Princeton Hydro

pH

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Consulting and Engineering
Services For
Water & Wetland Resources

The Completion of the Implementation of a Structural BMP for the Hemlock Gardens Section of the Harveys Creek Watershed, Luzerne County, PA ME #, 350385

PREPARED FOR:

The Borough of Harveys Lake and the
Harveys Lake Environmental Council
P.O. Box 60
Harveys Lake, PA 18618

and

Pennsylvania Department of Environmental Protection
2 Public Square
Wilkes-Barre, Pennsylvania 18701-3296

PREPARED BY:

Princeton Hydro, LLC
1108 Old York Road
Suite 1, P.O. Box 720
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Project No. 156.011

September 2003

Abstract

Harveys Lake is the largest natural lake, by volume, entirely located within the Commonwealth of Pennsylvania. Due to some sporadic cyanobacterial algal blooms experienced through the 1980's and 1990's, an US EPA Clean Lakes (314) Phase I Diagnostic / Feasibility Study was conducted on Harveys Lake. The resulting Restoration / Management Plan was used by the Borough of Harveys Lake to implement several watershed projects and conduct additional testing under an US EPA Non-Point Source (319) grant. In addition, the Pennsylvania Department of Environmental Protection conducted a TMDL analysis of the Harveys Lake watershed in early 2003, using data that were collected and developed as part of the Phase I Study.

As a result of the Clean Lakes study and the Non-Point Source pollution project, as well as local concern, a 28.4 acre (11.5 ha) portion of residential land, known as Hemlock Gardens, was identified as a site that generates a large non-point source (NPS) pollutant load for the lake. The NPS pollutants of concern were total suspended solids (TSS) and total phosphorus (TP). In order to address these concerns, the Borough of Harveys Lake and the Harveys Lake Environmental Advisory Council, were awarded a grant by the Pennsylvania Department of Environmental Protection (PA DEP) through the State's Growing Greener Program.

Princeton Hydro conducted on-site surveys and engineering analyses for a structural Best Management Practice (BMP) for the Hemlock Gardens site. The selected BMP was a nutrient separating baffle box in series with a water polishing unit. This structural BMP was designed to accommodate on-site restrictions and to reduce the TSS and TP loads that flow from Hemlock Gardens, into a nearby tributary that, in turn, flows directly into Harveys Lake. The BMP was specifically designed to treat the NPS pollutant loads during the 1 to 10-year storm events. The BMP was installed in the spring of 2003 and stormwater runoff samples were subsequently collected by students and staff of Wilkes University. As part of the BMP monitoring program, the Borough has already cleaned-out the baffle box on one occasion.

Once the monitoring program is complete, the storrnwater runoff data will be used to assess the relative effectiveness of the structural BMP in reducing the TSS and TP pollutant loads that enter Harveys Lake from the Hemlock Gardens portion of the watershed. The calculated reductions in the TP pollutant load will be compared to the lake's TMDL, which was recently completed by PA DEP.

It was estimated that when the first two chambers of the baffle box were cleaned-out in late August 2003, that approximately 14,578 lbs or 7.3 tons of material (soil, rock and gravel) were removed. The Borough will continue to be responsible for the maintenance and up-keep of the BMP. Although some additional roadside swale stabilization work is required for the Hemlock Gardens portion of the watershed, the installation of the BMP and associated pipework has resulting in a substantial improvement in the treatment of NPS pollution originating from Hemlock Gardens. In turn, this reduction in the NPS pollutant load will reduce the nutrient load entering Harveys Lake.

Introduction

The Harveys Lake watershed is 1,892 ha (4,673 acres) in size and is located in the Upper Susquehanna - Lackawanna watershed. Surface runoff within the Harveys Lake watershed eventually drains into Harveys Lake, the largest natural lake, by volume, within the Commonwealth of Pennsylvania. In turn, Harveys Lake forms the headwaters of Harveys Creek. Most of the watershed is located in Luzerne County, but a small portion extends into the northeastern comer of Wyoming County (Appendix A). Harveys Lake, its surrounding watershed and the downstream environments, are located in the State Water Plan Watershed of Toby-Wapwallopen Creeks (5B) and the approximate coordinates of the lake's centroid are 41'21 26" north latitude and 76'0'50" west longitude.

