C

71018

REPORT TO
TOWN OF ARLINGTON
ON
DIAGNOSTIC/FEASIBILITY STUDY
OF HILL'S POND
ARLINGTON, MASSACHUSETTS

JUNE, 1986

METCALF & EDDY, INC. / ENGINEERS

Metcalf & Eddy, Inc.
Engineers & Planners

10 Harvard Mill Square
Wakefield, Massachusetts
Mailing Address: P.O. Box 4043
Woburn, MA 01888-4043

June 23, 1986

J-1276

Mr. Frank Wright
Director
Department of Properties and
Natural Resources
Town of Arlington
730 Massachusetts Avenue
Arlington, MA 02174

Dear Mr. Wright:

We are pleased to submit the final report on the Diagnostic/Feasibility Study of Hill's Pond, Arlington, Massachusetts. The report presents analyses of the data collected and development of the recommendations for restoration of the pond.

The staff of Metcalf & Eddy enjoyed working with the Town of Arlington on this project, and we hope to continue our association with the Town.

If we can be of any further assistance at this time, please do not hesitate to contact us.

Very truly yours,

Richard L. Ball

Richard L. Ball, Jr.
Vice President

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

LIST OF TABLES

LIST OF TABLES
(Continued)

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

In accordance with the State of Massachusetts Clean Lakes Program, this report contains the findings of a Phase I Diagnostic/Feasibility Study for the restoration of Hill's Pond in Arlington, Massachusetts.

Chapter 628 Lakes Program

The Chapter 628 Massachusetts Clean Lakes and Great Ponds Program provides funds for the restoration, preservation and maintenance of the publicly owned lakes and ponds of the Commonwealth for public recreation and enjoyment. A Chapter 628 restoration program is carried out in two phases. Phase I includes a diagnostic survey to gather information and data to identify existing or potential sources of pollution and to determine the limnological, morphological, and other pertinent characteristics of the pond and its watershed. Diagnostic survey data is then analyzed to define methods for controlling causes of eutrophication in a Phase I feasibility study. The most cost-effective procedure to improve or preserve the quality of the pond is determined and a technical plan for implementing the restoration is developed. Phase II is the actual implementation of the recommended restoration plan. The Hill's Pond study is a Phase I Diagnostic/Feasibility Study.

Hill's Pond Description and Problems

Hill's Pond is a small pond with a surface area of approximately 2 acres, a mean depth of about 3 feet and a maximum depth of 5.7 feet. The location of the pond is shown in Figure 1-1.

The pond is located within Menotomy Rocks Park in the southern section of the Town of Arlington. The only inlet is from a storm drain which drains a 3.1-acre residential area adjacent to the pond. Normally, there is no surface outflow from the pond. There is an overflow pipe on the southern shore which flows only at times of excessively high pond level. This outflow empties into a storm sewer on Morton Road.

Historically, Hill's Pond and Menotomy Rocks Park have been used for a variety of recreational activities. There is a single public access to the park from the southeast via Jason Street. Recreational facilities provided include playground equipment, walking and jogging paths, a basketball court, a fitness course, a picnic area, and park benches. Currently, the recreational and aesthetic value of the pond is degraded. The present problems at Hill's Pond include:

- Excessive growth of aquatic plants (macrophytes)
- Low water level
- Algal blooms
- Sediment accumulation within the pond, especially around the storm drain

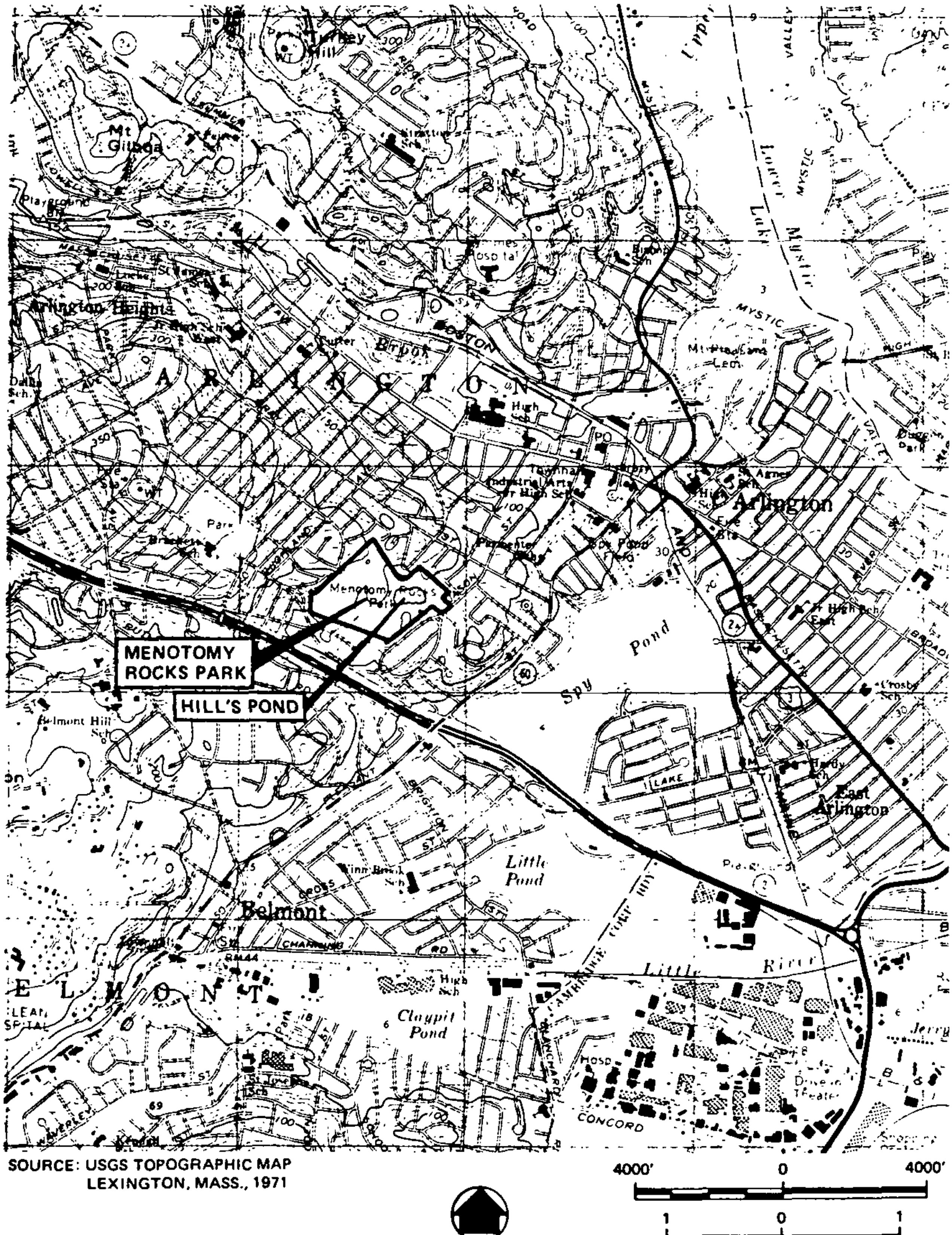


FIGURE 1-1. LOCATION OF MENOTOMY ROCKS PARK AND HILL'S POND.

These problems have created public concern and a desire to return the pond to a more aesthetically pleasing condition. The Town of Arlington successfully applied for Chapter 628 funds to conduct a Diagnostic/Feasibility Study under the Clean Lakes Program.

Eutrophication

Eutrophication is a process whereby a body of water becomes enriched with nutrients. Eutrophication is a natural process which occurs gradually and slowly. However, the process may be greatly accelerated by nutrient input from the routine activities of man when such nutrient sources as wastewater, fertilizer, decaying vegetation, and others are carried to the lake by stormwater runoff, tributaries, and the groundwater.

Excess nutrient input to a lake encourages the growth of undesirable plants and algae. Aquatic plants generally thrive in shallow parts of a lake where temperatures are warm and light is plentiful. Excessive phytoplankton growth stimulated by excess nutrients causes undesirable turbidity, thus decreasing the clarity of the water body. Some algae can also cause odor problems. The dead plant material settles to the lake bottom. Decomposition of this material exerts a demand on the dissolved oxygen in the water, thereby reducing oxygen levels and discouraging fish life. Further plant growth is encouraged since decaying plant material provides more nutrients to the lake sediments and the water column. Hill's Pond exhibits signs of advanced eutrophication both in terms of phytoplankton activity and macrophyte growth.

Report Organization

The Hill's Pond Diagnostic/Feasibility Study report is organized according to major tasks conducted. These are briefly described as follows:

Environmental and Diagnostic Assessment (Chapter 2). This chapter contains a discussion of the pond and its drainage area including morphometric features, land uses, recreational uses, historical water quality data, and other pertinent information. This chapter also includes a description and analysis of all data collected including limnological, stormwater, sediment and other surveys.

Restoration Alternatives (Chapter 3). An assessment of a variety of alternatives to mitigate the existing problems of the pond was conducted. Lake eutrophication can be reduced by various preventative alternatives. These include source control by such methods as reduction of nutrients and sediments entering the lake, and in-pond control by the use of herbicides, harvesting, dredging, or other methods. The latter category of controls tends to address symptoms, while the former type addresses causes.

Recommended Restoration Plan (Chapter 4). A recommended plan has been developed based on the alternatives evaluation. Selection criteria include ability to achieve restoration goals, environmental impacts, costs, available funding, and public input. For the recommended plan, a budget, work schedule, and other information have been prepared so that the restoration project can be advanced into Phase II implementation.

Public Meeting Documentation (Appendix). Two public meetings were held to present aspects of the environmental and diagnostic assessments and restoration alternatives to the Town. Agendas for these meetings, sign-in sheets and minutes have been included in the Appendix.

CHAPTER 2

ENVIRONMENTAL DESCRIPTION AND DIAGNOSTIC ASSESSMENT

As part of the Diagnostic Study of Hill's Pond, an environmental description of the pond and its drainage basin has been prepared. Existing historical data and other information have been used, and field surveys have been conducted as part of this project to obtain additional information. The available data have been used to assess existing conditions in the pond and to document problems in the pond. This chapter is organized to provide the following information:

- Environmental description of the pond and drainage area.
- Description of Diagnostic Survey program.
- Assessment of existing conditions.

ENVIRONMENTAL DESCRIPTION

This description is based upon both historical and new data and includes:

- Pond morphometry (physical dimensions)
- General watershed description
- Delineation of drainage area and land use
- Recreational use
- Soils and geology
- Historical water quality data

The environmental description serves as an information source for evaluation of existing conditions and for projections of future alternatives.

Morphometric Description

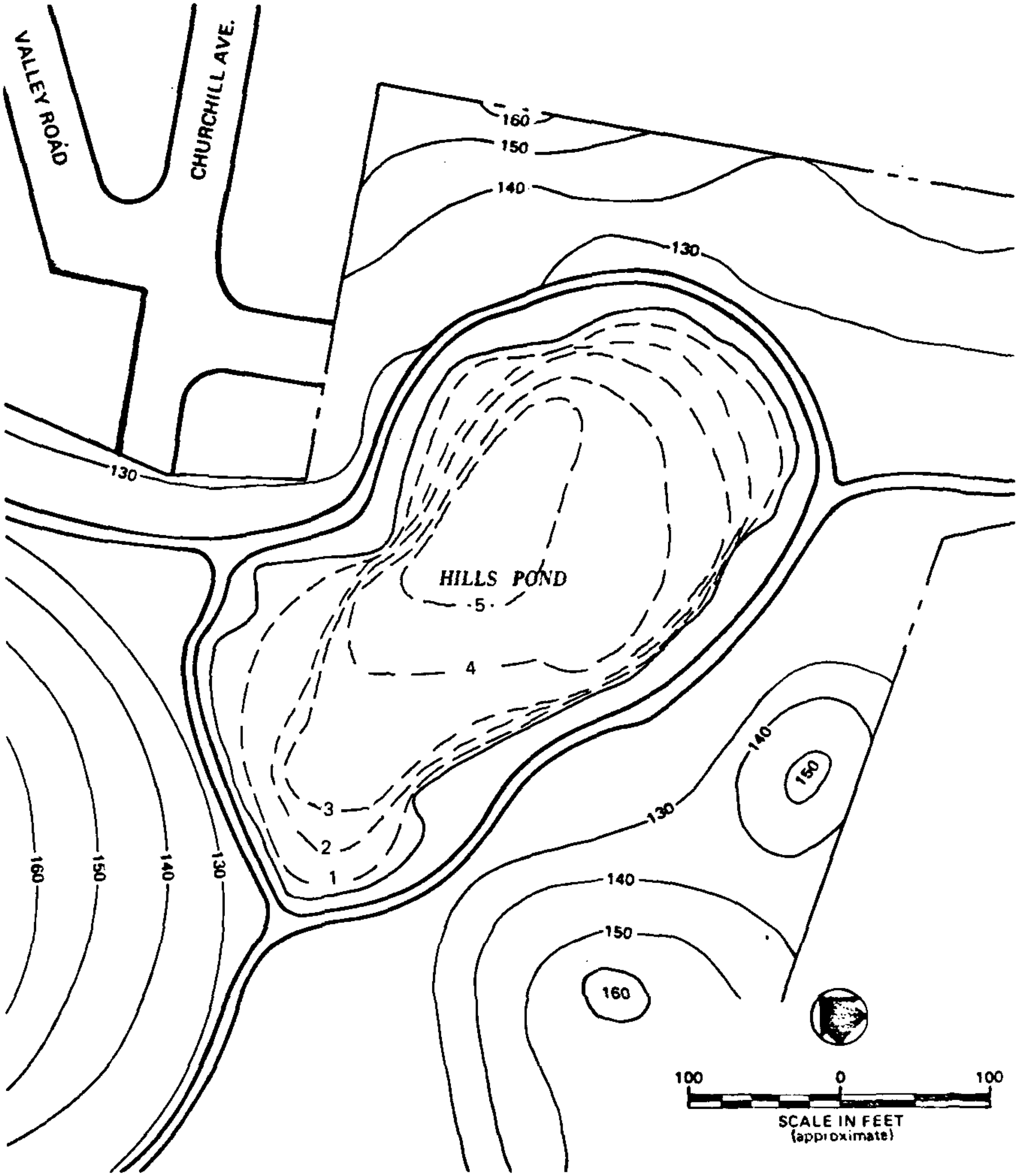
A morphometric survey of Hill's Pond was conducted by Metcalf & Eddy on July 24, 1985. Four transects across the pond were surveyed on this date. Distances along each transect were measured and depth readings were taken approximately every 40 to 50 feet. A total of 11 depth measurements were collected during this survey. Figure 2-1 presents the bathymetric contours of Hill's Pond as obtained from the morphometric survey. The deepest section of the pond is in the northeast end where the maximum recorded depth is 5.7 feet. Table 2-1 summarizes the morphometric characteristics of the pond.

TABLE 2-1. MORPHOMETRIC CHARACTERISTICS OF HILL'S POND

Surface Area	2 acres	0.8 ha
Mean Depth	3.0 ft.	0.9 m
Maximum Depth	5.7 ft.	1.7 m
Volume	6 acre-ft.	7400 m^3
Maximum Length	480 ft.	146 m
Maximum Width	238 ft.	73 m
Shoreline length	0.25 mi.	0.4 km
Average Elevation	125 ft.	38 m
Shoreline Development Index	1.3	1.3

Watershed Description

The Town of Arlington lies in the eastern plateau of Middlesex County and is located between the Towns of Lexington on the west, Winchester to the north, Medford and Somerville to the east and Cambridge and Belmont to the south. The general



NOTE: WATER DEPTH CONTOURS IN FEET

FIG. 2-1 BATHYMETRIC CONTOURS OF HILL'S POND elevations of the Middlesex County plateau, with the exceptions of the higher ridges and hills, range from 200 to 500 feet above mean sea level. The topography of Arlington is characterized by rolling hills with elevations ranging from approximately 20 to 350 feet above mean sea level. Elevations are higher in the western part of Arlington and the general slope is to the east. The Town drains to and is bordered by the Upper and Lower Mystic Lakes and the Mystic River to the northeast and by Alewife Brook on the east.

Figure 2-2 shows the general location of Hill's Pond within Menotomy Rocks Park in Arlington. A proposed plan of the park, drawn up in 1895, was obtained from the Town Engineer's office. This plan showed two brooks flowing to the pond. One flowed from the east along what is now the Jason Street entrance to the pond and the other flowed from the west along what is now part of the northern boundary of the park. A third brook was the outlet for the pond and was located at the present site of the pond drain outlet. This outlet was connected to a storm drain on Morton Street in 1939. The storm drain eventually empties into Spy Pond which is located about 0.5 miles east of Menotomy Rocks Park. The brook located at the Jason Street entrance to the park is now covered over and the other brook flowing from the west rarely flows to the pond (F. Wright, Town of Arlington, personal communication).

Hill's Pond is bordered to the west and east by deciduous trees. The north side of the pond has been planted with domestic

FIGURE 2-2.

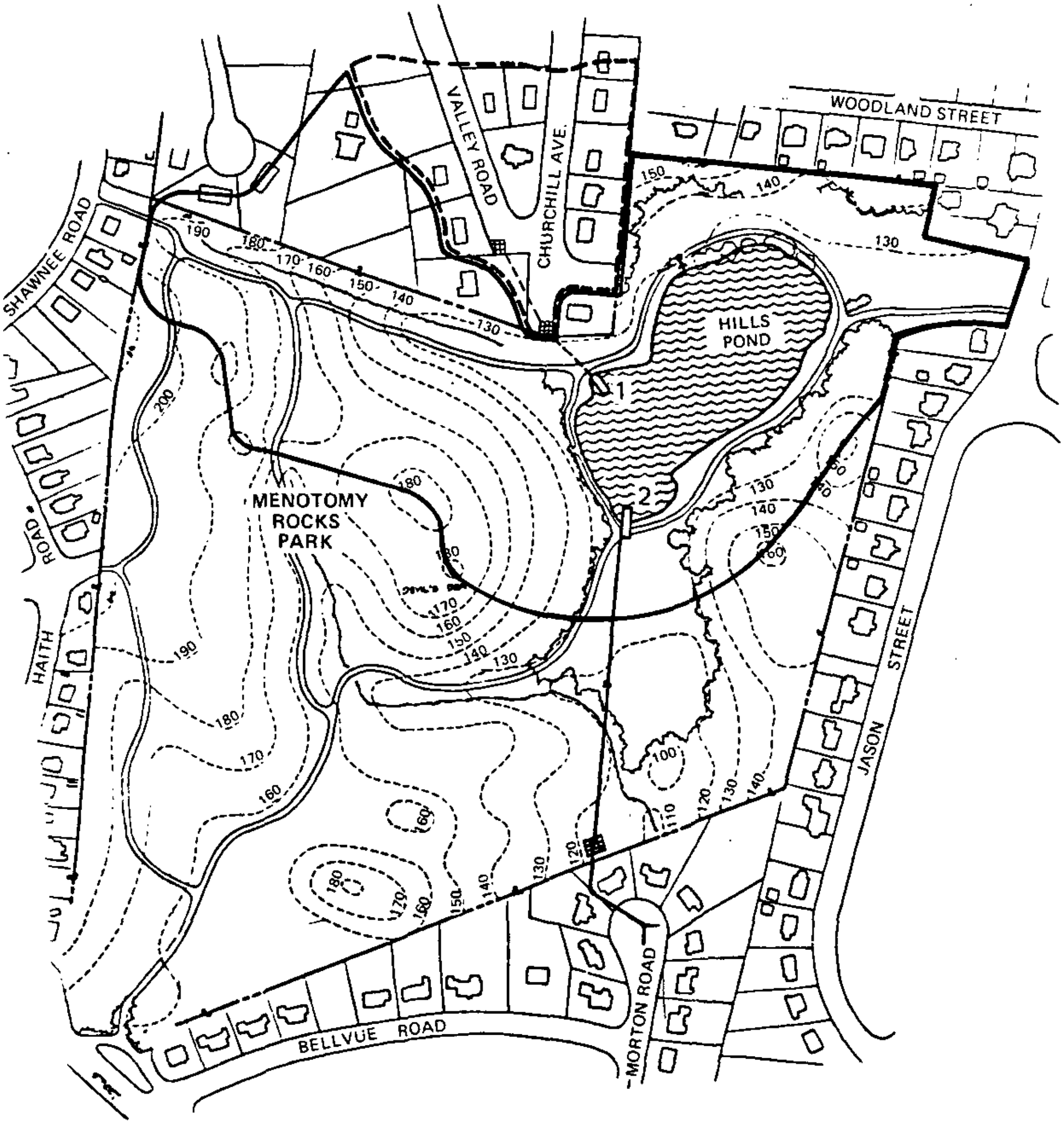
LOCATION OF HILL'S POND WITHIN MENOTOMY ROCKS PARK IN ARLINGTON

grass including the surface of a stone wall bulkhead at the water's edge. This bulkhead occupies land which may historically have been a wetland at the foot of Churchill Avenue. The northeast side of the pond is a city park with benches and domestic grass. A recreational area to the south of the pond features a picnic facility and an open grassy area for basketball, archery and other recreational activities. This recreational area may once have been a swampy wetland bordering the pond.

Hill's Pond is located in the Spy Pond drainage basin. The area that drains directly to Hill's Pond is about 15 acres in size and ranges in elevation from 125 to 200 feet above mean sea level. The shore is relatively flat on the northeast and south sides of the Pond. To the southwest the shore slopes steeply, reaching an elevation of 180 feet within 200 feet of the shoreline. To the northwest a less steep gradient is observed in the slope and to the east the land rises only 35 feet above the pond level within 150 to 200 feet of the shoreline.

Delineation of Drainage Area and Land Use

Figure 2-3 shows the 15-acre drainage basin of Hill's Pond. This map is based on field inspection surveys of the basin conducted during August and September, 1985. Subareas were determined by visual inspection of the surface water drainage system (catch basins and outlets to the pond), the topography around the pond and drainage maps provided by the Town of Arlington.



NOTE: 1. INLET FROM VALLEY ROAD / CHURCHILL AVENUE DRAINAGE AREA.
2. 10 INCH OVERFLOW DRAIN TO STORMSEWER ON MORTON ROAD.

- - - VALLEY ROAD / CHURCHILL AVENUE SUB-AREA.

—— DIRECT DRAINAGE TO POND.

FIGURE 2-3. HILL'S POND DRAINAGE BASIN.

From available information, it was determined that 66 percent of the drainage area is open parkland and the remainder is residential lots and paved roadways. Hill's Pond itself is completely surrounded by Menotomy Rocks Park. The density of residences around Menotomy Rocks Park is approximately 4.1 per acre. The pond area itself covers about 12 percent of the total watershed (17 acres).

Figure 2-3 also shows the location of the 10-inch diameter storm drain pipe that is the only inlet to Hill's Pond. This pipe drains approximately 3 acres of residential area containing 11 homes along Valley Road and Churchill Avenue. An additional eight residential lots, bordering Menotomy Rocks Park west and south of Valley Road and comprising about 2 acres, drain directly to the park. The remaining 10 acres of the drainage basin are part of Menotomy Rocks Park and contribute direct overland runoff to Hill's Pond. Based on these figures, about 20 percent of the Hill's Pond drainage area drains to the pond via stormwater pipes and 80 percent drains directly to the pond via overland runoff.

The Town of Arlington is connected to the MDC sewer system and receives its water supply from the MDC. No areas of the Town are on septic systems or receive their water supply from local wells.

Recreational Use

Hill's Pond is used extensively for passive recreation and, to some extent, for fishing and canoeing. The Arlington Recreational Department issues picnic permits for the picnic area adjacent to the pond. Based on the department's records, approximately 55 groups totaling about 2600 people used the picnic area from May through September, 1985. In addition, approximately 40 people (children and staff) use the Menotomy Rocks Park area on 42 summer days for an adventure camp. Camp activities include canoeing on the pond, athletic activities in the field adjacent to the pond and nature studies.

An exercise course named The Vita Course has been developed in Menotomy Rocks Park and winds around the pond shoreline. Jogging is quite popular around the pond as is walking and fishing by persons of all ages.

In the winter the pond is well-used for skating, both during the day and evening. Lights illuminate the pond to allow for evening skating. Sledding and cross-country skiing activities also take place in the park when adequate snowfall occurs. In summary, several thousand people regularly enjoy the recreational benefits of Hill's Pond each year.

Soils and Geology

Soils information in the vicinity of Hill's Pond was obtained from the U.S. Soil Conservation Service. The soils within the Hill's Pond drainage basin and throughout most of Arlington are primarily composed of Gloucester stony fine sandy loam. Gloucester loam was formed by the weathering in place of glacial drift derived largely from crystalline rocks. The drift ranges in thickness from 5 to 20 feet and rests mostly on granite and gneiss bedrock. The stony loam includes large quantities of partly rounded and subangular boulders and gravel of the parent rock material that are present on the surface and embedded in the soil and substratum. Ledges and protrusions of the bedrock occur on occasion. Areas of this soil are rolling or hilly and sloping.

Gloucester fine sandy loam is found on the north and northeastern edges of Hill's Pond. This soil is similar to the stony loam but does not contain as much parent rock material in the form of gravel and boulders. Gloucester fine sandy loam occurs on smoothly rolling uplands and is characterized by good internal drainage.

Because of the small drainage area of Hill's Pond and the lack of tributaries entering the pond, geologic and soil conditions within the drainage basin are not expected to have a major influence on water quality in the pond.

