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Project Number: CXDMB99 - 44

An Evaluation of Sediment Sources and Control Options for the Mill Brook

An Interactive Qualifying Project Report

submitted to the faculty

of the

Worcester Polytechnic Institute

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

By

Jonathan Hone

Greg Noetscher

Date: March 2000

Approved:

Professor Chrysanthe Demetry

Abstract

Currently, the Mill Brook is a heavy carrier of sediment into Salisbury Pond in Institute Park. Restoration of Salisbury Pond to its original state is the eventual goal of the Mill Brook Task Force. The purpose of this project was to determine the major sources of sediment going into the Mill Brook and to examine current sediment control methods. Based on this information, solutions to the problem of sedimentation have been recommended.

Acknowledgements

We would like to extend special thanks to the members of the Mill Brook Task Force. Their input and expertise were crucial to the success of this project. We are very grateful to Joe Buckley of the Department of Public Works who gave up much of his time to meet with us concerning every aspect of the proposal and finished product. Phil Jakubosky of the Worcester Public Health Department provided assistance in identifying important background information. The ideas of Ginny Scarlet and Terry Mounce of the Department of Environmental Protection helped mold our ideas into a project that can be useful to the Mill Brook Task Force. Chris Scholl, Norton Company Environmental Manager, played an integral part in the success of this project. We would like to thank him for allowing us to examine Norton Company's facilities and sediment control structures. We appreciate the encouragement and information Tristan Lundgren provided, without which our efforts would have been in vain. We would like to thank the people of the Massachusetts Highway Department, Anne Sullivan and Butch Olsen. Doug Frost of Frost Manufacturing provided historical as well as observational information. Thanks also to Brent McCarthy of Camp, Dresser and McKee. Finally, we would like to thank Professor Demetry for guiding and teaching us the finer points of writing a project of this magnitude.

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Executive Summary

Pollution is an increasing concern in all aspects of the environment. A type of pollution that is specific to water is known as sedimentation. Particles consisting of organic material like decaying plants and animals and inorganic material like man-made metals are suspended in a body of water and eventually become deposited when the velocity of the water decreases. Sediment may also consist of a number of different types of soils including silt. In this manner, ponds and lakes are filling at a rapid rate.

One Worcester waterway that is especially affected by sediment deposition is Salisbury Pond. Located in Institute Park, the pond is fed by the Mill Brook. Sources of sediment located upstream from the pond are loading the brook with a large amount of sediment. Since most of the brook is housed in a cement culvert, there are no barriers to the flow of water. The velocity of the water rises as it travels to the pond, and the sediment becomes deposited when it reaches the still waters of Salisbury Pond. If nothing done to alleviate the present situation, Salisbury Pond is likely to become a marsh within the next decade.

Many watersheds have a group of concerned citizens who are dedicated to the restoration and preservation of its waterways. One such group is the Mill Brook Task Force, which is comprised of Massachusetts Departments of Highway and Environmental Protection officials as well as members of the Worcester Departments of Public Works and Health. Industry representatives from Norton Company and Frost Manufacturing are also involved. Sediment deposition in the Mill Brook Watershed has been studied in the past, but these previous studies focused on broad issues like non-source point pollution.

The Task Force is specifically interested in identifying the major sources of sediment along the Mill Brook and significantly reducing the flow of sediment into Salisbury Pond.

The goals of this project were to determine the major sources of sediment located along the Mill Brook and to recommend control options that will decrease sediment deposition in this area of the Mill Brook Watershed. The methods used in completing this project can also be applied to sedimentation problems in other urban watersheds.

In order to accomplish these goals, we first conducted thorough background research in the areas of erosion, non-point source pollution, previous studies of urban watersheds, and general environmental management practices. We also found information on sediment control structures and control methods that are specific to an urban setting.

To identify sediment sources, we familiarized ourselves with the Mill Brook watershed and conducted several dry and wet site walks. We then examined topographical maps of the area to identify possible erosion problems and conducted interviews with members of the Mill Brook Task Force. Members at the city level included Joe Buckley of the Department of Public Works and Tristan Lundgren, director of the Blackstone River Coalition. State officials included Terry Mounce and Ginny Scarlet of the Massachusetts Department of Environmental Protection and Anne Sullivan and Butch Olsen of the Massachusetts Highway Department- District III. Chris Scholl, Environmental Manager of Norton Company, and Doug Frost, CEO of Frost Manufacturing, provided the perspective of local industries. Brent McCarthy of Camp, Dresser, & McKee was also contacted for a professional view of environmental management.

To identify and evaluate sediment control options, we first identified the existing control structures, both natural and man-made, along the Mill Brook. We sought information about maintenance of city and state streets and control structures. This information came from interviews with Joe Buckley of the Department of Public Works-Sewer Division, Anne Sullivan and Butch Olsen of the Massachusetts Highway Department- District III, and Chris Scholl, Environmental Manager of Norton Company.

The causes and sources of sedimentation can be summarized in the following manner:

- Removal of upstream settling basins and the filling of Marshall Pond, in particular.
- Poor street and construction site maintenance practices.
- Stormwater runoff from city streets and Interstate 190
- Erosion on unpaved roads like Wildey and Assumption Avenues

In order to stop sediment deposition, either the velocity of the water needs to be slowed to allow the sediment to settle, or the sources of sediment flow into the Mill Brook need to be eliminated. The former can be realized with the use of control structures like a settling basin or baffle. The latter can be accomplished by conducting a quantitative, scientific study of each sediment source and comparing with sediment in Salisbury Pond to identify the sediment producers. Appropriate action can then be taken to stop or reduce sediment production.

Unfortunately, the current high level of sediment in Salisbury Pond is irreversible unless the pond is dredged; the recommendations made in this project proceed on that assumption. However, dredging alone is an ineffective method of solving the problem of sedimentation. The pond may be free of sediment immediately after the dredging but if sediment continues to flow into the pond, the problem is not completely solved.

Our recommendations to the Mill Brook Task Force fall into three main areas: methods to stop sediment from flowing into the pond, informing local citizens about the consequences of sedimentation and involving them in the solution, and quantifying the amount of sediment to scientifically determine the major sources. The first area could be addressed with installation of control structures. Baffles in the double box culvert could be installed with a relatively small cost and virtually no excavation. An alternative idea would be a control structure of some kind placed at either the mouth of the Mill Brook or at some point upstream to absorb the impact of the sediment present in the water. These devices will lower the speed of the water and allow the sediment to settle out of the water. In order to remove the highest amount of sediment, the structure should be placed as close to the pond as possible. This way, all the catch basins in the surrounding area will have some common holding area to remove sediment. Regular cleaning and maintenance of any new control structure would be critical to its effectiveness.

Our second recommendation to the Mill Brook Task Force is to create a community action plan to educate citizens in the surrounding area and involve them in the efforts to restore Salisbury Pond. One element of this action plan could include working with the residents of private unpaved roads to establish a catch basin monitoring program and eventually to pave those roads. Another key element of an action plan would be to involve WPI students in all efforts to restore the pond to its original condition.

Finally, a scientific study of the composition and particle size of the sediment in Salisbury Pond and from various possible sources should be carried out. This study should be designed and implemented by either advanced environmental engineering students or environmental professionals.

1.0 Introduction

Sediment deposition is a problem in many waterways across the nation, and its effects are long-lasting and difficult to correct. Entire ecosystems have been permanently altered by sediment deposition in urban, suburban and rural environments. Over time, ponds and lakes have turned into marshes and swamps, changing the outlook of the land. This metamorphosis of the environment is due to sediment flow. Sediment consists of organic matter, including decaying plants and animals, and inorganic matter, including metals and soils. Its sources are classified as either natural or man-made and range from erosion to coal refineries. Sediment deposition is a difficult problem to solve given this large range of material sources.

Many waterways of Worcester are threatened by pollution and sedimentation. These waterways are divided up into six separate watersheds. A watershed is described as an ecosystem in which water is continuously cycling from evaporated water to rain. One body of water most affected by sediment deposition is Salisbury Pond, which is fed by the Mill Brook. Sediment flows down the brook and gets deposited into the pond.

If nothing is done to alleviate the present situation, Salisbury Pond will become a marsh within the next decade. This is due to the fact that sediment is flowing from the Mill Brook into the pond at an alarming rate. The causes of sediment flow in the Mill Brook are predominantly man-made and stem from a history of environmental and construction practices that have compromised the quality of the environment. Some possible sources include stormwater runoff from Interstate 190, drainage from the streets of the City of Worcester, and raw materials from construction and industry.

Most watersheds in the area have a task force that has been assembled with the sole purpose of restoring and preserving the various watersheds. The Mill Brook Task Force (MBTF) is a group of concerned citizens representing a wide spectrum of stakeholders including industry officials, state health, highway, and environment officers, and city officials involved in the maintenance of Worcester's infrastructure and natural resources.

The Mill Brook Task Force has been involved in or is aware of many past studies of Salisbury Pond and the surrounding watersheds. For example, the Blackstone River, into which Salisbury Pond empties, has been studied extensively. In 1997, WPI students conducted two separate studies of the river. Nonpoint source pollution was the focus of one study (Andrus and Parette, 1997), while nonpoint source pollution and suggested solution methods were addressed in the second (Catlow and Holcomb, 1997). A sediment control plan based on a chemical analysis of sediment that was bored out of the floor of the river was devised and prepared by McGinn in 1981. In another study, the quality of the water in Salisbury Pond was analyzed with respect to gas content, turbidity and other environmental factors (McLaughlin, Nelson and Weimerskirch, 1973). These reports provided detailed analysis of the quality of water and suggested some possible solution methods but did not pinpoint major sources of sediment in the surrounding area or recommend control methods. The MBTF is interested in identifying these sources, along with solution methods specific to each source.

The goals of this project were to identify major sources of sediment deposition into Salisbury Pond and to evaluate control methods to limit the extent of sedimentation. These goals were accomplished by a combination of background research, interviewing city, highway and industry officials, conducting wet and dry site walks, and studying sewer and topographical maps. Recommendations to the Mill Brook Task Force for addressing the sedimentation problem in Salisbury Pond and Mill Brook were then made. The methods used to complete this study can be applied to similar studies of other urban waterways.

2.0 Background

In order to gain knowledge about sedimentation relevant to the Mill Brook watershed, previous studies of similar situations were examined. Factors causing sedimentation were classified and control methods currently used in environmental management were identified. In this chapter, factors causing sedimentation as well as current control methods are presented.

2.1 Nonpoint Source Pollution

Nonpoint source pollution is a type of pollution that that does not originate from one place. It comes from a variety of locations all flowing to a similar area. This problem is a burden on suburban and urban waterways in many places throughout the world. Presently, nonpoint source pollution is the leading cause of water quality problems in the United States. This problem is a result of precipitation, melting snow, urban runoff, and irrigation runoff. When the water passes through these areas, it picks up pollutants, including sediment, and carries it into a body of water. Nonpoint source pollution is the main reason 40% of the nation's lakes, estuaries, and rivers are not adequate for swimming and fishing (www.epa.gov/OWOW/NPS/facts/point1.htm).

Other causes of nonpoint source pollution are construction mistakes in septic systems, agriculture and grazing practices, and water recreation. These causes disrupt the area so that nonpoint source pollution occurs. The National Water Quality Inventory indicates that agriculture, livestock, and grazing are the most detrimental factors to water quality; these factors degrade 60% of the polluted rivers and half of the polluted lake area (www.epa.gov/OWOW/NPS/facts/point1.htm).

The most common form of nonpoint source pollution is the erosion and transport of sediment and nutrients to the body of water. With the sediment, other chemicals are washed into these bodies, polluting them severely. Sediment can act as a carrier for hazardous chemicals. In urban runoff situations, sediment on the road collects chemicals from passing vehicles. These chemicals stick to the sediment so that when it is washed into the storm drains, the pollution is carried to wherever the sediment is deposited. Water can become undrinkable and cause human health problems. Beaches sometimes are closed due to highly polluted waters (www.epa.gov/OWOW/NPS/facts/point1.htm).

2.2 Erosion

One of the main causes of sediment deposition in urban waterways is erosion. There are many different types of erosion, and regardless of which type, sediment deposition in waterways is one of the results. Water is often described in high school chemistry classes as the universal solvent. In laymen's terms this means that, given time, water will break down anything into smaller chunks, pieces, bits, or molecules. Water erosion is no exception to this rule. Erosion caused by water is the most widespread and persistent type of erosion in existence. It is also the most severe and damaging. Water erosion takes on five different forms: raindrop or splash erosion, sheet erosion, rill erosion, gully erosion, and streambank erosion (Residential Erosion and Sediment Control, p18). Each type of erosion can be modified and exacerbated depending on the surrounding environment.

The first phase of water erosion is raindrop or splash erosion. As raindrops fall, the ground absorbs the kinetic energy from the fall. The impact of the drop has the ability to break apart soil particles, but has no ability to transport these particles. This detachment increases proportionally with increases in intensity, velocity, and drop size. On the other hand, raindrop force can create soil compaction and make the soil more resistant to erosion over time.

Sheet flow, observed as a flowing wave of water across the ground, is the second type of water erosion. A characteristic of sheet flow erosion is the loss of a relatively uniform, thin layer of soil from the surface. This type of erosion has very little ability to detach soil particles but can transport sediment very well. Sheet flow has the capacity to develop into more damaging types of erosion (Residential Erosion and Sediment Control, p20).

As sheet flow erosion moves down a steep slope, channels of up to approximately one foot in depth are formed. This situation is classified as rill erosion. Rill erosion can be especially damaging to loose and wind deposited soil types. This style of erosion has high detachment and transport capacities.

Gully erosion is an advanced form of rill erosion and a general result from concentrated stormwater flow. As rill channels continue to dig into the earth and remove soil, they can grow in width and reach depths of over 100 feet. Gully erosion moves large amounts of soil and is especially problematic for silty soils (Residential Erosion and Sediment Control, p21).

The removal of soil from stream-banks and stream bottoms is known as stream-bank or channel erosion. Alterations to the stream-bank including the clearing of protective vegetative cover, straightening and realigning of waterways, and construction projects that increase the rate and volume of runoff occurring in the watershed are all causes of this type of erosion. Stream-bank erosion can transport sediment for miles before deposition (Residential Erosion and Sediment Control, p21).

To a lesser extent, erosion can be caused by wind. This style of erosion is especially intense in arid regions like the Great Plains. Soils and other pollutants eroded by wind can be blown directly into streams, lakes, reservoirs, and other areas, which can cause problems for the environment. As strong turbulent winds with enough energy to move or lift particle flow across the surface, erosion begins. Erosion can occur to some types of soils with a wind velocity of as little as 10 miles per hour (Residential Erosion and Sediment Control, p23).

Soil is transported by wind erosion in three different ways: saltation or bouncing on land, surface creep or rolling, and suspension or flying through the air. Wind erosion intensity increases with exposure time and distance across a large area. The rate of soil movement depends on the velocity of the wind. When the wind velocity decreases, deposition of soil particles occurs in waterways or on land, and it usually occurs many miles away from their point of origin.

Water erosion moves through a series of chain reactive events each more damaging than the last. This erosion is intensified by wind erosion. It is therefore important to this project that all forms of erosion be addressed and corrected to stop further sediment deposition. Factors affecting water and wind erosion as well as existing measures to prevent erosion are discussed below (Residential Erosion and Sediment Control, p31).