The outlet of Harveys Lake discharges into Harveys Creek. The creek travels down the watershed, through Bryant Pond and discharges into the Susquehanna River at West Nanticoke. Based on Title 25, Chapter 93 classification, from the outlet of Pikes Creek Pond to the Susquehanna River, Harveys Creek is classified as a cold water fishery (CWF) for water quality protection. In contrast, the section of Harveys Creek from the outlet of Harveys Lake down to, and including, Pikes Creek Pond is classified as a high quality - cold water fishery habitat (HQ-CWF). The highly sensitive environmental status of Harveys Creek, especially in the portion immediately down stream of Harveys Lake, indicates that declines in the water quality of the lake will have a direct and negative impact on the stream. Thus, efforts to improve the water quality of the lake itself will benefit both the lake and the creek.

Algal blooms have periodically plagued Harveys Lake throughout the 20th century. In response to these blooms and their accompanying declines in water quality, a sewage system was designed and constructed to cover the entire area immediately surrounding the lake and most of the Borough of Harveys Lake. This sewage system was put on line in the summer of 1976 (Reif, 1986). While the sewage system substantially improved the water quality of the lake, periodic blooms were still a major problem. These blooms, in spite of the sewage system, prompted the funding of a Phase I Diagnostic/Feasibility Study of Harveys Lake and its watershed under the U.S. EPA Clean Lakes Program.

The Phase I Study was conducted in 1993-94 and was used to generate a limnological and watershed-based database on Harveys Lake, in an effort to develop a Restoration and Management Plan for the lake. The primary objective of the Restoration and Management Plan was to identify a series of cost effective in-lake and watershed-based techniques to improve the water quality of Harveys Lake. A number of structural Best Management Practices (BMPs) were recommended as part of this plan which included upgrading the catch basins along Route 415, the road that completely surrounds Harveys Lake, and the strategic installation of larger regional basins in key locations within the Harveys Lake watershed. This report documents the design, installation and efficiency of a structural BMP for a specific section of the Harveys Lake watershed.

Project Location

The project site is located in the southeastern portion of the Harveys Lake watershed, known as Worden Place (Appendix A). Specifically, the site is a 28.4 acre (11.5 ha) area of land in an older development known as Hemlock Gardens (Appendix A). There are approximately 26 homes located in Hemlock Gardens with a dirt road looping within the development. In addition, the percent slopes within Hemlock Gardens vary between 8 and 18%. These conditions have resulted in the generation of large non-point source (NPS) pollutant loads.

Prior to the implementation of this project, the Hemlock Gardens community did not have any form of stormwater conveyance system and overland runoff generated during storm events, flows across Second Street and into the unnamed tributary on the other side of the street. In turn, the tributary flows directly into Harveys Lake. It has been documented, both on video tape and through stormwater sampling, that this overland runoff transports a large NPS pollutant load to the tributary and, in turn, Harveys Lake.

The NPS pollutants of particular concern for Harveys Lake are total suspended solids (TSS) and total phosphorus (TP). TSS is essentially a measure of the amount of particulate material or "dirt" in the water. High concentrations of TSS produce muddy or turbid conditions and accumulate in receiving waterbodies. This in-filling of aquatic ecosystems reduces water depth which impacts both ecological habitat and recreational use.

The Phase I Diagnostic / Feasibility Study of Harveys Lake identified phosphorus as its primary limiting nutrient. It takes very little phosphorus to produce a lot of algal and/or aquatic plant growth. In fact, phosphorus has such a substantial impact on the growth of algae and aquatic plants, the targeted water quality parameter for the Harveys Lake Total Maximum Daily Load (TMDL) analysis is phosphorus. Given the impacts associated with TSS and TP, the Restoration and Management Plan for Harveys Lake focuses on these two NPS pollutants.

In most cases, the majority of the phosphorus in stormwater is adsorbed onto sediments particles. Thus, efforts to reduce the TSS load will also substantially contribute toward the reduction of the TP load. This strategy was employed for the Hemlock Gardens section of the watershed.

Both TSS and TP concentrations of stormwater directly leaving the Hemlock Gardens section of the watershed have been documented as being excessive. For example, during the pre-installation stormwater monitoring program, conducted by staff and students of Wilkes University, TSS concentrations were as high as 1,178 mg/L, while the TP concentrations were as high as 0.06 mg/L. In addition, TP concentrations downstream of Hemlock Gardens were as high as 0.14 mg/L. More details on the stormwater monitoring results are provided in subsequent sections of this report.