Historical Water Quality Data

In-pond sampling of Hill's Pond was conducted on July 11, 1983 by the Massachusetts Department of Environmental Quality Engineering, Division of Water Pollution Control (MDWPC). These measurements, summarized in Table 2-2, were taken at one sampling station in the center of the pond as indicated in Figue 2-4. Chemical samples were collected at the surface and at one meter, and biological samples were taken at the surface. Temperature, pH, dissolved oxgyen, and specific conductance were measured at the surface, at 0.5 m., and at 1.0 m.

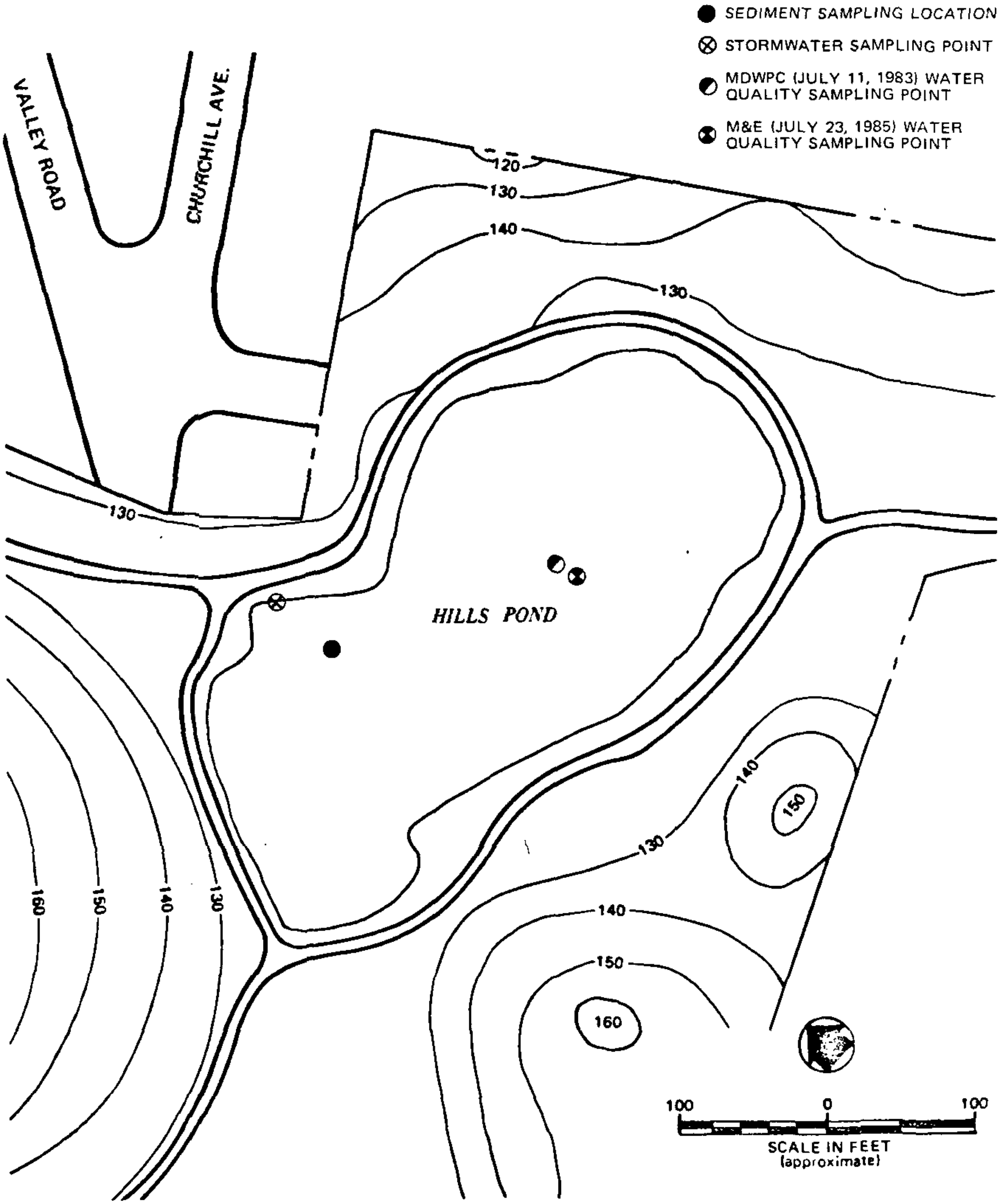


FIG. 2-4 SAMPLING LOCATIONS FOR HILL'S POND

Nutrient concentrations (phosphorus and nitrogen) measured in the past have been high. At total phosphorus and total nitrogen concentrations greater than approximately 0.03 and 0.5 mg/l, respectively, it is considered that eutrophic conditions may exist (Wetzel, 1975). The MDWPC measurements show that these levels have been exceeded in the past in Hill's Pond.

TABLE 2-2. SUMMARY OF MDWPC WATER QUALITY SAMPLING DATA FOR HILL'S POND, JULY 11, 1983.

Parameter	Units	Surface	0.5 Meter	1.0 Meter
Temperature	(°C)	26.1	24.8	23.7
pH		6.2	6.6	6.7
Dissolved Oxygen	(mg/l)	8.5	8.0	6.8
Conductivity	(μmho/cm)	263	262	266
Suspended Solids	(mg/l)	14		15
Dissolved Solids	(mg/l)	140		150
Chloride	(mg/l)	46		48
Alkalinity	(mg/l as $CaCO_3$)	37		37
Total Phosphorus	(mg/l)	0.10		0.09
TKN	(mg/l)	0.96		1.1
Ammonia - N	(mg/l)	0.03		0.01
Nitrate - N	(mg/l)	0.1		0.1
Total Coliform	(No./100ml)	1600		
Fecal Coliform	(No./100ml)	440		

Dissolved oxygen concentrations measured by the MDWPC indicated that levels generally remain near saturation during the daylight hours. This is due to the fact that the pond is shallow and the water column is generally well mixed from surface to bottom. Reaeration at the water surface and photosynthetic oxygen production both add oxygen to the water column. Lower dissolved oxygen levels can be expected at the very bottom of the pond due to sediment oxygen demand. Additional discussion of water quality conditions in the pond and their implications is given later in the Diagnostic Survey section of this chapter.

DIAGNOSTIC SURVEY DESCRIPTION

A Phase I Diagnostic Survey of Hill's Pond was conducted to provide baseline information on the pond and to aid in the development and evaluation of methods for improving conditions in the pond. The Diagnostic Survey included collection of data on in-pond water quality, stormwater runoff quantity and quality, pond bottom sediments and macrophyte growth in the pond. The data collection programs conducted are described in this section. Sampling techniques, sample preservation, and analytical methodology were conducted in accordance with Standard Methods and EPA Methods for Chemical Analysis of Water and Wastewater. A schedule of the surveys conducted at the pond is presented in Table 2-3.

In-Pond Data

Water quality data were collected on July 24, 1985 at one location near the center of the pond as indicated in Figure 2-4. In situ measurements of various water quality parameters

TABLE 2-3. SCHEDULE OF SURVEYS CONDUCTED AT HILL'S POND

Survey Type	Date
Stormwater sampling	May 3, 1985
Bathymetric survey	July 24, 1985
Pond sediment depth survey	July 24, 1985
In-pond water quality	July 24, 1985
Macrophyte survey	August 13, 1985
Stormwater sampling	October 3, 1985
In-pond sediment sampling	November 13, 1985
Water level monitoring	May through September

were obtained using a HYDROLAB Model 4041 water quality instrument. In addition, water samples were collected at the surface and at a depth of 2 feet below the water surface. The parameters measured during this survey are listed in Table 2-4.

Stormwater Runoff

To determine the cause and effect relationship between nutrient input and eutrophication response of Hill's Pond, it is necessary to quantify the sources of nutrients to the pond. Source quantification requires both flows and nutrient concentrations in order to calculate mass loadings to the pond. Since there are no natural streams that feed Hill's Pond, the primary external source of nutrient loading is stormwater runoff which enters the pond via a 10-inch concrete pipe and via overland runoff.

Two stormwater surveys were conducted at Hill's Pond on May 3, 1985 and October 3, 1985. Flow and water quality measurements were obtained at timed intervals during each rainfall event so as to monitor runoff to the pond for a minimum of two hours or until one hour after peak flow. A total of about eight samples were collected at the storm drain inlet pipe at the bottom of Churchill Avenue (as indicated in Figure 2-4). Flow measurements were obtained using either a portable weir or a

TABLE 2-4. PARAMETERS MEASURED DURING WATER QUALITY SURVEYS

DIRECT IN-POND MEASUREMENTS

- Temperature
- Dissolved Oxygen
- pH
- Conductivity

SAMPLES WITHDRAWN FOR LABORATORY ANALYSIS

<u>Physical-Chemical Parameters</u>
- Suspended Solids
- Dissolved Solids
- Chlorides
- Alkalinity

<u>Nutrients</u>
- Total Phosphorus
- Total Kjeldahl Nitrogen (TKN)
- Ammonia-Nitrogen
- Nitrate-Nitrogen

<u>Biological Parameters</u>
- Chlorophyll-*a*
- Phytoplankton Identification

<u>Bacteria</u>
- Total Coliform
- Fecal Coliform

portable flow-velocity meter. The total rainfall during each runoff event was also measured on site. The parameters analyzed are listed in Table 2-5.

TABLE 2-5. PARAMETERS MEASURED DURING STORMWATER RUNOFF SURVEYS[1]

Suspended solids
Dissolved solids
Total Kjeldahl nitrogen
Ammonia-nitrogen
Nitrate-nitrogen
Total phosphorus
Total and fecal coliform[2]
Heavy metals[3]
Discharge
Total rainfall

1. Flow-weighted composite of eight samples taken over a three hour period.
2. Separate samples taken that were not composited before analysis.
3. Chromium, manganese, iron, copper, zinc, cadmium, lead.

Sediment Data

A sample of soft sediments was collected near the storm drain inlet to Hill's Pond on November 13,1985. The location where the sediment sample was collected is illustrated in Figure 2-4. The sample was taken with a hand-operated, stainless steel van Veen grab sampler, transferred to bottles and preserved for transport to the laboratory. The sample was analyzed for the parameters listed in Table 2-6.

A sediment depth survey was conducted in conjunction with the water depth survey on July 24, 1985. Lengths of pipe were hand driven into the bottom sediment to refusal. Measurements were taken at a total of eleven locations on four equally spaced transects across the pond.

TABLE 2-6. SEDIMENT ANALYSIS PARAMETERS

Total phosphorus
Total nitrogen
Total solids
Total volatile solids
Oil and grease
Heavy metals[1]

1. Chromium, manganese, iron, copper, zinc, cadmium, lead, arsenic, mercury, nickel, vanadium.

Macrophyte Survey

A macrophyte survey of the entire pond was performed on August 13, 1985 to determine areal coverage and to identify dominant genera of submerged, emergent and floating aquatic macrophytes. Plants were also identified around the edges of the pond. The distribution and abundance of identified species are presented in the subsequent section of this Chapter on Pond Biology.

ASSESSMENT OF EXISTING CONDITIONS

The remainder of this Chapter includes an analysis of existing conditions in the pond, including presentation of the data collected during the Diagnostic Survey of Hill's Pond. The following general categories are included:

- Pond Hydrology
- Pond Water Quality
- Pollutant Loading Sources
- Pond Biology
- Trophic State Analysis

Pond Hydrology

The Hill's Pond surface water drainage area is approximately 15 acres. The surface area of the pond is 2 acres, yielding a ratio of the drainage area to the pond surface area of 7.5:1. The contribution of surface water runoff to the pond's hydrologic budget is expected to be small since more than half the basin is open parkland which absorbs most rainfall. Stormwater from the area surrounding the pond drains into the pond either as overland runoff or via the one storm drain. In addition to surface water flows, groundwater flow may be an important segment of the pond hydrologic budget.

Inlet/Outlet Data. With the exception of the 10-inch storm drain transporting stormwater runoff from Valley Road and Churchill Avenue, there is no direct inlet to Hill's Pond. The creek bed which transports flows intermittently was dry on all days that various surveys were conducted.

The outlet for Hill's Pond is a pipe located below the water surface which runs underground from the south shore of the pond and connects to a storm drain on Morton Street. The pond outflow is controlled by a valve which is operated by the Town's Park Maintenance Department as necessary during periods of high water level in the pond. No records are kept by the department on the opening of this valve. According to Mr. Frank Wright of the Department of Properties and Natural Resources, the valve was last opened in the spring of 1983 but has remained closed since then.

An emergency outlet pipe is visible on the south shore of the pond and acts as an outflow pipe if the pond level rises to a level that threatens flooding of the surrounding shoreline.

The water level in the pond was measured periodically from May through September, 1985. These data are presented in Figure 2-5 and Table 2-7.

TABLE 2-7. *MEASURED WATER SURFACE ELEVATIONS AT HILL'S POND*

Date (1985)	Water Surface Elevation (ft)[1]
3/7	47.02
3/14	47.17
3/28	47.30
5/1	47.52
5/4	47.71
5/8	47.73
5/13	47.69
6/14	47.60
6/21	47.52
6/28	47.44
7/5	47.27
7/12	47.15
7/24	47.15
8/2	46.98
8/13	46.85
8/21	46.65
9/4	46.60
9/17	46.69

1. Referenced to an arbitrary datum 50 ft. below top of north retaining wall.

Flushing rate and retention time are useful parameters to consider in the hydrology and water quality of the pond. The flushing rate is defined as the number of times per year that inflow to the pond will replace the pond's volume. The retention time is the inverse of the flushing rate, and is defined as the

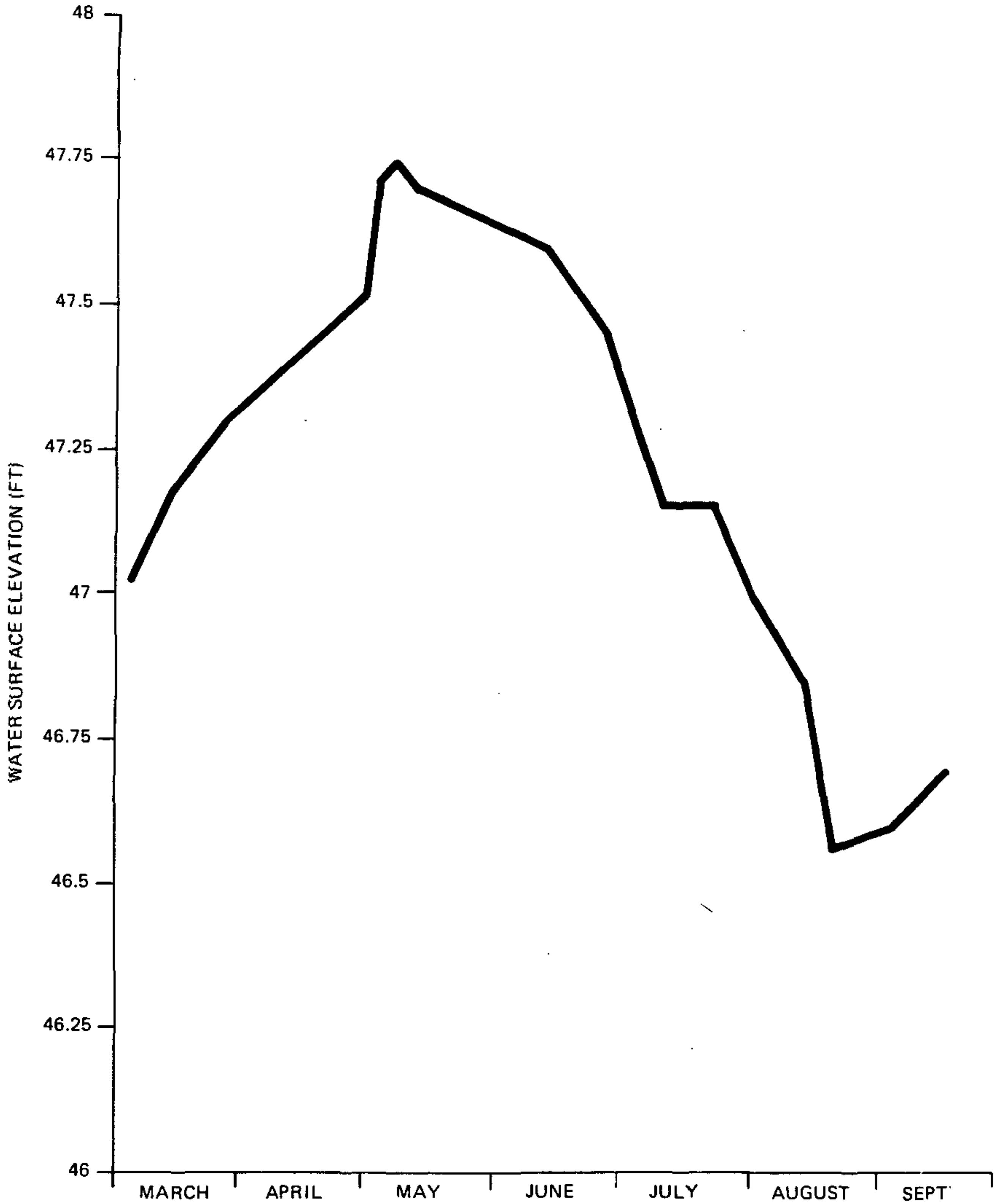


FIG. 2-5 WATER SURFACE ELEVATIONS AT HILL'S POND FOR THE PERIOD MARCH 7, 1985 TO SEPTEMBER 17, 1985

residence time of a conservative constituent, assuming the pond is completely mixed. High flushing rates are normally found in lakes fed by major inflow sources. The flushing rate and retention time indicate how rapidly short term pollutant loads from the inlet or from other sources will be diluted and passed through the pond.

Since no surface water outflow occurred in the pond from May to September, the flushing rate in the pond during this period was zero. This is expected since the inflow to the pond is limited to stormwater runoff, direct rainfall, and possibly groundwater flow. A net groundwater outflow from the pond would increase the hydrologic flushing rate of the pond. Further discussion of groundwater flow is given later in the Hydrologic Budget section.

Stormwater Inflows. The 10-inch storm drain that enters Hill's Pond was monitored during two rainfall events. Runoff coefficients for the area draining to this pipe were determined from these events and are presented in Table 2-8 along with results of other measurements.

TABLE 2-8. SUMMARY OF RUNOFF MEASUREMENTS OBTAINED DURING RAINFALL EVENTS

	Date	
	5/3/85	10/3/85
Valley Rd. - Churchill Ave. (3.1 acres)		
Total rainfall (in.)	0.31	0.10
Duration of monitoring (hrs.)	3.25	1.58
Total runoff (ft^3)	219.	48.
Runoff coefficient	0.06	0.04

The measured runoff coefficients from both rainfall events are similar. These coefficients are relatively low and indicate that most of the rainfall infiltrated to the ground and did not enter the pond as runoff. The two events monitored were similar with an average rainfall intensity of less than 0.1 in/hr during both events. Higher runoff coefficients would be expected during higher intensity rainfall events and during winter months when the ground is frozen and infiltration is reduced.

Hydrologic Budget. A hydrologic "budget" can be derived for Hill's Pond that accounts for sources and losses of water to the pond. The general equation for this hydrologic budget is given below:

$$\frac{dV}{dt} = R + T + S - E - O \pm GW$$

V = lake volume (Ft^3)

t = time (T)

R = direct rainfall, (Ft^3/T)

T = tributary inflow, (Ft^3/T)

S = stormwater inflow, (Ft^3/T)

E = evaporative loss, (Ft^3/T)

O = outflow from pond, (Ft^3/T)

GW = groundwater flow, (Ft^3/T)

The equation has been solved on a monthly basis with values of rainfall, stormwater inflow, and evaporative loss as known inputs. Daily precipitation records were obtained from the

City of Waltham gauges and monthly evaporation data are available from the Rochester, Massachusetts weather station. To adjust evaporation gauge measurements to actual lake evaporation values, a pan coefficient of 0.7 was used (Linsley et. al., 1975). An average runoff coefficient of 0.05 based on field measurements has been used to account for runoff from the surrounding drainage area during the hydrologic budget period. This coefficient was adjusted to 0.1 for March and April to account for higher than average runoff during late winter and early spring. Water level in the pond was measured periodically throughout the diagnostic survey period. This available information is expected to be adequate to calculate the hydrologic budget of the pond and to determine the relative magnitude of any inflow or outflow unaccounted for.

Since there was no observed inflow or outflow (other than stormwater inflow) at the pond, both the tributary inflow term (T) and the outflow term (O) are zero. The net groundwater flow (GW) into or out of the pond is treated as an unknown, and is used to balance the equation with known pond volume. Pond volume as illustrated in Figure 2-6 has been calculated from the periodic water level measurements of Table 2-7, and the bathymetric contours of Figure 2-1.

Based on the input described above, a tabular hydrologic budget has been calculated for the Diagnostic Survey period as shown in Table 2-9. After rainfall and stormwater inputs and evaporative losses have been accounted for, calculated pond level

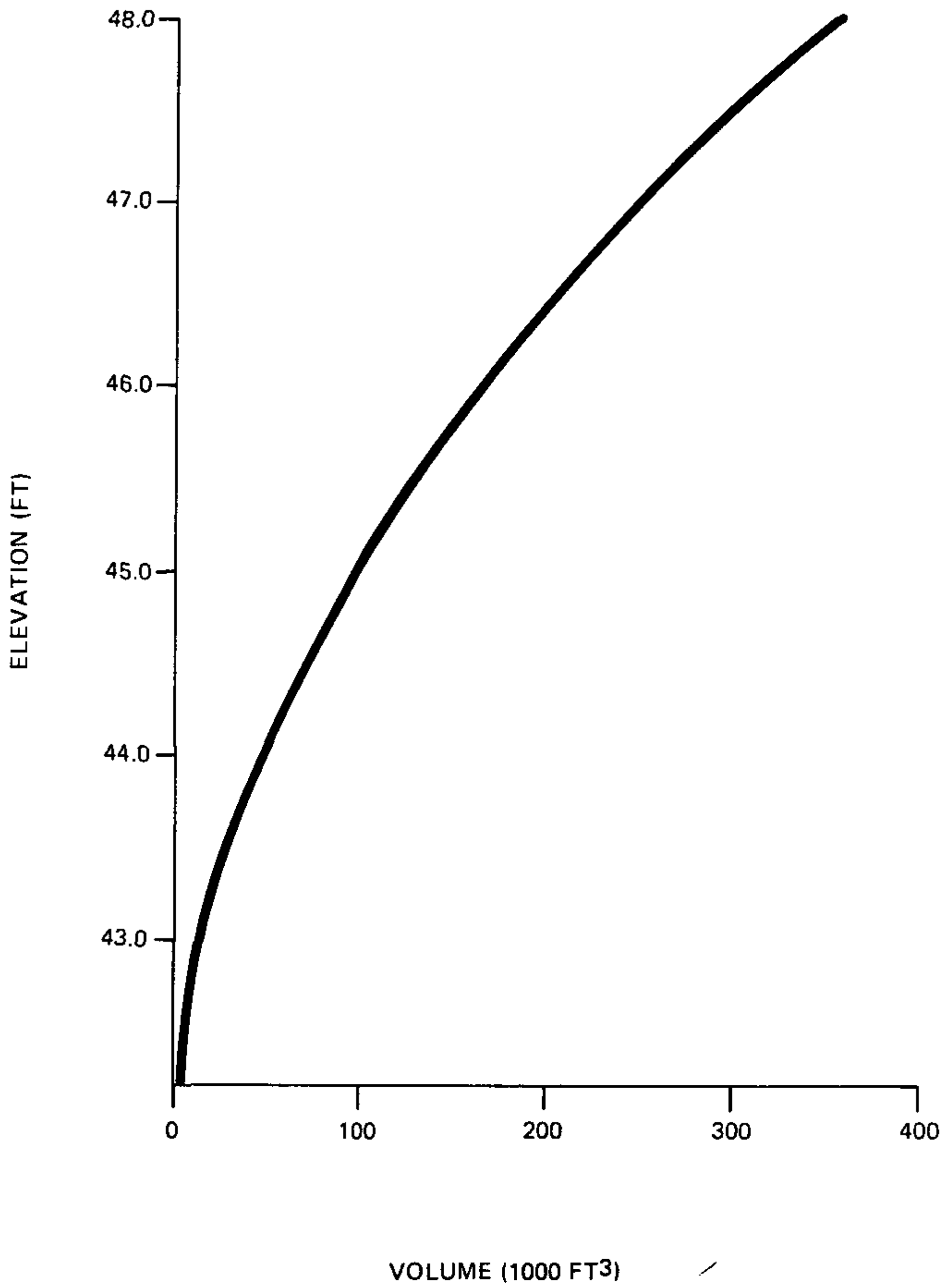


FIG. 2-6 HILL'S POND DEPTH TO VOLUME RELATIONSHIP.

measurements indicate a water level higher than that measured. In order to maintain a mass balance of water entering and leaving the pond, an additional outflow of water must be accounted for. This additional loss of water is attributed to net groundwater outflow from the pond possibly due to a decline in the surrounding water table elevation.

As is shown in Table 2-9, the net groundwater outflow accounts for a significant portion of the hydrologic budget of the pond. The calculated groundwater flow from May to mid-June is negligible, but from mid-June to September there is a significant groundwater outflow from the pond. The maximum groundwater outflow calculated was approximately 17,000 gallons/day during July. Rainfall for this period was lower than during an average year.

