

Response: A detention and/or infiltration basin(s) upstream of the lake and within the upstream towns' stormwater system would trap nutrients and sediments before they reach the lake and thus avoid downstream movement of nutrients and algae. Such a system would greatly aid in reaching the TMDL phosphorus target. Planning and installing such systems should be done in cooperation with the upstream towns (Auburn, Paxton, Leicester, and Millbury) after the stormwater system is surveyed. These upstream detention basins would probably not improve the flushing or water quality of the south basin to any significant degree.

7. Is the diversion listed in Table 3 meant to increase flow in the south basin?

Response: Yes, the proposed pipe diversion is simply to redirect some of the flow going through the north basin to the south basin. The overall flow of water through the pond remains the same. This increase in flow is predicted to flush water through the south basin and reduce the low dissolved oxygen levels observed there. Given the limited funding available, this should be listed as a lower priority than the nonpoint source BMPs to control stormwater or repairs to the dam.

8. A recent dam study indicated approximately $150,000. in repairs to the dam are needed. This should be a priority and a necessity in the restoration and saving of Leesville Pond.

Response: The cost of maintaining a dam over the long term is expensive and the Town of Auburn must decide which option to proceed with. If the dam is to be retained, then the dam must be maintained, both for reasons of safety and liability, as well as for active management of water quality, quantity and weed control via drawdowns. There may be some additional options to save money, perhaps by permanently closing one gate and only repairing the other, or perhaps replacing the concrete key slots for the flashboards with metal angle iron key slots.

9. Apparently the building of Interstate I-290 cut off a needed freshwater supply and compounded the problem of excessive algae in the pond with it's runoff of various pollutants and salts. The pond is in trouble and needs help.

Response: The Department is trying to work cooperatively with MassHighways to both quantify the pollutants from the freeways and to implement more effective Best Management Practices (BMPs) to minimize impacts to freshwaters in Massachusetts. See also Comment #15 below.

10. The pond is a resource to be reclaimed for several reasons listed below. First, because there are two drinking water wellfields at the head of Leesville Pond. Also, when the flood gates close to divert flood water backs up onto Brook Road, Perry Street and Rochdale Street. The Auburn Board of Selectmen have tried for years to get the USACOE to correct the problem. What has been the effect on the pond? The pond is perfect wildlife habitat for all wildlife.

Response: The area of well recharge (Zone II) for the wells does not include Leesville Pond because the wells are located a distance upstream of the pond and thus water quality in the pond is not expected in influence water quality of the wells. We have discussed the flooding of streets in Auburn with the ACOE and they believe the problem lies with debris in the channel, not any effect of closing the gates. Removal of debris may be explored as an option to solve the flooding problem. Only extreme floodwaters are diverted down the diversion tunnel and the effect on Leesville Pond is probably beneficial as these floods carry large amounts of sediments and nutrients that may otherwise accumulate in the pond. The Department agrees the lake does offer valuable wildlife habitat and consideration should be given to classifying the south basin of Leesville Pond as a wetland habitat rather than a lake.

11. Note: numerous comments were received regarding MassHighways failure to maintain and clean catch basins and perform other needed BMPs.

Response: We have noted in the draft Salsbury Pond TMDL report (DEP, 2001b) that MassHighways is apparently not cleaning the catch basins adequately nor adequately maintaining other stormwater structures of the highways. DEP has sent a letter to the local regional office of MassHighways asking for additional attention to stormwater BMPs in the area. See also Comment #15 below.

12. Sanding of streets needs to be controlled.

Response: Some amounts of sanding and/or salting of streets and highways is required during winter months to allow safe driving conditions. The policies on how often and how much of sand and salt to be applied should be reviewed periodically to ensure that excessive amounts are not being applied. In addition, street and highway sweeping of sand should be conducted periodically (at least twice a year) to reduce the amounts of contaminants entering the stormwater systems.