2.3 Factors Affecting Water Erosion

One primary factor affecting the water erosion process is soil erodibility. The properties leading to soil erodibility include particle size distribution, clay and organic content, pore water chemistry, soil structure, permeability, specific gravity, and root structure.

Soil particle size distribution is the relative proportion by weight of various sizes of soil particles found in a general sample of soil. This distribution affects the water infiltration rate and the permeability of a soil type.

Organic matter present in the soil decreases soil erodibility. As organic matter decomposes, soil humus results and this, in turn, is important in producing organic clods that are able to retain water better and hold soil together.

Soil porosity, capillarity, and water content also affect soil erodibility. Soils that have massive, "blocky" structures will be more resistant to erosion than soils with granular, non-cohesive structures. This is evident when comparing soils consisting of clay or organic matter to fine soils and silts (Residential Erosion and Sediment Control, p42).

2.4 General Control Methods

There are many current technologies, both technical and non-technical, that can solve problems of sediment deposition or at least keep current problems from getting worse.

2.4.1 Use of Vegetation

A primary control method is the use of vegetation, which is the universal tool to help the problem (Erosion and Sediment Control Handbook, p6.1). Vegetation is quite cost effective, and beautifies places that may seem unattractive. Due to the biology of plants, they have the ability to be self-sufficient and self-repairing. Vegetation does many things to prevent erosion and sediment runoff. Plants that have canopies can shield loose soil from being eroded by heavy rains. Mulching provides the same protection and comes in many forms: straw, wood fiber, wood chips, bark, fabric, plastic mats, and heavy gravel. Mulches protect loose soil and immature vegetation (Erosion and Sediment Control Handbook, p6.23). Various types of vegetation can slow the velocity of the runoff or channel it in some situations. It also holds the soil particles in the ground, keeping the soil stable and retain water. Vegetation on the slopes of hills, which are sources of runoff, is an effective control method. Grass is also used in runoff channels to reduce the velocity of water and to absorb as much as possible (Erosion and Sediment Control Handbook, p6.1).

There are several criteria for a successful erosion control plan that uses vegatation. Plants that have dense root systems are ideally used because of their ability to hold the soil together and absorb the runoff. The plants should be easy to plant and have immediate results. These plants should be able to adapt to many environmental factors including temperature, climate, and soil quality. It is also helpful if the plants re-grow annually. "Low maintenance," meaning little if any irrigation or even rain is important. Finally, the plants should be available at many places at a very low cost to the consumer (Erosion and Sediment Control Handbook, p6.3).

Annual grasses, perennial grasses, legumes, flowers, shrubs, and trees all provide the same protection but by different means. These control methods have advantages and disadvantages. Annual grasses reproduce and grow very quickly, making them disperse quickly across the area of protection. This grass has a fibrous root mat that is conducive to holding existing soil. Examples of these are barley (Hordeum vulgare), oats (Avena sativa), and ryegrass (Lolium multiflorum). These are available at a low cost and in many places (Erosion and Sediment Control Handbook, p6.5).

Perennial grasses are not as easy to spread as ground cover. They require more water or possibly irrigation. They are poor competitors in the sense that these grasses need to be isolated from other grasses to be successful. The advantage of these grasses, however, is that they stay greener longer in the year, during fire season and late summer. Examples of these include tall fescue (Festuca arundinacea), red fescue (Festuca rubra), and perennial ryegrass (Lolium perenne) (Erosion and Sediment Control Handbook, p6.6).

Such legumes as red clover (Trifolium pratense), rose clover (Trifolium hirtum), and birdsfoot trefoil (Lotus corniculatus and Lotus tenuis) are used with grasses in the control process. A Legume's ability to make nitrogen is helpful to soils that are poor in quality, (Erosion and Sediment Control Handbook, p6.6).

Flowers are often added to the landscape for aesthetic value. Because they are poor competitors, flowers adapt to poor soil conditions due to lack of weed growth. Although expensive, flowers are used very effectively on less erodable soil (Erosion and Sediment Control Handbook, p6.10).

Shrubs and wood chip mulch are used as permanent landscaping control methods of erosion. They can act as a control to hold large soil masses together. Unique sites, such as desert conditions or high elevations, can be prime sites where native shrubs can be effective. Shrubs that are native to an area can be transplanted to slopes or areas affected by erosion. These shrubs are adjusted to the local soil type and conditions (Erosion and Sediment Control Handbook, p6.11).

Like shrubs, trees have a difficult time being effective immediately due to the long growing time. Trees provide a canopy to shelter loose ground under the tree, while still holding the soil stable on a slope (Erosion and Sediment Control Handbook, p6.12).

2.4.2 Commercial Products

Wood chips or mulches are commonly used to supplement the erosion control effects of grasses, shrubs and trees. Products consisting of natural and synthetic tissues are currently available. These products duplicate the positive effects of vegetation in areas that are susceptible to erosion.

Northeast Distributors carries a variety of products to control sediment erosion. Two common products are *EcoAegis* and *EcoFibre*. *EcoAegis* is sprayed onto slopes and inclines to prevent erosion. The material itself is a bonded fiber matrix of wood fibers. These shredded fibers act as an "interlocking" process that holds the slope together, preventing erosion and the impact of rain and wind. *EcoFiber* is a natural material with no chemicals that could possiblly slow or prevent growth. This product is applied in a similar manner and provides similar protection as the *EcoAegis* (http://www.hydrograsstech.com/hgt-&2homepage.html).

Like the mulch products, GEOCOIR/DeKoWe is a textile that prevents erosion. The fibers are woven from coir, a type of hair located on the husks of coconuts. This product is all natural without any synthetics. This geotextile is best suited for stabilization of soil, reinforcement, landscaping, and erosion control. GEOCOIR/DeKoWe claims that it has the following qualities: handles high water velocities, ultra-violet resistant, has high tensile strength, biodegradable in 4-10 years, is water absorbent, accepts hydro-seeding, can plant through fabric, is flexible, traps sediment, blends with the environment, is economical, is effective on all soil types, and aesthetically pleasing. It can be effective in the following applications: waterway bank stabilization, silt fencing, revegetation projects, slopes and inclines, channel revegetation, and resedimentation projects (http://www.hydrograsstech.com/hgt-&2homepage.html).

2.4.3 Dry Detention Basins

Dry detention basins are very effective for pollution control of large bodies of water. This device is a detaining area where storm water collects before it moves on to the stream. The purpose of this structure is to allow suspended solids, pollutants, and nutrients to settle out in this basin when the velocity of the water is relatively stagnant or moving slowly. By holding the storm water back, this prevents flooding of the stream and erosion of its banks. These detention basins are very effective at allowing pollutants to settle out. This device can work well in both large and small communities. The release of the water is solely dependent on the engineering of the basin. The release of water can be modified depending on the situation in which the runoff occurs. If the area is already quite wet, the ground will not be able to absorb a lot of water. The release would be delayed in this type of environment. The opposite would occur if the area were especially dry. This structure is referred to as a “dry” detention basin because the device dries up between intervals of rain (Erosion and Sediment Control Handbook, p8.4).

Dry detention basins can be very unpleasant if not properly maintained since they can generate a foul smell. If trash should be washed into the drains, that trash will float there until it is removed. Landscaping is often used to make the dry detention basins more aesthetically pleasing. Maintenance of a dry detention basin is extremely important to the health of the basin and the water into which it leads. Regular upkeep of the basin is important to unclog drains and pull out debris so that water does not become stagnant (Erosion and Sediment Control Handbook, p8.4).

2.4.4 Porous Pavement

The purpose of porous pavement is to reduce surface runoff. This can be done in two ways. The first method makes use of either concrete or asphalt but without the finer particles. Then it is laid over a thick layer of gravel or crushed stone. The second method involves laying a geo-textile to prevent soil from coming upwards. Then interlocking open-cell cement blocks are laid on a bed of gravel or crushed stone; interlocking open-celled blocks are largely more successful. This can not be a solution for a heavily traveled road, however. The road needs to exclude heavy machinery and large hauling trucks. Treatment of the runoff is done through adsorption, filtration, and microbial decomposition under the surface of the road (Erosion and Sediment Control Handbook, p7.18).

Unfortunately, porous pavement is not very successful. Due to excessive clogging, improper construction, sediment build up and resurfacing, drainage problems are common. These problems cause the pavement to seal. Although generally unsuccessful, porous pavement can very successful if proper maintenance is followed. Frequent sweeping, hosing, and vacuuming can maintain the porous nature of the area (Erosion and Sediment Control Handbook, p7.19).

2.4.5 Common Control Structures

A "riprap" is another common practice to prevent erosion at water outlets. This preventive measure is a channeled runoff, which is usually lined with larger stones to prevent erosion and to collect flowing sediment if the velocity should carry it (Erosion and Sediment Control Handbook, p7.16).

A very common and simple sediment collection method is the sediment trap. Construction areas are often a source of sediment runoff and erosion. Sediment traps can consist of straw bale dikes, silt basins, and silt basins that are located below the areas where construction occurs. This technique can also be used in situations to hold up or slow runoff. Silt fences and straw bails can be placed on declines for this purpose. Sediment basins on this incline can collect storm runoff, allowing the runoff to settle. After time, the sediment will settle leaving behind only silt. If the silt should be unhealthy and in large quantities, it could be costly to remove on a large scale. Many basins on a small scale would be effective (Erosion and Sediment Control Handbook, p8.3).

Dikes are an important method for erosion prevention and for directing the eventual settling of sediment. A diversion dike is mounded earth either placed at the top of a runoff site or slope, or going across and down the slope to divert the flow somewhere appropriate. An interceptor dike is a little different from the previous. It is built across "graded roads" to catch runoff and bring it to a place of vegetation or settling area. These structures are often built of compacted soil and crushed stone (Sedimentation Engineering, p25).

2.5 Urban Runoff Control Methods

The methods used to fix sedimentation problems in a rural setting may not apply to the problems of an urban area. The environment under discussion is an urban setting, and there are some additional control methods specific to urban and suburben environments including the elimination of curbs, debris removal, exposure reduction and proper landscaping and lawn maintenance controls (Sedimentation Engineering, p28).

2.5.1 Elimination of Curbs

The removal of some sections of curbing has been shown to reduce the quantity of pollutants being deposited in streams. Curbs are often made from concrete or asphalt. These act as channels that collect storm water into storm drains, carrying pollutants with it to its destination. By removing the curb, bordering vegetation that can soak up pollutants slows water flow and settles polluted sediment. Of course, the curbing system can not be abandoned. Only sections should be removed at certain areas to avoid erosion. Street cleaning and other maintenance practices should be executed to prevent garbage build up and erosion (Sedimentation Engineering, p31).

2.5.2 Debris Removal

As mentioned in the previous section, outlets, storm drains, catch basins and grates need maintenance in order to be effective. This is very important to the health and stability of the control structure. If debris, leaf litter, or grass should clog the drain, storm water will flood the road causing transportation problems. Because of this flooding, erosion will occur and cause sediment to appear in the runoff. This sediment will eventually end up in the catch basin and travel with the stream (Sedimentation Engineering, p36).

2.5.3 Exposure Reduction

A very easy way to prevent hazardous chemicals from getting into ground water and streams is to prevent the chemicals from combining with rain. Merely covering the pollutant with a silt fence or erosion control material can prevent the salt from washing into the ground. This very easy and inexpensive method can be very effective in anti-pollution controls. Another preventative measure is the "Move or Remove" practice. This is when machinery, chemicals, and manufacturing products that could be hazardous are moved into an indoor location so that no rain washes over them, which would create polluted runoff. The Environmental Protection Agency refers to this practice as "Maintenance or Good House Keeping." It involves site cleaning, recycling of industrial materials, the filling of leaks, preventing of spills, planting of vegetation to avoid erosion, and cleaning (sweeping) of parking lots and areas where materials could get washed into catch basins and storm drains. One of the most important preventative measures in the area of "Good House Keeping" is proper training of personnel in responding to accidents or spills (Sedimentation Engineering, p42).

2.5.4 Landscaping and Lawn Maintenance Controls

Pesticides and fertilizers can be a problem if they are applied improperly or in large amounts. At times, lawn service professionals can over fertilize to please the customer. Through storm water and service watering, these chemicals can leach into the ground water, or wash out of the soil into a body of water. Ordinances can be used to prevent this problem. These ordinances, focused on large areas of landscaping, could mandate certain types of fertilizers or plants that require less of the fertilizers. It is also encouraged that homeowners and amateur gardeners use proper amounts to avoid ground water contamination (Erosion and Sediment Control Handbook, p10.2).

2.6 Nonstructural Management Practices

Sediment deposition can be slowed or stopped without the use of a synthetic structure. In many situations, laws regulating construction practices or paving materials can stop the process of erosion and curb stormwater runoff. Proper enforcement of any type of legislation is required for the regulation to remain effective.

Many governments focus on Best Management Practices, which include legislation, better ecological management practices, and education of the public regarding the causes and preventative measures of nonpoint source pollution (www.epa.gov/owowwtr1/NPS/ ordinance_old/erosion.htm).

Large cities, including Washington D.C. and Seattle, are developing "Green Space" programs. These programs encourage tree growth, overall environmental health, and biological integrity. They are meant to "connect natural areas while providing recreational areas." (www.epa.gov/owowwtr1/NPS/ ordinance_old/erosion.htm). A similar project is the Evergreen Agenda Project in the state of Washington. This project is a fund in which local communities can purchase land for conservation.

The Florida Everglades Protection Act mandates that storm water drainage must be treated before emptying into the Everglades, so that phosphorus levels stay low. The Southwest Florida Management District set up ordinances for small communities to follow. The ordinances consisted of protection of habitats, the establishment of vegetative buffer zones, and protection of riverbanks from erosion. Washington and New Jersey each have waterways that are carried by artificial concrete channels. They require storm water tests to ensure that the channels can support the high velocities of the urban runoff. Massachusetts and New Jersey ordinances also require buffers of various distances between construction and wetlands or places of possible erosion (www.epa.gov/owowwtr1/NPS/ ordinance_old/erosion.htm).

These are only a few examples of nonstructural sediment controls. Controls vary between communities. Some communities organize storm drain stenciling, street sweeping on bridges, recycling of oils and coolants, and establishment of education programs concerning herbicides and pesticides (www.epa.gov/owowwtr1/NPS/ordinance_old/erosion.htm).

2.7 Sediment Problems at the Great Lakes

Sedimentation and soil erosion contribute directly to the pollution level in the Great Lakes and the eventual overall health of the Great Lakes basin. The Great Lakes Basin Program (GLBP) was set up to improve the water quality by controlling sedimentation. This program includes stakeholders that have a personal interest in this problem, such as farmers, property owners, developers and contractors, local officials, and the general concerned citizen (www.glc.org).

Construction, lumber, agriculture, and mining industries intensify the sedimentation problem in the Great Lakes. The problem becomes worse when this runoff picks up chemicals, such as phosphorus, nitrogen, and toxic manufacturing chemicals, pesticides and heavy metals. The sediment then brings these chemicals to the Great Lakes and its surrounding waterways. From this chemical deposition, algae blooms become a potential threat (www.glc.org).