TABLE 2-9. HILL'S POND HYDROLOGIC BUDGET[1]

$$\frac{dV}{dt} = R + S - E \pm GW$$

Period	Volume	dV/dt	R	S	E	GW
3/7/85	256	-	-	-	-	-
3/8/85 to 5/1/85	303	47	35.5	27.2	19.7	4.0
5/2/85 to 6/14/85	312	9	44.9	17.4	45.1	-8.2
6/15/85 to 7/5/85	278	-34	21.2	8.2	19.3	-44.1
7/6/85 to 8/2/85	252	-26	49.8	19.3	33.6	-61.5
8/3/85 to 9/17/85	226	-25	51.5	19.9	55.3[2]	-42.1

1. All values are in $ft^3 \times 1000$.
2. Estimated value.

Pond Water Quality

The various physical, chemical and biological measurements obtained during the in-pond sampling of Hill's Pond are presented in Table 2-10. A brief discussion of the significance of each parameter is provided. The Massachusetts Water Quality Standards define Hill's Pond as a Class B water. Reference is made to the State's Standards for those parameters for which water quality criteria have been established.

Dissolved Oxygen. A dissolved oxygen (DO) concentration of 11.7 mg/l was measured during the in-pond survey. Based on a measured water temperature of 25.8°C the saturated DO concentration would be 8.2 mg/l. The measured DO level indicates supersaturated DO conditions due to photosynthetic activity in the pond. Measurements obtained on July 11, 1983 by the MDWPC indicated DO concentrations from 8.5 mg/l at the pond surface to 6.8 mg/l at 1 meter depth. These concentrations were below saturation level. This may be related to the fact that aquatic macrophytes, which produce oxygen during photosynthesis, were less dense during the 1983 survey. The State standard for dissolved oxygen in Class B waters is a minimum of 5.0 mg/l. Measurements at Hill's Pond do not indicate a violation of this standard, although nighttime dissolved oxygen levels are expected to be lower due to plant respiration.

Suspended Solids. The suspended solids at the surface and 2 feet below the surface of the pond were 4.5 and 3.5 mg/l, respectively. These values are reasonably low and indicate low turbidity in the pond. The suspended solids measurements during the 1983 MDWDC survey were 14 mg/l and 15 mg/l, somewhat higher than the 1985 measurements. This could be due to a variety of factors including higher algae concentrations, more recent stormwater runoff or sediment resuspension.

Nutrients. A variety of elements are required to stimulate plant growth in a water body. Most commonly the elements in least supply are the nutrients nitrogen and phosphorus. Total phosphorus, nitrate-nitrogen (NO_3-N), ammonia nitrogen (NH_3-N), and total Kjeldahl nitrogen (TKN) were measured during the in-pond water quality survey. These nutrients are present in commercial fertilizers, animal manure, phosphorus-based detergents, and other products which may enter the pond from the drainage basin. Available evidence suggests that when a water body develops an increase in phytoplankton and macrophyte growth as the result of pollution, it is due to the increased supply of nutrients.

Although nitrogen is required in much greater quantities for plant growth, it is most commonly phosphorus that is the limiting nutrient in lake systems. The concentration of total nitrogen in Hill's Pond waters exceeds that of phosphorus by approximately an order of magnitude. Both phosphorus and nitrogen levels are sufficient to sustain plant growth in the pond.

The total phosphorus measurements obtained at the in-pond station were 0.28 and 0.089 mg/l for the surface and 2-foot depth

TABLE 2-10. RESULTS OF IN-POND SAMPLING JULY 24, 1985

Parameter	Units	Water Surface	1-ft Depth(1)	2-ft Depth
Temperature	°C		25.8	
Dissolved Oxygen	mg/l		11.7	
pH			9.2	
Conductivity	μmhos/cm		171.	
Alkalinity	mg/l as $CaCO_3$	36.		30.
Total Suspended Solids	mg/l	4.5		3.5
Total Dissolved Solids	mg/l	140.		150.
Ammonia-N	mg/l	0.22		0.19
Nitrate-N	mg/l	0.032		0.046
Total Kjeldahl Nitrogen (TKN)	mg/l	1.6		1.8
Total Phosphorus	mg/l	0.28		0.089
Chlorides	mg/l	36.		33.
Chlorophyll-a	mg/m^3	11.		
Total Coliform	MPN/100 ml	30.		-
Fecal Coliform	MPN/100 ml	4.		-

1. Measurements were not taken at greater depths due to interference caused by dense macrophyte growth.

samples, respectively. Total phosphorus measurements obtained during the 1983 MDWPC survey were similiar, at 0.10 mg/l at the surface and 0.09 mg/l at 1 meter depth. At total phosphorus concentrations greater than 0.03 mg/l, a lake may be considered eutrophic (Wetzel, 1975) and excessive plant growth may be a problem. Although this number varies for every pond based on several factors, including pond flushing rate, phosphorus loading and type of algae, it is useful as a general guideline. The Hill's Pond total phosphorus concentrations are greater than 0.03 mg/l for all past and present data available.

The principal forms of nitrogen are ammonia, nitrate, nitrite, and organic-nitrogen. Total Kjeldahl nitrogen (TKN) represents the combined total of ammonia and organic nitrogen. Wetzel (1975) cites total nitrogen concentrations significantly greater than 0.5 mg/l as being sufficient to cause eutrophic conditions. The combined ammonia, nitrate, and organic nitrogen concentrations measured in Hill's Pond were greater than 1.0 mg/l during both the 1985 survey and the 1983 MDWPC survey, thus indicating the presence of sufficient nitrogen to cause eutrophic conditions. Although much of the nitrogen present in the pond is organic, it may potentially be converted to forms of nitrogen available for algae growth (i.e. ammonia and nitrate).

Phytoplankton and macrophytes can utilize both nitrate and ammonia, although there is some discussion as to which is the preferred form during plant assimilation (Wetzel, 1975; Brezonik, 1972). Also, organic nitrogen may be transformed to ammonia and nitrate. Some types of algae (e.g. filamentous blue-green algae) are able to fix nitrogen from the atmosphere and thus have an unlimited nitrogen source.

Alkalinity and pH. The alkalinity of a water body gives an indication of its buffering capacity or ability to withstand changes in pH. The alkalinity of a lake is controlled to a large degree by the characteristics of its watershed. In

Massachusetts, carbonate-rich watersheds (i.e. limestone regions) tend to have higher alkalinities, whereas lakes in the Cape Cod and other regions tend to have lower alkalinities. The alkalinity measurements obtained in Hill's Pond ranged from 30 to 36 mg/l as $CaCO_3$ during the 1985 survey, and alkalinity was measured at 37 mg/l during the 1983 MDWPC survey. As a general guideline, a well-buffered lake has an alkalinity of 20 mg/l or more. Therefore, Hill's Pond is considered to have a good buffering capacity and is not susceptible to changes in pH due to inflows and processes within the pond.

The principal reason for considering a lake's alkalinity is its effect on pH. Most lakes have pH values between 6 and 9. The pH in Hill's Pond was measured as 9.2, which is high and probably due to algal activity. Uptake of carbon dioxide by macrophytes and phytoplankton during photosynthesis tends to raise the pH. During nighttime, pH levels may be lower due to carbon dioxide production by respiration. During the 1983 MDWPC survey, the pH measured in the pond was between 6.2 and 6.7. Nevertheless, the data indicate that acidification of Hill's Pond is not a problem.

Chlorides and Conductivity. The chloride ion concentrations measured at the surface and at 2 feet below the surface of the pond were 36 and 33 mg/l respectively. During the 1983 MDWPC survey chloride measurements were 46 mg/l and 48 mg/l at the pond surface and 1 meter depth, respectively. These values are reasonably low and indicate a low concentration of dissolved ions in the water. Conductivity is a measure of the total concentration of ionized chemicals and minerals in the water including chlorides. Conductivity is indicative of the level of dissolved solids present. Conductivities in the range of 150 - 1000 μmhos/cm are generally considered safe for aquatic communities. The conductivity measured in Hill's Pond was 171 μmhos/cm, which is at the low end of the acceptable range and like the chloride concentrations, indicative of a low concentration of dissolved ions.

Coliform Bacteria. Total and fecal coliform bacteria were measured in Hill's Pond during the in-pond sampling. The State water quality standard for Hill's Pond is in terms of fecal coliform bacteria, which states that the log mean for a set of samples shall not exceed 200 organisms per 100 ml. This standard is for primary contact recreation such as swimming. Though Hill's Pond is not used for swimming, the 1985 fecal coliform measurement of 4 MPN/100 ml is well below the State standard. During the 1983 MDWPC survey, the fecal coliform concentration was much higher, at 440 mg/l.

Pollutant Loading Sources

The primary sources of inflow to Hill's Pond are stormwater runoff via a 10-inch storm drain, overland runoff, direct precipitation and groundwater inflow. Water quality measurements were obtained at the stormwater drain. Samples of the pond bottom sediments were collected to determine the potential for an influx of pollutants from the sediments into the water column. The water quality data collected at these influent sources are presented in the following paragraphs.

Stormwater Data. *Summaries of concentrations for the* parameters measured in stormwater runoff are presented in Tables 2-11 and 2-12.

The nutrient concentrations in the stormwater are generally higher than in-pond nutrient concentrations. Total

TABLE 2-11. SUMMARY OF COMPOSITE STORMWATER MONITORING DATA

Parameter	Units	Monitoring Date 5/3/85(1)	Monitoring Date 10/3/85(2)
Composite Sample			
Total Suspended Solids	mg/l	80	21
Total Dissolved Solids	mg/l	120	81
Chlorides	mg/l	28	9.4
Ammonia-N	mg/l	0.29	1.2
Nitrate-N	mg/l	<0.01	0.94
Total Kjeldahl Nitrogen	mg/l	2.7	2.4
Total Phosphorus	mg/l	0.58	0.70
Total Chromium	mg/l	<0.05	<0.05
Total Manganese	mg/l	0.044	0.065
Total Iron	mg/l	2.0	0.18
Total Copper	mg/l	<0.02	<0.02
Total Zinc	mg/l	0.027	0.042
Total Cadmium	mg/l	<0.01	<0.005
Total Lead	mg/l	<0.01	<0.1

1. Flow-composite of eight samples collected over a 3-hour period.
2. Flow-composite of three samples collected over a 1.5-hour period.

phosphorus concentrations of the stormwater runoff are significantly higher than in-pond levels.

The coliform concentrations entering the pond in the stormwater are much higher than the in-pond concentrations, but are generally within the normal range expected in stormwater (10^4 - 10^5 per 100 ml).

The pollutant loads entering the pond and the associated water quality impacts are dependent on the total runoff volume and will vary significantly from one event to the next. This is taken into consideration when modeling the pond's nutrient budget, as presented later in this Chapter.

TABLE 2-12. SUMMARY OF DISCRETE STORMWATER MONITORING DATA

Date	Parameter	Time of Sampling	Minutes After Start of Storm	Concentrations (MPN/100 ml)
5/3/85	Total Coliform	4:30 am	45	<45
		5:50 am	155	40,000
		6:50 am	215	20,000
	Fecal Coliform	4:30 am	10	<45
		5:50 am	155	600
		6:50 am	215	500
10/3/85	Total Coliform	10:15 am	30	110,000
		11:05 am	80	160,000
	Fecal Coliform	10:15 am	30	31,000
		11:05 am	80	45,000

Bottom Sediments. Sediment samples were collected at the in-pond station in Hill's Pond illustrated in Figure 2-4. The results of the analyses of these samples are presented in Table 2-13. Concentrations of nutrients in the bottom sediments are high. Resuspension of these sediments due to wind mixing can be expected to contribute a significant nutrient load to the water column. Concentrations of other parameters are within acceptable limits and will be discussed more thoroughly later as they pertain to dredging.

TABLE 2-13. SUMMARY OF SEDIMENT SAMPLE ANALYSES

Parameter	Units	Concentration
Total Phosphorus	mg/kg	16
Total Kjeldahl Nitrogen	mg/kg	1200
Total Solids	-	38%
Total Volatile Solids	% of Solids	10%
Oil & Grease	% of Solids	2.0%
Chromium	mg/kg	22
Manganese	mg/kg	150
Iron	mg/kg	140
Copper	mg/kg	22
Zinc	mg/kg	92
Cadmium	mg/kg	1.4
Lead	mg/kg	130
Arsenic	mg/kg	2.1
Mercury	mg/kg	.059
Nickel	mg/kg	19
Vanadium	mg/kg	<4

A sediment depth map was prepared from probings of the pond bottom sediments as shown in Figure 2-7. The sediment depths measured ranged from 3 feet at the center to about 8 inches around the perimeter. Sediment depths in the area of the storm drain inlet were determined to be relatively shallow during the survey. This is because the method used (probing by hand to

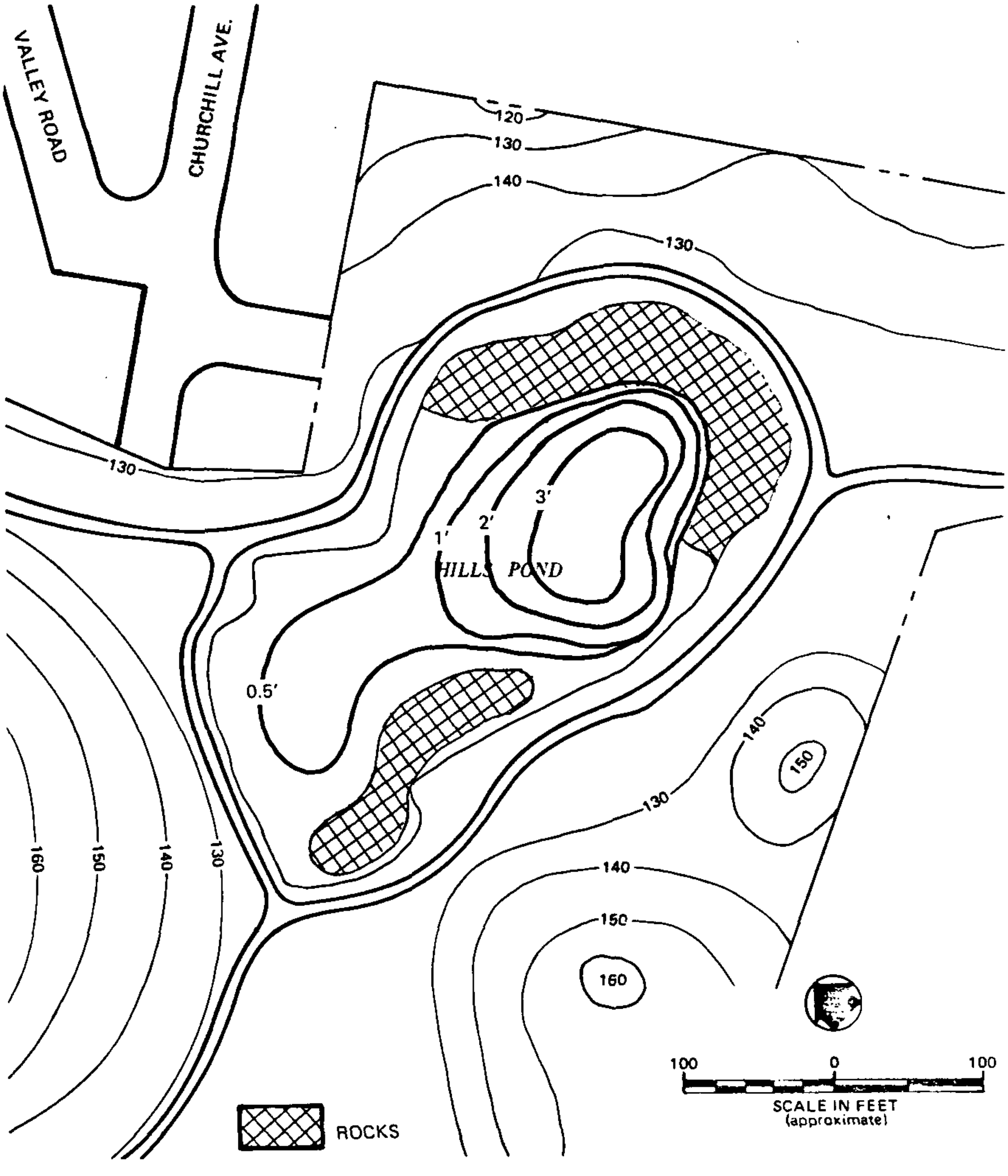


FIG. 2-7 SEDIMENT DEPTH CONTOURS FOR HILL'S POND

refusal) indicates depth of only the soft organic sediments. In this area, a good portion of the sediments are heavier sand and gravel material washed in from Valley Road and Churchill Avenue. It is not possible to probe this more dense material, therefore actual depths of sediment in this area are not known.

Based on the sediment depth contours of Figure 2-7, the total volume of soft organic sediments is calculated to be about 2000 cubic yards. It is estimated that there are approximately 1000 cubic yards of heavier sediments in the area of the storm drain inlet. There is a total of approximatley 3000 cubic yards of material deposited at the bottom of Hill's Pond.

Nutrient Budget. Measurements obtained during the Diagnostic Survey and from the literature have been used to quantify the nutrient budget of Hill's Pond. Controlling phosphorus input to the pond is the most effective means of limiting the nutrients essential for plant growth, and thus the nutrient budget presented here is based on the total phosphorus loads to the pond.

The phosphorus loads to the pond are summarized in Table 2-14. The principal sources of external phosphorus loading are stormwater runoff and direct precipitation. Measurements of total phosphorus in stormwater runoff ranged from 0.58 to 0.7 mg/l, on a flow weighted average basis. A runoff coefficient of 0.05 was used to calculate average annual runoff based on annual rainfall of 42 inches. Phosphorus concentrations in rain falling directly on the pond and in runoff from forested parkland were

TABLE 2-14. EXTERNAL PHOSPHORUS LOADS TO HILL'S POND

Source	Annual Average Flow(1) (cfs)	Total Phosphorus (mg/l)	Annual Phosphorus Load (kg/yr)
Stormwater (2)	0.001	.58 to .7	.52 to .62
Direct Precipitation	0.009	.01 to .06	.08 to .48
Forested Parkland	0.002	.02 to .06	.04 to .11
Total Phosphorus Inflow			0.64 to 1.21

1. Based on 42 inches average annual rainfall.
2. Valley Road and Churchill Ave. drainage subarea.

estimated from literature values (Brezonik, 1972). Total phosphorus loading from stormwater and direct precipitation was calculated based on these values.

It should be noted that the storm drain at the base of Churchill Avenue is estimated to contribute about 50 percent of the total external phosphorus loading to the pond. In addition, it is expected that the organic bottom sediments in the pond also contribute a significant amount of nutrients to the water column. These organic sediments are rich in nutrients, which, due to the shallow depth of the pond, are likely to enter the water column from wind mixing and sediment resuspension. Sediment nutrients are also recycled to the water column through uptake by macrophytes and subsequent nutrient release during decomposition of the plant materials. Also, it is possible that periods of low dissolved oxygen are experienced in the pond during the night when photosynthesis is not occuring. This can facilitate release of nutrients from the bottom sediments. Thus, the bottom sediments are expected to be a significant source of the nutrients in the pond water in addition to the external sources listed in Table 2-14.

Pond Biology

Freshwater, or lentic ecosystems, are characterized by standing water habitats and associated communities of living organisms. Lentic ecosystems can be subdivided into vertical and horizontal strata based on photosynthetic activity. The littoral or shallow water zone is the nearshore zone in which light penetrates to the bottom. This area is occupied by rooted aquatic plants such as waterlilies, rushes and sedges. Beyond this is the limnetic or open water zone, which extends to the depth of effective light penetration. It is inhabited by plant and animal plankton and the nekton or free swimming organisms such as fish which are capable of moving about voluntarily. Beyond the depth of effective light penetration is the profundal zone, which depends on organic material settling from the limnetic zone as an energy source. Common to both the profundal zone and the littoral zone is the benthic zone, or bottom region, which is the zone of decomposition of settled organic material.

The following discussion focuses on the biological life in Hill's Pond, including phytoplankton (floating, microscopic algae) which inhabit the littoral and limnetic zones, aquatic macrophytes (rooted, aquatic plants) which inhabit the littoral zone and the fishes or nekton which inhabit all zones of lentic environments.

Phytoplankton. The most fundamental level of the food web of Hill's Pond is occupied by phytoplankton which use sunlight and incorporate nutrients to form plant matter. They are photosynthetic, non-vascular, free-floating plants that exist as single cells, colonies or filaments. Factors which affect their distribution and abundance include concentrations of nutrients (nitrogen and phosphorus), penetration and intensity of light, and various physical and chemical interactions. The lower limit of phytoplankton distribution is known as the compensation depth, or the depth at which phytoplankton photosynthesis and respiration rates are equivalent.

Qualitative and quantitative knowledge of the organisms growing in an ecosystem is a valuable indicator of environmental stress and, in the case of Hill's Pond, the trophic state. The trophic state is the stage of nutrient enrichment of a water body. The three basic trophic states that may exist in a lake are oligotrophy, in which the water body is low in nutrients, algae, and may be well-oxygenated; eutrophy, the state which is rich in plant nutrients, algae and aquatic macrophyte growth, and in which the hypolimnion may be deficient in dissolved oxygen; and mesotrophy, the stage between oligotrophy and eutrophy. Phytoplankton composition in general, as well as species in particular, are perhaps the best indicators of water quality and trophic condition of a lake (Vollenweider, 1974). This is because certain species are better adapted to compete under nutrient enriched conditions, resulting in changes in community composition. Thus, specific algal associations may be indicative of eutrophic conditions. Excessive phytoplankton concentrations can cause adverse DO impacts such as (a) wide diel variation in surface DO due to daytime photosynthetic oxygen production and nighttime oxygen depletion by respiration and (b) depletion of bottom DO through the decomposition of dead algal and other organic matter. Excessive algal growth may also result in shading which reduces light penetration in the water.

Water samples were collected at Hill's Pond for biological analysis on July 24, 1985 by Metcalf & Eddy and on July 11, 1983 by the MDWPC. Phytoplankton and chlorophyll-a samples were collected from the water column to obtain an indication of phytoplankton biomass, cell count and taxonomic composition. Chlorophyll-a was sampled by Metcalf & Eddy only.

Chlorophyll-a is the principal photosynthetic pigment in algae and vascular plants. The chlorophyll-a concentration is a good indicator of phytoplankton biomass and nutrient over-enrichment or trophic state. Chlorophyll-a above 10 μg/l is considered evidence of eutrophy. The chlorophyll-a concentration found in Hill's Pond by Metcalf & Eddy was 11.0 μg/l which is slightly above this guideline.

Phytoplankton species identified are presented in Table 2-15. Samples stained and preserved with Lugol's solution were allowed to settle, the supernatant decanted, and known volumes observed under a microscope to identify algae cells. Organisms grouped under unidentified centric diatoms and unidentified chlorella-like algae could not be identified to

TABLE 2-15. PHYTOPLANKTON TAXA OF HILL'S POND
ON JULY 11, 1983 (MDWPC) AND ON JULY 24, 1985 (METCALF & EDDY)

Taxonomic Identification	7/11/83 (DWPC)	7/24/85 (Metcalf & Eddy)
Cyanophyta (Blue green algae)		
Anabaena		X
Anacystic cyanea	X	
Anasyostic sp.	X	
Chlorophyta (Green algae)		
Scenedesmus		X
Scenedesmus dimorphus	X	X
Scenedesmus guodricauda	X	X
Sphaerocystis		
Schroederia		
Pediastrum	X	
Ankistrodesmus	X	
Gloecystis	X	
Tetraedron	X	
Closteriopsis	X	
Crucigenia tetrapedia	X	
Unid. Chlorella - like	X	
Euglenophyta		
Euglena		X
Chrysophyceae (Golden Browns)		
Opmiocytium	X	
Pyrophyceae		
Ceratium hirudinella	X	
Bacillariophyceae (Diatoms)		
Cocceoneis		X
Unid. Centric Diatoms		X
Navicula	X	
Synedra	X	

genus. In the identification of phytoplankton cells, problems often arise from preservation methods, lack of recognizable internal structure of the cells, or due to the presence of cells that have not been described in the scientific literature.

The composition of the phytoplankton community by class division for samples taken in 1983 and 1985 is illustrated in Figure 2-8. The variation in taxonomic composition between 1983 and 1985 cannot be directly attributed to a specific environmental factor. A variety of physical and chemical conditions affect phytoplankton populations including recent weather, light, temperature, season, nutrient availability and type of nutrients present. However, if a water body becomes over-enriched with nutrients, species favored by nutrient rich conditions may proliferate. Green algae and blue-green algae or cyanobacteria are typically present under nutrient enriched or eutrophic conditions. A great diversity of green algae species was found in 1983 by the MDWPC together with blue greens, diatoms, golden-browns and dinoflagellates. Far less green algae were found in 1985 by Metcalf & Eddy but relatively higher concentrations of Euglenophytes and diatoms.

Euglenophytes occur in most freshwater habitats but particularly in waters contaminated by animal pollution or decaying organic matter. In an index of organic pollution tolerant/intolerant genera of phytoplankton, Palmer (1969) found Euglena to be the genera most indicative of organic pollution. In Hill's Pond, this organic pollution may be provided by the abundant population of the aquatic plant *Myriophyllum sp.* which covers most of the aerial extent of the pond.