13. Nutrient inputs must be controlled through public education.

Response: Public education is very important for controlling nutrient runoff and this is included in lake watershed surveys proposed in the TMDL and should be included in the new Phase II stormwater permit which many urbanized towns, including Auburn, must comply with.

14. **I believe the Federal and State Government harmed Leesville Pond with the construction of I-290, therefore they should surely pay to help us restore the pond as much as possible.**

Response: Both the Federal and State governments offer various grant and loan programs for lake management and nonpoint source control programs. We encourage the towns to contact Brian Duval of DEP (508) 792-7650, who can assist the towns in development of competitive grant and loan applications. See also Comment #15 below.

15. **These reports set forth an assumption that highways are significant contributors of nutrients to receiving waters. To our knowledge, the majority of the contaminants contained in highway runoff (especially in particulate form) are associated with the sand used during winter maintenance operations, which is assumed to contain only minor amounts of nutrients. However, conditions may be different along Interstates 290 and 190. It is for these reasons that we need a valid method of calculating nutrient (and other contaminant) loadings from highways. As I have mentioned in the past, MassHighway is working toward developing a research study that would collect data and develop a contaminant loading model for highway runoff. Sometime in the next couple of weeks I would like to provide you with a general scope of work for this study -- for your review and comment.**

Response**:** While sand may be considered low in nutrients, high concentrations of nutrients are known to be associated with highway runoff in both dissolved form and associated with fine sediments that run off the roadway. A review of many highway runoff studies conducted by the Federal Highway Administration (FHWA) reported the Event Mean Concentration for suspended solids was 143 mg/l and that the EMC for PO_4-P was 0.435 mg/l (Driscoll et al., 1990). These levels that are not considered “minor amounts” as EPA generally recommends that phosphorus inputs to lakes be less than 0.050 mg/l. A USGS review of dozens of other reports also indicated substantial biological impacts from highway runoff (Buckler and Granato, 1999). Note that there are more than four lane miles of Interstate 290 that drain to Leesville Pond or immediate tributaries to the pond. In addition, nutrients are not the sole focus of pollutant runoff from MassHighways. Highway sand and other solids discharged from roadways are a pollution source that also contributes to infilling of wetlands and lakes, as is the case in the Leesville Pond.

We are pleased that you have developed scope of work for further research on highway runoff. Unfortunately, the study as written does not currently address the parameters of concern associated with this and other TMDLs (total phosphorus, suspended solids, bedload sediments and bacteria). As previously discussed, DEP would be happy to work with you on a revised scope to address these issues from a statewide prospective. However, DEP cannot delay the development of the TMDLs any further. The Federal Clean Water Act, Federal regulations and EPA policy require us to complete the TMDLs based on best available evidence and that is basis for this TMDL. In order to implement the TMDL in the absence of loading information for specific highways and city streets, DEP has established a set of performance standards for maintenance of all roadways within the affected watershed. We have discussed specific recommendations with the MassHighways District office and have received assurance that efforts will be made to reduce non-point source pollutants from State controlled roadways within the sub-watershed.

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Appendix I Reprint of Ganzon and Sutt (1990).

The following pages are selectively reproduced from Ganzon, N.B. and E.G. Sutt. 1990. Diagnostic/Feasibility Study of Leesville Pond.

Project Number: 41-FLH-RE70

DIAGONOSTIC/FEASIBILTY STUDY OF LEESVILLE POND

An Interactive Qualifying Project Report
submitted to the Faculty
of the
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Science
by

Nicolas W. Ganzon
and
Edward G. Sutt Jr.

Date: July 9, 1990

Approved:

E.B.Silver
Project Coordinator
Regional Environmental
Council, Inc.