One recommendation of the Great Lakes Basin Program was to improve public knowledge and awareness of sediment deposition. The report of the GLBP explains the problems that sedimentation and its subsequent pollution can cause in detail. It continues by stating that people living in the area could be affected in a variety of ways including flooding that could cause massive erosion of property on the coast. As sediment makes its way into the Great Lakes, water quality is affected which directly affects the people in the area. The presence of sediment increases the amounts of nutrients and minerals in the water. These plants breath by a process know as respiration and grow very quickly. The oxygen level of the water decreases as a result of an increase in respiration. The final product of the process is a decrease in the numbers of fish and animals able to live in the area. Riverbank vegetation is also at risk due to rapidly moving waters, which erode the soil and eventually uproot the existing vegetation. From this eroding soil, crevices in which fish lay eggs are filled with sediment or cover the already laid eggs (www.glc.org).

The report of the GLBP continues by citing specific methods used to fix the problem. Dredging occurred in several areas to remove sediment. Over a million dollars was spent to dredge Duluth-Superior harbor so that navigating the harbor would be possible. One of the most incredible statistics mentioned in the program was that 10,000 tons of topsoil was eroded by two inches of rain in a matter of twenty minutes. The implication of this statistic is that this problem is not over. Unless other measures are taken, the money spent on dredging will have been wasted (www.glc.org).

The GLBP report states that the sedimentation problem in the Great Lakes, though being worked on, is still serious. There are several federal bureaus that deal specifically with this problem, specifically the U.S. Department of Agriculture's Soil

Conservation Service (SCS) and the Agricultural Stabilization and Conservation Service (ASCS). These two groups provide technical help and financial support, respectively. Locally, the districts involved with water conservation offer assistance to land users, like farmers, by giving them best management practices for sedimentation and erosion control and water quality protection techniques (www.glc.org).

Internationally, the United States has an agreement with Canada, the "Great Lakes Water Quality Agreement," to reduce sedimentation and erosion into the Great Lakes. This agreement calls for each country to "designate Areas of Concern and develop Remedial Action Plans where persistent water pollution is impairing the area's ability to support aquatic life or sustain beneficial water uses; establish phosphorus load reduction targets to minimize water quality impacts in the lakes; and provide guidelines for the reduction of non-point source pollution from land use activities." These programs are making strides to help non-point source pollution, but the problem of sedimentation and erosion into the Great Lakes is not being solved. The Great Lakes Commission an Soil Erosion/Sedimentation Task Force believes that the Great Lakes Basin Program and government agencies need to create some legislation and best management practices to improve the overall quality of the water (www.glc.org).

2.8 Past Studies of Salisbury Pond

Both the Mill Brook watershed and Salisbury Pond have been studied in the past. Before the process of dredging began in 1973, a study of Salisbury Pond was conducted. The contents of this document center around the characteristics of the water, including turbidity, biochemical oxygen demand, nitrogen content, and pH. These factors were used as proof that a problem with Salisbury Pond existed. The source of this problem was left for another study (McLaughlin, Nelson and Weimerskirch, 1973).

In 1981, Joseph McGinn of the Department of Environmental Quality Engineering devised a sediment control plan for the Blackstone River. This report used metallic content to prove that a problem existed. Again, the source of this problem was not discussed (McGinn, 1981).

In 1997, WPI students conducted two separate studies of the river. Nonpoint source pollution was the focus of one study (Andrus and Parette, 1997), while nonpoint source pollution and suggested solution methods were addressed in the second (Catlow and Holcomb, 1997).

3.0 Methods

The goals of this project were to determine the primary sources of sediment around Mill Brook and Salisbury Pond, to investigate alternative control measures, and to recommend appropriate solutions. To accomplish these goals, the following methodology was designed and implemented. Information was gathered by conducting interviews, reviewing topographical and sewer layout maps, and performing site walks before and after storms occurred. A more detailed description of the types of information collected as well as the means for data collection is given in this chapter.

3.1 Determination of Sediment Sources

Throughout the course of the project, several methods of finding direct evidence of sediment sources were discussed. One of these methods was to analyze the sediment at various locations along the Mill Brook and determine its metallic composition or particle size to pinpoint a possible source. These direct methods were not used due to time constraints and the intentionally non-technical nature of this project. The following methods are more subjective and attack the problem indirectly but effectively. These methods were chosen because of their ease in use and understanding.

3.1.1 Interviews of Experts

Interviews were important to the success of this project. Talking to the people that are directly involved with the fight to save Mill Brook and Salisbury Pond was effective in gathering opinions about the major sources of sediment present in the surrounding area. The people interviewed have each spent the majority of their lives working in the fields of environmental protection, environmental management, or stormwater management. Due to the subjective nature of sedimentation, it was necessary to use the opinions of informed individuals to find a basis on which to build. Despite our best efforts to ask objective questions, some of the responses seemed opinionated which could be due to the nature of this problem (Qualitative Research Methods for the Social Sciences, p77).

Mr. Joe Buckley, of the Department of Public Works-Sewer Division, was knowledgeable in the areas of storm drain management and sewer design. Tristan Lundgren, director of the Blackstone River Coalition, was asked in detail about the general state of the river and the history of the area. Terry Mounce and Ginny Scarlet, of the Massachusetts Department of Environmental Protection, were interviewed for information concerning current regulations and watershed management. Anne Sullivan and Butch Olsen, of the Massachusetts Highway Department- District III, were helpful in discussing the subject of highway runoff with specific reference to Interstate Route 190. Chris Scholl, Environmental Manager of Norton Company, was consulted on the environmental practices of his company and the conditions of the property owned by Norton Company. Doug Frost, CEO of Frost Manufacturing, gave corporate insight as well as a life long perspective of how Salisbury Pond has changed due to sedimentation. Brent McCarthy, an environmental engineer with Camp, Dresser, & McKee, was able to give a professional opinion of the problem.

The types of interviews performed in this project were semi-standardized. A semi-standardized interview involves asking a number of pre-determined questions. Questions are typically asked in a consistent and systematic order, but interviewers are allowed freedom to digress if the interviewee goes off track on a relevant topic. In other words, an interviewer is permitted and even encouraged to probe for information beyond that asked of the prepared questions.

The set of pre-determined questions the interviewer uses to keep on track is called a questionnaire. The questionnaire is written in a particular manner. The questions in the beginning of the interview are very simple in order to develop a good rapport with the interviewee. Doing this is crucial in gaining his or her attention and making sure both the interviewer and interviewee are on track. The questions in the middle of the interview are more difficult to answer and begin to convey the goal of the study. The remaining questions are specific to the goal of the interview. If the questionnaire is worded properly, the interview will remain on schedule and the desired information will be obtained. It is important for the interviewer to keep the interview on schedule and not allow the interviewee to avoid the topic unless the information is useful to the study.

The questionnaires used in the interviews of the Mill Brook Task Force members and other officials are provided in Appendix A: Questionnaires.

3.1.2 Examination of Maps

Maps were reviewed to identify possible sources of sediment in a given area. Topographical maps provide a layout of the surrounding area and are especially useful in identifying large elevation changes. Since water flows downhill, potential heavy flow areas were marked on a map and subsequently visited. Sewer maps were helpful in understanding the sources and destinations of piped water. The Department of Public Works was able to supply the necessary topographical and sewer maps to cover the Mill Brook Watershed. The Massachusetts Highway Department provided maps of the same area. These maps show Interstate 190 and the control structures located in the general vicinity.

3.1.3 Site Walks

Site walks were another important method of identifying major sources of sediment. On a site walk, existing sediment, possible sources of sediment, and sediment control measures that are currently in use were viewed first hand. Walks performed shortly after a storm, or "wet" walks, were useful to see where the water flows in large quantities and at high velocities. Fast moving water can beat down vegetation, carry sediment, and deposit sediment on the vegetation. This can clearly show the path of travel that the water takes. Dry site walks, or site walks that occur before a storm, were used as a baseline for comparison.

While conducting wet and dry site walks, photographs of the existing sediment control structures, unpaved roads, and the surrounding environment were taken. These pictures were helpful in identifying the need for a solution to this problem since they provided the visual evidence that sedimentation on the surrounding vegetation is occurring. While taking these pictures, observations for each site were made and recorded. These observations included, among other things, the condition of any surrounding vegetation and the types of control structures in use.

3.2 Evaluation of Control Options

The first step in examining and recommending control measures was to understand the current laws and regulations governing sediment control and water quality. Laws that deal with settling basins, urban runoff, and current control methods were especially useful to the eventual suggestion of solutions.

Current control methods along the Mill Brook were examined and evaluated during site walks. Evaluation of these methods was done through a study of their past performance and the recommendations of industry professionals including Chris Scholl of Norton Company and Tristan Lundgren of the MBTF.

An investigation of street and catch basin cleaning schedules, routes, and routines was effective in discovering ways to improve the general maintenance or "housekeeping" of streets and highways. These schedules were provided by the Massachusetts Highway Department and the Worcester Department of Public Works.

3.3 Analysis

The information gathered by the methods described above was analyzed in a number of ways, specific to the type of information. To analyze the information gathered by interviewing members of the MBTF, common themes were identified. In this way, the largest contributors of sediment were hypothesized and the most effective control methods were also suggested. Suggestions for control methods were then compared with information from our literature review, addressing both technical and non-technical solutions.

Topographical maps were used to find the highest elevation differentials. Using these differentials, we predicted where erosion was most likely to occur. The elevation differentials were also used in conjunction with visits to private, unpaved roads. Observations were made to determine if the problems on these streets were serious or trivial. Sewer maps were examined to see the paths of piped water in the surrounding area. They were specifically useful in identifying the double box culvert that houses the Mill Brook.

Site walk information was analyzed by compiling the data into a site walk log and identifying changes that occurred in the areas of visitation. Because there was a dry spell between the months of October 1999 and December 1999, the frequency of wet site walks was much lower than expected. Therefore, the wet site walks that were performed weigh heavily in our recommendations.

4.0 Results

Information gathered about sediment sources and control options is presented in this chapter. The opinions of the people interviewed are presented in an objective manner and will be analyzed in a subsequent chapter. The observations obtained from performing site walks and examining maps are also described in this chapter.

4.1 Interviews

Much of the information gathered by this project was found by conducting interviews. Appointments were made with members of the Mill Brook Task Force. The goal of these interviews was to compare the perspectives of Worcester City, Massachusetts State, and area industry representatives. Worcester City representatives include Joe Buckley of the Department of Public Works and Phil Jakubosky of the Department of Public Health. State officials include Terry Mounce and Ginny Scarlet of the Department of Environmental Protection and Anne Sullivan of the Highway Department. Doug Frost of Frost Manufacturing and Chris Scholl of Norton Company represented the industry perspective. Tristan Lundgren, the coordinator of the Mill Brook Task Force, was also very helpful.

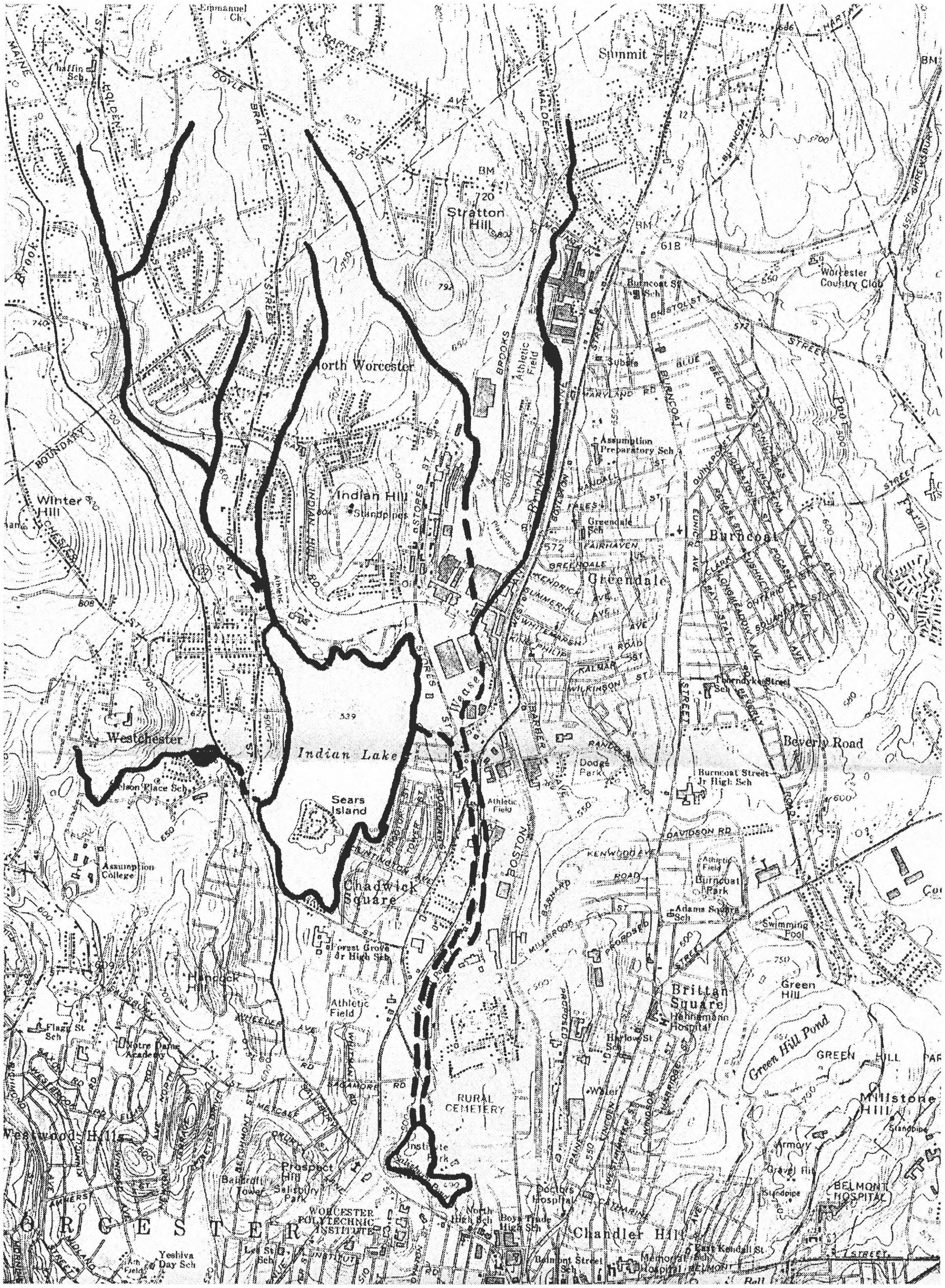


Figure 1: The map above shows the Mill Brook. The dashed lines represent the double box culvert that empties into Salisbury Pond.

4.1.1 Sediment Sources

Mr. Jakubosky of the Worcester Department of Public Health, explained that many storm drains located near the culvert are a "straight shot" into the culvert. He explained that because storm drains are put at the bottom of a decline, the rain, which carries sediment, is moving at a high velocity. Sediment is collected in these storm drains, and, when a storm comes, the sediment is disturbed. It is then able to go into the culvert. He continued to explain that the sedimentation problem Salisbury Pond is not due to the large particles in the street sand. The larger and heavier particles settle out and gradually work themselves to the bottom of the Mill Brook. The problem is with lighter particles that are easily disturbed. Doug Frost of Frost Manufacturing mentioned silt as an example of these smaller particles. The silt is suspended in the water and follows the culvert directly into Salisbury Pond. He continued to say that this problem is a growing one, and action needs to be taken immediately.