Project Implementation

The Borough of Harveys Lake (the Borough) and the Harveys Lake Environmental Advisory Council (the EAC) were awarded a Growing Greener grant by the Pennsylvania Department of Environmental Protection (PA DEP) in 2001 to design, install and evaluate the pollutant removing efficiency of a structural BMP to be installed in the Hemlock Gardens drainage area of the Harveys Lake watershed. The total amount of funds awarded for the project was $ 156,050.00. The Borough provided general management of the project as part of their in-kind contributions.

As will be described below, the Borough and the EAC worked with a number of organizations in the successful completion of this project. Specifically, Princeton Hydro was the technical manager for the project, completing the majority of the technical tasks (i.e. field work, engineering design and calculations, acquiring permits, oversight of BMP installation). In terms of the field work, Princeton Hydro conducted the topographic survey of the site, as well as collected soil borings to quantify various soil characteristics such as depth to bedrock and depth to groundwater. Such data were essential in order to determine the feasibility of installing a BMP at Hemlock Gardens. The BMP that was original proposed for Hemlock Gardens was an infiltration basin. However, as explained below, this recommended BMP had to be substantially modified.

The Borough surveyor, Michael J. Pasonick, Jr., Inc., also provided assistance toward the project by completing the necessary property boundary surveys for Hemlock Gardens. Given the complexity associated with the site (i.e. water lines, sewer lines), the property survey was required to determine the right-of-ways and property limits. The Borough paid for the property boundary survey as part of their in-kind contribution toward the project.

Staff and students from Wilkes University, managed by Mr. Brian Oram, conducted all of the project-related stormwater sampling and laboratory analyses to assess the pollutant removal efficiency of the structural BMP. A portion of their time counted as an in-kind contribution toward the project.

Princeton Hydro worked with a number of agencies in obtaining the necessary permits and approval for the project. From PA DEP, general permits GP-4, GP-5 and GP-8 were obtained for the BMP discharge pipe which travels through private property to the unnamed tributary. In addition, a PennDOT Highway Occupancy Permit was required for the installation of a 24" reinforced concrete pipe that was placed under Second Street, connecting the BMP to the discharge pipe. A letter of adequacy for erosion & sediment pollution control was obtained from the Luzerne Conservation District.

In order to properly size the BMP, the Rational Method was used to determine the 10 year storm runoff peak flow. More detailed information on the required permits, the stormwater flow modeling, and the design of the BMP are provided in the engineering report which was submitted to the Borough of Harveys Lake (Appendix B).

Structural Best Management Practice used at Hemlock Gardens

The original concept for a structural BMP at Hemlock Gardens was a large, infiltration basin that would allow surface runoff from small to moderately-sized storms to infiltrate back into the groundwater, while retaining particulate pollutants and their associated pollutants (i.e. TSS and TP). However, the results of the soil borings indicated that an infiltration basin would not be very effective. The soil borings revealed that the depth of groundwater in the soil profile was high and the depth to bedrock was shallow. Thus, the capacity for infiltration was very limited.

Given the on-site limitations associated with the soil, it was decided to use a Nutrient Separating Baffle Box, combined with a Water Polishing Unit, to reduce the NPS pollutant load originating from Hemlock Gardens (Appendix B). The entire system was designed by Suntree Technologies, Inc. Essentially, the baffle box is a three chambered basin with screens above its static water line. The screens provide a means of collecting vegetation, gravel and rock, litter and larger debris. The polishing unit provides a secondary degree of treatment after the larger material has been removed. The system was designed in such a manner as to not obstruct design storm flows if either of the structures are completely filled. Thus, while the system would no longer retain NPS pollutants at this point, it would not obstruct stormwater flow.

Suntree Technologies provided a local contractor with the design specifications for the construction of the structures. More detailed information on the baffle box and polishing unit are provided in Appendix B. As an in-kind contribution, Suntree Technologies provided a 25% reduction in the purchase of the materials and the construction of the baffle box and nutrient polishing unit.