Professor F.L.Hart
Advisor

Figure 7 Mass Loading Calculation

Leesville Pond Land Use Information Based Upon MacConnel 1971

Land Use Category	Comments	Reference
Forest		Reckhow 1980
Residential (low)		Reckhow 1980
Agricultural		Reckhow 1980
Residential (dense)		Reckhow 1980
Open Water	Atmospheric Deposition	Reckhow 1980
Urban Open/Transpor.		Reckhow 1980
Open Space		CDM 1982
Industrial		Reckhow 1980
Wetland	No Data, Open Space Used	Reckhow 1980
Sand and Gravel Pits	No Data, Industrial Space Used	Reckhow 1980
Commercial		Reckhow 1980

Leesville Pond Phosphorous Loading from Land Use- Total Watershed

Land Use Category	Area (sq .km.)	Annual Phosphorous Load (kg)
Forest	45.73	1079.3
Residential (low)	7.33	139.3
Agricultural	6.44	729.8
Residential (dense)	6.43	707.1
Open Water	5.63	152.1
Urban Open/Transpor.	4.04	771.4
Open Space	3.32	129.4
Industrial	1.14	200.2
Wetland	0.90	35.1
Sand and Gravel Pits	0.46	80.0
Commercial	0.38	66.0
	81.8	4089.7

Taken From BSC Data Sheet for Leesville Pond

Appendix II. Results of Lake Management Questionnaire.

Preliminary Lake Management Survey For Municipalities, ConComms and Lake Associations

This information will be used to help develop Total Maximum Daily Load Reports as part of the Federal Clean Water Act requirements under section 303(d) and to help develop funding priorities. If you are unsure of the accuracy of your answer to any question then add a question mark? and provide a name and phone number that we can call for further information on the subject. Add a separate page with additional comments if you wish.

Return to: Dr. Mark D. Mattson, Dept. Environmental Protection, DWM, 627 Main St. 2nd Fl
Worcester, MA 01608 (508) 767-2868 email mark.mattson@state.ma.us

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Type of Waterbody: Lake Town, Basin:Auburn/Worcester, Name: LEESVILLE POND
ID number: MA51087 Pollutant Stressor: , Nutrients , Organic enrichment/Low DO
Comments:HISTORICALLY D.O. BELOW 50% SATURATION, VERY DENSE GROWTHS OF AQUATIC MACROPHYTES (PRIMARILY CABOMBA CAROLINIANA) COVER THE POND, WOLFFIA SP. COVERS SURFACE, AND DIURNAL OXYGEN PULSES SUSPECTED. URBAN SETTING AND NO RESTORATION ACTIVITY MAKES FOR A REASONABLE JUDGEMENT THAT CONDITIONS HAVE NOT CHANGED. HISTORICALLY HIGH TOTAL PHOSPHORUS LEVELS WERE TOO OLD TO USE IN MAKING ASSESSMENTS.

1996:
A 30 June 1994 synoptic survey indicated that conditions were virtually unchanged since the last assessment.

---

1)Your Name and position title: Phone: email:
Joan Crowell, Pres./Treas. (508) 754-1074 joan.crowell@realtor.com

2)Name of Municipality or Lake or Watershed Association and address:
Leesville Pond Assoc. 5 Bernice ST., Worcester MA 01603

3)Describe any unique or valuable features of the lake (ownership, historic, watersupply, only beach in town, in a park, tourist attraction, rare species etc.)
Part of the Blackstone River Watershed and covers an area of 34 Acres

4)Roughly estimate daily public use (# of people on lake during the day) during summer months for each of the following activities:
a) Boating b) Fishing 6-8 c)Swimming d)Sightseeing, picnic e)other

5)Does the lake have a dam at the outlet? Yes ✓ No ____ If yes, how high? (ie how many vertical feet of water does the dam hold back? 15 ft.) Is the lake level adjustable from the dam? (i.e., splash boards, [✓ gate,] or valve?) and are they in good working order to conduct a drawdown? inoperable Are annual drawdowns conducted? no If yes, how many feet?
Who owns the dam ?
Town of Auburn

6)How many public bathing beaches are present? (where): none

7)How many other beaches (e.g. resorts) are used by public (where):

8)Are there current problems with swimming in the lake? [✓ a) bacteria,] [✓ b)transparency] <4ft [✓ c) weeds,] d)no serious problems
e)other Have the beaches been closed last year due to any of above causes? ___
no swimmable areas

9)How many public boatlaunches are available? (where): none

10)How many other boat launches (e.g. resorts) are used by the public?