During both surveys, cell counts were high with 13,510 cells/ml during the MDWPC survey in 1983 and 7,356 during the

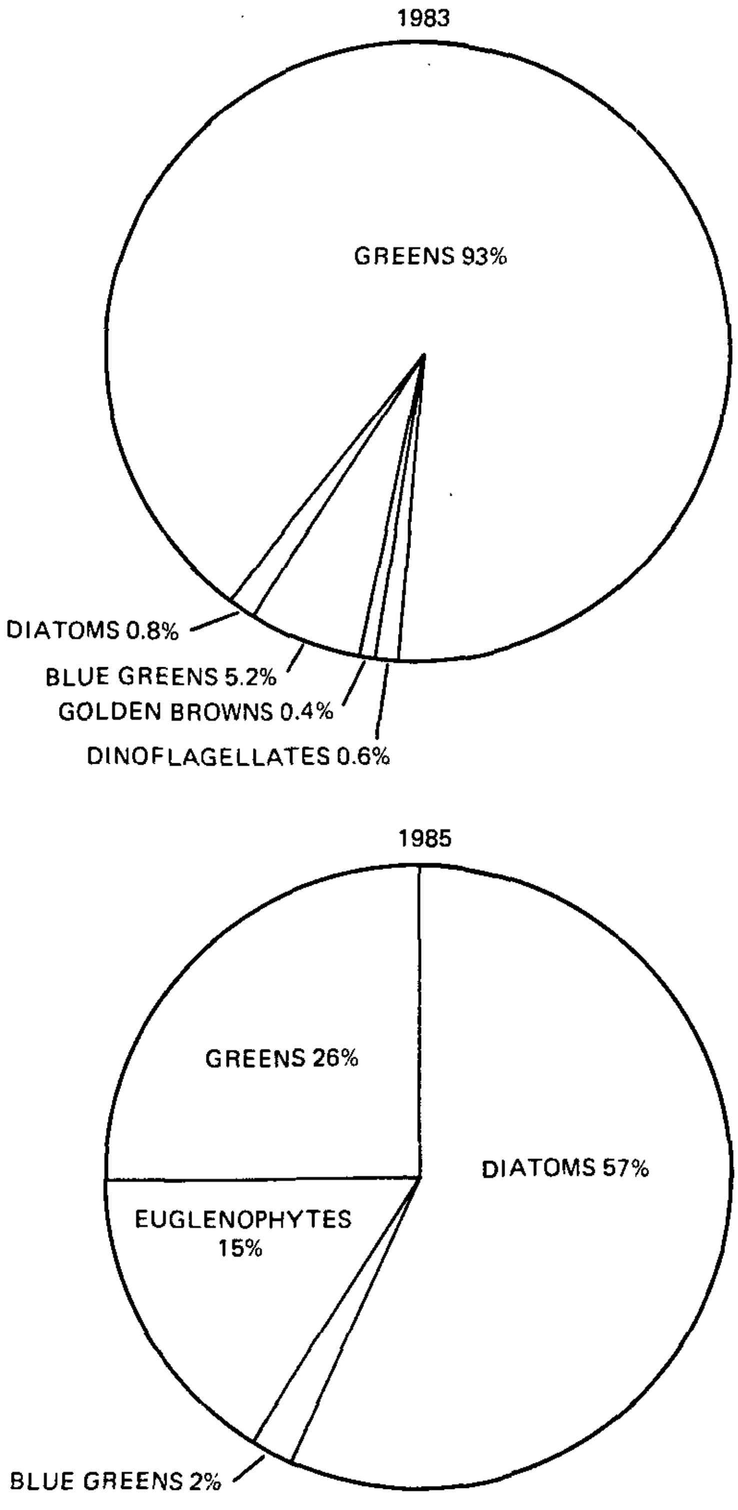


FIG. 2-8
TAXONOMIC COMPOSITION OF PHYTOPLANKTON IN HILL'S POND ON JULY 11, 1983 (DWPC) AND JULY 24, 1985 (METCALF & EDDY)

Metcalf & Eddy survey in 1985. The typical range of algae cell counts for healthy lakes in this region is 0-500 cells/ml (DEQE, 1982). Thus, the counts found during both surveys indicate algal blooms. Die-off of algae cells following severe algal blooms can cause surface scums and offensive odors in severe situations.

Aquatic Macrophytes. Aquatic plants play a variety of roles in lake ecosystems. They produce oxygen through photosynthesis, shade sediments and provide food and habitat for microbes, insects and fish. Although aquatic macrophytes are vital to the ecosystem, eutrophication and the subsequent overgrowth of plants may be detrimental to the water body. Oxygen depletion in the hypolimnion may be caused by decaying macrophytes. Low dissolved oxygen levels may cause fish kills and eliminate sensitive species.

The aquatic macrophytes of Hill's Pond were surveyed on August 13, 1985 by Metcalf & Eddy and on July 11, 1983 by the MDWPC. The MDWPC survey identified two aquatic macrophytes, Arrowhead (*Sagittaria sp.*) and three-square (*Scirpus sp.*). Discussion of the aquatic macrophyte population at Hill's Pond will focus on the Metcalf & Eddy survey which included scrub-shrub wetland species as well as submerged and emergent species. A larger number of species were identified during the M&E study due to this expanded scope.

Submerged and emergent wetland macrophytes were identified to the lowest practicable taxa during the Metcalf & Eddy study. Figure 2-9 depicts the areal distribution of floating, submerged

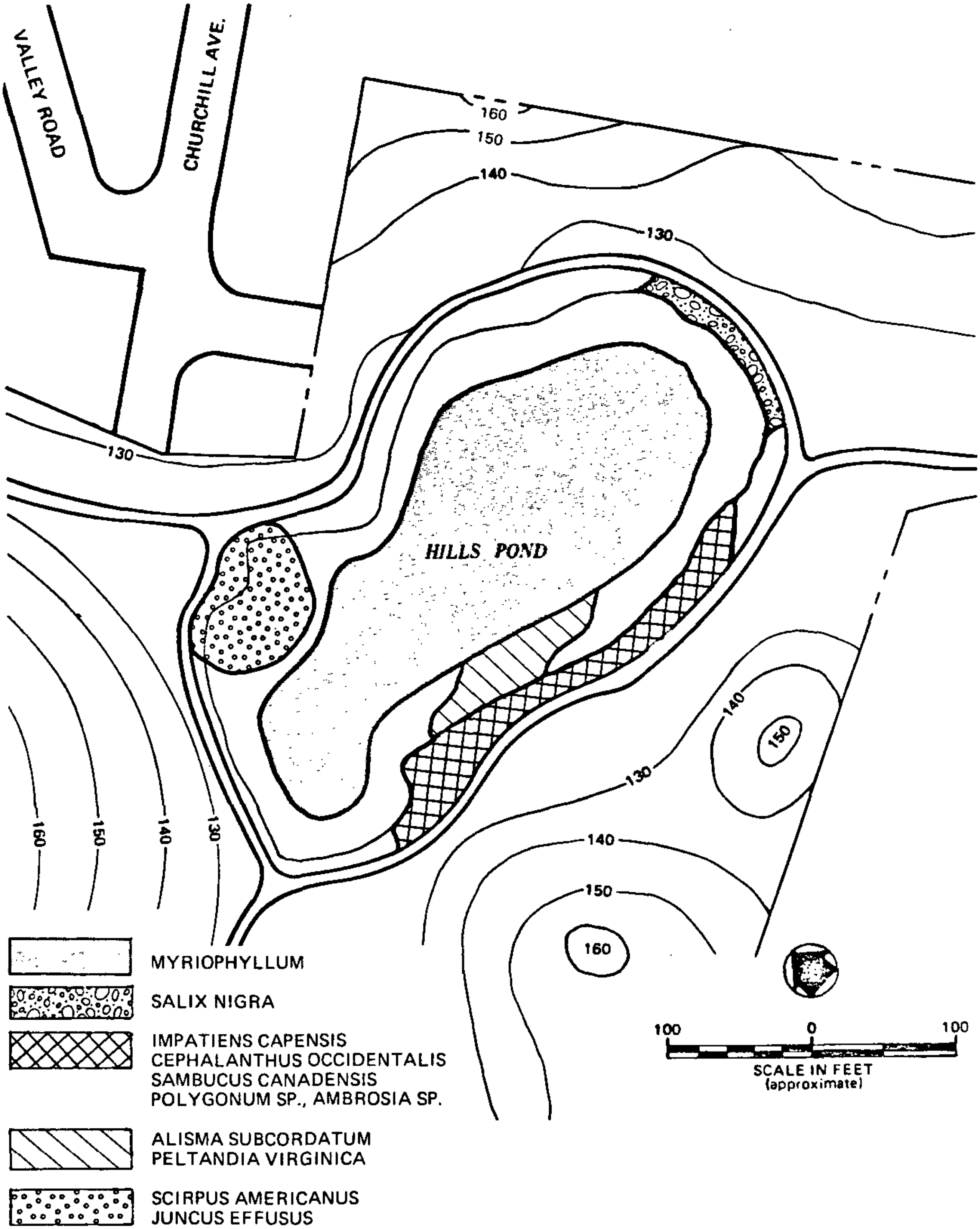


FIG. 2-9
AREAL DISTRIBUTION OF FLOATING, SUBMERGED, AND EMERGENT VASCULAR PLANTS FOUND IN METCALF & EDDY SURVEY, AUGUST 13, 1985

and emergent vascular plants found during the Metcalf & Eddy survey. The dominant submerged aquatic plant was Milfoil or *Myriophyllum sp.*, which covered almost the entire aerial extent of the pond. Milfoil is a common nuisance aquatic weed in the United States. Under nutrient-enriched conditions, Milfoil will thrive and eliminate other aquatic plants that would normally occur. Milfoil grows in long stalks that often extend to the water surface, blocking the light required by other plants. Emergent wetland plants around the periphery of the pond include Smartweeds (*Polygonum* spp.), Jewelweed (*Impatiens capensis*), Buttonbush (*Cephalanthus occidentalis*), Common Elder (*Sambucus canadensis*), Small Water Plantain (*Alisma subcordatum*), Black willows (*Salix nigra*), Arrow-Arum (*Peltandra virginica*) and Ragweed (*Ambrosia sp.*). In addition, emergent species were identified at the northwest corner of the pond. Bulrush (*Scirpus americanus*) and Common Rush (*Juncus effusus*) have grown on the substrate created by the storm drain that drains runoff from Valley Road and Churchill Avenue.

Trophic State Analysis

Empirical trophic state assessments are subject to wide variations depending on the assumptions used to develop inputs. A large amount of judgement is required to properly utilize these methods. After review of the data collected during the Diagnostic Survey, the following procedures were selected to describe the trophic state of Hill's Pond:

* Vollenweider's (1968) nutrient loading criteria
* Massachusetts Lake Classification

These procedures are described in the following sections.

Assessment of Trophic State. Trophic state assessments attempt to relate physical features of ponds to nutrient input using empirical correlations. By comparing characteristics of large numbers of lakes and ponds and developing correlations, a projection is made of the conditions in other ponds.

Trophic state assessments began with Vollenweider (1968) and have been modified by many others (for example Dillon (1974) and Kirchner and Dillon (1975)) to account for additional factors which affect the eutrophication of lakes. As pointed out by Snow & DiGiano (1976) and others (Najarian, 1981), however, there are several drawbacks to these methods including:

1. They do not apply to all lakes since the methods are empirical.
2. The time varying nature of the eutrophication process, for example the response time of a lake to a change in loading, is ignored.
3. Effects of individual processes are combined though they may not be interrelated.

However, as a rough estimate, the trophic state assessments are useful and are widely used.

The eutrophic condition of Hill's Pond is illustrated in Figure 2-10. This calculation is based on the method of Vollenweider (1968). This method was chosen because it does not rely on pond flushing rate as do later methods (Vollenweider,

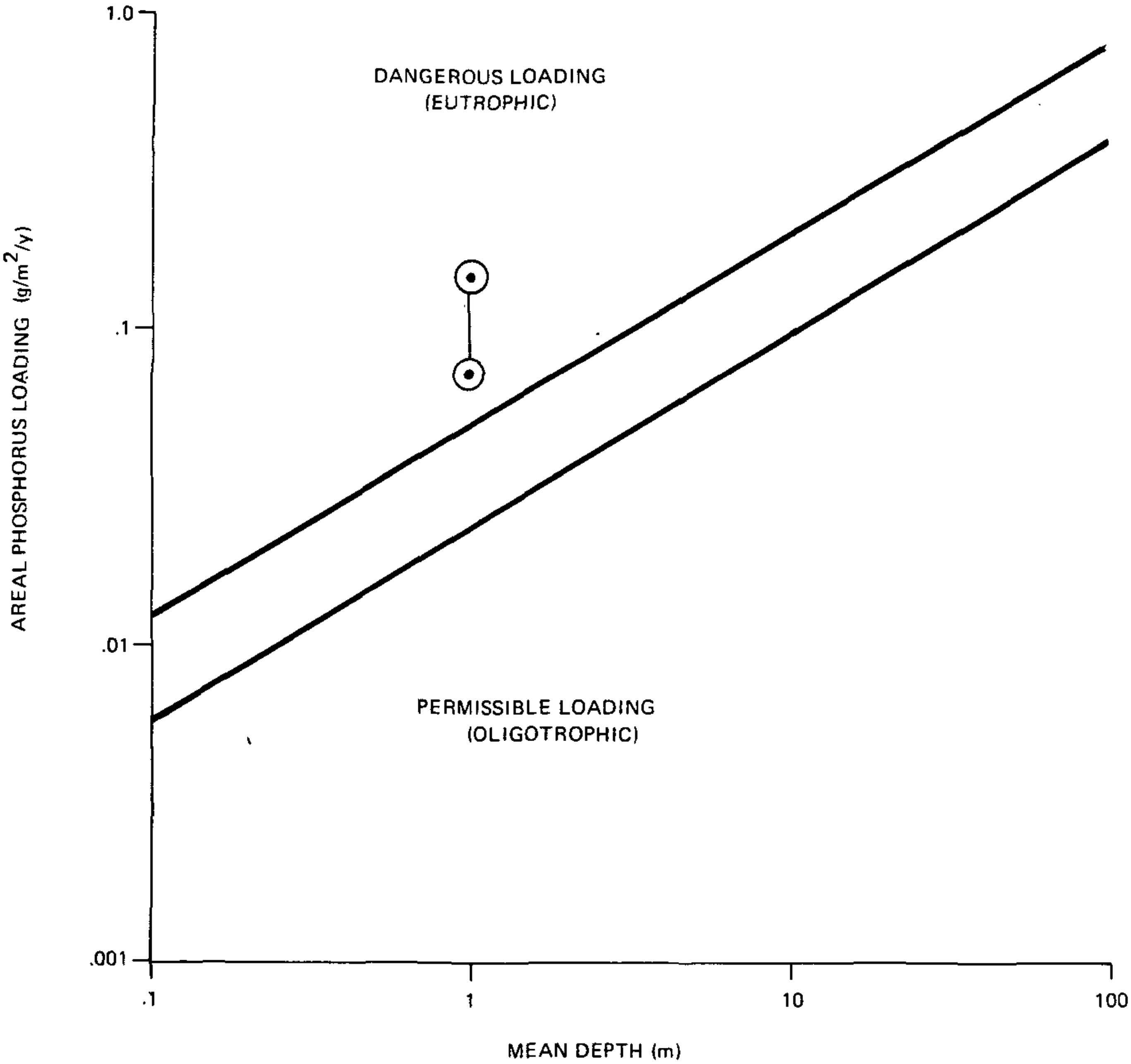


FIG. 2-10 TROPHIC STATE OF HILL'S POND

1974). A flushing rate for Hill's Pond is not well defined. If a nominal flushing rate of once/year is assumed, similar eutrophic conditions are indicated using this later method. This is in agreement with the in-pond water quality data discussed previously. There is sufficient phosphorus and nitrogen in the lake to support growth of algae and aquatic weeds, which is verified by the nutrient and algae data and macrophyte mapping.

The calculations used to define Figure 2-10 are based on approximations of the total phosphorus loading to Hill's Pond from external sources and the pond bathymetry. The principal sources of external phosphorus loading to the pond are stormwater runoff and direct precipitation as discussed in the nutrient budget section of this chapter. Additional internal loading from the bottom sediment is also expected to be significant in Hill's Pond. This internal loading has not been included in calculations for Figure 2-10 because of the difficulty of determining an accurate value. The actual trophic status is therefore even more severe than indicated in Figure 2-10 due to the added contribution of this internal load.

It is possible to control only two of the sources of nutrient loading to Hill's Pond. These are stormwater runoff and sediment resuspension. If nutrient input from these two sources can be significantly reduced, the eutrophication potential of Hill's Pond will be correspondingly reduced. Measures to control these two nutrient sources will be considered in the following chapter.

Massachusetts Lake Classification. The State of Massachusetts has a Lakes Classification System (State of Massachusetts, 1982), the purpose of which is to provide input for the State lake restoration program. This classification scheme is used to assist in prioritizing restoration grant applications. It is useful to classify Hill's Pond according to this scheme in order to: 1) develop an understanding of the severity of problems at Hill's Pond in relation to other lakes in the State, and 2) supplement the trophic state analysis to check on the overall pond status (i.e.: eutrophic).

A summary of the classification of Hill's Pond is provided in Table 2-16. Points are assigned based on diagnostic survey data from July, 1985. A total of 13 points are obtained for Hill's Pond based on this recent data, which places it in the eutrophic category (12 to 18 points). This agrees with the trophic state classification (Figure 2-10) of eutrophic and with the pond biology data previously discussed.

Based on a total of 335 lakes rated within Massachusetts (State of Massachusetts, 1982), Hill's Pond falls in approximately the 90th percentile range in terms of severity, verifying the extensive problems in the pond. There were 24 lakes with higher (more eutrophic) scores, 295 lakes with lower scores, and 16 other lakes within Hill's Pond's classification. The median score for the 335 lakes was eight.

Table 2-16. STATE CLASSIFICATIONS SYSTEM APPLIED TO HILL'S POND

Parameter	Concentration or Degree of Severity	Unit	Points(1)
Hypolimnetic dissolved oxygen	6.8-11.7	mg/l	0
Secchi disk transparency	1-2	ft.	3
Phytoplankton	>1,500 or summer "blooms"	cells/ml	3
Epilimnetic ammonia plus nitrate	0.24-0.25	mg/l	1
Epilimnetic total phosphorus	0.09	mg/l	3
Aquatic vegetation	very dense	-	3
TOTAL			13

1. Points vary from 0 to 3 for each parameter; higher points indicate greater severity.

REFERENCES

Brezonik, P.L., "Nitrogen: Sources and Transformations in Natural Waters", in Nutrients in Natural Waters, H.E. Allen and J.R. Kramer,Editors, Wiley and Sons, 1972.

Dillon, P.J., "The Phosphorus Budget for Cameron Lake, Ontario: The Importance of Flushing Rate to the Degree of Eutrophy in Lakes", Limnology and Oceanography 20 (I), 1974.

Kirchner, W.B. and Dillon, P.J., "An Empirical Method for Estimating the Retention of Phosphorus in Lakes", Water Resources Research, February, 1975.

Linsley, R.K., Jr., M.A. Kohler, and J.L.H. Paulhus, Hydrology for Engineers, McGraw Hill, Second Edition, 1975.

Massachusetts, State Division of Water Pollution Control, Department of Environmental Quality Engineering, "Massachusetts Lakes Classification Program," Technical Services Branch, Westborough, Massachusetts, January, 1982.

Najarian, T.O., and Taft, J.L., "Nitrogen Cycle Model for Aquatic Systems: Analysis", Journal of the Environmental Engineering Division, ASCE, Vol. 107, No. 6, December, 1981.

NOAA, National Climatological Data Center, Climatological Data for New England.

Palmer, C.M., "A Composite Rating of Algae Tolerating Organic Pollution", Journal of Phycology, 5: 78-82.

Snow, P.D., and DiGiano, F.A., "Mathematical Modeling of Phosphorus Exchange Between Sediments and Overlying Water in Shallow Eutrophic Lakes", Report No. Env. E. 54-76-3, Department of Civil Engineering, University of Massachusetts, Amherst, Massachusetts, 1976.

US Environmental Protection Agency, "The Relationships of Phosphorus and Nitrogen to the Trophic State of Northeast and North-Central Lakes and Resevoirs", National Eutrophication Survey Working Paper No. 23.

Vollenweider, R.A., "Scientific Fundamentals of the Eutrophication of Lakes and Flowing Waters with Particular Reference to Nitrogen and Phosphorus as a Factor in Eutrophication", Report No. 27, DAS/CIS/68, Organization for Economic Cooperation and Development, Paris, 1968.

Vollenweider, R.A., M. Munawar and P. Stadelmann, "A Comparative Review of Phytoplankton and Primary Production in the Laurentain Great Lakes", J. Fish. Res. Board Can. 31:739-762, 1974.

Vollenweider, R.A. "Input-Output Models with Special Reference to the Phosphorus Loading Concept in Limnology", Schweiz. Z. Hydrol., 1975.

Wetzel, R.G., Limnology, Saunders College Publishing/Holt, Rinehart and Winston, 1975.

CHAPTER 3

ASSESSMENT OF ALTERNATIVES

The objective of the restoration program for Hill's Pond is to develop recommendations to correct problems identified in the pond. In order to develop these recommendations, a number of alternative solutions were formulated and analyzed, as presented in this Chapter. Initially, specific problems were identified at Hill's Pond. Based on these problems, a set of objectives was identified which would alleviate the problems. Alternatives were then formulated and evaluated. Certain of the alternatives were selected to become a part of the recommended restoration plan, which is described in Chapter 4.

Hill's Pond Problems and Objectives

The first step in alternatives assessment was to define the problems in the pond and to develop a set of objectives which, when achieved, would overcome these problems. In order to provide for public input to the problem assessment process, a general public meeting was held on April 9, 1985. During this meeting, desired uses of the pond were identified along with complaints and problems which currently inhibit those uses. The desired uses of Hill's Pond are as follow:

1. Aesthetic enjoyment
2. Fishing
3. Passive recreation-canoeing

Use of the pond for primary contact recreation (swimming) is not a desired objective.

Based on these desired uses, along with analysis of the diagnostic survey data collected for the pond, objectives for the Hill's Pond restoration program have been developed, as summarized in Table 3-1.

TABLE 3-1. HILL'S POND PROBLEMS AND OBJECTIVES

Problem	Cause	Objective
Low water level	Pond outflow and evaporation exceed inflow at different times of the year	Maintain adequate water level year-round
Extensive macrophyte growth	High nutrient concentrations	Reduce phosphorus concentration
Algal blooms	Excessive nutrient concentrations	Reduce phosphorus concentration
Sediment accumulation at storm drain	Excessive sediment content in stormwater	Remove accumulated sediments; reduce sediment content of stormwater inflow

The problems identified in Hill's Pond relate to water level, eutrophication, and aesthetics. Table 3-1 also shows the objectives that define success for the restoration program. The following is a discussion of each problem and its corresponding objective.

Low Water Level. In the last few years, low water levels have become a recurring problem in Hill's Pond. This problem restricts use of the pond and is a contributing factor to excessive macrophyte growth. Since there is no regular inflow to the pond, the only input of water occurs as direct rainfall on the pond, runoff from storm events and possibly groundwater flow. Based on recent measurements, the net groundwater flow is outflow during the summer months. During extended periods of low precipitation, inflow becomes insufficient to renew losses due to evaporation and possibly groundwater outflow. It is at these times that excessively low water levels occur. One of the main objectives of the recommended plan will be to maintain a stable water level adequate for the desired uses of the pond.

Macrophyte Growth. Excessive densities of undesirable macrophytes occur within the pond during the summer months. Although some species can provide useful habitat for aquatic life, nuisance species interfere with the aesthetic value and recreational use of the pond. During the Diagnostic Survey period, it was evident that aquatic macrophyte growth was detrimental to the aesthetic value of Hill's Pond.

In order to reduce macrophyte growth, reduction of nutrient concentration is required. Because macrophytes can utilize the sediments as a supply of nutrients, it is difficult to identify specific in-pond nutrient concentrations needed to limit macrophyte growth. Removal of these nutrient rich bottom sediments will help reduce macrophyte growth. In addition, reduction of sediment content of storm drain flows may also reduce in-pond nutrient concentrations and help limit macrophyte growth.

For areas of particularly dense growth, reduction of nutrients alone may not result in significant reduction in growth. Physical characteristics of these pond areas, such as depth of water and substrate type, may be especially conducive to macrophyte growth. For these areas, it may be necessary to remove nuisance species. Additionally, deepening the pond may inhibit some aquatic macrophyte growth. Some nuisance species do not grow well in deeper water. Specifically, *Myriophyllum sp.* tends to succeed in shallow areas where light penetrates to the bottom. By deepening the pond, the area where sunlight penetrates to the bottom will be reduced, limiting the growth of submerged aquatic plants and the substrate on which the macrophytes currently grow will be removed.

Algal Blooms. Excessive algal growth has been a problem in Hill's Pond. During the past few years macrophyte growth has been the dominant plant growth in the pond. Prior to this, algal blooms were more common. Copper sulfate treatments had been used in the past to control these blooms. Treatments have not been used in recent years.

The most effective way to limit algal growth is to reduce the concentration of nutrients in the pond. Determining an acceptable upper limit for nitrogen and phosphorus is a somewhat arbitrary process due to the difficulty in predicting the growth of algae in response to nutrient loadings. However, the present level of nutrients in the pond is excessive, and reducing these nutrients will help control algal growth in the pond.