Chris Scholl said that the water table at Norton Company is approximately 3 to 4 feet. From time to time, Norton's old pipes may burst or break. Excavation of the immediate area is required to fix these pipes. During this process, water is continuously being pumped out. This volume of water can be very large and may contain a substantial amount of sediment. Norton uses control measures such as holding tanks and other structures to lower the amount of sediment entering the brook. Unfortunately, some water containing sediment is able to pass through the structures and into the storm drains, which flow into the brook.

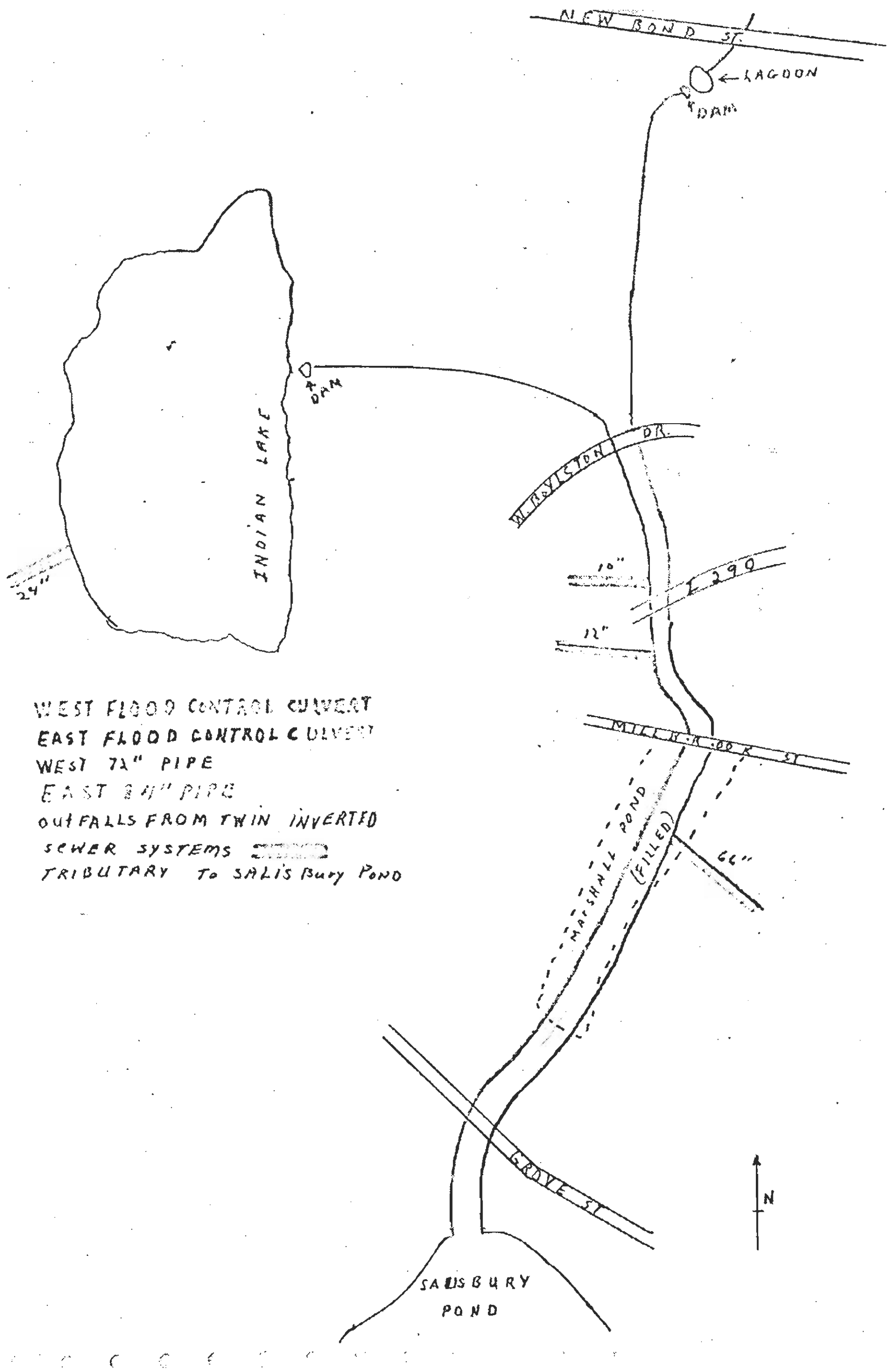


FIGURE 2: LOCATION OF MARSHALL POND WAS BEFORE IT WAS FILLED. THE DOTTED AREA REPRESENTS THE DOUBLE BOX CULVERT.

Mr. Buckley, of the Worcester Department of Public Works, explained that the biggest change affecting the Mill Brook in the past twenty-five years has been construction practices. He said that when much of the Mill Brook area was developed, there were no sediment control measures. In the last five to ten years, however, there has been legislation to change the codes governing construction to prevent erosion and sedimentation. He continued to say that there once was a pond (Marshall Pond) where Harr Ford is presently located, but it was filled in the late 1950's. Figure 2 shows the prior location of Marshall Pond. This was before the Clean Water Act and the Wetlands Protection Act. According to Brent McCarthy of Camp, Dresser and McKee, Marshall Pond served as a natural settling basin. Because there are no control structures of similar size located upstream from Salisbury Pond currently, the urban runoff and storm water flowing through the culvert moves at a high velocity. This causes erosion and the eventual deposit of sediment.

Mr. Buckley of the Worcester DPW also said that in the past, storm water management was ineffective. This includes construction procedures, catch basin architecture, and street maintenance practices. Recently the local agencies, including DEP and DPW, have done a much better job by using more effective catch basin designs and increasing the frequency of maintenance. These catch basins are built with a deeper area to store more sediment. They also have curved outflow pipes that accepted water from below the surface. In this way, oil is left in the basin and cannot continue into the culvert. Worcester DPW is doing all that it can to manage over 15,000 catch basins in the city. Mr. Buckley believed that storm water runoff from Interstate 190 is a large problem in the area, however.

Terry Mounce and Ginny Scarlet, of the Massachusetts Department of Environmental Protection, explained that the place of concern in Salisbury Pond is at the mouth of the Mill Brook and the western corner of the pond. As the water comes out of the culvert, it scours the soil in the pond. As water continues into the pond, the sediment settles and large deposits are formed. In a canoe investigation, they found that water depth in this area, once measured at one meter in 1987, is now approximately five inches in some places. If this continues, these deposits will eventually rise above the water level and form small islands. These islands represent the first signs of marsh formation. As this continues, the pond will fill in completely making restoration almost

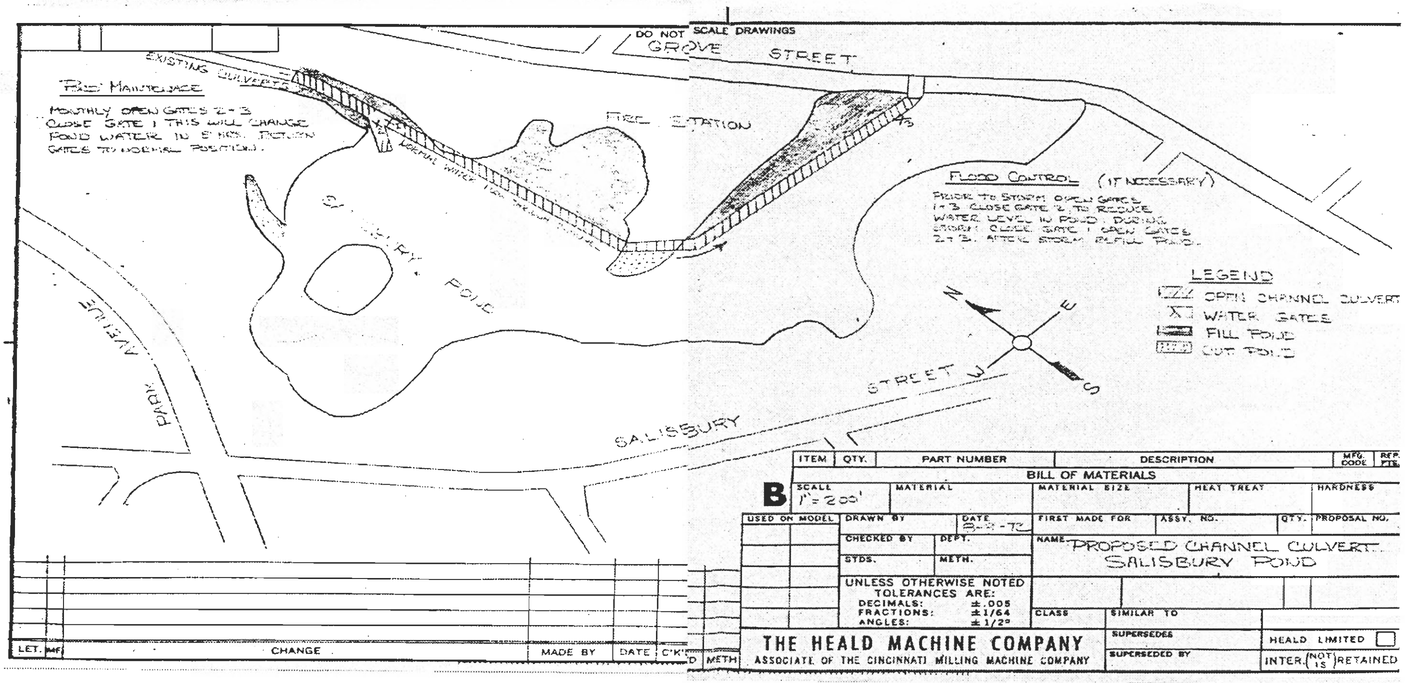


FIGURE 3: THE BYPASS SYSTEM GOING THROUGH SALISBURY POND CAN BE SEEN IN THIS PLAN. THIS IS TO ALLEVIATE THE STRESS OF BEING A SETTLING BASIN, ON SALISBURY POND.

impossible. Both DEP officials believed that the main sources causing sedimentation are from the treatment of roads with sand in the winter, weak environmental construction site practices, oil and sand volumes running off of parking lots, and storm water runoff from private unpaved roads.

4.1.2 Control Options

Phil Jakubosky of the Department of Public Health believed that a structure or a series of structures simulating the positive effects of Marshall Pond would be most effective in controlling sedimentation in Salisbury Pond. Joe Buckley of the Worcester Department of Public Works suggested that an underground control structure be built upstream to relieve sediment stress placed on Salisbury Pond. As an alternative, he suggested that a tunnel or culvert be built to completely redirect the Mill Brook around Salisbury Pond as shown in Figure 3. This way, no further sediment would enter the pond. Both Mr. Buckley and Mr. Jakubosky explained that, in order to permanently solve this problem, it is important to stop sediment from coming into Salisbury Pond. The location of any control structures is a source of concern since businesses currently occupy the area in question.

According to Doug Frost of Frost Manufacturing, upstream sediment control is necessary to prevent the Salisbury Pond from becoming polluted with the sediment. Mr. Buckley believed that better "housekeeping," or maintenance, of Interstate 190 by the Massachusetts Highway Department would reduce the effects of sedimentation from the stormwater coming off that highway. He continued to say that the Worcester DPW is doing the best job that it can in keeping up with the maintenance of catch basins. Ginny Scarlet of the DEP also stated that the DPW is doing all that is possible to prevent the problem through their current maintenance practices.

The non-technical solutions of the sedimentation problem were mentioned at length by the DEP representatives and reinforced by Mr. Jakubosky. He believes that the solution needs to start with the Mill Brook Task Force. The Health Department is part of a team whose goal is to end sediment deposition in Salisbury Pond. He feels that a project of this magnitude needs to be a "city-wide effort." Mr. Jakubosky mentioned that public awareness is a major step in solving the problem but raising public interest is a difficult task. He said that there were many more complaints concerning the Mill Brook and Salisbury Pond back in the 1970's than there are in the 1990's. He feels that Institute Park does not have a large draw for many citizens in the Worcester area and that people are more likely to go somewhere else to picnic or play. This results in a general lack of public interest to solve the problem.

Ginny Scarlet and Terry Mounce agree that the public needs to be more involved in solving this problem. They suggested a program that would introduce the problem of sedimentation in the Mill Brook to citizens in the immediate area. The program would also explain that this problem affects everyone in the community. Another method of generating public interest is the inception of community watch posts. On problematic roads, a citizen in the area would be responsible for monitoring a catch basin, making sediment depth measurements, and notifying the Department of Public Works if maintenance is required. This program could be established using literature, public broadcasting, and community programming. By giving the literature to the individual personally, a connection is made and the citizen is more likely to become involved.

Doug Frost of Frost Manufacturing recalled the days when Salisbury Pond was used as a division for the WPI Freshmen-Sophomore rope pull. This annual event is no longer held across the pond due to pollution and sedimentation. Mr. Frost would like to see the pond clean enough for students to again use the pond as a barrier. Mr. Frost agreed with the other interviewees that a control structure is needed at the mouth of the Mill Brook to filter out sediment entering Salisbury Pond. His vision includes a wall placed before the pond that will slow the water down. In this area, sediment can filter out and this basin can be emptied from time to time. An oil boom could be placed atop this structure to remove oil from the water.

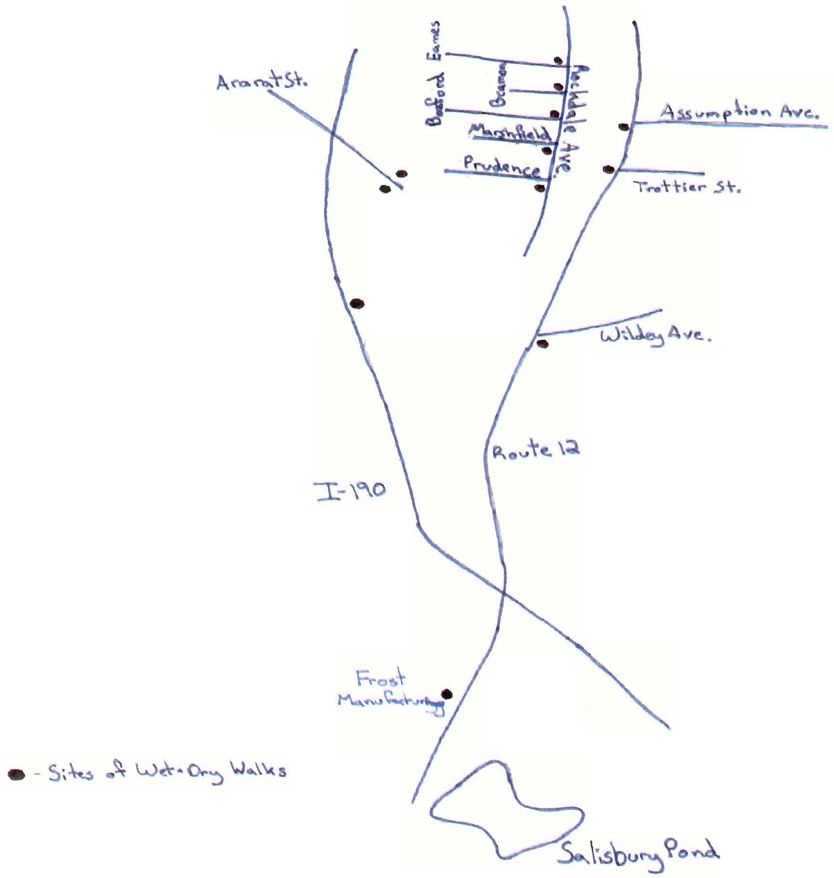


FIGURE 4: LOCATIONS OF WET AND DRY SITE WALKS.