11)Are there current problems with boating or fishing on lake? [✓ a)weeds along shore] [✓ b) weeds cover on 95% of lake surface] c)fish kills d) exotic weeds (list) e)boating noise f) boating turbidity, g) algae blooms [✓ h) low oxygen] i)no serious problems, Other problems? Explain.

In addition to excessive weed growth, L.P. has a sediment problem. Sediment tested in 1985 was listed as Category 3.

12) Are aquatic weeds a problem in the lake? yes Have the species been identified? yes

13)What is considered to be the major sources of pollution? a)Farms [✓ b) urban runoff,] [✓ c)septic systems] d)gravel pits e)unknown e)other

14)What type of sewage treatment is used for homes on the lakeshore (within 100 yards) ?: [✓ a)private septic] [✓ b)sewer] c)unknown
Contact person and phone ______________

15)For each category listed below, what has been done in the past ten years to remedy lake problems? (Roughly estimate money spent and provide contact person):

a) Volunteer or local water quality monitoring; Yes ✓ No_____ Years 1989 Contact DEP/DEM

Diagnostic Study - $35,000 (Clean Lakes Program)

b)Please provide title, year and author of any recent studies or lake management plans:

I.Q.P. - Worcester Polytech - D/F Study, 1990
Nicholas Gannon and Edward Sutt, Jr.

c) Describe any in-lake treatments (i.e. harvesting, herbicide, water level drawdown, etc.) and include what kind are bing applied, what years were the treatments conducted, details of treatments and approximate cost (continue on back or separate sheet)

d)How effective and long lasting was the treatment?

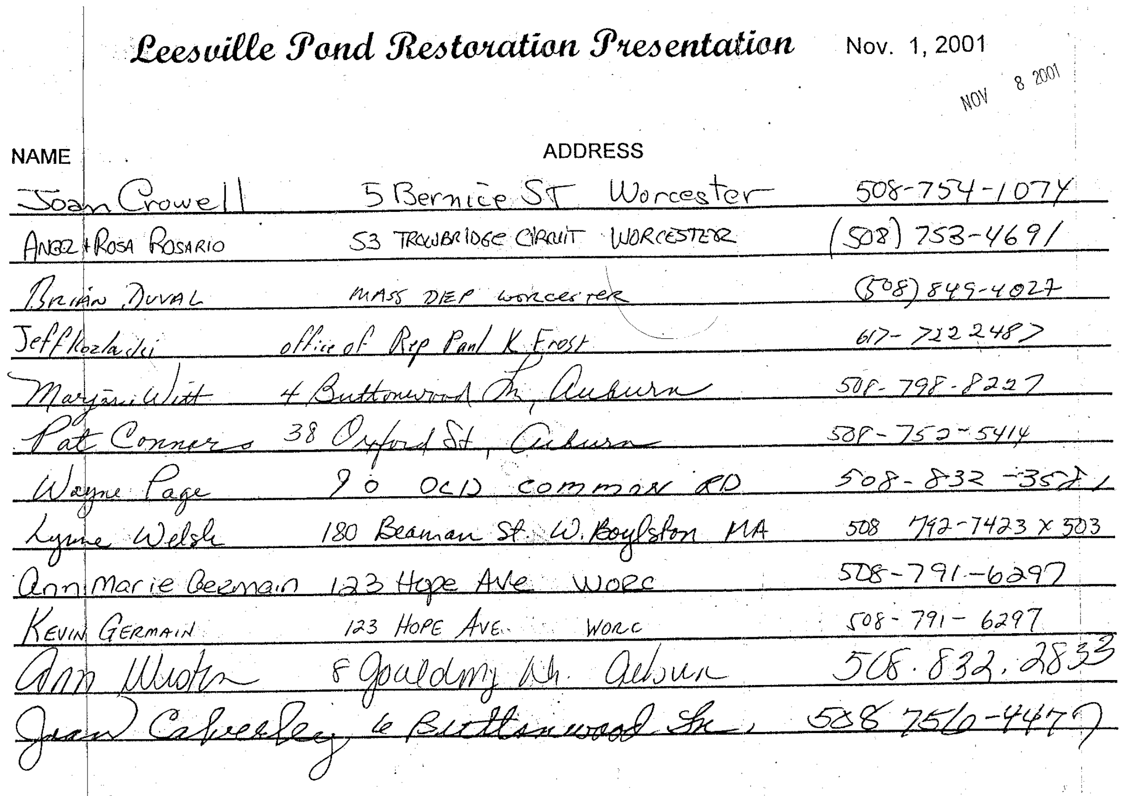
e) Work either on shore or in the watershed to reduce pollution entering lake .e.g. new sewer hookups for homes, major sewer repairs, public education, erosion control, BMPs etc.:

Installation of a sewer on Rockwell St has been assigned a Priority #1 by the City of Worcester. Ongoing Education through Watershed Association.

f) Please identify any other grants or grant applications or future management plans, including sewer upgrades, street maintenence:

The Town of Auburn has appropriated $50,000 to study the Leesville Pond Dam.

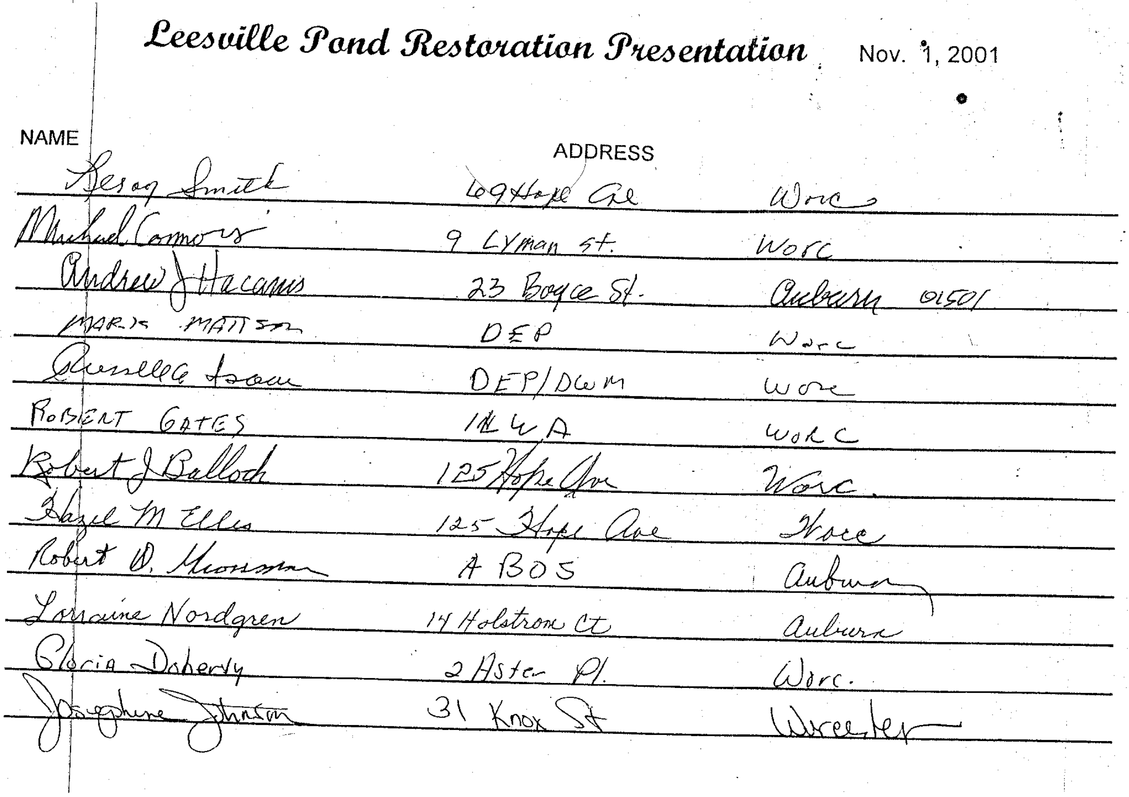
Appendix III. Attendance at Public Meeting, Nov. 1, 2001.