Sediment Accumulation. Sediment accumulation is particularly significant at the north end of Hill's Pond where the storm drain from Churchill Avenue enters. During a storm, eroded material and pollutants are washed directly into a catch basin at the base of the 3.1 acre Valley Road/Churchill Avenue drainage area. A significant portion of this material comes from an unpaved section of Valley Road. The steep slope of this area contributes to its erosion and transport to the catchbasin. Flow from the catch basin is piped directly to Hill's Pond. Currently the catch basin is filled with sediment, providing minimal removal of suspended material before this stormwater enters the pond. Upon reaching the quiescent water of the pond, sediment quickly settles in the area of the drain. Currently, the pond area near the storm drain is very shallow and often above the water level due to the accumulation of sediment. Emergent vegetation flourishes in this area.

The restoration plan will evaluate the removal of accumulated sediment and methods for reducing future accumulation. A reduction in the sediment load entering the pond will result in a corresponding reduction in nutrient load. This will be of benefit in controlling excessive macrophyte and algal populations.

Alternatives Development

The remainder of this chapter will be devoted to development and analysis of various alternative methods to meet the above objectives for Hill's Pond. Before beginning, however, it should be noted that reduction of nutrient levels and maintenance of acceptable water level may be difficult and costly objectives to meet. Trade-offs may be necessary to balance the desirability of these objectives with the cost of obtaining them.

Low Water Level. Two conditions contribute to the low water levels in Hill's Pond. First, there is no continuous source of influent water. The only net inflow to the pond occurs as direct precipitation and runoff from rainfall. Second, based on recent water level measurements there is a net loss of water from the pond, possibly due to groundwater outflow. Proposed solutions will concentrate on correcting these conditions.

Water Supply. Alternatives for increasing the inflow to Hill's Pond have been investigated. The Town of Arlington uses MDC water as its public water supply, and this source is not available for use as a supplement to Hill's Pond. There are several places within Menotomy Rocks Park that are wet or have flowing water for some part of the year. One low area to the west of the pond may have sufficient flow to provide input to the pond for part of the year. In order to utilize surface water from this wet area, flow would have to be intercepted at an elevation high enough to provide gravity flow to the pond. From field observations it appears that at this elevation there is little flow except during rainy periods. During storm events there is considerable runoff in this area due to the surrounding impervious rocky areas. Diversion of this runoff into the pond may result in flooding problems during periods of heavy rainfall. In addition, considerable construction expense would be involved in installation of a channel or pipe in this rocky area. Due to the inconsistent nature of this flow and the increased potential for flooding during wet weather, this is not considered to be a reliable alternative source of water during dry weather periods.

Another potential source of water to supplement the inflow to Hill's Pond is groundwater pumping. By installing a well in the vicinity of Hill's Pond, water could be pumped to the pond during periods of low water level. Because low water level is a problem only occasionally, continuous groundwater pumping would not be expected. Based on the hydrologic budget for the Diagnostic Survey period (Chapter 2), an increased inflow on the order of 12 gpm would have been required to maintain the water level during the month of July, 1985. Greater or less pumping may be required depending on rainfall. This rate is comparable to household pumping rates and it is expected that a similar type of pump could be used. Further investigation of the groundwater pumping capacity in the vicinity of Hill's Pond would be required to select a well location and determine if the required pumping capacity is available. This would include installation of a test well, with a pump test extending approximately 3 days to determine the capacity of the well. Since the pumping rate is low and there is no other groundwater pumping in the area, observation wells are not considered necessary. If sufficient capacity is available, the test well could be modified and used as a permanent well. There are no public or private water supply wells in the pond area that would present a conflict with this alternative.

The cost for installation of a well of this type and appurtenant piping would be dependent on the well depth and proximity to the pond. A single test well installation and a three day pump test would cost on the order of $7000. Assuming that the test well can be used for the permanent well installation, additional capital costs for the permanent well, installation and piping would be in the range of $12,000 for a shallow well and minimal piping distance. Low annual expenses similar to household pumping costs are expected.

An adverse impact of maintaining higher water levels may be an increased possibility of flooding. In the past it has been necessary to take measures to prevent flooding on the southeastern shore of the pond. Improvements of the shoreline in this area may be necessary. Increasing the elevation by approximately 1 foot or addition of a low bulkhead similar to that on the north side of the pond would provide additional flood protection at a relatively low cost of about $5000.

Water Loss. Several types of liners are available to block the flow of water out of Hill's Pond. These consist of chemical coatings applied to bottom sediments, asphaltic compounds, and rubber or synthetic membranes. Of these, the most practical would be a PVC membrane liner installed following dredging of the soft sediments. A liner of this type would remove any connection with the groundwater, prohibiting water flow into or out of the pond. In addition, it would destroy all benthic organisms. This effect could be corrected, however, by placing a layer of clean soil or sand on top of the liner to provide a suitable substrate for reestablishment of the benthic community. The cover material would also help to maintain the position of the liner and protect the liner from punctures and tears. This may be a reasonable solution to water loss only if a dredging operation is first performed. Without dredging, addition of a liner and clean soil layer would decrease the depth of the pond. Also, decomposition of covered organic material might cause gas pockets that could lift and damage a liner.

Potential difficulties with using a pond liner include keeping the liner in place and undamaged. Factors such as groundwater forces, recreational activities such as fishing, and vandalism could result in damage or displacement of the liner. The effectiveness of a liner to stop groundwater flow is uncertain, and it also has the potential of requiring maintenance to keep it intact. Since restoration alternatives requiring maintenance activity are undesirable to the Town, the pond liner option is less desirable than the flow augmentation option. Also, by eliminating all contact with groundwater flows, the pond would become more like a "goldfish bowl" with very little inflow and outflow of water. Under these conditions the water may become more stagnant and water quality may deteriorate.

Phosphorus Reduction. In order to reduce the phosphorus concentration in the pond, several alternatives were considered. In general, these consist of reduction of sources of phosphorus entering the pond, or direct reduction of phosphorus within the pond.

In the previous chapter, a phosphorus budget for Hill's Pond was developed from in-pond and influent phosphorus measurements. These analyses showed that there is significant phosphorus loading from the bottom sediments. The following methods have been considered to reduce this contribution:

- Aeration
- Nutrient inactivation
- Capping with soil
- Lining with synthetic materials
- Dredging
- Stormwater controls

These are discussed in the following paragraphs.

Aeration. Nutrient release from bottom sediments is facilitated by low dissolved oxygen concentrations. To alleviate this condition, compressed air can be injected into a pond to insure that DO concentrations remain high. There is no evidence that low DO conditions exist at the bottom of Hill's Pond. In addition, the shallow depth of the pond facilitates reaeration from wind mixing. Therefore, release of nutrients at low dissolved oxygen levels is not a major concern.

Nutrient Inactivation. To reduce nutrient concentrations in the pond water, chemicals can be added to cause precipitates to form. These precipitates chemically and physically bind phosphorus from the water and settle, forming a layer on the bottom. This layer tends to limit release of sediment phosphorus as well. Unfortunately, the precipitate layer has a low density and is easily resuspended. Because of the shallowness of Hill's Pond, this layer would likely be resuspended due to wind mixing, and the phosphorus released back to the water. In addition, treatment at high concentrations could be harmful to aquatic organisms. Because the effectiveness of this method is uncertain, it is not an adequate solution to the nutrient problem in Hill's Pond.

Capping With Soil. This technique involves placement of clean fill or sand on top of the nutrient rich bottom sediments. This is not a feasible alternative by itself because reducing water depth could be detrimental to conditions in the pond.

Synthetic Liner. Liners have been discussed previously as they pertain to maintaining the water level in Hill's Pond. They can also be an effective way of reducing sediment phosphorus loads to the pond. The liner is placed over top of the nutrient rich sediments, removing any interaction between sediment and water. As noted previously, placement of a liner and sand layer on top of existing sediments would reduce the depth of the pond. A significant amount of sediment material would have to be removed before such an application could be used.

Dredging. Dredging would be an effective restoration method for Hill's Pond. Nutrient influx from the bottom sediments would be reduced due to sediment removal. It is also consistent with other objectives such as increasing pond depth and removal of sediment accumulations.

Because of the small size of Hill's Pond and the shallow sediment depths, it is expected that most of the sediment accumulations could be removed. This would substantially reduce phosphorus loading in the pond. In addition, it would deepen the pond and remove the nutrient-rich substrate, two conditions which would help reduce the excessive macrophyte growth problem. Any remaining or future sediment deposits would be at a greater depth and would thus be less susceptible to resuspension due to wind-induced currents.

It is possible that temperature stratification may occur during the summer methods depending on the ultimate depth of the pond. It is not likely, however, that stratification would be maintained for any extended period of time.

Due to the shallow depth and small size of Hill's Pond, it is expected that mechanical dredging would be used as opposed to hydraulic dredging. Based on the sediment depth survey conducted as part of the Diagnostic Survey, there are approximately 3000 cubic yards of relatively soft sediments at the pond bottom, with a maximum sediment depth of approximately 3 ft.

The disadvantages of dredging are the higher initial costs and problems often associated with locating suitable sediment disposal sites. The dredging operation would also be temporarily disruptive to the use of the pond and surrounding park land. The volume of material to be removed from the pond will be dependent on these factors.

Stormwater Controls. Recent research has shown that sedimentation basins can provide significant removal of nutrients from stormwater. This may be a particularly applicable method of reducing stormwater nutrient loading to Hill's Pond. This method will be discussed later in this chapter under Reduction of Stormwater Sediment.

Macrophyte Growth. Removal of dense macrophyte growth is considered important to maintain the aesthetic value of Hill's Pond. Reduction of the in-pond phosphorus concentration of Hill's Pond will help control macrophyte growth. However, because some nuisance species in the pond are rooted, they are able to utilize nutrients from the bottom sediments. It may be necessary, therefore, to employ additional methods to control these species. Prevention of excessive macrophyte growth can be accomplished by the following methods.

Herbicide Application. Chemical herbicides can be applied to control macrophytes, however, this method has significant drawbacks. The herbicides may be toxic to other aquatic life, particularly in a case such as Hill's Pond where the entire pond would need treatment. In addition, the plant material is recycled to the bottom, and the source of the problem (excessive nutrients) is not treated. This method is therefore a maintenance activity that provides only short-term relief.

Harvesting. Purchase of a plant harvester or hiring of a firm to remove nuisance growth is somewhat costly. Sometimes, the plants must be removed two or three times in a summer. Harvesting could also be accomplished using hand tools, although this would be a regular maintenance activity. There is a net removal of phosphorus with removal of plant material. This phosphorus removal is affected by the method of harvesting, density, and type of vegetation. Harvesting, like herbicide application, provides only temporary relief.

Dyes. Dyes are available that can help control macrophyte and algal growth by reducing the amount of light which penetrates to the pond bottom. These dyes are non-toxic, vegetable based products which can be poured into the water by hand. Treatment generally results in an aqua-blue color which absorbs light needed for photosynthesis by aquatic plants. It is recommended that additional treatments be made as needed to maintain adequate concentration of the product. The treatments would be relatively inexpensive given the small size of Hill's Pond and may provide good control of macrophytes in the deeper areas of the pond. Expenses of about $250 per year could be expected for the material. Application can be done by Town employees.

Disadvantages of this method would be reduced water transparency and monthly maintenance procedures and costs. Also, dyes, like harvesting and herbicides provide only temporary relief and do not treat the source of the problem.

Overwinter Drawdown. Drawdown of pond water levels during winter months has been shown to provide effective control over *Myriophyllum sp.* (Smith et al. (1967)). Annual drawdown of the pond would, however, conflict with use for winter recreation. In addition, an unreasonable period of time may be required to refill the pond unless supplemental water is supplied. Partial drawdown may be a compromise that could provide control of macrophytes in the shallow areas of the pond.

Liners. A synthetic liner would also serve to limit macrophyte growth. As previously discussed, a liner would inhibit phosphorus release from sediments to the water. It would also provide a barrier separating rooted macrophytes from the nutrient rich sediments. With this removal of nutrient source, reduction in macrophyte growth can be expected.

Dredging. Dredging would help to reduce aquatic macrophyte growth for several reasons. The plant material is removed, the nutrient rich sediments are removed, and the area is deepened which helps limit future growth. The eutrophication potential of the pond can be reduced by a significant number of years. Problems involved with removal and disposal of the dredged material can make this an expensive method. However, it is expected to be one of the more effective methods for providing extended control of macrophyte growth.

Reduction of Stormwater Sediment. Several methods are available to remove suspended solids from stormwater before it reaches Hill's Pond. Some of the more practical of these methods are discussed in the following paragraphs.

Diversion. For many ponds and lakes, it is more beneficial to divert stormwater flow directly to a storm sewer. This completely removes this source of sediment and nutrient load from the pond. For Hill's Pond, however, the stormwater from Churchill Avenue is a major source of surface water inflow to the pond. Although flow is intermittent depending on rainfall, this source is a significant portion of the hydrologic input to Hill's Pond. Diversion, therefore, would not be a reasonable method for reducing sediment input unless an alternate water source could be found.

Inlet Improvements. Improvement of the two catchbasins at the ends of Valley Road and Churchill Avenue would serve to inhibit sediment transfer to Hill's Pond. A properly designed and maintained catchbasin can remove significant amounts of suspended solids from stormwater. This efficiency is maintained, however, only if accumulated sediments are regularly removed from the catchbasin. At present, the Churchill Avenue catchbasin is filled to the level of the outlet with sediment. Any material that enters is passed on to Hill's Pond.

Improvements such as deepening or enlargement of the catchbasin sump would provide greater retention time, allowing increased settling of suspended solids. Additional maintenance procedures such as paving of Valley Road, and regular removal of accumulated sediment in the catchbasin sump could significantly reduce the amount of sediment transported to Hill's Pond via stormwater runoff.

Stormwater Treatment. There are several treatment alternatives that can be used to remove sediment and some nutrients from stormwater. The methods investigated are all end-of-pipe type systems that would serve to maintain most of the flow to the pond.

Swirl or Helical Bend Concentrators are passive devices which concentrate settleable solids from stormwater flows. EPA (1984) has reported removal efficiencies of up to 60 percent when the units were operating properly. Disadvantages of these devices include frequent blockage and short circuiting problems as well as poor performance at low flows. In addition, there is a concentrated underflow that must be disposed of or treated. Nutrients in stormwater are generally dissolved or finely suspended particles that would not be effectively removed by this type of treatment device.

Shallow sedimentation basins to contain stormwater flows would be an effective method of removing sediment from stormwater. Flow from the Churchill Avenue catchbasin could be diverted to such a basin. If adequate retention time is provided, significant sediment would be removed before the water is passed on to Hill's Pond. Randall et. al. (1982) have shown that as much as 80 percent of suspended solids and 50 percent of phosphorus can be removed from stormwater by retention for as little as 12 hours. Removal rates were variable depending on initial suspended solids concentration, grain size distribution, and retention time. However, available evidence suggests that water quality would be much improved following retention in a sedimentation basin. Removal of 50 percent of the phosphorus in stormwater from the Churchill Avenue/Valley Road drainage area would reduce the loading rate of Figure 2-10 below the dangerous level to mesotrophic conditions.

If a sedimentation basin was placed adjacent to the pond, much of the water retained in the basin could be expected to percolate into the pond. Disadvantages of this method would be that occasional removal of accumulated sediment and maintenance to control weed growth would both be necessary. In addition, it may be difficult to adequately conceal the basins given the small size of Hill's Pond. Placement of such basins at a more concealed point away from the pond may be possible. Such placement would result in some loss of water due to percolation that does not reach Hill's Pond. If implemented in conjunction with a supplemental water supply, this may be acceptable.

Complete concealment of stormwater treatment could be accomplished using an underground sedimentation tank. A tank of sufficient size to contain at least the first flush of stormwater would intercept a significant portion of sediment before entering the pond. Further investigation of groundwater and soil conditions would be necessary to fully develop this alternative.

Costs associated with stormwater treatment systems would vary significantly depending on the method. Swirl or helical bend concentrators would involve significant expense related to design and construction. In addition, there is the concentrated underflow that must be disposed of either to the sewer or through some treatment method. The total cost of this method would not be justified, given the poor removal efficiencies and related problems reported. Shallow sedimentation basins would require the least initial expense and are expected to be effective in removal of sediment and nutrients. Costs in the range of $15,000 to $20,000 would be expected for excavation and piping, depending on placement within the park. Costs in excess of $25,000 could be expected for proper engineering and installation of an underground sedimentation tank and leaching field.

To assure continued proper operation of any type of stormwater treatment system, periodic maintenance will be required. Sedimentation basins require periodic excavation to remove sediment accumulations. This is a simple operation that could be performed by Town personnel using a backhoe. Excavation would probably need to be performed no more than bi-annually. Underground tanks must be pumped and cleaned annually to prevent clogging of the leaching field. For the proposed tank this could entail considerable expense.

Source Controls. In conjunction with development of a method of sediment removal, it would also be desirable to control sources of sediment within the drainage basin. Paving of roadways and regular street maintenance including street-sweeping and cleaning of catchbasins are effective methods of limiting erosion and sediment transport in a residential drainage area. These are relatively low cost activities and can effect significant reductions in stormwater sediment loads.

Evaluation of Alternatives

Each of the alternatives developed in the previous section has been evaluated in terms of its effectiveness and its relative cost. Based on this evaluation, the most cost-effective alternatives have been selected for the recommended plan. In addition, the alternatives developed in the previous section were presented at a second public meeting held on December 3, 1985 at the Arlington Town Hall. Comments and suggestions from this meeting have been used in the screening of alternatives.

Table 3-2 summarizes the comparison of the various alternatives developed. The effectiveness of each method is evaluated as it applies to the specific objective under which it is listed. In several cases, the method may also be effective in obtaining another objective. For example, dredging, while providing a reduction in phosphorus loading from sediments would also diminish wind-induced resuspension of sediment by deepening the pond. In selecting a recommended plan, the cost of each method was evaluated based on its relative effectiveness in obtaining all objectives, and the ease with which it could be integrated with other alternatives.

TABLE 3-2. COMPARISON OF HILL'S POND RESTORATION ALTERNATIVES

Objective	Method	Expected Effectiveness	Cost		Comments
			Capital	Annual	
Maintain Constant Water Level Year-Round	Diversion of surface water from other areas of Park	Moderate	Medium	Low	• Unreliable source during times of low water table
	Groundwater Pumping	Good	Medium	Low	• Reliable easily controlled source
	Pond Liner	Moderate	High	Low	• Also reduces nutrient load from sediments • Dredging necessary before liner can be installed • Liner may be damaged during pond use
Phosphorus Reduction	Aeration	Poor	Medium	Medium	• Pond does not stratify
	Nutrient Inactivation	Poor	Low	Low	• Mixing due to wind would cause resuspension of sediments
	Capping bottom with soil	Moderate	Medium	None	• Reduces depth of pond
	Dredging	Moderate	High	None	• Increases depth of pond • Inhibits macrophyte growth by removing nutrient source • Reduces nutrient load to pond water from sediments

TABLE 3-2 (Continued). COMPARISON OF HILL'S POND RESTORATION ALTERNATIVES

Objective	Method	Expected Effectiveness	Cost		Comments
			Capital	Annual	
	Diversion	Moderate	Medium	None	• Assume connection to Morton Road Storm drain • Inflow to pond reduced • Passes sediment downstream to Spy Pond
Reduce Macrophyte Growth	Herbicide	Moderate	None	Low	• Not a permanent solution • Possibly toxic to fish
	Harvesting	Moderate	Low	Low	• Hand Harvesting in shallow areas of pond • Not a permanent solution; may have to be done several times each season
	Overwinter Drawdown	Moderate	None	Low	• May be difficult to refill pond unless alternative water supply found • May interfere with winter recreational use of pond
	Dyes	Moderate	None	Low	• Transparency of pond will be reduced
	Dredging	Good	High	None	• Fulfills other objectives also
Reduction of Stormwater Sediment	Catchbasin Improvements	Moderate	Low	Low	• Only removes gravel and heavy particulates • Requires regular maintenance

TABLE 3-2 (Continued). COMPARISON OF HILL'S POND RESTORATION ALTERNATIVES

Objective	Method	Expected Effectiveness	Cost		Comments
			Capital	Annual	
	Swirl & Helical Bend Concentrators	Poor	Medium	Medium	• Poor performance at any other than design flow-rate • Blockage & shortcircuiting a problem
	Sedimentation Basin	Good	Medium	Low	• Periodic cleaning necessary
	Sedimentation Tank	Moderate	High	Medium	• Regular cleaning and maintenance necessary
	Street Paving	Good	Medium	None	• Significantly reduces sediment load especially on steep grades as on Valley Road.

METCALF & EDDY

A summary of the alternatives selected for inclusion in the Recommended Plan is given in Table 3-3.

It is interesting to note that a program of dredging and installation of supplemental water supply were recommended in a 1979 Recreation Facilities Improvements Plan (Arlington Recreation Facilities Committee, 1979). Sediment in the area of the storm drain has been removed in the past, however the soft organic sediment in the rest of the pond has never been dredged. Although dredging is an expensive option, it is the only alternative that will provide long-term benefits. The other restoration recommendations are designed to reduce the nutrient and sediment load entering Hill's Pond. This will help to slow future eutrophication of Hill's Pond. Without first dredging, however, these other alternatives would have little effect.

TABLE 3-3. HILL'S POND RECOMMENDED PLAN COMPONENTS

Recommendation	Purposes
Dredging	Reduce sediment nutrient load.
Groundwater Pumping	Maintain water level in Pond during dry periods.
Sedimentation Basin	Reduce sediment and nutrient load from stormwater.
Street Paving	Reduce erosion in drainage basin.
Shoreline Improvements	Reduce possibility of flooding.
Monitoring Program	Monitor effectiveness of implemented alternatives and determine if other controls are needed.

REFERENCES

Arlington Recreation Facilities Committee, "Recreation Facilities Improvements, Phase II", March, 1979.

Environmental Protection Agency, "Swirl and Helical Bend Regulator/Concentrator for Storm and Combined Sewer Overflow Control", Publication No. 85-102 523, October, 1984.

Randall, Clifford W., Kathy Ellis, Thomas J. Grizzard, William R. Knocke, "Urban Runoff Pollutant Removal By Sedimentation", in "Stormwater Detention Facilities", American Society of Civil Engineers, 1982.

Smith, et al, "Eurasian Water Milfoil in the Tennessee Valley", 1967, in "Survey of Lake Rehabilitation Techniques and Experiences", Technical Bulletin No. 75, Department of Natural Resources, Madison, Wisconsin, 1974.

CHAPTER 4

RECOMMENDED PLAN

The recommended restoration plan for Hill's Pond includes a number of alternatives which, when implemented, will achieve the restoration objectives for the pond. The purpose of this Chapter is to set forth the specifics of the restoration plan, including:

- Engineering description
- Environmental impacts and mitigation measures
- Post-implementation monitoring program
- Implementation schedule
- Cost estimates and funding sources

This recommended plan may then be used during Phase II (implementation) of the restoration project. In the following sections, each recommendation is presented in terms of its engineering concept. Also, potentially adverse environmental impacts and mitigation methods (where appropriate) are discussed.

Groundwater Pumping

The most cost-effective method of augmenting the water supply to Hill's Pond would be through groundwater pumping. Installation of a pump would provide a reliable way to maintain a consistent water level at minimum capital and operational cost. It would also facilitate refilling of the pond within a reasonable amount of time should drawdown be necessary for maintenance, weed control, or other purposes. The Town of Arlington would be responsible for implementation and daily operation of groundwater pumping.

It is recommended that a well and pump be installed of sufficient capacity to supply water at a rate of 20 gal/min for at least 30 days. A survey of the park has shown a wet area to the west of the pond. Figure 4-1 indicates the location of this area and the preliminary well location. The wet area and proposed pump location lie outside the Hill's Pond drainage basin. Some drawdown of the water table in the vicinity of the pump may occur during periods of heavy pumping. It is expected, however, that the radius of influence of the pumping will not have a significant influence as far away as Hill's Pond. Due to shallow bedrock in the Hill's Pond area, there is a possibility that the well will be a bedrock well, which is less likely to draw water from Hill's Pond through water table drawdown.

A small concrete pad and lock box would probably be required to house pumping controls and to prevent vandalism. Discharge to the pond in the area of the existing overflow pipe would minimize piping distance.