4.2 Examination of Maps

Topographical maps were examined to determine where water erosion is most likely to occur. Unpaved roads located in the watershed including Eames Road, Beaman Avenue, Boxford Street, Marshfield Street, Prudence Street, Assumption Avenue, Trottier Street, Wildey Street were visited as well as control structures located on

Interstate 190 and Norton Company properties. These visitation sites are shown on Figure 4 and in the topographical map attached to this document.

4.3 Site Walks

For the purpose of this project, a dry site walk is a walk conducted when no precipitation is visible on the ground. Dry site walks were conducted to be used as a baseline in making visual observations. Wet site walks were conducted and the information gathered on these walks was compared with the information from the dry site walks. The locations of these site walks are provided in Figure 4. This is an important process when trying to find the major contributors of sediment in the Mill Brook Watershed. A log of the site walks is presented below.

Site Walk Log

September 17, 1999- A wet site walk was conducted during Hurricane Floyd. We visited Ararat Street and observed the rapid pace in which the water pushed the vegetation down and poured out of the riprap. The water from the very small marsh was moving at an extremely quick pace. On the other side of the street, closest to Norton Company, water was coming out of the riprap at a high rate of speed. Because of the pitch of the street, the water was flooding down the street and over the street shoulders washing sand and other street material into the brook. We also visited Frost Manufacturing, seeing that the water was up to Mr. Frost's drive way and moving at a high rate of speed.

September 23, 1999- With Professor Demetry and Environmental Manger Chris Scholl, we were able to visit the facilities at Norton Company. We looked at the sediment basin off Interstate 190. The water was moving at a low velocity from the structure. Sediment was visible on top of the vegetation close to the Norton Company property line. We continued to examine control structures on the property along with a marsh located on Ararat Street. Water flow under the street can be seen in Figure 5.

FIGURE 5: HIGH VELOCITY OF WATER COMING DOWN ARARAT STREET. AT A HIGH VELOCITY, THE EROSION OF THE ROAD SHOULDER AND STREET SAND IS EXTREMELY LIKELY.

November 10, 1999- A dry site walk was conducted at the sediment basin off Interstate 190. The flow of water coming out of the pipe was minimal. It looked as if there were only a couple inches of sediment in the basin, but it is difficult to determine the depth of the basin. From the pipe, water trickled under a chain link fence onto the Norton Company property. We found no significant sediment on the vegetation in the path of the

FIGURE 6: A SMALL MARSH LOCATED OFF ARARAT STREET. THE SWIFT MOVING WATER FORCES THE VEGETATION PRONE, MAKING ITS ABSORPTION AND FILTRATION ABILITIES USELESS.

water coming out of the structure. Ararat Street had no evidence of strong water flow and vegetation was upright as shown in Figure 6. The pipe leading across the street was dry.

November 18, 1999- Because of light precipitation the night before, a wet site walk was conducted. The sediment basin off Interstate 190 looked the same as the week before. There seemed to be a little more water flowing through the basin, but nothing of real significance. The sediment levels within the basin and on the surrounding vegetation looked the same. A stronger storm would more effectively show the paths of water flow and sediment.

November 22, 1999- A dry site walk was conducted and Interstate 190 was visited. Due to the lack of precipitation there did not appear to be any significant change in the amount of sediment or water flow from the previous week.

December 1, 1999- A dry site walk was conducted at the sediment basin off Interstate 190. Nothing was changed from the previous visit. Off West Boylston Street, Assumption Ave and Trottier Street are private streets that are unpaved. In our dry investigation of the streets, we found that the streets had a steep grade, were in very poor condition, and had a catch basin at the bottom of the street. The streets had been paved once before but a lack of maintenance has caused this asphalt to become partially eroded. The holes are filled with gravel and sand. We suspected that this may be a potential problem, and a wet site walk was planned to seek more evidence.

December 8, 1999- A dry site walk was done in the area of Rockdale Ave. The streets that look as if they are a problem due to their grade and lack of pavement are: Eames Road, Beamon Ave., Boxford Street, Marshfield Street, and Prudence Street. These private roads are very poorly maintained. They have catch basins at the bottom of each street, so the potential for erosion and deposition of sediment in the catch basins is very high.

December 13, 1999- There was a strong rain storm the previous night, so we conducted a wet site walk. This was a good opportunity for observations, because the ground was completely saturated. We first went to the sediment basin off Interstate 190. The water was rushing out of the pipe into the sediment basin. The sediment level in the basin looked lower than the previous observations and we suspect that the rushing water cut away the settled sediment. The volume of the water was high so the probability of erosion is high. Examples of control structures and environmental conditions are shown in Figures 6 through 8.

FIGURE 6: SEDIMENT BASIN FOUND ON INTERSTATE 190, CONTAINING SEDIMENT FROM THE HIGHWAY RUNOFF. ACCUMULATION OF THE SEDIMENT CAN CAUSE A PROBLEM. WATER MOVING AT A HIGH VELOCITY CAN ERODE THIS SEDIMENT MOVING IT INTO THE MILL BROOK.

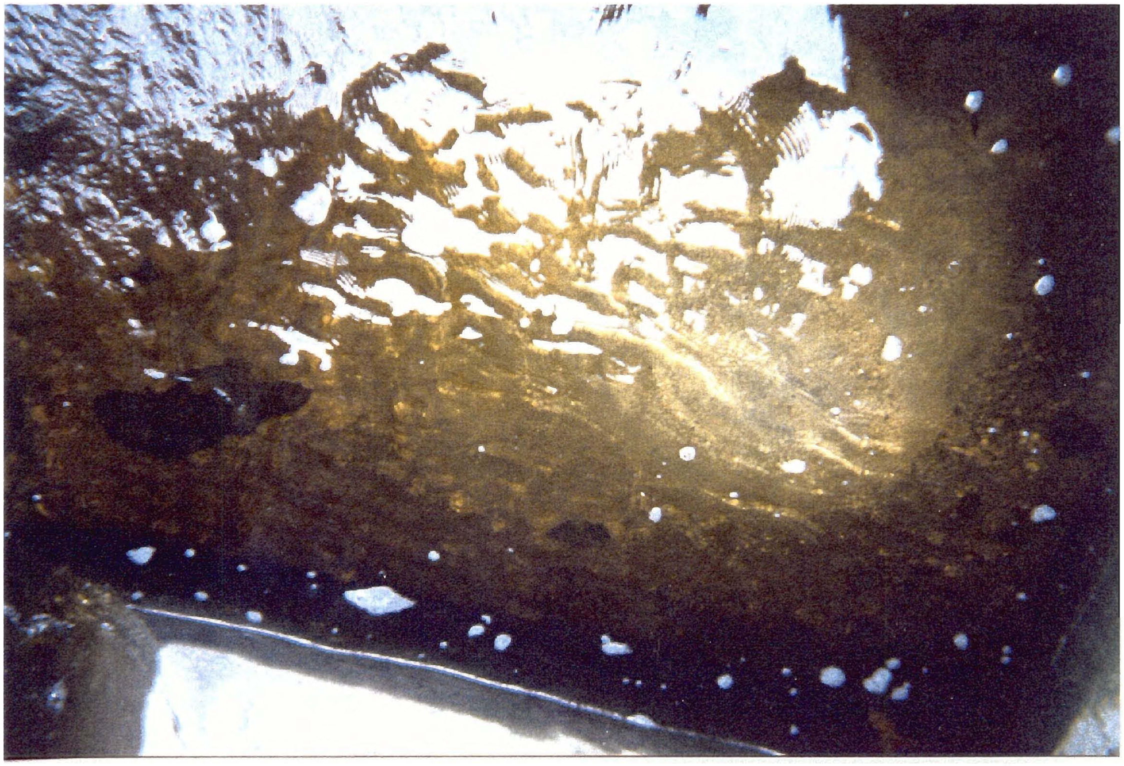


FIGURE 7: WATER MOVING AT A HIGH VELOCITY IN A SETTLING BASIN LOCATED OFF I-190.

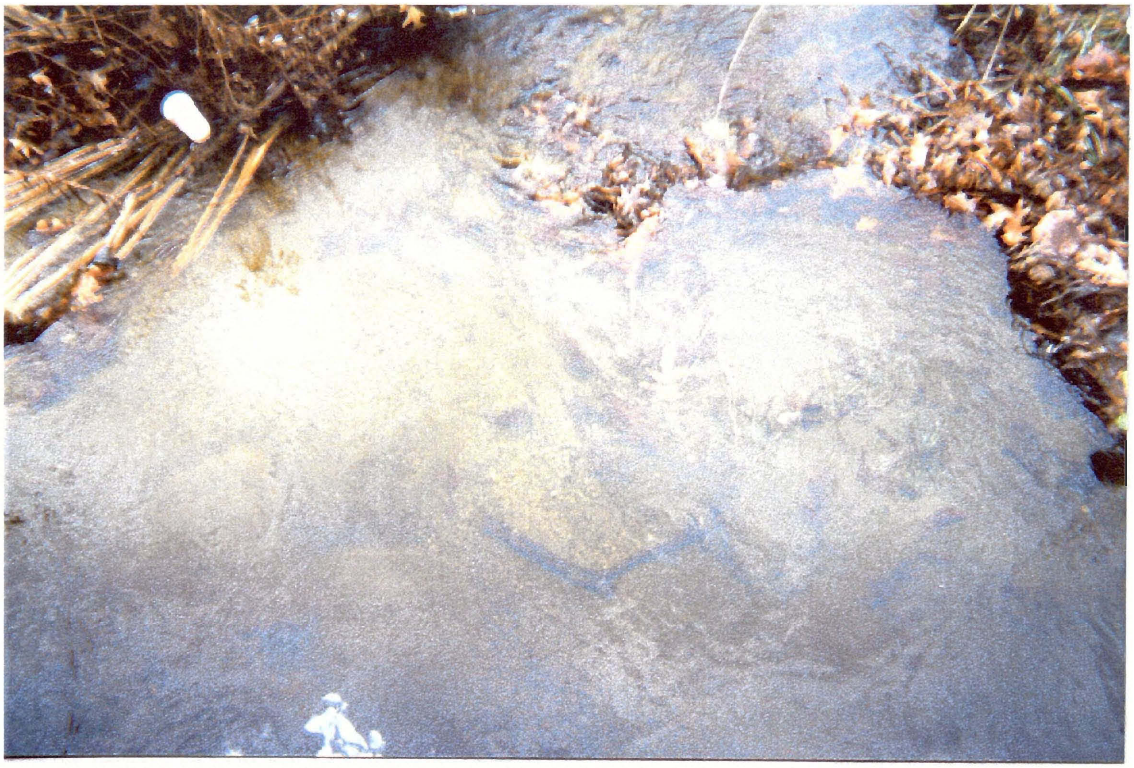


FIGURE 8: SEDIMENT ACCUMULATION AT THE EXIT OF A SEDIMENT BASIN LOCATED OFF I-190. FAST MOVING WATER FROM THE SEDIMENT BASIN CAN EASILY ERODE THIS SEDIMENT, WASHING IT INTO THE MILL BROOK.

We then went to Assumption Ave. shown in Figures 9 and 10, Trottier Street, and Wildey Street shown in Figures 11 and 12. There we saw water flowing down the street and into the catch basin, which was covered and somewhat clogged. The streets were full of puddles. The water had eroded the gravel and sand that had been observed previously as filler in pavement holes. In the Rockdale Ave. area, the catch basins were full of leaves and trash. The water had worn grooves through the cracked pavement. There seemed to be more loose sediment at the bottom of the street than the top. The road was not maintained well and the catch basin was full of leaves, trash, and street sand. In the area behind Norton Company (Pullman Street shown in Figures 13 and 14), we observed unpaved parking lots. The street was covered with sand due to the erosion of the shoulders. This was evident through the loose sand on the sides of the street and nowhere else. Our last stop was in the Tyson Road area as depicted in Figures 15 and 16. This road was very similar to the roads in the Rockdale Ave. area.

FIGURE 9: ASSUMPTION AVE AFTER A STORM. IT IS A PRIVATE UNPAVED ROAD. DUE TO THE STEEP INCLINE, WATER ERODES THE ASPHALT, CREATING TRENCHES THAT ARE FILLED WITH SAND AND GRAVEL. IN TIMES OF HEAVY PRECIPITATION, THIS SEDIMENT IS WASHED INTO THE CATCH BASINS AT THE BASE OF THE STREET.

FIGURE 10: CATCH BASIN AT THE BASE OF ASSUMPTION AVENUE. THE CATCH BASIN HAS SEDIMENT AROUND IT, SHOWING THE LIKELIHOOD OF SEDIMENT GOING INTO THE CATCH BASIN.

FIGURE 11: WILDEY STREET, ANOTHER EXAMPLE OF A PRIVATE UNPAVED ROAD.

Figure 12: Catch basin at the base of Wildey Street. The catch basin has sediment around it, showing the likelihood of sediment going into the catch basin.

Figure 13: Unpaved parking lot on Pullman Street. During a heavy rain, the parking lot may drain into a catch basin in the street.

FIGURE 14: POORLY MAINTAINED CATCH BASIN ON PULLMAN STREET. THERE IS STREET SAND AND TRASH SURROUNDING THE CATCH BASIN.

FIGURE 15: TYSON ROAD, ANOTHER EXAMPLE OF AN UNPAVED PRIVATE ROAD.

FIGURE 16: CATCH BASIN AT THE BASE OF TYSON ROAD. THE CATCH BASIN HAS SEDIMENT AROUND IT, SHOWING THE LIKELIHOOD OF SEDIMENT GOING INTO THE CATCH BASIN.

5.0 Discussion

Unfortunately, the existing sedimentation in Mill Brook and Salisbury Pond cannot be reversed. Therefore, another dredging of the pond will likely be necessary at some point in the future. This process will remove existing sediment and restore the Pond to its original depth and soil consistency.

In order for the positive benefits of dredging to be long lasting, however, the flow of sediment down the Mill Brook and into Salisbury Pond must be stopped or significantly decreased. If not, Salisbury Pond will continue to fill with sediment, and funds used for the dredging operation will have been wasted. It is also very important to make the public aware of the consequences of pollution and sedimentation. Everyone involved needs to be uniformly educated in order to have the most effective and lasting solution possible. Since the watershed is located in an urban setting, location of any control structures as well as the space that these structures occupy are two major concerns and need to be addressed when any action on this problem is taken. Also, regular maintenance of any solution method must be carried out in order for that method to be effective.