Leesville Pond Restoration Presentation Nov. 1, 2001

NOV 8 2001

NAME	ADDRESS	
Joan Crowell	5 Bernice ST Worcester	508-754-1074
Angel + Rosa Rosario	53 Trowbridge Circuit Worcester	(508) 753-4691
Brian Duval	Mass DEP Worcester	(508) 849-4027
Jeff Kozlarski	office of Rep Paul K Frost	617-722 2487
Marjorie Witt	4 Buttonwood Ln, Auburn	508-798-8227
Pat Conners	38 Oxford St, Auburn	508-752-5414
Wayne Page	90 OLD COMMON RD	508-832-3571
Lynne Welsh	180 Beaman St. W. Boylston MA	508 792-7423 x 503
Ann Marie Germain	123 Hope Ave Worc	508-791-6297
Kevin Germain	123 Hope Ave. Worc	508-791-6297
Ann Wooten	8 Goulding Dr. Auburn	508.832.2833
Jean Calverley	6 Buttonwood Ln,	508 756-4477



Leesville Pond Restoration Presentation Nov. 1, 2001

NAME	ADDRESS	
Betsy Smith	69 Hope Ave	Worc
Michael Connors	9 Lyman St.	Worc
Andrew J Hacanis	23 Boyce St.	Auburn 01501
Mark Mattson	DEP	Worc
Russell Isaac	DEP/DWM	Worc
Robert Gates	IHWA	Worc
Robert J Balloch	125 Hope Ave	Worc.
Hazel M Ellis	125 Hope Ave	Worc
Robert D. Moosman	ABOS	Auburn
Lorraine Nordgren	14 Holstrom Ct	Auburn
Gloria Doherty	2 Aster Pl.	Worc.
Josephine Johnson	31 Knox St	Worcester