Should dredging be conducted at the pond it is not expected to have a major impact on the water level in the pond. Groundwater flow from Hill's Pond is expected to be primarily controlled by the water table gradient in the area. Although removal of fine grained organic sediments may increase the permeability of the lake bottom, rapid exfiltration from the pond is not expected to occur. The soils in the vicinity of Hill's Pond are generally composed of fine sandy loam as opposed to highly permeable sand and gravel, and thus the permeability of

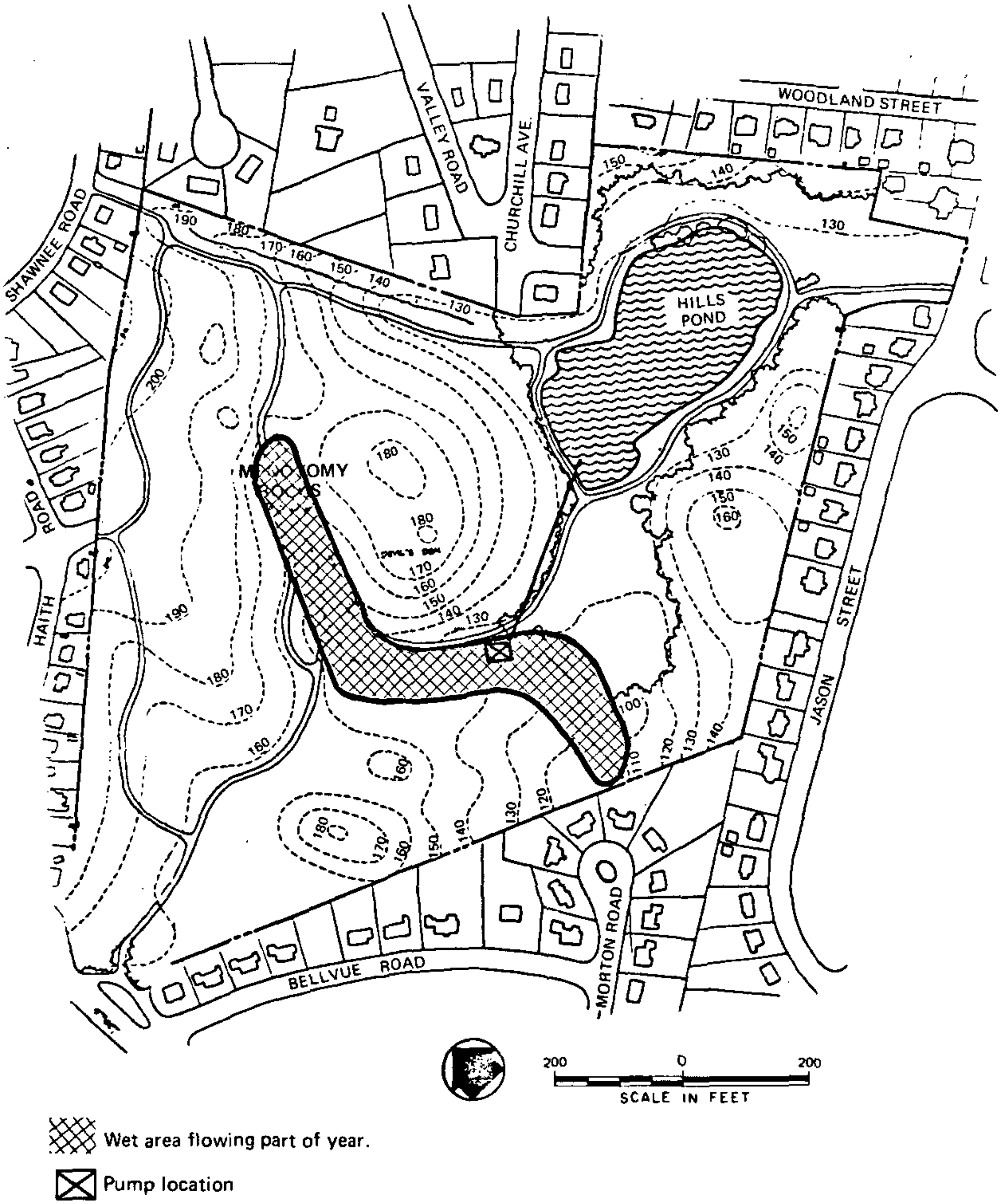


FIGURE 4-1. PROPOSED PUMP LOCATION FOR HILL'S POND.

the lake bottom is not expected to be radically changed due to dredging. Since raising the pond level by groundwater pumping will alter the local groundwater gradient, there may be an increase in groundwater outflow from the pond. Because of this possibility, the design groundwater pumping rate (20 gpm) is well in excess of the pumping rate calculated from the Diagnostic Survey data (12 gpm) as being necessary to maintain the pond level at a more desirable elevation.

Before final installation of the well, it is necessary to investigate groundwater availability in the vicinity of Hill's Pond. Such an investigation would require drilling of a test well and conducting a pump test to determine if sufficient aquifer capacity exists to support the required pumping rate. Testing of the aquifer should be done preferably during a period of low water table (late summer). It would be necessary to monitor the water level at the test well for approximately three days during pumping to determine water table fluctuations and the well capacity. It is expected that sufficient pumping capacity is available, however, the well location, depth, and size are uncertain. If the pump test results are favorable, the test well could be modified and used as the permanent well installation.

Environmental impacts resulting from groundwater pumping into Hill's Pond are not expected to be significant. Groundwater is generally low in dissolved oxygen and nutrients. The pumping rate of 20 gal/min would increase the volume of Hill's Pond by about 1 percent per day. It is expected that the pond will be able to assimilate this flow without adverse effect on in-pond conditions. There are no other private or municipal wells in the area that would be affected by pumping groundwater. Long-term environmental impacts are not expected to result from groundwater pumping.

Dredging

In order to reduce the nutrient load to Hill's Pond, removal of the bottom sediment is considered essential. This requires that a dredging program be undertaken. This section presents the evaluations and conclusions related to dredging of Hill's Pond.

Evaluation of Data. Data on sediment chemical and physical characteristics were summarized in Table 2-13. These data are compared with information from three sources, as follows:

1. Massachusetts dredge material disposal classification (314 CMR 9.00, 1979) (Table 4-1).
2. Massachusetts regulations for land application of sludge (310 CMR 29.00, 1983) (Table 4-2).
3. Great Lakes sediment rating criteria (Mass. Dept. of Environmental Quality Engineering, 1982) (Table 4-3).

Comparisons to these references show that Hill's Pond sediments are quite clean.

One parameter, lead, causes the sediment to be rated as Category Two (Table 4-1) according to the dredge material classifications. Category One is the cleanest classification, however, there is little difference in the regulations between the two classifications, except with respect to ocean disposal. Ocean disposal of Hill's Pond sediments is not feasible due to

TABLE 4-1. CLASSIFICATION OF DREDGE OR FILL MATERIAL

	Allowable Concentrations (ppm)		
Parameter	Category One[1]	Category Two[2]	Category Three[3]
Arsenic (AS)	< 10	10-20	> 20
Cadmium	< 5	5-10	> 10
Chromium (Cr)	< 100	100-300	> 300
Copper (Cu)	< 200	200-400	> 400
Lead (Pb)	< 100	100-200	> 200
Mercury (Hg)	< 0.5	0.5-1.5	> 1.5
Nickel (Ni)	< 50	50-100	> 100
Polychlorinated Biphenyls (PCB)	< 0.5	0.5-1.0	> 1.0
Vanadium (V)	< 75	75-125	> 125
Zinc (Zn)	< 200	200-400	> 400

1. Category One materials are those which contain no chemicals listed in Table 4-1 in concentrations exceeding those listed in the first column.

2. Category Two materials are those which contain any one or more of the chemicals listed in Table 4-1 in the concentration range shown in the second column.

3. Category Three materials are those materials which contain any chemical listed in Table 4-1 concentrations greater than shown in the third column.

TABLE 4-2. CLASSIFICATION OF SLUDGE FOR LAND APPLICATIONS

Parameter	Allowable Concentrations (ppm) Type I	Type II	Type III
Cadmium	< 2	2-25	> 25
Lead	< 300	-	>1000
Nickel	< 200	-	> 200
Zinc	<2500	-	>2500
Copper	<1000	-	>1000
Chromium (Total)	<1000	-	>1000
Mercury	< 10	-	> 10
Molybdenum	< 10	-	> 10
Boron (water soluble)	< 300	-	> 300
PCBs in Type I sludge which is a commercial fertilizer	< 2	2-10	> 10
PCBs in type I sludge which is a commercial soil conditioner	< 1	1-10	> 10

TABLE 4-3. GREAT LAKES SEDIMENT RATING CRITERIA (mg/kg dry weight)

Parameter	Nonpolluted	Moderately Polluted	Heavily Polluted
TKN	<1,000	1,000-2,000	>2,000
Lead	<40	40-60	>60
Zinc	<90	90-200	>200
Ammonia	<75	75-200	>200
Phosphorus	<420	420-650	>650
Iron	<17,000	17,000-25,000	>25,000
Nickel	<20	20-50	>50
Manganese	<300	300-500	>500
Arsenic	<3	3-8	>8
Cadmium	*	*	>6
Chromium	<25	25-75	>75
Copper	<25	25-50	>50
Mercury	*	*	≥1

*No lower limits defined.
Source: Mass. DEQE, 1982

economic considerations because of the long distance to any disposal site. Under Category Two, land or in-harbor disposal with bulkheading is allowable.

Comparison with land application of sludge criteria shows that the material would be rated Type 1. This is the cleanest rating, which means that it may be "...used, sold, or distributed or offered for use, sale or distribution on any site without further approval..." (310 CMR 29.00, 1983). Thus, depending on the physical characteristics of this sediment it could potentially be used for fill, topsoil or other purposes without harming the environment. The final comparison with Great Lakes data shows the sediment to be nonpolluted except for lead. Lead is a common constituent of urban runoff.

Physical characteristics for the Hill's Pond sediments were also shown in Table 2-13. The sediments are fairly high in water content but not excessively high in organic content. This sample represents soft sediments in the shallow area of the pond near the storm drain inlet. Sediments in the deeper areas of the pond may be more organic. These values may be compared with the state dredge material disposal classifications, as given in Table 4-4. Based on the physical characteristics of the sampled pond bottom sediments, the material is classified as Type C. Type C material may be disposed of on land with bulkheading, but effluent control will be required.

The recommended plan calls for drawdown of the pond and in-place dewatering. It is expected that this procedure will reduce the water content of sediments sufficiently to enable land application without bulkheading.

The 10 percent organic content of the sediments makes this material acceptable for use as topsoil. A more complete analysis would be necessary to determine suitability as structural fill, however it is not expected to be acceptable for this use without mixing with more solid material.

TABLE 4-4. CLASSIFICATION OF DREDGE OR FILL MATERIAL BY PHYSICAL CHARACTERISTICS

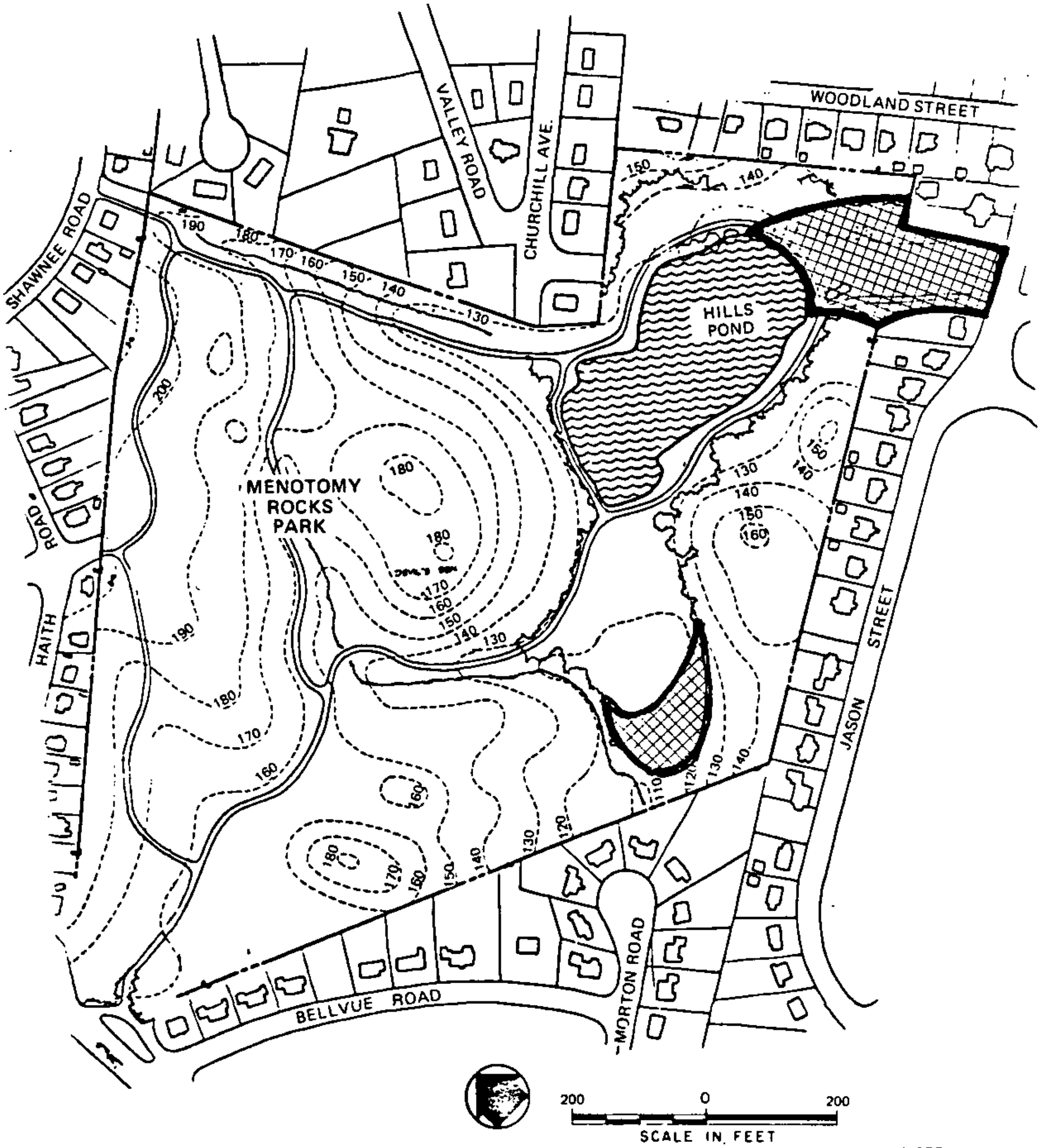
Parameters	Type A	Type B	Type C
Percent silt-clay	< 60	60-90	> 90
Percent water	< 40	40-60	> 60
Percent volatile solids (NED methods)	< 5	5-10	> 10
Percent oil and greases (hexane extract)	<0.5	0.5-1.0	>1.0

Dredging Technique. The recommended method for dredging Hill's Pond would be drawdown and in-place dewatering followed by mechanical excavation. This method was chosen over other methods such as hydraulic or bucket dredging because of the small volume and shallow depths of sediment in the pond, and the ease with which the water level can be drawn down. It is expected that the pond would be partially drained using an existing valve-operated drain located near the bottom of the pond in the vicinity of the overflow pipe. Surface inspection of the valve indicates that the drain is approximately 3 to 4 feet below the water surface. Opening of the valve would drain a significant portion of the pond volume. Portable pumps could be used to remove the remaining water. The most preferable time of year for drawdown would be during the late summer months when the water table is usually at its lowest level and the maximum effect of in-place dewatering of the sediments would be possible.

After the pond is pumped dry, the sediments must be allowed to dewater to facilitate excavation and hauling. During this time, pumps will be needed to remove water released by the compacting sediments. Outflow from Hills Pond is to the Arlington storm drain system, which eventually enters Spy Pond. During dewatering of the pond, care should be taken to avoid stirring up the bottom sediments and passing excessive suspended solids concentrations downstream. Following this dewatering period, excavation may proceed. A bulldozer would be used to remove the material which would be loaded into trucks for transport to a disposal site. Pumps will be needed throughout the dredging program to remove any rainwater or groundwater that may enter the pond. It is expected that four weeks would be required for sediment dewatering and four to eight weeks for excavation.

Disposal Area. The most convenient and cost-effective disposal site would be an appropriate area within Menotomy Rocks Park. Such a site would minimize transportation costs and eliminate disposal charges. A possible disposal area is to the south and west of the pond as shown in Figure 4-2. This area has been filled in the past to create portions of the adjacent playing field. The area where dredged material would be placed is to the south and west of the playing field and is a relatively little used portion of the park. A fill depth of three to four feet in this area would dispose of about 1500 cubic yards of sediment. It is expected that this amount of material could be placed without the need for diversion of the intermittent stream which flows to the west of the proposed disposal area. Some clearing would be required and a low level containment dike may need to be constructed on the low lying sides of the disposal area.

Another area which could be utilized for disposal is the open area to the north of the Jason Street entrance. This is a low area that would not be adversely impacted by addition of organic material. A six to eight inch layer of material could be spread over the entire area, or deeper layers added in selected areas. Filling of such a large and heavily used area of the park would seriously restrict use for picnicing and jogging. This may not be an acceptable disposal alternative for aesthetic reasons. Dredged materials could also be used in construction of the sedimentation basin and for the shoreline improvements recommended near the Jason Street entrance. The heavier sediments in the vicinity of the storm drain inlet to the pond may be suitable for use as they are removed from the pond. The softer sediments from the rest of the pond would probably need to be mixed with more



Proposed disposal areas for dredged material.

FIGURE 4-2. DREDGED MATERIAL DISPOSAL AREAS WITHIN MENOTOMY ROCKS PARK.

solid material in order to be used. It is expected that 500-1000 cubic yards of dredged material could be used in the construction of the sedimentation basin and shoreline improvements.

The Arlington cemetery could accept up to 1000 cubic yards of dredged material for use as loam (Frank Wright, Town of Arlington, personnal communication). The soft sediment may have to be mixed with sand in order to be used as loam. Trucking of the sediment to the cemetery would incur additional transportation costs of up to $3,500.

If disposal within the park is not feasible, an alternative site would be within the Great Meadows area in Lexington that is owned by the Town of Arlington. There are several drawbacks to using this area for disposal of dredged material. First, it would be approximately a seven mile round trip from Hill's Pond to this disposal site. The additional transportation costs would add $10,000 to $15,000 to the dredging program. Second, the area is a wetland and significant effort may be required to obtain permits from federal and local agencies. Third, additional expenses may be required to build access roads into the Great Meadows area.

Environmental Impacts. The environmental impacts of the dredging operation on organisms living within the pond would be severe but temporary. Fish would be eliminated and would have to be restocked. The Massachusetts Department of Fisheries and Wildlife does not restock warm-water fisheries such as Hill's Pond (Bob Madore, Division of Fisheries and Wildlife, personnal communication). The state will however, provide comments to the Town on restoration alternatives recommended in this report, including advice on restocking of the pond following dredging.

Benthic organisms would be removed along with sediments. It is expected that there will be sufficient numbers of these organisms in the remaining sediment to recolonize the pond within a reasonable amount of time. Long-term beneficial impacts are expected due to reduction of nutrient input from the sediments. A corresponding reduction in phytoplankton and macrophyte densities will result.

Environmental impacts on the disposal area within the park are not expected to be severe. It may be necessary to clear some trees before filling can begin depending on the disposal area selected. Following placement of the material, care will be taken to assure that the material is stable and does not cause sediment-laden runoff during rainfall events. If necessary, a containment area will be constructed and appropriate runoff control measures will be instituted. The filled area will be graded and planted upon completion of the dredging program. Long-term adverse impacts are not expected in the filled area.

Impacts of dredging operations on local traffic would depend on selection of the final disposal site. If disposal is within Menotomy Rocks Park, very little impact will be felt in adjacent residential areas. If it becomes necessary to dispose of dredged material outside the park, some truck traffic would have to be tolerated for the 4 to 8 week dredging period. Other impacts would be local noise and some odors related to excavation of the exposed mud and organic material. Careful attention should be focused on eliminating unnecessary noise, traffic, and disturbance of other areas of the park and adjacent residential areas. It is also important to establish a project coordinator within the Town to accept suggestions and complaints from residents before and during dredging activities.

Sedimentation Basin

A sedimentation basin has been included in the recommended plan in order to reduce the amount of sediment and nutrients entering Hill's Pond from the Valley Road/Churchill Avenue drainage area. A basin as described below would also significantly reduce the nutrient load to the pond. Reduction of sediment and nutrient load is an important step in controlling the overall eutrophication process in Hill's Pond.

Figure 4-3 shows the preliminary site chosen for a sedimentation basin. Located close to the northern border of Menotomy Rocks Park near an area that was formerly a brook flowing into the pond, this site is adjacent to Churchill Avenue and would therefore require minimal re-routing of existing storm drain pipes. Access to the basin could be provided from Churchill Avenue to facilitate later maintenance. The area is slightly below street level and could be concealed with appropriate plantings.

Sizing of the basin is based on maximum 24 hour rainfall with a one-year return period. A basin with dimensions of 60 feet by 25 feet and an average depth of 4 feet would be

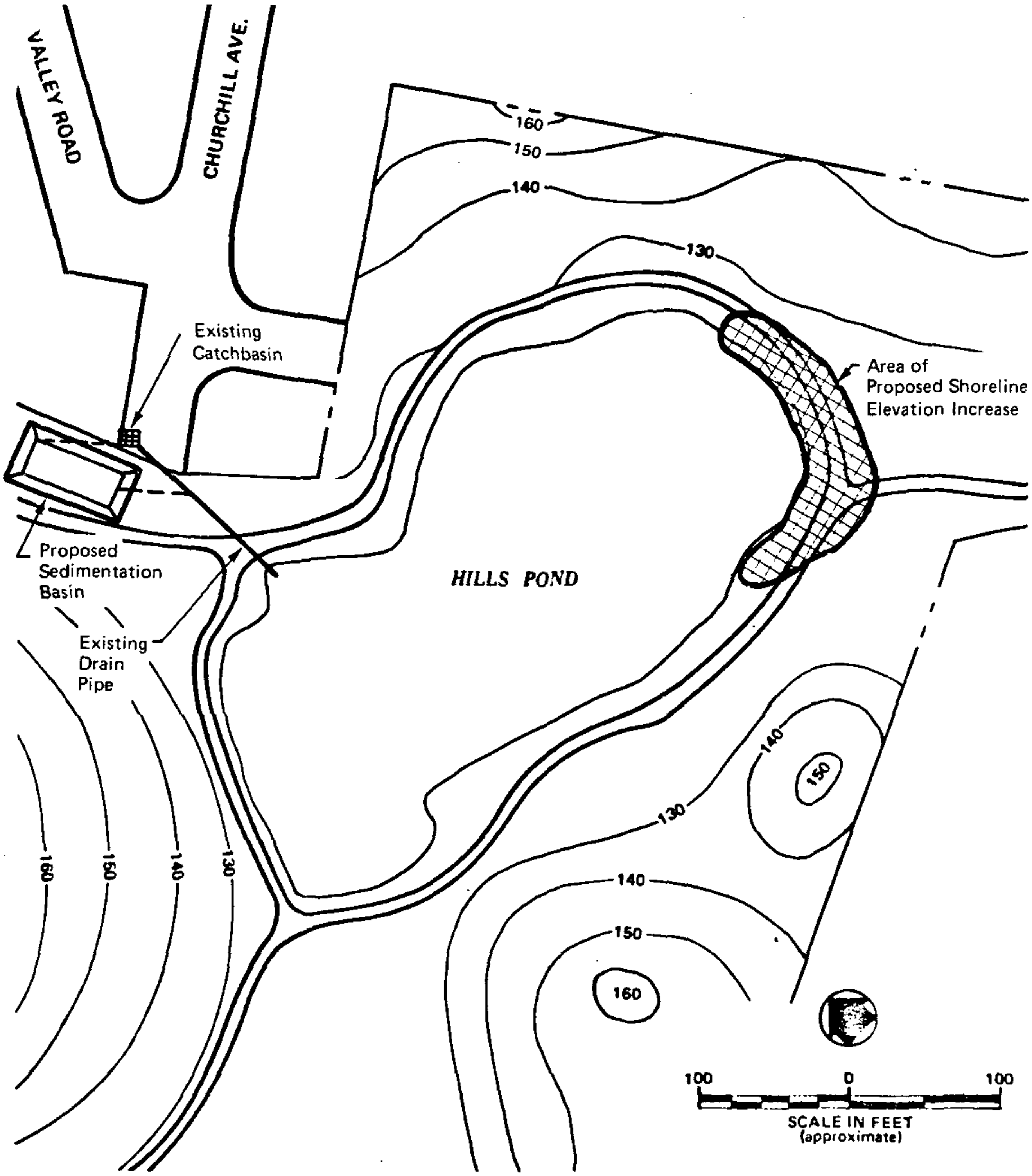
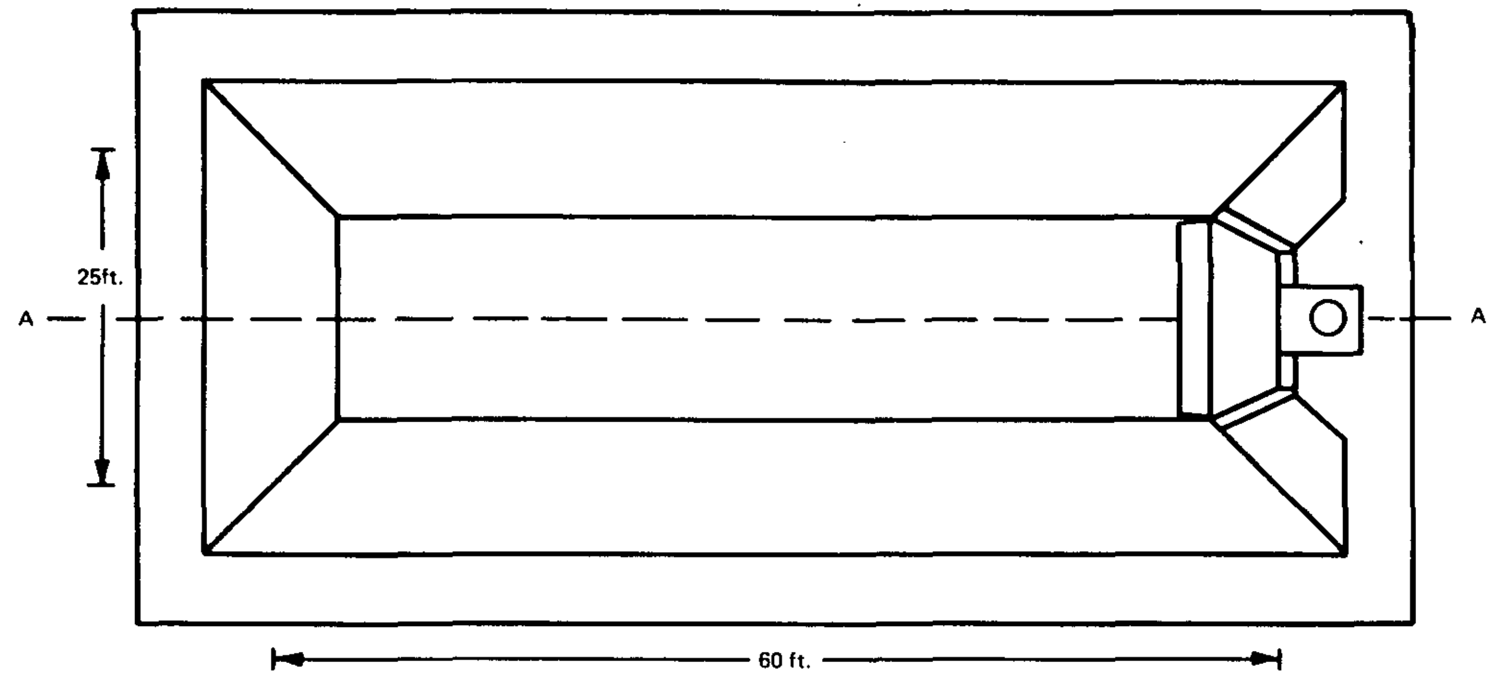


FIGURE 4-3. PROPOSED STORMWATER POLLUTION AND FLOOD CONTROL MEASURES FOR HILL'S POND.