5.1 Sediment Sources

The feelings of the Task Force seem to point to Interstate 190 as a large source of sediment into the Mill Brook Watershed. Because the sediment present in the Mill Brook and Salisbury Pond is very fine, it is thought that this sediment is the direct result of sanding Interstate 190 during the winter. However, as of yet there does not appear to be direct evidence to support Interstate 190 as the major source. The amount of sediment in the area can be seen visually when performing wet and dry site walks along the area in question. This flow of sediment should be quantified in order to make a meaningful comparison between possible sources. Measuring stations at various points off Interstate 190 could be set up and checked regularly to characterize the amount and type of sediment flowing off the highway. By measuring sediment flow over a specific time, action can be taken to solve the problem or prevent it from getting any worse. Data of this type could be presented to any organization contributing to this problem whether it is on a city, state, or industry level. This organization could then make informed changes to maintenance and environmental management practices. Awareness is an essential factor to solving this problem and without this information, informed decisions will be difficult to make. If a problem like this is quantified, various agencies like the EPA can take the necessary actions involved to legally intervene and slow down or stop the flow of sediment.

Other areas in which sediment flow needs to be quantified include catch basin structures along Gold Star Boulevard and catch basins located at the end of unpaved private roads near Norton Company. Studies like this conducted on streets like Tyson Road and Assumption Avenue would prove how much of a factor unpaved roads play in causing sedimentation in Salisbury Pond. Although site walks, photographs, and multiple interviews were helpful in identifying the most probable sediment sources, direct evidence needs to be gathered in order for action to be taken.

5.2 Control Structures

In order for sediment to settle out of a body of water, the water must be slowed down dramatically. The smaller the size of the sediment, the slower the water must be moving in order for the material to settle out. Since the sediment flowing down the Mill Brook is mainly composed of silt and other very fine particles, the velocity of the water must be lowered dramatically. A structure located upstream would be able to serve this function. Since this retention basin would be located up stream, it would take the pollution stress off Salisbury Pond. This structure would be in principle quite similar to a large catch basin and, like catch basins, it would need to be cleaned and regularly maintained. Regular maintenance for this solution cannot be stressed enough since, once a structure like a catch basin is full, it does no good to the waterway whatsoever. Sediment would no longer settle out. It would remain suspended in solution and continue to flow into Salisbury Pond. Support for this approach was evident from interviews with the members of the Mill Brook Task Force. Each member had a different idea as to what the structure might look like, but the consensus was that the former Marshall Pond, which used to act as a natural sediment detention basin, needs to be replaced in some way. This basin does not necessarily need to be one large settling basin. The stress of the sediment placed on the system could be absorbed using a series of smaller basins. This way, the system would feel the effects of a very large structure. Since space in the current location of the waterway is quite limited, smaller concrete basins located along the culvert might be the easiest way to implement this suggested solution. These basins would require a minimal amount of excavation and would be cleaned in the same manner that catch basins located on the street are. In addition, the effects of this method are by far the best to the waterway in question. Sediment flow is halted and further cleaning and restoration tactics can be taken in Salisbury Pond itself.

Another method of slowing the water to allow sediment to settle out is the use of baffles in the double box culvert. These baffles act as a barrier to the flow of water and will slow the water to a certain extent. Usually, baffles are used on a much smaller scale, but their principle functions remain the same. The effectiveness of a solution of this type is hinged on how many baffles are installed. Obviously, more baffles will be more effective in slowing the water. They would need to be placed in a location where they could be cleaned regularly. Like the previously suggested retention basins, these structures need to be regularly maintained in order to be truly effective. Once sediment clogs these structures, the baffles cease to work as designed.

5.3 Non-Structural Control Measures

There was widespread agreement among our interviewees that public awareness regarding the effects of erosion needs to be increased. Local funds could be used to create an awareness program. A project of this type should focus on an education program that explains the problem in Salisbury Pond and the results of erosion in their particular area. Through the distribution of literature describing the problem, citizens may be persuaded to help the overall state of their surrounding environment. Literature should be focused on the problem in which the unpaved streets contribute. Then it should discuss the benefits of paving the street. Many streets remain unpaved because they are privately controlled. Many residents located on these streets choose not to pave the street due to the preliminary costs of its construction and the continual costs of maintenance including plowing and surface repairs.

In addition, getting citizens involved in a monitoring program would help the Worcester Department of Public Works (DPW) with their maintenance practices. A citizen-monitoring program would increase the frequency of maintenance at these catch basins. If the DPW is unaware that a catch basin is full, it could remain full until the DPW's cleaning cycle runs through all 15,000 catch basins located in Worcester. By implementing a citizen-monitoring program, the citizen could make and record sediment depth measurements and call on the DPW to clean the basin when it becomes full.

Public interest in restoring Salisbury Pond should be increased. The location of the pond may pose somewhat of a problem in restoring Salisbury Pond to its original state. The pond is close to student housing, the fire station, and an apartment complex. Perhaps the students of Worcester Polytechnic Institute could get involved in the restoration. WPI students could be targeted due to the proximity of the college and the housing of the students close to Salisbury Pond. The college has an Environmental Club that is quite involved on campus. Contacting this club may be the first step in getting the college involved as a whole and would give students the opportunity to give back to the surrounding environment.

A web page for the Mill Brook Task Force could be created. This may help boost public interest since the Internet has become such an integrated part of society. It may also act as a guide to other task forces that have similar problems in urban watersheds. The Mill Brook Task Force is a model for other task forces to follow. It is a collection of individuals from the city, state, industry, and private sectors. These different views help the task force work more effectively and efficiently towards solving various problems. By creating a web page for this organization, other task forces can access information and use the infrastructure of the Task Force as a model for their own. Networking among surrounding areas would also be increased since individual email contact information and other information regarding important stakeholders could be posted on the site.

6.0 Conclusions

Based on our site walks and interviews with Mill Brook Task Force members and other experts, the following conclusions can be made regarding sediment sources and the effectiveness of existing control structures along the Mill Brook. It is important to realize that these conclusions are subjective rather than scientifically based. However, these findings are certainly credible since they are based on the opinions of experts with much combined knowledge of the history of the Mill Brook watershed, stormwater management and environmental management practices.

1. *Sediment sources.* One reason that Salisbury Pond has a problem with sediment is that the problem is historic. Marshall Pond, which acted as a natural settling basin, was filled in during the 1950's. Without this barrier, sediment is free to flow down the Mill Brook and into Salisbury Pond.

Poor construction management practices over the past twenty-five years have also contributed to the existing sediment. The environment was not a primary concern when an area was undergoing construction. Sediment barriers were not in place in previous years and the area around the Mill Brook is highly developed. Laws are now in place that minimize these sediment sources. Several large shopping centers and many oversized parking lots exist along Gold Star Boulevard and continuous traffic on this roadway has taken its toll on the surrounding environment. Stormwater runoff from these city streets adds a significant amount of pollutants to the water.

Stormwater runoff from Interstate 190 contributes to sediment accumulation in the Mill Brook. Although the Mass Highway Department uses a minimal amount of sand to keep the highway safe, particles contained within this sand as well as particles carried onto the highway by vehicles accumulate on the highway. These particles are washed away by the rain and make their way into control structures and eventually into the Mill Brook.

Unpaved roads and parking lots are eroded by wind and rain and easily clog catch basins located in the immediate area. When the catch basins become clogged, they lose the ability to stop sediment from flowing into the culvert.

2. *Existing control structures.* Norton Company has approximately 30 catch basins currently in use on Norton property. Most of these catch basins are modeled after an older design. The sumps to catch sediment are not as deep as the new models and the outflow pipe is straight. As these older catch basins are breaking down, they are replaced with the newer models. Norton Company also makes use of ripraps at water outlets coming off Interstate 190 and other areas. Rocks and vegetation surround these ripraps to maximize their effectiveness. Along the Mill Brook within Norton Company property, there is also a series of small stagnant ponds that can serve as settling basins. Water comes to a complete stop and sediment in the water is able to settle.

The City of Worcester has approximately 15,000 catch basins. Most of these catch basins are of the newer design, making them as efficient as possible. These catch basins line the area around the Mill Brook, including Gold Star Boulevard and the unpaved roads in the Assumption Avenue area. Storm drains located in parking lots along this area were designed to stop large pieces of trash by blocking the flow with metal bars. They do nothing to stop sediment and oil from flowing into the culvert, however.

Catch basins are located around Interstate 190. They attempt to slow the velocity of the stormwater runoff and collect sediment as it flows off the highway. Vegetation is also employed to absorb sediment and reduce the velocity of the water before it enters the culvert.

These control structures alone do not do an adequate job at stopping sediment flow. Sedimentation in Salisbury Pond would be nonexistent if this were the case. When properly maintained, these control structures serve well outside the culvert, but once water is in the culvert, sediment within it is free to flow into Salisbury Pond.

3. *Effectiveness of maintenance practices.* The city of Worcester cleans its 15000 catch basins at least once per year. With current resources, this is the highest frequency at which they can be cleaned. Based on the opinions of experts, the frequency of maintenance at the city level is acceptable.

The Massachusetts Highway Department cleans the catch basins located along Interstate 190 at least once every two years. This highway is advanced because it possesses sediment control technology like catch basins. Many interviewees seem to agree that the frequency of maintenance is not sufficient and that these advanced control structures are not able to do an adequate job because of this.

Norton Company cleans its catch basins once every year. When higher priority spills consisting of large amounts of abrasive material or chemicals occur, they are dealt with swiftly. If a large amount of water is flowing off Norton property, measures are taken to limit the amount of erosion and sediment deposition.

4. *Lack of public awareness.* The opinions of several interviewees suggest that the public does not know the consequences of sediment deposition. Many people are unaware that a problem in Salisbury Pond exists and fewer people know how to correct the problem.

7.0 Recommendations

The process of sediment deposition will not go away by itself. If nothing is done to solve this problem, Salisbury Pond will evolve from a pond surrounded by Institute Park into a swamp that contains islands of muck penetrating the surface. The entire ecosystem will shift, and the plants and animals that inhabit the area will be affected, and the park will be forever changed.

The recommendations made in this project are working under the assumption that Salisbury Pond will eventually be dredged since the existing high sediment level of the pond is irreversible without such action. However, dredging alone is an ineffective method of solving the problem of sedimentation. The pond may be free of sediment immediately after the dredging, but if sediment continues to flow into the pond, the problem is not completely solved. The following recommendations are made in order to minimize sedimentation in the future.

1. *Install a control structure at the mouth of the Mill Brook or a series of structures in the double box culvert upstream from Salisbury Pond.* Either of these ideas would slow the velocity of the water and allow an area in which sediment can settle. By placing a structure at the mouth of the Mill Brook, the maximum amount of sediment could be trapped. It is important to realize that any new control structures would need to be continuously monitored and regularly maintained in order to be effective.

2. *Create a community action plan to educate and involve citizens in the surrounding area.* Through education, citizens could be made aware of the consequences of sedimentation and ways to reverse the problem. Such a plan could have the following elements:

- Start a collaborative effort between the MBTF, the City of Worcester DPW, and residents of unpaved roads. The residents on Eames Road, Beaman Avenue, Boxford Street, Marshfield Street, Prudence Street, Assumption Avenue, Trottier Street, Wildey Street and Tyson Road chose to leave their roadways unpaved. Therefore, for the short term, they can help monitor the catch basins located on their respective roadways so that the DPW can clean them more frequently if necessary. In the long term, a solution to pave these roads in a way that is beneficial to all parties should be found.
- Involve Worcester Polytechnic Institute students. Many students use Institute Park every day. They represent a large amount of human resource that should be used to help restore Salisbury Pond. A good way to tap this resource is to contact the WPI Environmental Club and perhaps other groups interested in restoring the traditional Homecoming rope pull through Salisbury Pond. By working together, the MBTF and the Environmental Club could harness the students' energy and help them give back to the surrounding environment.
- Create a web page for the MBTF. The MBTF is a model for other environmental task forces. Are stakeholders are represented in this group, including the city, state, industry, and private citizens. Other task forces may be lacking in their efforts to solve similar problems. A web page would allow for a free exchange of ideas and contact information.

3. *Undertake a scientific study of sediment sources.* This process would provide a more definitive assessment of the primary sources of sediment and should be designed

and carried out by advanced environmental engineering students or environmental professionals.

8.0 References

American Society of Civil Engineers. Sedimentation Engineering. New York: The Society, 1975.

Andrus, Michael, Robert Parette (1997, March). "A Study of Nonpoint Source Pollution in the Headwaters of the Blackstone River."

Berg, Bruce L., Qualitative Research Methods for the Social Sciences, Needham Heights, Massachusetts: Viacom Company, 1998.

Camp, Dresser, & McKee (Worcester DPW). Stormwater Management Plan, Worcester, MA: Camp, Dresser, & McKee, 1999.

Catlow, Ian, Patrick Holcomb (1997, March). "Analysis of Nonpoint Source Pollution and Suggested Remediation Activities for the Headwaters of the Blackstone River."

Environmental Protection Agency. http://www.epa.gov/OWOW/NPS/facts/point1.htm. September 1999.

Environmental Protection Agency. http://www.epa.gov/owowwtr1/NPS/ordinance_old/erosion.htm. September 1999.

Goldman, Steven J., Katharine Jackson, Taras A. Bursztynsky. Erosion and Sediment Control Handbook. New York: McGraw-Hill, 1986.

Great Lakes Commission. http://www.glc.org. September 1999.

McGinn, Joseph M. A Sediment Control Plan for the Blackstone River. Department of Environmental Quality Engineering, 1981.

McLaughlin, Brennan, Robert Nelson, Helen Weimerskirch. Restoration of Salisbury Pond. Worcester Polytechnic Institute: Department of Civil Engineering, 1973.

Northeast Distributors. http://www.hydrograsstech.com/hgt-&2homepage.html. September 1999.

Urban Land Institute. Residential Erosion and Sediment Control. Urban Land Institute, American Society of Civil Engineers, National Association of Home Builders, 1978.

Appendix A: Interview Questions

Phil Jakubosky-City of Worcester Department of Public Health

- What do you feel are the major sediment contributors to the Mill Brook?

  Mr. Jakubosky explained that many storm drains near the culvert is a "straight shot" into the culvert. He explained that because storm drains are put at the bottom of a decline the rain, with the sediment is moving at a high velocity. He said that the sediment collects in these storm drains, and when a storm comes, sediment is disturbed and goes into the culvert. He continued to explain that the problem with Salisbury Pond was not with the large particle street sand. Because of the density, the larger and heavier particles settle out and gradually work themselves to the bottom. The problem is the lighter particles that are easily disturbed. He continued to say that this problem is a growing one and "rapid" action needs to be taken.

- How do you feel the problem can be solved?

  Mr. Jakubosky feels that the best solution of sediment control is a series of settling basins before the sediment goes into Salisbury Pond. He feels that the dilemma is that there is very little space in the area for such a structure. Businesses and commerce in the area prevent construction, which would have to be done. He continued to say that Salisbury Pond is very good for birds, but not good for much else. He said it was once good for boating (small boats). He said that there are iron rings in concrete in which to tie a boat.

- How can the Department of Public Health be involved in solving the problem?

  He feels that the Department of Public Health is part of a team to solve the problem. Mr. Jakubosky feels that this project needs to be a "City wide effort". People need to be aware of the pollution problems, people need to be involved in solving the problem rather than just fixing it by engineering means.

- How would you suggest raising public interest and concern for this problem?