Leesville Pond Restoration Presentation

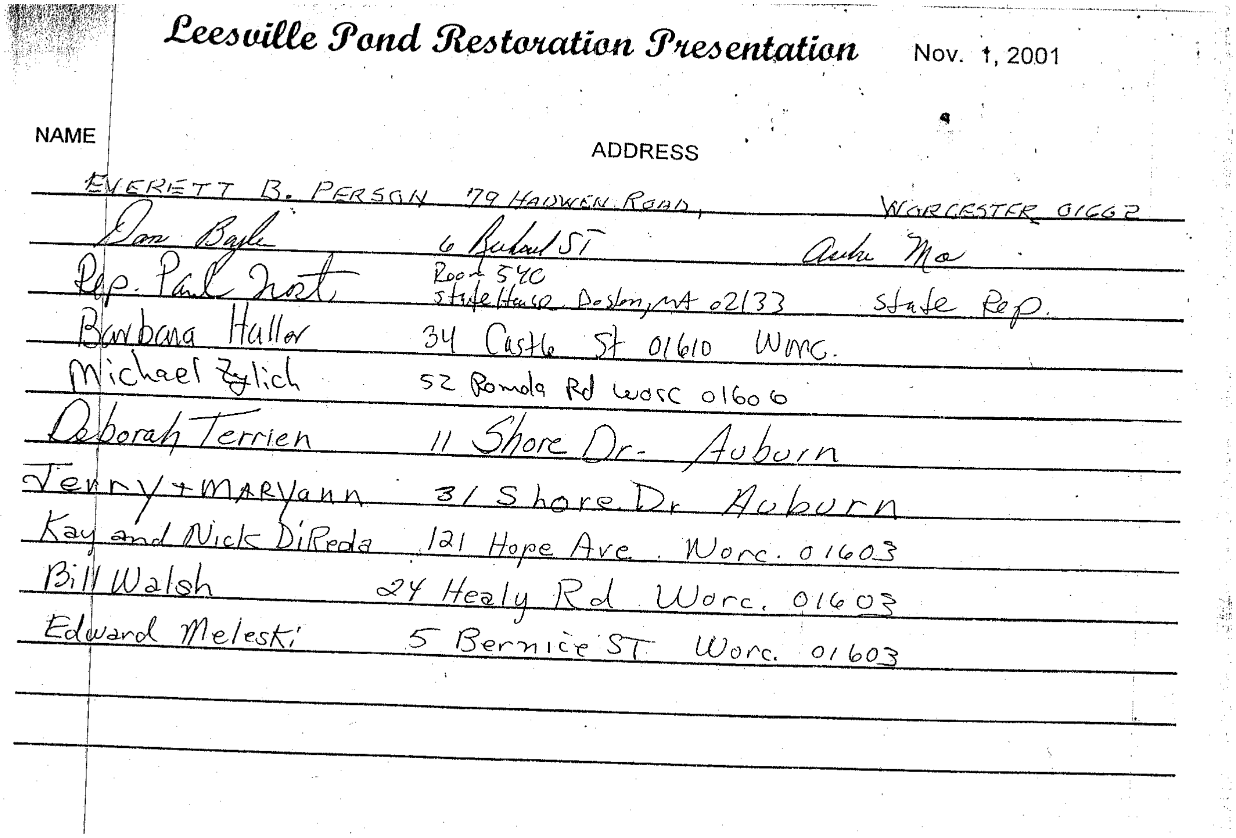
Nov. 1, 2001

NAME	ADDRESS
Wilbert H. Valiquette	153 HOPE AVE Worcester Ma.
John Sullivan	70 GATES LN. " "
Rick + Barbara Walker	33 Woodland Rd Auborn Ma
David J. Maillet, PE	Princeton, MA.
Francis X McMenemy	35 Laurier St Worc 01603
Kevin Clancy Aquatic control Tech.	
SELECTMAN	
RUTH O'NEILL	14 SHORE DRIVE AUBURN,
Tony Umura	19 Shore Drive Auburn
Mark Voorhees	U.S. EPA -
MATT LABOVITES	WORC. DPW
MARY NABOHAY	570 OXFORD ST. SO AUBURN