Due to the particularly severe winter of 2002-2003, as well as a wet spring season, the installation of the baffle box and polishing unit did not commence until April of 2003 (Appendix C). In addition to the installation of the BMP a limited amount of roadside swale stabilization work was also conducted. Some local funds were also contributed toward the stabilization portion of the project. In addition, funds from other State-based grants were used to augment the added costs associated with the revised BMP design.

By May 2003 the BMP was installed and the identified roadside swale stabilization work was complete. Additional stabilization work in the upper areas of the Hemlock Gardens section of the watershed, as well as paving of the roads, has yet to be completed. However, these tasks were outside of the identified Scope of Work for this Growing Greener project. The Borough has recently secured funds to pave the road and is currently seeking funds to complete the remaining roadside stabilization work.

A series of digital photographs provided in Appendix C document pre-existing conditions at Hemlock Gardens, as well as the actual installation of the structural BMP and post-installation conditions.

Budget Associated with the Hemlock Gardens Project

The total amount funded under the Growing Greener project for the Hemlock Gardens section of Harveys Lake (ME #350385) was $156,550.00, with approximately $95,000.00 being allocated toward the purchase of materials and installation of the structural BMP. Originally, an infiltration basins was going to be installed at Hemlock Gardens, however, collected soil borings revealed that the depth to groundwater was only 6 inches below the soil surface. Since these soil borings were collected during relatively dry conditions in early May 2002 (Appendix B), it was determined that an alternative BMP was more appropriate for the site. This alternative BMP turned out to be the Nutrient Separating Baffle Box, combined with a Water Polishing Unit (Appendix B). This increased the cost associated with the construction section of the project to $134,183.00.

The actual cost of the construction and installation of the Hemlock Gardens project was $39,183.00 higher than the budgeted amount. Additional tasks associated with the project, such as the replacement of the saturated soils and some of the roadside swale stabilization work, were also conducted. In order to fund both the Hemlock Gardens project and these additional tasks, monies remaining in two other completed Borough grants, the first being a Non-Point Source (319) grant (ME #359579) and the second being a supplement to the NPS grant (ME #350206), were used toward the Hemlock Gardens Project.

A monetary contribution of $10,000.00 was given to the Borough by Ruckno, a local developer, toward the project. These funds were used to conduct some of the roadside swale stabilization work.

Local contributions toward the Hemlock Gardens project included both monetary and in-kind sources. As previously mentioned, $10,000.00 was contributed to the Borough by Ruckno toward the stabilization work. In addition, Suntree Technologies, Inc. reduced its price for the materials and construction of the structural BMP by 25% for a contribution of $7,776.00.

In addition to the monetary contribution of reducing materials and construction costs by 25%, the owner and President of Suntree Technologies, Mr. Henry Happel, came to Harveys Lake to oversee the construction of the BMP at a local foundry and its installation at Hemlock Gardens. Mr. Happel did not charge the Borough or the project for his travel or any of these services. Mr. Happel's in-kind contribution was conservatively estimated to be $1,500.00.

Another local contribution toward the project was the property survey work conducted at Hemlock Gardens by Michael J. Pasonick, Jr., Inc. The survey cost $4,500.00 and was paid by the Borough of Harveys Lake. Given the complexities associated with the site, such as water lines, sewer lines, and questions over property boundaries, such a survey was absolutely necessary. An additional contribution was with the easement authorized and given by Mr. Sardoni, the owner of the property where the BMP outlet pipe discharges into the small unnamed tributary of Harveys Lake. The easement and related legal fees were very conservatively estimated to be $2,000.00.

Both the Borough of Harveys Lake and the Harveys Lake Environmental Council provided in-kind services toward the successful completion of the Hemlock Gardens project. These services and their associated costs are provided in Table 1. Combined these local in-kind services total $15,600.00. Finally, some in-kind services were provided by students and staff of the Wilkes University GeoEnvironmental Science and Engineering Department. These services included the collection and analysis of stormwater samples prior to and after the structural BMP was installed at Hemlock Gardens. The in-kind contribution made by the students and staff of Wilkes University was calculated to be $1,740.00. This contribution included six stormwater sampling events and attendance at two project meetings.

Combined, the monetary and in-kind local match toward the State PA DEP-funded Growing Greener grant was $54,396.00. This total match accounted for almost 26% of the total project budget.