  He explained that the Salisbury Pond problem was a concern in the 1970's. There was a project done by WPI, which lead to the partial dredging of it. There were serious problems with oil slicks and other assorted pollutants. Visible litter on the banks of the pond caused many people to file formal complaints. He said that the "out cry" to fix Salisbury Pond is extremely low. He feels it has a lot to do with people being more automobile oriented. If someone does not like the appearance of the pond, they will drive somewhere else to take their child or dog. Because of the area, it is difficult to gain support.

Anne Sullivan-Mass Highway Department, District III

- What standards does the Mass. Highway department go by for the catch basins?

  Ms. Sullivan explained that the catch basins that belong to Mass Highway are the standard 3-foot sump. They follow the snow and ice operating procedures. She continued to say that if reconstruction of any catch basins, they are fixed immediately.

- What is the real name of the concrete structures on 190?

  Sediment basins

- Is there a maintenance schedule for the sediment control structures on Interstate 190? When was the last time they were swept?

  She directed our specific questions to the head of Maintenance, Butch Olsen. She was unsure of the control structures but she said the schedules of catch basins were cleaned every other year and they are inspected periodically. In the spring, April 1 to June 30, Mass Highway sweeps Interstate 190. This is done to get all the road salt and sand.

- Do you have any records of the amount of sediment taken from the control structures?

  To be answered by Butch Olsen

- Is there any construction planned for 190 in the future?

  Ms. Sullivan said that since Interstate 190 was resurfaced about three years. She said that the resurfacing should last another ten years so that any construction on Interstate 190 will be minimal and done when a problem should occur.

- Is there any other relevant information to solving the sedimentation in the Mill Brook and Salisbury Pond?

  Anne Sullivan said that Interstate 190 is "ahead of its time" in terms of sediment control and construction practices. Maintenance of control structures is difficult to follow. It is difficult to inspect so many catch basins, things are always happening which may take precedence over the catch basins

Butch Olsen- Foreman of Maintenance for Mass Highway District III

- Please specify the policies of Mass Highway governing sediment management.

  Mr. Olsen said that Mass Highway spreads only salt during the winter to make roadways safe for travel. He mentioned that this policy is not always followed and that a minimal amount of sand is used to soak up water on the road.

- How often are catch basins cleaned?

  Mr. Olsen stated that Mass Highway cleans its catch basins at least once every two years.

- What are the control structures off I-190 that border Norton Company called?

  These structures were referred to as settlement basins and slow the flow of stormwater runoff. Sediment is allowed to settle at these points.

Chris Scholl- Environmental Manager of Norton Company

- How often do you clean your catch basins?

  Mr. Scholl explained that the catch basins on Norton Company land are cleaned every other year. He then explained that 95% of the catch basins are cleaned every other year. He said the other 5% are cleaned yearly. They inspect their catch basins when they feel it may be a problem area. The cleaning yearly depends on the volume of sediment in the catch basin.

- Does Norton Company do any street sweeping of its parking lots?

  Due to salt and sand, all parking lots are thoroughly swept in the spring.

- Is there a procedure to follow if there should be a spill of some kind?

  There are specific procedures for a particular spill or accident. Most of the spills deal with grain used for abrasives. He explained that the grain is kept in large sacks. When a forklift goes to pick up many sacks, there is a potential for a puncture. These spills are cleaned within the day. Oil or hazardous material spills have a high priority and are taken care of as soon as possible.

- What kind of regulations do you have to meet, city, state, or etc.?

  Mr. Scholl explained that technically, they are not regulated. They have applied for a permit for all the catch basins on the property. The Environmental Protection Agency is backed up to 1975. Norton Company follows the same Storm water management plan and Storm water pollution prevention plan that the City of Worcester follows. He added that individual issues concerning the stormdrains are assessed as necessary.

- Does Norton have catch basins that are treated before they go into the Mill Brook?

Mr. Scholl explained that Norton Company has approximately 30 catch basins. He explained that there is no chemical treatment of the water in the stormdrains. It does have many settling ponds to help the sediment settle out.

- Is there anything that you could tell us that may be necessary in assessing the problem in the Mill Brook?

  He said that the water table at Norton Company is approximately 3 to 4 feet. From time to time, Norton's old pipes may burst or break. In order to replace these pipes, excavation needs to be done. When fixing these pipes, water is constantly being pumped out. This volume of water is very large and contains a lot of sediment. Norton uses control measures such as holding tanks and other structures to lower the amount of sediment in to the brook. Unfortunately, some water, with the sediment, avoids the structures and gets into the storm drains and into the brook.

Joe Buckley-Department of Public Works

- How would you best describe the problem of sediment in the Mill Brook and Salisbury Pond?

  Mr. Buckely explained that the biggest change in the past twenty-five years was the construction practices. He said that when much of the Mill Brook area was developed, there were no sediment control measures. In the last five to ten years, there has been legislation and codes to prevent erosion and sedimentation. He continued to say that there once was a pond (Marshall Pond) where Harr Ford is presently. Mr. Buckely also said that in the late fifties was when Marshall Pond was filled. This was before the Clean Water Act and the Wetlands Protection Act. Because there are no previous structures before Salisbury Pond, the urban runoff and storm water moves at a high velocity, which causes erosion and the eventual deposit of sediment. He continued to say that in the past storm water management was ineffective. Recently, the local agencies have done a much better job. Worcester DPW is doing all that it can to keep up with the problem. Interstate 190 is a problem, he directed me to speak with Anne Sullivan of Mass. Highway.

- What do you feel is the biggest contributor to the sediment build-up in Salisbury Pond?

  Mr. Buckley that there are many contributors to the build up of sediment in Salisbury Pond. The main problem is that is acts like a very large sediment basin. The entire storm drain system, near the Mill Brook, flow into Salisbury Pond. The storm flows, construction, and possibly poor maintenance contribute to the increased level of sediment in the pond.

- What solutions do you feel are the most plausible for this problem?

  The ideal solution would be a settling basin further upstream to take the stress off Salisbury Pond. Another possible solution would be a pipe by-pass system that would diminish the water from going into the pond. Further control measures, upstream are necessary to prevent pollution into the Blackstone River. Another problem, in terms of pollution, is sewer leaks. During the construction of many buildings, the sewer pipes were misconnected; some connected to the storm water pipes. This is a source of pollution in Salisbury Pond. There are many of these misconnections throughout the City of Worcester.

- Is the backup of twin inverts a large contributor?

  It is not a large sediment contributor, but it is a pollution contributor to Salisbury Pond and the Mill Brook.

- What control measures do you feel to be most affective?

  Mr. Buckley feels that the bypass system may be very effective if proper control structures are present up stream. A big part of the problem is "housekeeping". Whether it is more frequent catch basin cleaning or street sweeping, a combination of those two things may be effective.

- How often are catch basins cleaned, annually, biannually?

  Worcester city catch basins are cleaned every other year.

Terry Mounce-Department of Environmental Protection, Massachusetts Watershed Initiative

Ginny Scarlet- Department of Environmental Protection, Division of Watershed Management

- How will the DEP be used to help solve the problem in the Mill Brook?

The primary concern of the DEP is hazardous waste and emergencies. They said that they could only encourage local officials to do their jobs. They can only provide technical assistance along with materials if necessary. In regards to the Task force, they are encouraging different part of the Task Force to get different "players" involved to solve the problem.

- In your opinion, what are the major sources to sedimentation along Mill Brook?

  Terry and Ginny explained that the place of concern in Salisbury Pond is at the mouth of the Mill Brook and the western corner of the pond. As the water comes out of the culvert, it scours the soil in the pond as the water continues the sediment settles and a very large mound has formed. In a canoe investigation, they found that this area once measured at one meter in 1987 is now at approximately five inches in some places.

  They feel these sources are the sand from the winter, construction sites, parking lots, and private unpaved roads.

- What means would you use to stop this sedimentation?

  They felt that better maintenance practices in catch basins and other control structures would help the problem. They also mentioned education. For example, educating the residents that live on high grade unpaved roads. Let them know where the sediment from their streets are going. They suggested a volunteer program to help monitor the catch basin, so the DPW would be better informed on the level of sediment in the catch basin.

- If it is determined that Interstate 190 is a large contributor, what power does the DEP have to fix the problem?

  The Department of Environmental Protection can not do anything without evidence that someone is breaking a law or code. They can act for example if a company or agency is filling a wetland or dumping hazardous material.

- How are major projects, like dredging, funded?

  The EPA, through grants, can fund much of the dredging and cleaning up process.

- What are some of the laws or guidelines that a Settling basin comes under?

  The pond and park are two separate entities. The pond belongs to the Department of Public Works, and the park belongs to the Parks and Recreation Department. The City of Worcester classifies Salisbury Pond as a settling basin. A settling basin is an artificial structure; Salisbury Pond is called this because of the dam. The department of Environmental Protection views it as a water body, because that is what it was originally. The DEP is a state agency so their classification is overriding.

- How long does Salisbury Pond have until it becomes a "problem"?

  They felt that Salisbury Pond had between three and four years before the mounds in the pond would surface and begin to cause problems.

Doug Frost- CEO of Frost Manufacturing

- How long has Frost Manufacturing been in business?

  Mr. Frost said that Frost Manufacturing has been in operation for 105 years. The company has been located on Salisbury Pond since 1976.

- What do you feel are the main causes of sedimentation in the Mill Brook and Salisbury Pond?

  Mr. Frost explained that silt is the main contributor to sedimentation. He continued by saying that stormwater runoff from I-190 and construction sites that have weak environmental management practices are the main sources of this silt.

- What solution methods do you feel would best solve this problem?

  He said that some type of settling basin with proper maintenance is required. Mr. Frost suggested that a wall be placed at the mouth of the Mill Brook to slow the velocity of the river. An oil boom could be employed at the top of this wall to absorb oil and other contaminants that sit on top of the water.

- Are there any uses associated with material dredged from a pond?

  Mr. Frost said that dredge material can be tested for possible uses in farming and industry.

Brent McCarthy- Camp, Dresser, & McKee

- What is the source of the sediment, and what control structures would you recommend for the Mill Brook sediment problem?

  He explained that the problem in the Mill Brook is historical. He further explained that the industry and construction of the area is the major contributor, rather than current contributors. He discussed Best Management Practices such as frequent street sweeping, the cleaning of catch basins, education of where sediment and toxins go, and the architecture of sediment traps. He referred me to the Worcester Storm Water Management program.

- What do you feel are the problem areas of the Mill Brook area?

  Mr. McCarthy really did not know in regards to the sediment in the area. He explained that examining the industrialized areas would be appropriate in determining the sources of contamination and pollution.