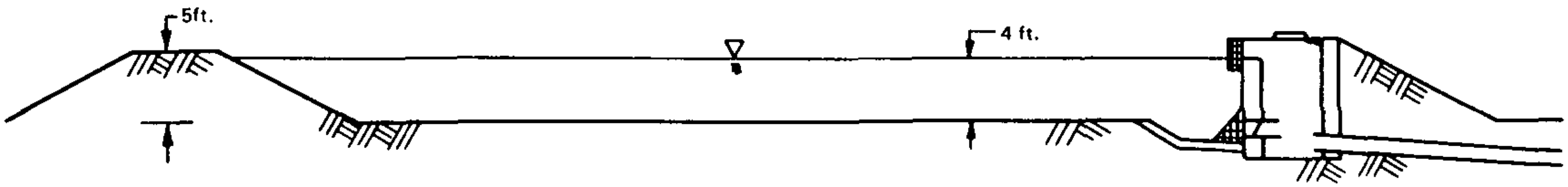
sufficient to contain the runoff from such a storm and provide adequate surface area for sedimentation. An outlet structure would be required that would minimize short-circuiting and scouring of the basin during a storm event of greater intensity than the design storm. Similar design considerations are important for the inlet structure. The inlet should be located at one end of the basin with the outlet at the opposite end. This configuration would provide maximum opportunity for sedimentation within the basin.

Figure 4-4 shows the proposed sedimentation basin and outlet structure. Normal drainage from the basin would be via an overflow weir. A trash-rack should be included to protect the overflow from debris. It is recommended that a valve-controlled drain be provided at the bottom of the outlet structure. This would allow the basin to be drained periodically for sediment removal and general maintenance. In addition, the drain would allow flexibility in operation of the basin. If a permanent pool within the basin is not desired, the basin could be drained following each storm. A retention period of 24-36 hours would be required to effect maximum sediment and nutrient removal. It is expected that proper operation of such a sedimentation basin would result in significant reduction in sediment and nutrient loads to Hill's Pond.

Construction of this basin would require the filling of a low area to the north of Hill's Pond. The area is in an unused



SEDIMENTATION BASIN - PLAN



SEDIMENTATION BASIN - SECTION A - A

FIGURE 4-4. PROPOSED SEDIMENTATION BASIN FOR HILL'S POND.

portion of the park adjacent to a foot path leading from Churchill Avenue. It is not expected that any adverse environmental impacts will result from this construction. The earthen faces of the basin will be planted with domestic grass to blend in with the surroundings. Bushes and trees should completely surround the basin in order to conceal it from view. Given the low profile and relatively small size of the basin, this should be sufficient to mitigate any adverse aesthetic impacts. A safety fence is recommended to restrict access to the basin.

Several additional improvements are recommended for the park and surrounding area. These include street paving and catchbasin maintenance to control erosion as well as improvements around the pond to prevent flooding. Detail on each of these recommendations is provided in the following paragraphs.

Paving

Paving of about 250 feet of the upper portion of Valley Road is recommended as a part of the restoration plan. A significant amount of erosion of the existing gravel road bed occurs during storms. This eroded material is washed directly into the Churchill Avenue catchbasin which leads to Hill's Pond. This erosion has contributed large amounts of sediment to the pond in the past. Paving is recommended to stabilize the road bed and prevent future erosion.

Catchbasin Maintenance

At present, the stormwater catchbasin at the foot of Churchill Avenue is filled with sediment. It is recommended that accumulated sediment be removed from this basin and that similar maintenance be performed on a regular basis. A properly maintained catchbasin will provide significant removal of gravel and heavy sediment from stormwater. Preventing this material from entering the sedimentation basin will limit deposition and reduce the frequency of maintenance needed within the sedimentation basin.

Shoreline Elevation

The shoreline elevation in the area of the Jason Street entrance should be raised to reduce the possibility of future flooding. In the past, occasional sandbagging of this area has been necessary to keep water from overflowing toward Jason Street. With the use of groundwater pumping to maintain the water surface at a higher level, storage within Hill's Pond will be reduced. This could result in more frequent occurance of high water levels during wet periods. An increase in elevation of about 1 foot in the area, noted in Figure 4-3, will provide more flood storage volume than that which will be lost due to maintenance of a constant water level. Approximately 200 cubic yards of fill will be needed. Dredge spoils could be used for this purpose, however it may be necessary to mix the material with sand to provide adequate stability for the slope along the water's edge. Material dredged from near the storm drain inlet may be suitable for use as fill without mixing.

Outlet Improvements

Currently the pond outlet consists of an overflow pipe 10 inches in diameter located above the pond normal water level and an outlet pipe located below the pond water level. The overflow pipe is located so as to automatically release water from the pond when the pond level becomes too high. The outlet pipe is controlled by a valve which must be manually opened to release additional water. The Town of Arlington controls the outlet valve. The valve is opened only during periods of high water level and potential flooding.

Periods of high water are most likely to occur at Hill's Pond during spring wet weather periods or following a major storm event. Although high water periods are not likely to occur during the period in which groundwater flow augmentation is proposed (late summer), there is the possibility that storm events will occur during a period when the pond level has been raised due to flow augmentation. Because of this possibility, it may be necessary to operate the outlet valve more often. It is reported that the valve has not been used recently and the present operational condition is uncertain. This valve should be tested to determine its operational condition. Based on this determination, replacement or improvement of the outlet, or valve, may be required.

Operation of the outlet valve should continue as it is currently conducted, with the valve being opened only when necessary during periods of high water and potential flooding. It is not anticipated that the outlet valve will need to be opened more than once or twice annually during an average year. Enlargement of the overflow pipe capacity is also recommended. This could be accomplished by replacing the existing 10 inch overflow pipe with a larger pipe compatible in diameter to the downstream pipe to which it discharges (estimated to be a 12 inch to 18 inch pipe; this should be verified prior to design). Also, the overflow pipe inlet should be improved by installing a small wingwall inlet or some other type of improved pipe inlet located flush to the pond embankment. The purpose of this is to increase the influent flow capacity to the overflow pipe, thereby reducing the need to operate the outlet valve.

The preceeding measures will reduce the eutrophic condition of Hill's Pond and eliminate or control many of the current problems. At times, however, it is possible that undesirable algal or macrophyte populations may occur in response to conditions which cannot be controlled. To control such growth, it may be necessary to use occasional applications of dyes or herbicides. Such applications would be made on an as needed basis, based on monitoring of conditions in the pond.

Permits

Several permits may be required prior to implementation of the Hill's Pond project. These permits and approvals are described in the Clean Lakes Program 1984 Permit Guide and in the following paragraphs.

Massachusetts Environmental Policy Act (MEPA). An Environmental Notification Form (ENF) must be filed with the Massachusetts Executive Office of Environmental Affairs. Following this review a determination will be made as to whether an Environmental Impact Report (EIR) is required for any portion of the project.

Wetlands Protection Act. This permit is required for activities within 100 feet of the 100 year floodplain or within vegetated wetlands. This permit is required for the proposed dredging activities and must be filed by submitting a Notice of Intent to the Town Conservation Commission describing the proposed project activities. The Conservation Commission will then approve the project or issue an Order of Conditions which must be met.

Army Corps of Engineers Section 404 Permit. This permit is required for disposal of dredged materials in all waters of the United States, including their adjacent wetlands. It is unlikely that this permit would be required if the dredged materials from Hill's Pond are disposed of within the Menotomy Rocks Park area and in the Town cemetery, as planned.

Chapter 91 Waterways License. This license is required for construction or dredging activities in tidewaters, Great Ponds, or rivers or streams in which government expenditures have been made. Since Hill's Pond does not fall into any of these categories, it is unlikely that this license would be required.

Water Quality Certificate. This permit is required only if an Army Corps of Engineers permit on a Chapter 91 license is required, which is not likely.

Massachusetts Historical Commission (MHC). MHC approval is required prior to initiation of any construction activities. The Hill's Pond Draft Report has been reviewed by the MHC. The MHC feels that the project is unlikely to affect significant historic or archaeological resources. No further review of the project will be required.

Division of Fisheries and Wildlife Notification. Written notification must be submitted to the Massachusetts Division of Fisheries and Wildlife prior to any activity which requires the complete draining of a lake or pond. Thus, this notification must be filed prior to implementing dredging activities.

Post-Implementation Monitoring Program

In order to assess the effectiveness of the restoration measures, a post implementation monitoring program will be conducted. The program will be similar to the Diagnostic Survey undertaken during this study. It will include collection and analysis of in-pond data focusing on assessment of the dredging and sediment reduction programs.

A survey should be taken in August for the three years following dredging to provide information on in-pond water quality and biology. In-situ profiles of temperature, dissolved oxygen, conductivity and Secchi depth should be taken at a station in the center of the pond. Samples should be collected and analyzed for the parameters measured in the Diagnostic Survey. A phytoplankton analysis should be made to determine species and numbers of algal populations. At the same time, a macrophyte survey should be conducted to determine the extent and type of plants present in the pond.

Following implementation of groundwater pumping, a water level monitoring program should be instituted. Regular measurements of the water surface elevation should be taken relative to a fixed datum established for this purpose. Measurements should be taken at least weekly throughout the year, except when the pond is covered with ice. This monitoring of the water level is necessary to determine an operating schedule for groundwater pumping. Pumping rates will be based on measured changes in pond elevation.

Public Education Program

During the Hill's Pond restoration program, it is important to keep citizens informed regarding all restoration activities. In particular, due to the environmental impacts associated with the dredging program, the need is even more acute.

The public education program for Hill's Pond would consist of meetings at which status reports of the implementation activities would be presented. It could also involve information lectures and handouts by involved parties knowledgeable about the Hill's Pond restoration program. The formation of a Hill's Pond Association would be a useful catalyst for the Public Education Program. Such an association could serve as the focal point for setting up meetings, developing lists of concerns (as was done during the Diagnostic/Feasibility Study), providing other input and assistance such as keeping pressure on legislators, political representatives, etc. in support of the program and funding, and interacting with the City as the program proceeds. A budget of $2,000 has been estimated for these public education activities.

Restoration Plan Schedule

A schedule has been prepared for the implementation of the restoration plan. This schedule is presented in Figure 4-5. The first year of the program would be taken up by procurement of funding, consultant selection, initiation of the public education program, and obtaining necessary permits for the dredging program. The actual construction and dredging activities would be completed during the summer and fall of the following year. Post implementation monitoring would be conducted in August of 1989. With this schedule, disturbances of the park and surrounding area would be limited to approximately a six month period during late summer and fall of 1988.

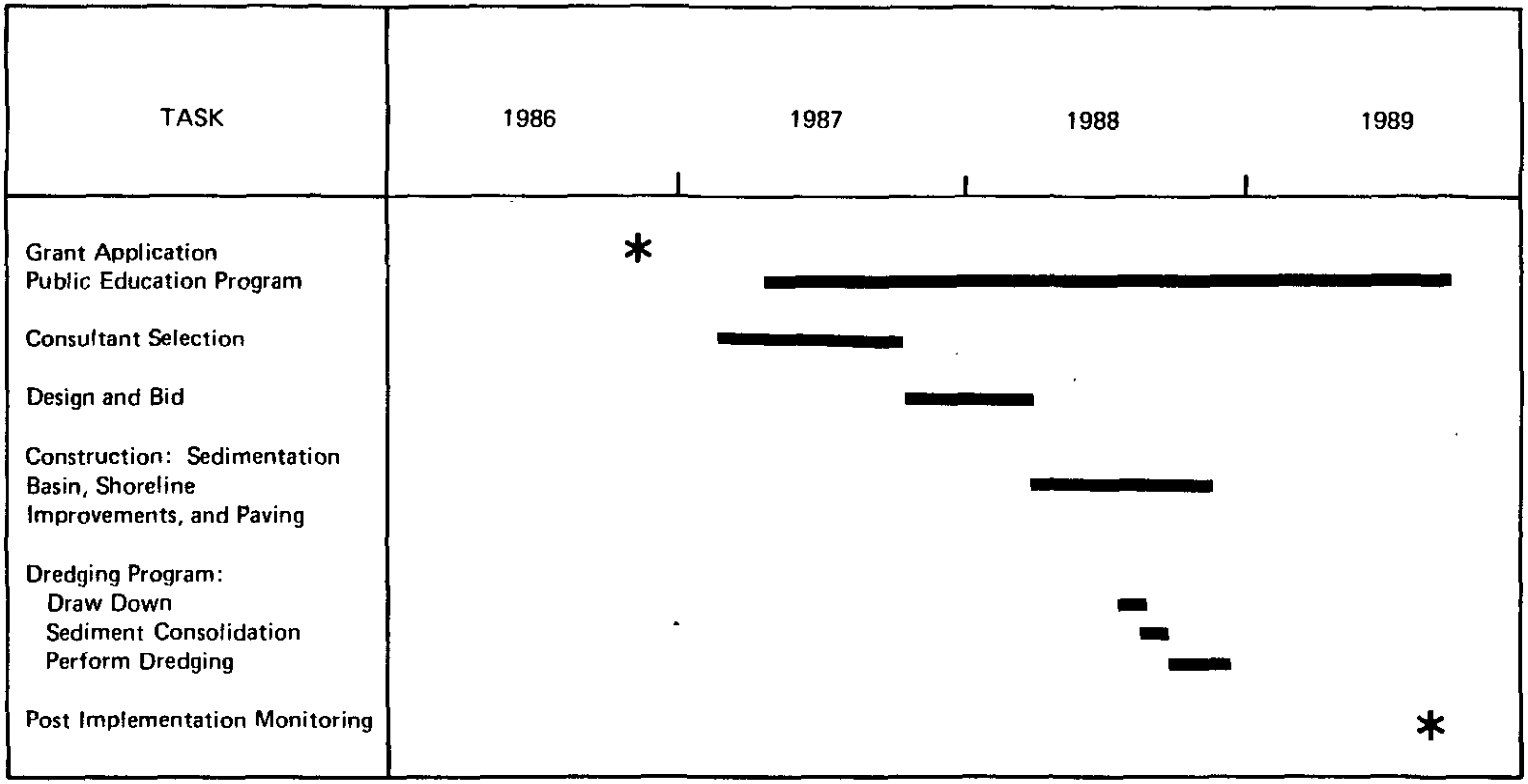


FIGURE 4-5. SCHEDULE FOR HILL'S POND RESTORATION PROGRAM.

Cost Estimates and Funding Sources

Cost estimates have been prepared for each of the recommended alternatives at Hill's Pond. Costs associated with dredging are presented in terms of a range due to variables involved in the disposal costs and the fact that sediment disposal sites have not yet been finalized. The costs shown reflect the difference between disposal within the park and disposal in the Great Meadows area. The major cost items include design and construction of facilities, dredging, and material hauling costs. Construction costs for all items are based on the 1985 Means Construction Cost Data publication. An engineering design and contingency factor of 30 percent is included in all construction cost estimates. Table 4-5 presents a summary of the estimated costs of each of the recommended alternatives.

The total capital cost associated with this program will be between $150,000 to $175,000. Given this amount, various funding sources should be considered for program implementation. The Chapter 628 State of Massachusetts Clean Lakes program is the best available funding source. This program is administered by the State Department of Environmental Quality Engineering.

Approximately $3,000,000 per year in grants are awarded for restoring publicly owned freshwater lakes in Massachusetts, such as Hill's Pond. A grant application must be submitted and is then prioritized based on such factors as public support, pond uses, and status of eutrophication. The funding shares for

TABLE 4-5. ESTIMATED COSTS FOR HILL'S POND RESTORATION PLAN

Recommendation	Capital Cost ($)	Annual Cost ($)
Dredging		
Dewatering	7,500-11,000	
Excavation & hauling	20,000-33,000	
Containment area (clearing & earthen berm)	17,500	
Grading & seeding	7,000	
Mixing with sand for loam (for sediment to be hauled off-site)	3,500	
	55,500-72,000	
Groundwater Pumping		
Test well and pump test	7,000	
Pump	1,300	
Piping	4,300	
Excavation & backfill	2,600	
Modify test well to permanent well	1,000	
Electrical	2,800	
Annual operating costs		1,000
	19,000	1,000
Sedimentation Basin		
Excavation & construction	15,700	
Outlet structure modifications	3,300	
Piping	1,700	
Grading & planting	6,400	
Fencing	2,900	
Excavation of accumulated sediment		500
	30,000	500
Shoreline Improvements		
Transport, placement, and grading of fill	3,500	
Planting & seeding	1,500	
	5,000	

TABLE 4-5. (Cont.) ESTIMATED COSTS FOR HILL'S POND RESTORATION PLAN

Recommendation	Capital Cost ($)	Annual Cost ($)
Pond Outlet Improvements		
Replace overflow pipe	1,500	
Replace 10" diam. gate valve	1,500	
Excavation and backfill	1,000	
	4,000	
Paving of Valley Road	19,500	
3 Year Monitoring Program	7,500	
Public Education Program	2,000	
Construction contingencies[1]	14,250 - 15,900	
TOTAL	$156,750 - 174,900	$1,500

1. Due to the current instability of the construction market, a 10% cost contingency has been added.

implementation work are 75 percent State and 25 percent local. Since the Diagnostic/Feasibility Study is funded through this source, State review and approval is required.

A Clean Lakes grant must be submitted by October 1, 1986. The entire amount should be requested on the grant application. The local share would be appropriated through Town meeting proceedings. It would be helpful if these local funds could be in place before the State acts on the grant application.

Another potential source of funding is the Department of Environmental Management's Massachusetts Rivers and Harbors

Program. Lake dredging programs may be eligible for funding under this program. The local matching funds required for dredging projects is 25 percent.

Respectfully submitted:

COMMONWEALTH OF MASSACHUSETTS
DAVID R. BINGHAM
SANITARY
No. 32615
REGISTERED
PROFESSIONAL ENGINEER

David R. Bingham
Project Manager

Approved:

Richard L. Ball, Jr.
Vice President

Appendix A

Documentation of Public Meetings

Public Meeting No. 1 April 9, 1985

LAKE RESTORATION STUDY OF HILLS POND, ARLINGTON

AGENDA

Introduction	Mr. Frank Wright Arlington Dept. of Properties and Natural Resources
Project Outline	Mr. David Bingham Metcalf & Eddy, Inc.
Lake Eutrophication	Mr. John Cardoni Metcalf & Eddy, Inc.
Hills Pond Problems	
Evaluation of Restoration Alternatives	
Sampling Program Description	
Questions and Answers	

Public Meeting No. 1 April 9, 1985

LAKE RESTORATION STUDY OF HILLS POND, ARLINGTON

FACT SHEET

State Lakes Program

Chapter 628 of the State of Massachusetts regulations provides funding to assist communities in carrying out methods and procedures for restoration of publicly owned freshwater lakes. The approach to lake restoration as adopted by the Commonwealth of Massachusetts is similar to that used by the federal government for conduct of Section 314 studies. The state program is carried out in two phases. Phase I is a diagnostic survey conducted to gather information and data to determine existing characteristics of the lake. This information then is analyzed to define methods for controlling causes of eutrophication in a Phase I "Feasibility Study". The best procedure to improve lake quality is determined and a technical plan for implementing the restoration plan is developed. Phase II is the actual implementation (i.e., design and construction) of the recommended restoration plan.

The Hills Pond restoration study being undertaken at this time by Metcalf & Eddy, Inc. is a Phase I Diagnostic/Feasibility study. The recommended plan for restoration of Hills Pond developed during this study must be submitted to the Mass. Division of Water Pollution Control in order to obtain further funding for implementation of the recommendations.

Lake Eutrophication

The main purpose of a lake restoration program is to correct problems caused by the process of eutrophication. Lake eutrophication is a process whereby a body of water is enriched with nutrients which encourages an overabundance of plant growth that eventually chokes the lake. Eutrophication is a natural process which occurs gradually and slowly. The process can be greatly accelerated by nutrient input from the routine activities of people. Such nutrient sources as wastewater, lawn fertilizer, grass clippings, and others are carried to the lake by stormwater runoff, tributaries, and the groundwater, potentially resulting in eutrophication.

Aquatic plants (macrophytes) generally thrive in shallow parts of a lake where temperatures are warm and light is plentiful. The dead plant material settles to the lake bottom and slowly decreases the lake depth. Decomposition of this material on the lake bottom exerts a demand on the dissolved oxygen in the water, thereby reducing oxygen levels and discouraging fish life. Further plant growth is encouraged since decaying plant material provides more nutrients to the lake sediments and the water column. The lake area gradually develops into a marsh and eventually fills up.

Eutrophication and macrophyte growth are two major problems dealt with during a pond restoration study.

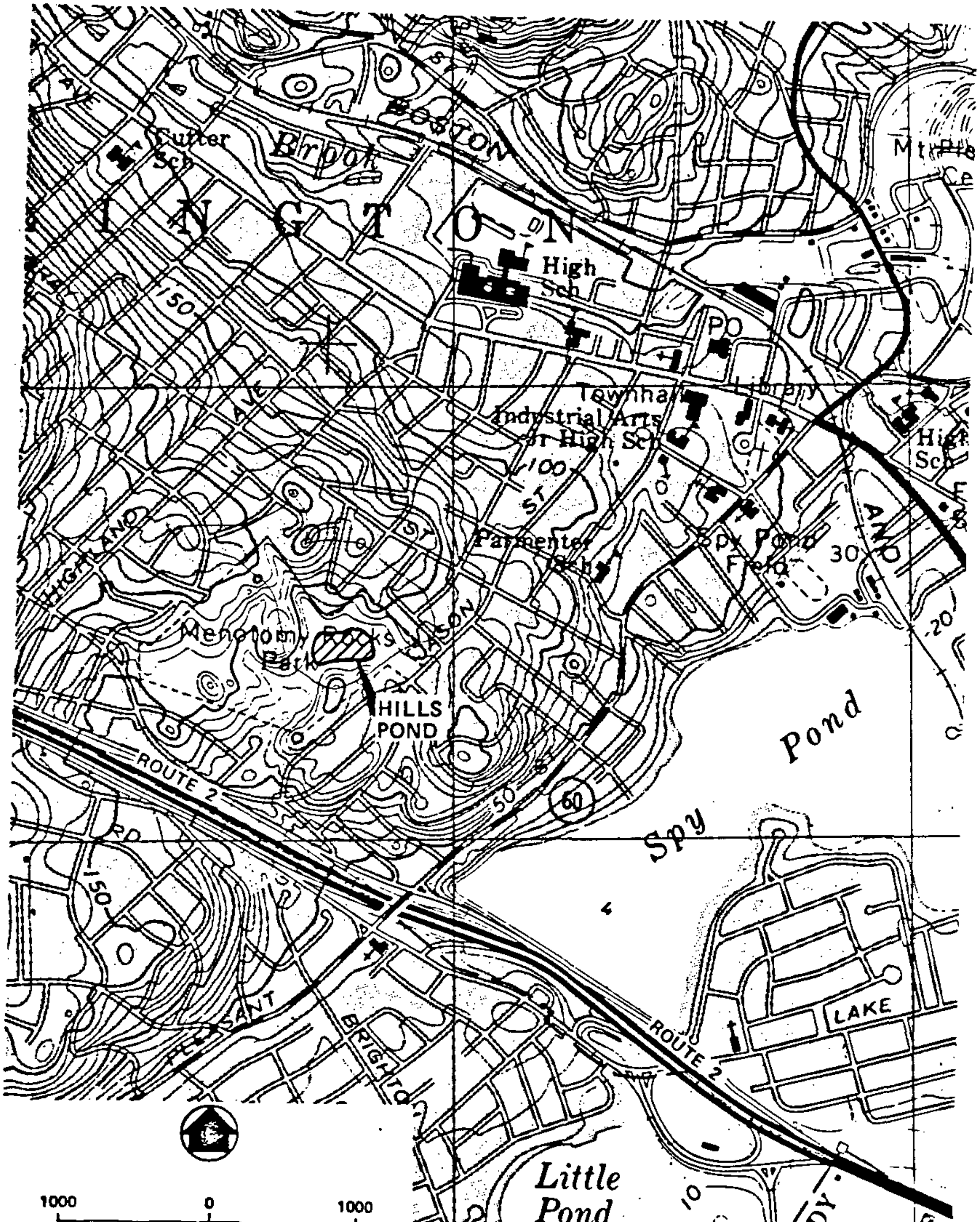
Hills Pond

Hills Pond is located within the 33-acre Menotomy Rocks Park in Arlington, Massachusetts. It is a small man-made pond, with a surface area of approximately 2 acres and an average depth of less than 5 ft. The pond receives inflow from stormwater and groundwater. During periods of high water, outflow from the pond is via an overflow pipe connecting to the Town stormwater sewer system. A map showing the pond location is attached.