Leesville Pond Restoration Presentation

Nov. 1, 2001

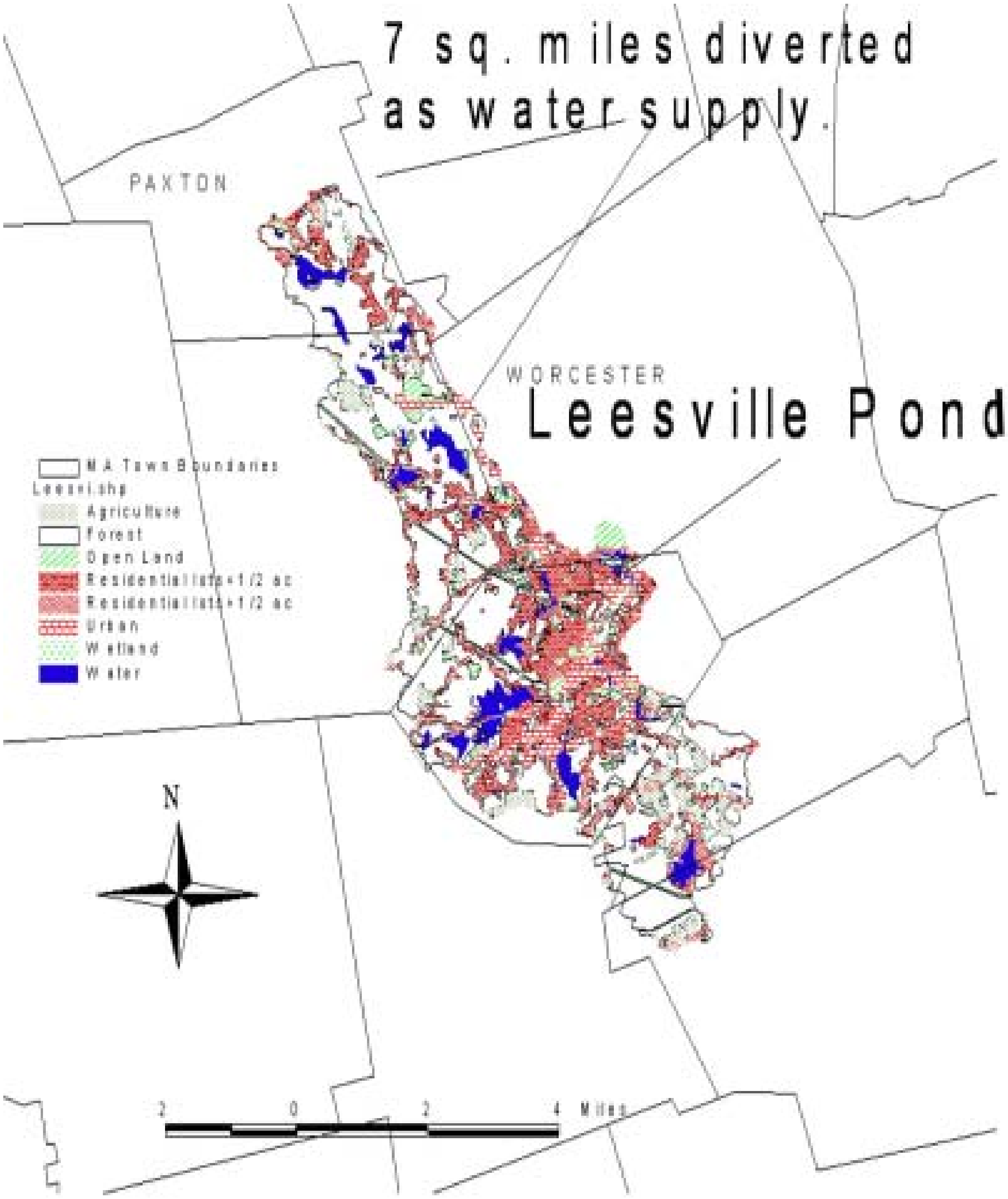
NAME	ADDRESS
Sandra Sjoberg	PO Box 52 Auburn
John Rooney	8 Simonds St. Auburn 01501
Sharon Haley	32 Wamsutta Ave. Worcester 01602
J.D. BRIGGS	36 ARROWHEAD AVE AUBURN
Jo Ann Mealey	Worc.
Michael Murphy	58 SHORE DRIVE AUBURN
Peter Coffin	237 Chandler St Worc
Janice Nadeau	67 Southgate Worc
Pat + Bill Westerlind	17 Forest Dr Auburn
Joseph Zwirblia	4 Fourth St Worc.
WES SHEPELUK	29 HILLCROFT AVE, WOR
	274 Webster St WORC WORC



Leesville Pond Restoration Presentation Nov. 1, 2001

NAME	ADDRESS
EVERETT B. PERSON	79 HADWEN ROAD, WORCESTER 01602
Don Bayle	6 Rutland ST Aubu Ma
Rep. Paul Frost	Room 540 State House Boston, MA 02133 State Rep.
Barbara Haller	34 Castle St 01610 Worc.
Michael Zylich	52 Romola Rd Worc 01606
Deborah Terrien	11 Shore Dr- Auburn
Jerry + MARYann	31 Shore Dr Auburn
Kay and Nick DiReda	121 Hope Ave. Worc. 01603
Bill Walsh	24 Healy Rd Worc. 01603
Edward Meleski	5 Bernice ST Worc. 01603

Appendix IV. Land use map of Leesville watershed.



Land use within Leesville Pond watershed. Note that the pond is located midway down the right side of the watershed as indicated by the line. Also note that approximately 7 square miles of the upper watershed are not used in the modeling as this is diverted for public drinking water.