Appendix B: Catch Basin Architecture

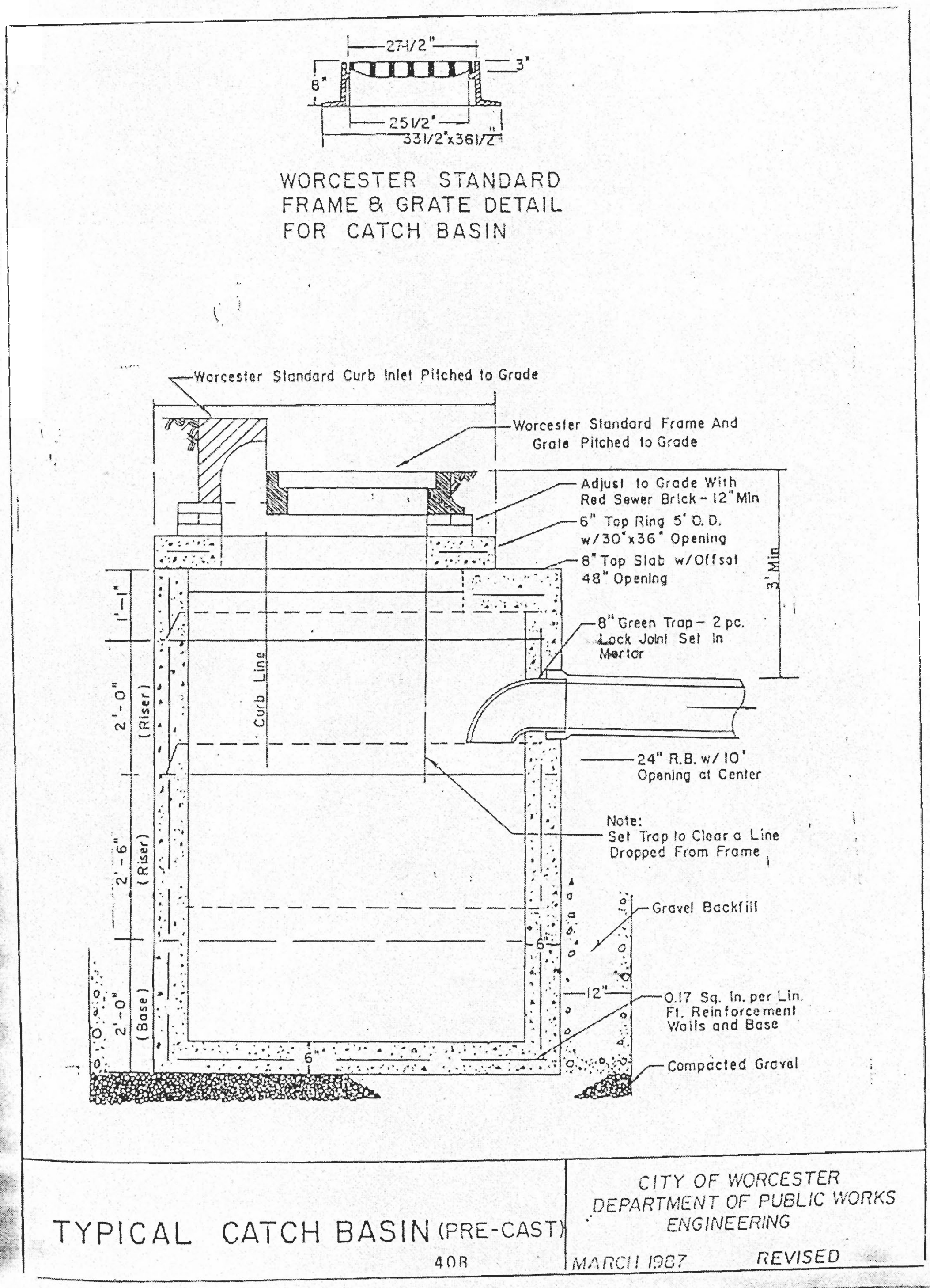


Figure 17: A typical pre-cast catch basin

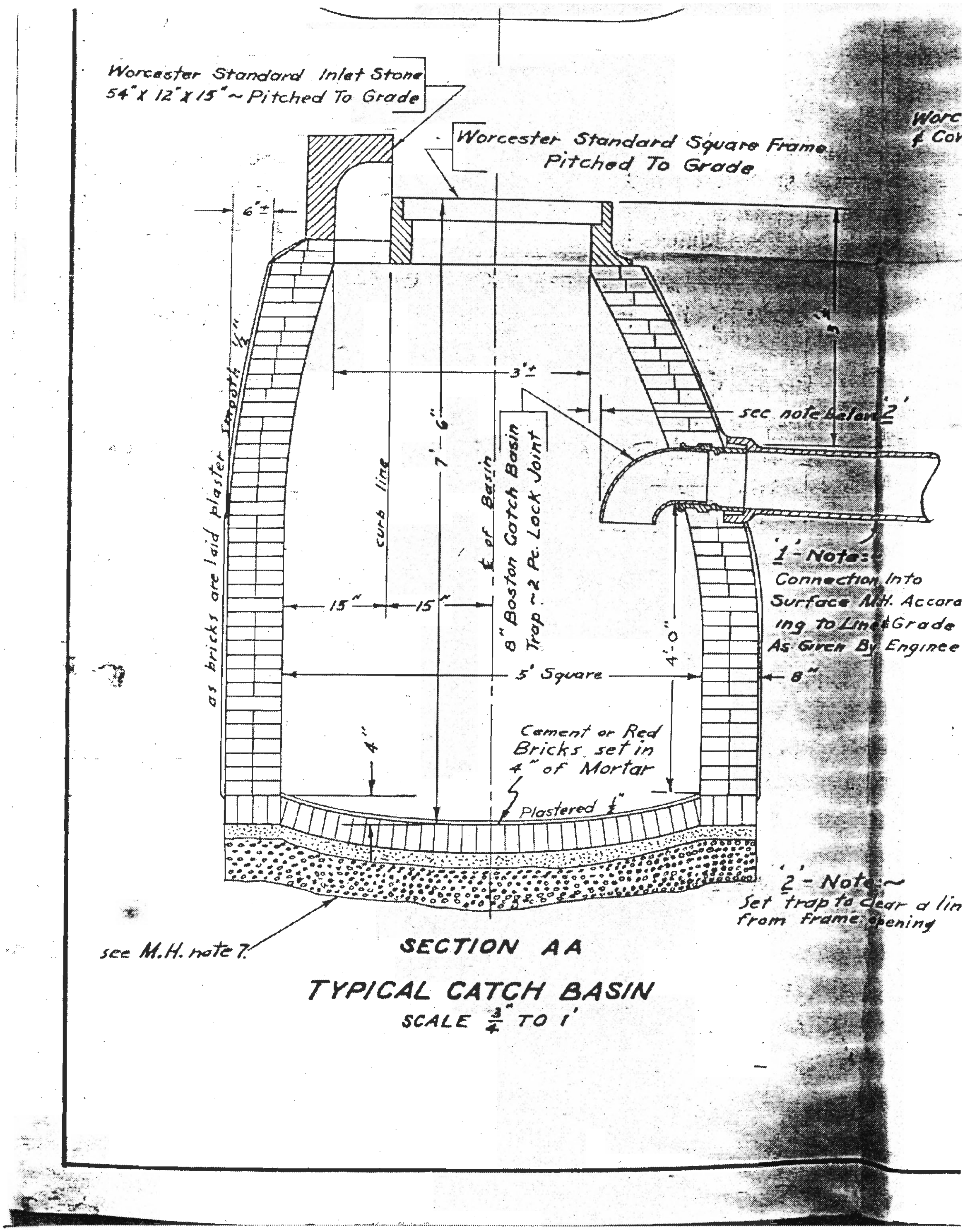


FIGURE 18: A TYPICAL CATCH BASIN SURROUNDED BY BRICK.

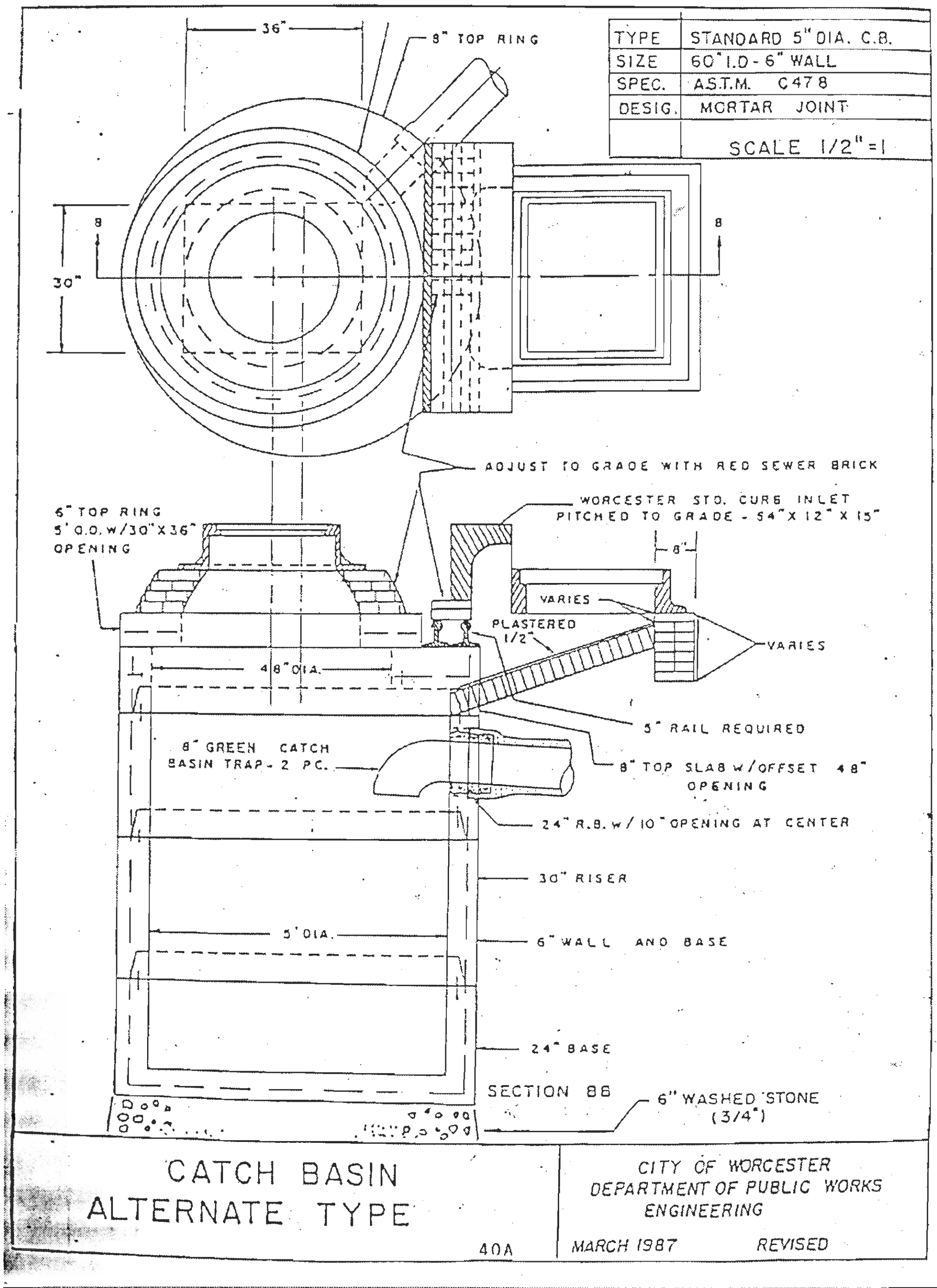


FIGURE 19: AN ALTERNATIVE CATCH BASIN DESIGN.

Appendix C: Street Cleaning Schedule of Worcester

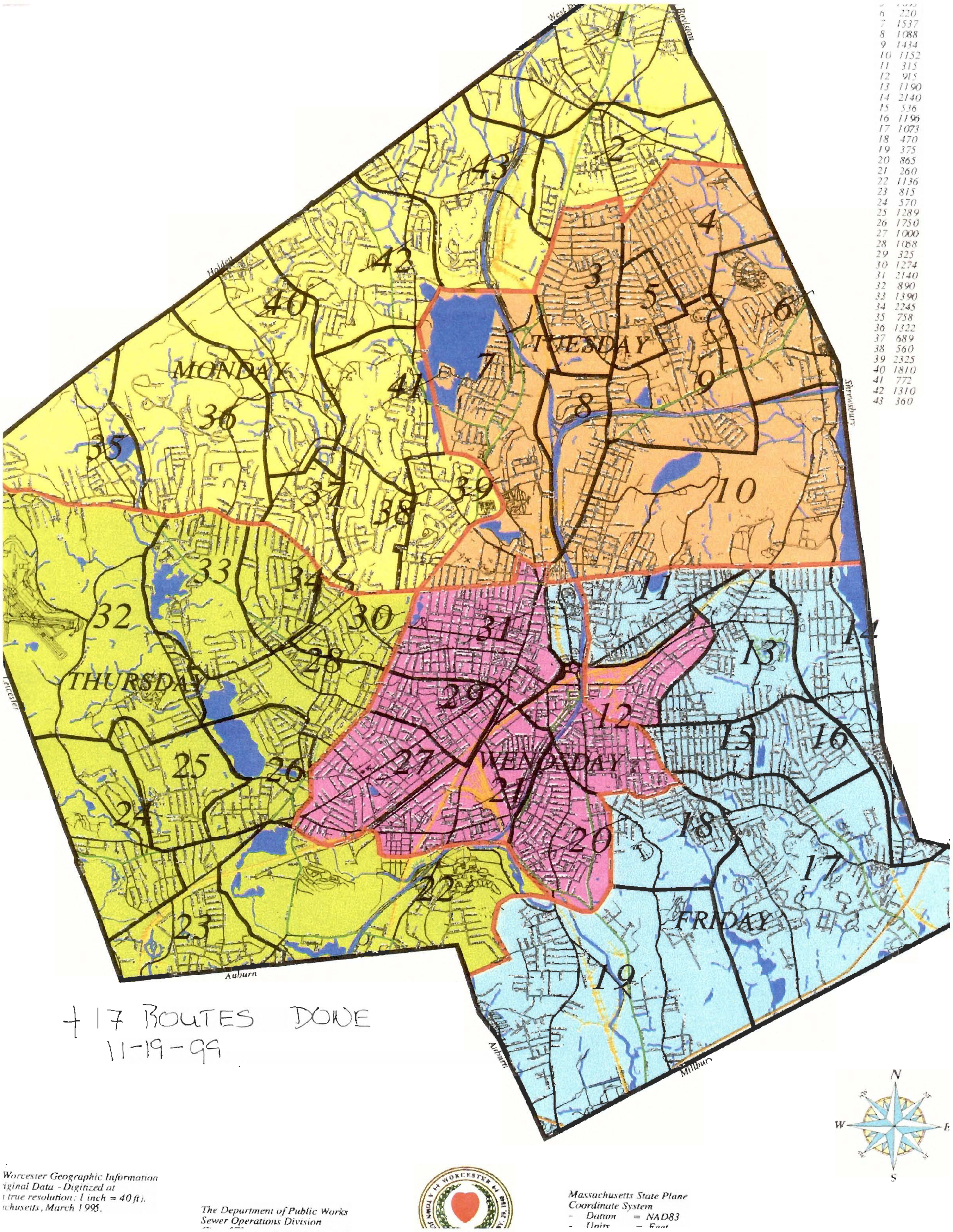
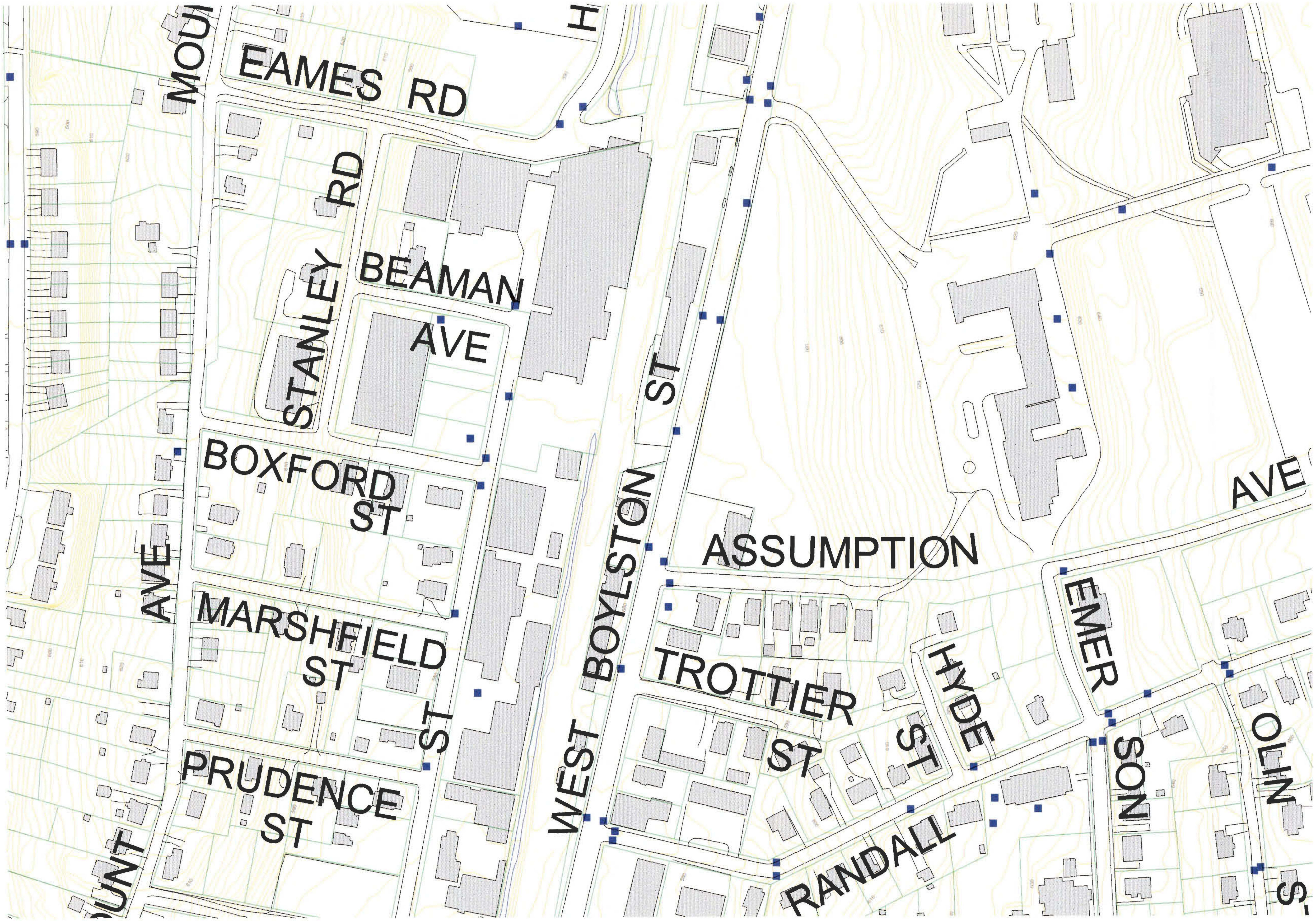


FIGURE 20: THE WORCESTER DPW STREET CLEANING SCHEDULE.

The Worcester Department of Public Works cleans its catch basins in a piecewise manner as shown in Figure 20. The city is divided into five sections and named according to the days of the workweek. These sections are cleaned sequentially starting with "Monday" section and finishing with "Friday" section. Joe Buckley of the Department of Public Works said that it takes workers approximately 8-9 weeks to finish one section.

Weasel Brook
Silt Source
Investigation



View1

■ Cb — Parcels — Bldgs — Contours

Prepared by the City of Worcester DPW Serwer Operations Division, Stormwater Management Program, 02/23/00
In Cooperation with WPI, IQP project for the Mill Brook Task Force
Students: Jonathan Hone & Greg Noetscher