Hills Pond is used primarily for aesthetic enjoyment. Activities on and around the pond include picknicking, boating, fishing and skating. The pond has not been used for swimming in the past, and development of the pond for this use is not intended.

Concern over the existing and future quality of the pond centers on several factors, including the following:

1. Excessive growth of rooted plants and algae deter from the aesthetic quality of the pond.
2. Lower than desirable pond water levels have been a problem in recent years.
3. Decreasing pond depth due to sedimentation, especially in the vicinity of the storm drain entering the pond, is not desired.
4. Generally degraded water quality conditions in the pond presently exist.



HILLS POND AND SURROUNDING AREA

Project Approach

The tasks to be conducted during the Diagnostic Feasibility study are as follows:

1. Diagnostic Survey

   The diagnostic survey of Hills Pond involves several data collection and analysis surveys. Water quality measurements will be obtained in the pond, at the pond outlet, and in the stormwater entering the pond. The water level in the pond will be monitored during the entire length of the project. A survey will be conducted to identify the areal coverage and dominant species of macrophytes (rooted plants) present in the pond. A bathymetric map will be prepared depicting the water depths throughout the pond, as well as the depth of sediment in the pond. In addition, sediment samples will be collected and analyzed.

2. Prepare Hydrologic and Nutrient Budgets

   Hydrologic and nutrient "budgets" will be calculated for the pond. The hydrologic budget is an accounting of all contributions and losses of flow to and from the pond. This calculation is performed in order to determine the major factors that affect the lake level and the flushing time. The nutrient budget calculations are used to investigate the sources of nutrients such as nitrogen and phosphorus to the lake. The hydrologic and nutrient budget calculations are checked using the available data.

3. Develop and Assess Alternatives

   An assessment of various hydrologic, source, and in-pond alternatives will be conducted to mitigate the existing problems of the pond. The hydrologic and nutrient budgets developed will be used to assess the alternatives. Lake eutrophication can be slowed by various preventative measures. These include the control of nutrients and other pollutants entering the lake, the use of herbicides on aquatic plants, lake drawdown, and dredging of nutrient-rich sediment. Water level control measures, if required, will be selected and described along with preliminary engineering drawings of the selected alternatives.

4. Prepare Recommended Plan

The recommended plan will be based on the alternatives evaluation. Selection criteria include environmental impacts, costs, available funding, and public input. For the recommended plan, a budget, work schedule, and other information will be prepared so that the restoration project can be advanced into Phase II implementation.

5. Public Participation

Public meetings will be held at three stages of the project. After the initial meeting, a second meeting will be held to describe and obtain input on the various alternatives to be assessed. A final meeting will be held to describe in detail the recommended restoration plan. Public input during all stages of the project is crucial, in order that the eventual recommendation will be one that is widely supported.

Project Schedule

All work conducted as part of the Hills Pond Diagnostic Feasibility Study is to be completed by February, 1986.

ARLINGTON HILLS POND
PUBLIC MEETING No. 1
APRIL 5, 1985

SIGN-IN SHEET

NAME	ADDRESS
T Wright	Town Hall
R Bean	125 JASON ST (AL)
Margaret Bean	" "
Peter B Howard	12 Woodland St
Jane L. Howard	" "
Joanne Morel	Park & Rec Comm.
Margo [illegible]	" "
William Shea	9 Lincoln St
Don Bronner	422 Summer St.
[illegible]	23 DRAPER AVE.
Bernice Jones	21 Kensington Rd

J-1276

April 9, 1985

HILLS POND, ARLINGTON

DIAGNOSTIC/FEASIBILITY STUDY

Summary of Public Meeting No. 1

The initial public meeting for the Hills Pond Diagnostic Feasibility Study was held at the Arlington Town Hall on April 9, 1985 at 7:00 PM. An agenda for the meeting is attached, as well as the names and addresses of those in attendance. An information package was also provided to those in attendance.

Mr. Frank Wright, Director, Dept. of Natural Resources, gave an introduction and outlined the past problems in the pond. Mr. David Bingham, Project Manager, Metcalf & Eddy, outlined the Chapter 628 State lakes program and the public participation process. Mr. John Cardoni, Project Engineer, Metcalf & Eddy, presented the technical aspects of sampling and analysis work to be undertaken, and the project schedule. The meeting was held in conjunction with a Park and Recreation Commission meeting.

Comments and input were sought from all present after the presentation. In particular, input on the desired uses and water quality goals for the pond, as well as on problems which exist at the pond, was solicited. The following major points were raised:

1. The desired uses of the pond are and have been (in order of importance) aesthetic enjoyment as part of the Menotomy Hills Park, fishing and limited secondary contact recreation such as canoeing. This last use is minor due to the small size of the pond.

2. Use of the pond for primary contact recreation (swimming) is not desired.

3. Many organizations use the park and pond for outings. A complete record of these uses, with number of people, can be obtained from Mr. Dan Borsnan, Arlington Recreation Dept.

4. Routine recreational use of the park and pond area is not recorded. A questionnaire mailing was considered by those in attendance so that this use could be estimated.

5. The pond is currently not stocked with fish due to its poor water quality. Improved quality would be needed before the State would be willing to stock.

6. Fish population appears to be declining. This year, none have been observed. Fish populations changed from mainly carp and sunfish within the last few years. Dead fish were observed early this year.

7. Currently, no information on pond history has been obtained. The Historical Society should be contacted and old deeds should be located.

8. Odors do not appear to be a major problem, however low water level is. The reason for the recent decline in water level is unknown. It was suggested that possibly material settled to the bottom may have interfered with groundwater base flow. The low water level has exposed muddy areas which do cause some odors.

9. There may have been a past surface water source which has been diverted or ceased to flow.

10. A suggestion was made to import groundwater to increase the water level.

11. Town water supply has been used occasionally in the past to fill the pond. This is probably not a desirable method for doing this.

12. There is an unpaved road which drains directly into the pond.

13. The sediment delta at the end of the stormwater drain has been removed twice in the past 15 years. There is currently a visible delta there.

14. To address stormwater pollutant load, it would be possible to divert the drainage around the pond to the outlet. If the flow is needed, an end of pipe treatment system could be considered.

15. Plans of sewers around the pond area should be checked.

16. Historically, algal blooms have been a problem. However, macrophytes have proliferated within the past year or two.

17. The issue of disposal of any dredged material was discussed. If recommended a suitable site must be located.

18. Use of park land for any recommended structures would be considered, but only if adequate mitigation measures (i.e. putting the structure undergound) are included.

19. There are occasional vandalism problems, but not excessive.

The next public meeting is in November to discuss pond restoration alternatives. Until that time project status will be available in the form of quarterly progress reports submitted by Metcalf & Eddy to Mr. Wright

David R. Bingham
Project Manager

CC: All Attendees, E. Cheseborough, MDWPC

Public Meeting No. 1 April 9, 1985

LAKE RESTORATION STUDY OF HILLS POND, ARLINGTON

AGENDA

Introduction	Mr. Frank Wright Arlington Dept. of Properties and Natural Resources
Project Outline	Mr. David Bingham Metcalf & Eddy, Inc.
Lake Eutrophication	Mr. John Cardoni Metcalf & Eddy, Inc.
Hills Pond Problems	
Evaluation of Restoration Alternatives	
Sampling Program Description	
Questions and Answers	

Public Meeting No. 2 December 3, 1985

LAKE RESTORATION STUDY OF
HILLS POND, ARLINGTON

Introduction	Mr. Frank Wright Arlington Dept. of Properties and Natural Resources
Project Status	Mr. David Bingham Metcalf & Eddy
Diagnostic Survey Program	Mr. Steven Benton Metcalf & Eddy
Pond Water Quality	
Pond Biology	Mr. Peter Boucher Metcalf & Eddy
Assessment of Existing Conditions and Problems	Mr. John Cardoni Metcalf & Eddy
Alternatives for Pond Improvements	
Questions and Answers	

LAKE RESTORATION STUDY OF HILLS POND, ARLINGTON

Introduction

The Diagnostic/Feasibility study of Hill's pond is being conducted under the State Chapter 628 Clean Lakes Program for the Town of Arlington by Metcalf & Eddy. This is the second of three public meetings during this study. The purpose of the meeting is to present results of data collection efforts, the restoration objectives for the pond and alternatives for pond improvements.

Project Status

Data collection has been completed. After this public meeting, a draft report will be submitted to the Town and the State for review and comment. This draft report will include analysis of the data, development and assessment of alternatives, and the recommended plan. A third public meeting will be held to review the proposed recommendations. After this, the final report will be submitted and the Town can apply for funding to implement the recommendations to restore Hills Pond.

Pond Biology and Water Quality

The biological resources of Hill's Pond are characterized by extensive growth of Milfoil (Myriophyllum) a stubborn aquatic macrophyte. Historically, the pond has also had problems with dense phytoplankton, or algae, growth. During the 1985 survey conducted by Metcalf & Eddy, very dense macrophyte growth was observed throughout the pond. In-pond phytoplankton concentrations were moderate during the July 1985 survey.

Species indicative of nutrient enriched conditions were found to predominate.

Measurements during the Diagnostic Survey indicate that the water quality in Hills Pond is degraded. Nutrient concentrations (phosphorus and nitrogen) are high, and indicate eutrophic conditions. These high nutrient concentrations encourage the excessive macrophyte and phytoplankton growth observed at Hills Pond. Dissolved oxygen levels were well above the State standard of 5.0 mg/l due to daytime oxygen production by plants during photosynthesis. Coliform bacteria levels did not violate water quality standards. Survey measurements indicate that the maximum water depth in the pond is approximately 5 ft., and the maximum soft sediment depth is approximately 3 ft.

The storm drain entering the pond at the base of Churchill Avenue carries a significant sediment and phosphorus load into the pond. The pond area near the inlet of this drain is filled with sediment.

Pond Water Level

Periods of low water have been reported at Hills Pond in recent years. The pond level was measured periodically throughout the Diagnostic Survey. During this period, the pond level varied over approximately a 1 ft. range. The main inflow to the pond is from rainfall runoff and direct precipitation on the pond. Normally, there is no surface water outflow, although evaporation does result in water loss from the pond. A water budget was calculated based on the Diagnostic Survey measurements. This budget indicated that there is a net subsurface outflow from the pond which is in part responsible for the low water levels observed.

Problems and Objectives

The desired uses of Hill's Pond are aesthetic enjoyment, recreation, fishing, and canoeing. The major problems inhibiting these uses are accelerated macrophyte growth, phytoplankton blooms, and periodic low water levels in the pond. Problems and objectives for Hill's Pond are listed as follows:

HILL'S POND PROBLEMS AND OBJECTIVES

Problem	Objective
1. Excessive Macrophyte Growth and Phytoplankton blooms	Remove or control nuisance species; Reduce in-pond nutrient levels
2. Low water level	Maintain adequate water level year round
3. Sedimentation in pond	Remove accumulated sediments; reduce sediment content of stormwater inflow

Development of Alternatives

A number of in-pond restoration alternatives have been developed which will be analyzed in detail. These alternatives are summarized in the attached table. For control of aquatic macrophytes, alternatives include herbicide application, harvesting, and use of dye to tint the water color, all of which are ongoing maintenance activities. Dredging would remove the plant material and the nutrient-rich sediments. Drawdown would entail letting enough water out of the pond during winter to expose the weeds and sediments to freezing temperatures. This could control macrophyte growth temporarily. Plant nutrients and suspended sediment loading to the pond may be reduced by controlling stormwater loading to the pond.

These and other alternatives will be evaluated in detail in order to develop a recommended restoration plan, which will be presented at the next meeting.

SUMMARY OF HILL'S POND RESTORATION ALTERNATIVES

Objective	Method	Remarks
Control Macrophyte and phytoplankton	Herbicides	Maintenance activity
	Harvesting	Maintenance activity
	Dyes	Reduces water clarity
	Overwinter drawdown	Restricts winter pond use; effectiveness uncertain
	Dredging	Sediment disposal often a problem
	Reduce stormwater nutrient load	Alternatives include catch basin improvements, sedimentation basin construction, and stormwater diversion.
Maintain Pond Water Level	Groundwater pumping	Dependent on available aquifer capacity
	Pond liner	High cost; dredging also required; liner may be damaged
Pond Sedimentation	Dredging	
	Reduce stormwater sediment load	

HILLS POND
PUBLIC MEETING No. 2
DECEMBER 3, 1985

SIGN-IN SHEET

NAME	ADDRESS
Francis B Creighley	31 Morton RD
John G Snow	18 Morton Rd
Scott D Lawrence	10 Lincoln St.
Marion H Crampton	109 Bartlett Ave
Arnold E. Johnson	22 Morton Road
Geo. Boday	106 Brantwood Rd
Mr + Mrs G. F. Mahoney	54 Brantwood Rd.
Valeska von Allwörden	23 Lincoln Street
Barbara Wood	26 Woodland St
Nancy McKorsie	197 Jason ST.
Mr & Mrs Phil McDonald	96 Churchill Ave
Elaine + Bill Shea	9 Lincoln St
Joan Ogilvie	110 Gray St.
Gail Matthiesen	112 Churchill
Mr + Mrs John Cumming	160 Jason St
Don Matthiesen	112 Churchill
Carol E. Mahoney	111 Jason ST.
Kenneth A. Dunn	159 Jason
Frank J Bonzoni	89 Churchill Ave
Michael J. [illegible]	5 Morton Rd
Jamie Simon	20 Woodland St

Peter B Howard	12 Woodland St
* WALTER L. BOYLE	109 GRAY ST.
Jean Lokensgard	92 Churchill Ave.
Kenneth C Spengler	189 Jason St.
Margaret H Spengler	189 Jason St
* William J. Gibbons	3 Longfellow Rd.
* Patrick J. Hurley	2 Morton Rd
Thomas V. Miller	7 Bellevue Rd.
Karen Watson	100 Churchill Av.
Peter Holton	100 Churchill Av.
James B Earley	192 Spring St.
Coleen Hurley	

* Pls. send information

NAME	ADDRESS
* Paul Fennelly	97 Gray St
Kathy Fennelly	97 Gray St
Lois Keating Baker	24 Valley Rd

J-1276
December 4, 1985

HILL'S POND, ARLINGTON

DIAGNOSTIC/FEASIBILITY STUDY

Summary of Second Public Meeting

The second public meeting for the Hill's Pond Diagnostic Feasibility Study was held at the Arlington Town Hall on December 3, 1985 at 7:30 PM. An agenda for the meeting is attached, as well as the names and addresses of those in attendance. An information package was provided to approximately 40 people who attended the meeting.

Mr. Frank Wright, Director, Dept. of Natural Resources, gave an introduction and outlined the past problems in the pond. Mr. David Bingham, Project Manager, Metcalf & Eddy, outlined the project approach and progress-to-date. Mr. Steven Benton, Engineer, Metcalf & Eddy, reviewed the Diagnostic Survey Program and presented data collected. Mr. Peter Boucher, Biologist, Metcalf & Eddy, presented the results of biological surveys of the pond. Mr. John Cardoni, Project Engineer, Metcalf & Eddy, finished the presentation with an overview of the problems in Hill's Pond, objectives designed to alleviate these problems, and recommended restoration alternatives.

Comments and input were sought from all present after the presentation. In particular, reaction to the recommended restoration alternatives was solicited. The following major points were raised:

1. A question was raised concerning the potential health hazards of Hill's Pond. Based on the M&E water quality survey, coliform bacteria levels were well below state standards for primary contact (swimming) recreation. There may be higher coliform levels at times (i.e. after storms), however, there does not appear to be a consistently high coliform population in Hill's Pond.

2. A suggestion was made to line the bottom of the pond with rocks following dredging. This alternative will be considered if draw down and dredging is recommended.

3. There is an area of Menotomy Rocks Park to the southwest of the pond in which there is some surfacewater flow for much of the year. It was suggested that this water be collected and diverted to the pond. Elevations in the area will be investigated to determine the feasibility of this alternative.

4. The issue of funding for the restoration plan was raised. Mr. Bingham briefly explained some of the sources and procedures for applying for grants to cover these costs. The Town is planning to address the issue of local funding at the next Town Meeting.

5. There is a low point in the Park adjacent to the Jason Street entrance. This area is wet for a significant portion of the year.

It was suggested that water may be moving out of the pond in this direction. This possibility will be investigated along with preventive measures such as clay or bentonite barriers to inhibit flow.

6. Odors have been noted during summer months. This is probably a result of sediments and decaying organic matter becoming exposed by dropping water levels. Maintaining a constant water level in the pond should eliminate this condition.

A Draft Report on the Hill's Pond project will be submitted within the next month.The next public meeting will be held in about three months to present the recommended restoration plan. Until that time project status will be available in the form of quarterly progress reports submitted by Metcalf & Eddy to Mr. Wright.

Appendix B

Massachusetts Division of Water Pollution Control
Draft Report Comments

Hills Pond Draft Diagnostic/Feasibility Report

Key: Page, Paragraph, Line

Technical Comments

2-23	Incorrect value listed for August-September lake volume.
2-25, Pond Water Quality	Suggest providing a brief comparison of the 1983 and 1985 data.
2-33, 3, 9	Suggest including references used to derive these phosphorus loading values.
2-38, 3, 3 to 5	Further discussion of variations in phytoplankton species composition with varying nutrient concentrations would be useful. Also, suggest deleting the Palmer index discussion later in this section. As stated in the report, it is an organic pollution index and it is not applicable to this situation.
2-44, 2	Differences in aquatic macrophyte species composition between the 1983 and 1985 surveys should be discussed. A list of other aquatic macrophytes found on the 1985 survey should be provided.
3-7, 1	Should provide a cost estimate for the groundwater pumping capacity investigation.
3-8, 2	Estimated costs for liner placement should be provided.
3-11, 4	Could temperature stratification of the pond be avoided through groundwater pumping?
3-18, 1	Estimated costs for an underground sedimentation tank, both preliminary investigation and construction costs, should be provided for comparison.
3-18, 2, 8	Have these investigations been completed? If not an estimate of their costs, duration, etc. should be provided.
3-19, 3, 5-7	Suggest adding "wind-induced resuspension" to describe the resuspension mechanism.
Chapter 4	Has Mass. Fisheries and Wildlife commented on this report? Recommendations on restocking rates and species to restock should be provided in this section.

4-1 to 4-4, Groundwater Pumping	This alternative would benefit from further discussion combining all project elements. For instance, is the "wet area" depicted in figure 4-1 "recharged" by groundwater losses from Hills Pond? What effect, if any, would dredging have on groundwater losses? Attempts to maintain Hills Pond water level above the water table also may increase the hydraulic gradient of the groundwater which would increase losses. Would an ordinary household pump be sufficient to supply an increased need for water?
4-2, 1	Preliminary design plans for the groundwater pump structure should be provided.
4-9, 1	Will this effluent require treatment to avoid adverse downstream impacts?
4-17, 1, 10	The safety fence surrounding the sedimentation basin is a good idea with or without maintenance of a permanent pool. Is it included in the cost estimate?
4-18, 2	An estimate of the cubic yards of fill required should be provided. Are you proposing to use dredge spoils?
4-18 to 19	The inclusion of a spillway in the outlet modifications is one alternative which may warrant further discussion. The need for frequent opening and closing of the outlet valve to maintain the desired lake level could thus be avoided. Estimated frequency, duration, criteria and responsibility for opening the valve should be specified.
4-19, 2 to 3	The duration of the monitoring program should be increased to three years.
4-23, Table 4-5	More detail on the cost breakdown should be provided in the final draft. For instance, for the groundwater pumping alternative separate costs for the pump, housing structure, piping, etc. should be provided. Also, the paving of Valley Rd. is not covered under the Clean Lakes Program.

MEMORANDUM

TO: Gary P. Gonyea, Chief Aquatic Biologist, DWPC-TSB, Westborough

FROM: Alice M. Rojko, Sanitary Biologist, DWPC-TSB, Westborough

DATE: February 28, 1986

RE: Review of the Hill's Pond Diagnostic/Feasibility Study

The author has reviewed the draft Diagnostic/Feasibility Study Report on Hill's Pond in Arlington. The report is clearly written, well organized and technically sound. My comments which follow are divided into two categories - general (comments on typos, misspellings, grammatical errors, etc.) and technical (comments relating to the Scope of Work).

KEY: Page, Paragraph, Line

TECHNICAL COMMENTS

2-4 Table 2-1.	The Scope of Work in the Substate Agreement states the data should be reported in metric units. This morphometric table should include a value for development of shoreline.
2-9, 1, 3	The calendar of picnic permits in the Appendix is barely readable. Also, since this information has been nicely summarized, it is not necessary to include the individual sheets.
2-9, 4	A more thorough description should be presented detailing how the soils and geology of the area affect water quality.
2-25	The Pond Water Quality Section should present a brief discussion on the conductivity and chloride parameters.
2-31	Table 2-12 should indicate the time of sample collection in relation to when the storm started.
2-40, 2, 4	A reference should be cited for the typical range of algae cell counts for healthy lakes.
3-4, 2, 7	An analysis of the nuisance species and its growth in deep water specific to Hill's Pond should be presented.
3-8, 3	What is the life expectancy of the various types of liners? Will an increase in flooding result? What are the costs associated with the various types of liners?
Chapter 3	General or "ball park" cost figures should be presented for the various alternatives.

3-23 Table 3-3	The street paving recommendation is not discussed previously. Although a more thorough description is contained in Chapter 4, this information should be discussed and presented in Chapter 3.
4-1	Who is to be responsible for implementation of the groundwater pumping alternative and the day-to-day operation?
4-4, 3, 1	What of the parameters in which the laboratory results were not available?
4-7, 2, 3	Where exactly were the sediment samples taken? This paragraph indicates they were taken in a shallow area near the storm drain inlet while the sediment discussion on page 2-31 indicates they were taken at the in-pond station. A sampling station map should be presented for both water quality and sediment sampling to indicate where the in-pond station is located.
4-9, 1	Is there a particular time of year when draining and dredging of the ponds should be performed?
4-12, 3	The permit section for the dredging alternative should also discuss the requirements for the Massachusetts Environmental Policy Act (MEPA), Water Quality Certificate, Chapter 91 Waterways License and the Massachusetts Historical Commission. If these permits are not required the reasons should be presented.
Chapter 4	A discussion should be included describing the permits which would be required for the groundwater pumping and sedimentation basin alternatives.
4-23, 2	The funding sources should also include a discussion on the Department of Environmental Management's Rivers and Harbor's Program which provides funding for dredging projects.
Chapter 4	This chapter should indicate which group or agency will be responsible for implementing each alternative (Article A.3.2.3 of the Substate Agreement).
Chapter 4	The environmental evaluation should consider the state Historical Commission and Division of Fisheries and Wildlife (Article A.3.3.1 and A.3.3.4 of the Substate Agreement).

A discussion of the public participation that was involved in the development and review of the selected alternatives should be presented (Article A.3.2.8 of the Substate Agreement).

A more thorough discussion should be presented regarding methods and procedures for restoring a balanced fish population (Article A.3.2.2 of the Substate Agreement).

GENERAL COMMENTS

1-5, 1, 1	Eliminate the period after Feasibility.
1-5, 2, 3	Typo - "morphametric"
1-5, 3, 3	Typo - "entrophication"
2-37, 1, 18	Typo - "diel"
2-38, 2, 4	What does the ")" sign for chlorophyll-a values represent? Perhaps a "u" would be more appropriate.
2-38, 3, 7	Typo - "phytoplanton"
2-41, 3, 1	Typo - "general"
3-4, 2, 4	Typo - "conducive"
4-4, 4, 2	Typo - "Table 9-1"
4-9, 2, 14	The "3000 yards" should read "3000 cubic yards"
4-18, 2, 7	Typo - "occurances"

AMR/kt

Appendix C

Massachusetts Historical Society
Review Letter

The Commonwealth of Massachusetts

Office of the Secretary of State
Michael Joseph Connolly, Secretary

Massachusetts Historical Commission
Valerie A. Talmage
Executive Director
State Historic Preservation Officer

June 16, 1986

Mr. John J. Cardoni
Metcalf & Eddy, Inc.
P.O. Box 4043
Woburn, MA 01888-4043

RE: Hills Pond Lake Restoration Project, Arlington

Dear Mr. Cardoni:

Thank you for supplying the Massachusetts Historical Commission with information concerning the proposed project referenced above. Staff of the MHC have reviewed the materials you submitted.

MHC feels that this project is unlikely to affect significant historic or archaeological resources. No further review is required in compliance with Massachusetts General Laws, Chapter 9, Sections 26C and 27C, as amended by Chapter 152 of the Acts of 1982 (950 CMR 71).

If you have any questions, please feel free to contact Jordan Kerber at this office..

Sincerely,

Valerie Talmage

Valerie A. Talmage
Executive Director
State Historic Preservation Officer
Massachusetts Historical Commission

VAT/ls