Stormwater Monitoring for the Hemlock Gardens Project

In order to estimate the current NPS pollutant loads that originate from Hemlock Gardens, as well as quantify the relative pollutant-reducing efficiency of the installed structural BMP, a limited amount of stormwater sampling was conducted. This storrnwater sampling program focused primarily on quantifying the total phosphorus (TP) and total suspended solid (TSS) NPS pollutant loads leaving the Hemlock Gardens community both prior to and after the installation of the structural BMP. Discrete samples were collected by students and staff of the GeoEnvironmental Science and Engineering Department at Wilkes University.

The stormwater data set was designed to document and quantify the relative pollutant-reducing efficiency of installed structural BMP. In addition, the collected stormwater data will be valuable in evaluating long-term reductions in the NPS pollutant loads originating from the Hemlock Gardens section of the watershed, relative to the State's TMDL on Harveys Lake. Specifically, the Harveys Lake TMDL focused on TP as the primary pollutant of concern, however, given the impacts associated with TSS (i.e. in-filling of near shore areas, loss of littoral habitat) the reducing capacity of this pollutant was also evaluated.

The raw stormwater data for the three storm events that were monitored prior to the installation of the structural BMP are provided in Appendix D. At this time, storm water data for two of the three post-installation storm events are being processed and the third storm event has yet to be sampled. A detailed evaluation of the pollutant-reducing efficiency of the Nutrient Separating Baffle Box and Water Polishing Unit will be conducted once all of the stormwater data are received from Wilkes University. This detailed evaluation will be an addendum to this final report.

While the stormwater data have yet to be analyzed, preliminary information collected to date certainly demonstrate that the Nutrient Separating Baffle Box and Water Polishing Unit are effective in collecting and retaining particulate material and the pollutants (i.e. phosphorus) adsorbed onto its surface. Some digital photos are provided in Appendix E as evidence to support this statement.

The center photo (INFLOW) in Appendix E is the first chamber within the Nutrient Separating Baffle Box during a storm event on 22 July 2003. As shown in the photo, a large amount of material have accumulated in the first chamber; gravel collected on the filtration baskets and smaller particulate material collected on the bottom of the chamber. The inflow was extremely turbid with a brown color. The photo in the upper right (OUTFLOW) is the Water Polishing Unit, after the stormwater passes through the three chambers of the Baffle Box. Note that the water is almost clear and has a slightly gray color (Appendix E). These photos clearly demonstrate that the installed structural BMP is extremely effective in removing a large portion of the NPS pollutant load, specifically particulate material, from the Hemlock Gardens portion of the watershed.

On 23 August 2003, the Borough of Harveys Lake cleaned out the Baffle Box. Due to watershed activities upstream of the basin, such as the excavation of the leaking water line and the roadside swale stabilization work, a large amount of material accumulated in the basin since it was on-line in late April 2003. By 23 August 2003 the first two of the three chambers in the Baffle Box were filled with gravel and soil. Approximately 4 cubic yards of material was removed from the first two chambers on 23 August 2003, not including the gravel that accumulated on the filtration baskets. The material was removed with the use of a rented Vac-All unit.

Using a weight estimate of 135 lbs per cubic foot, the amount of material removed from the first two chambers was approximated to be 14,578 lbs or 7.3 tons. Once the Hemlock Gardens section of the watershed is stabilized and the soil excavating projects are completed, the amount of material accumulating within the BMP over a given period of time should decline. However, even with the added loads experienced during the summer of 2003, only the first two chambers were filled after 4-5 months.

Given the observations made during the summer of 2003, the following recommendations are being made with regard to the maintenance of the Hemlock Gardens BMP. Excluding any particularly large storm events (> 50 storm events), the BMP should be cleaned out twice a year; once in late autumn after all of the leaves have fallen from the trees and in late spring, after road de-icing activities are finished. It should be emphasized, that additional cleaning events might be required, depending on the frequency and magnitude of storm events. Thus, the Borough should inspect the BMP after a storm event if more than 2 inches of rain is expected within a 24 hour period or a flash flood warning is issued for the area. Again, it shouldbe emphasized, that the inspections should occur after the storm event to avoid any issues associated with safety. These inspections will be used to determine if accumulated material needs to be removed from the BMP.

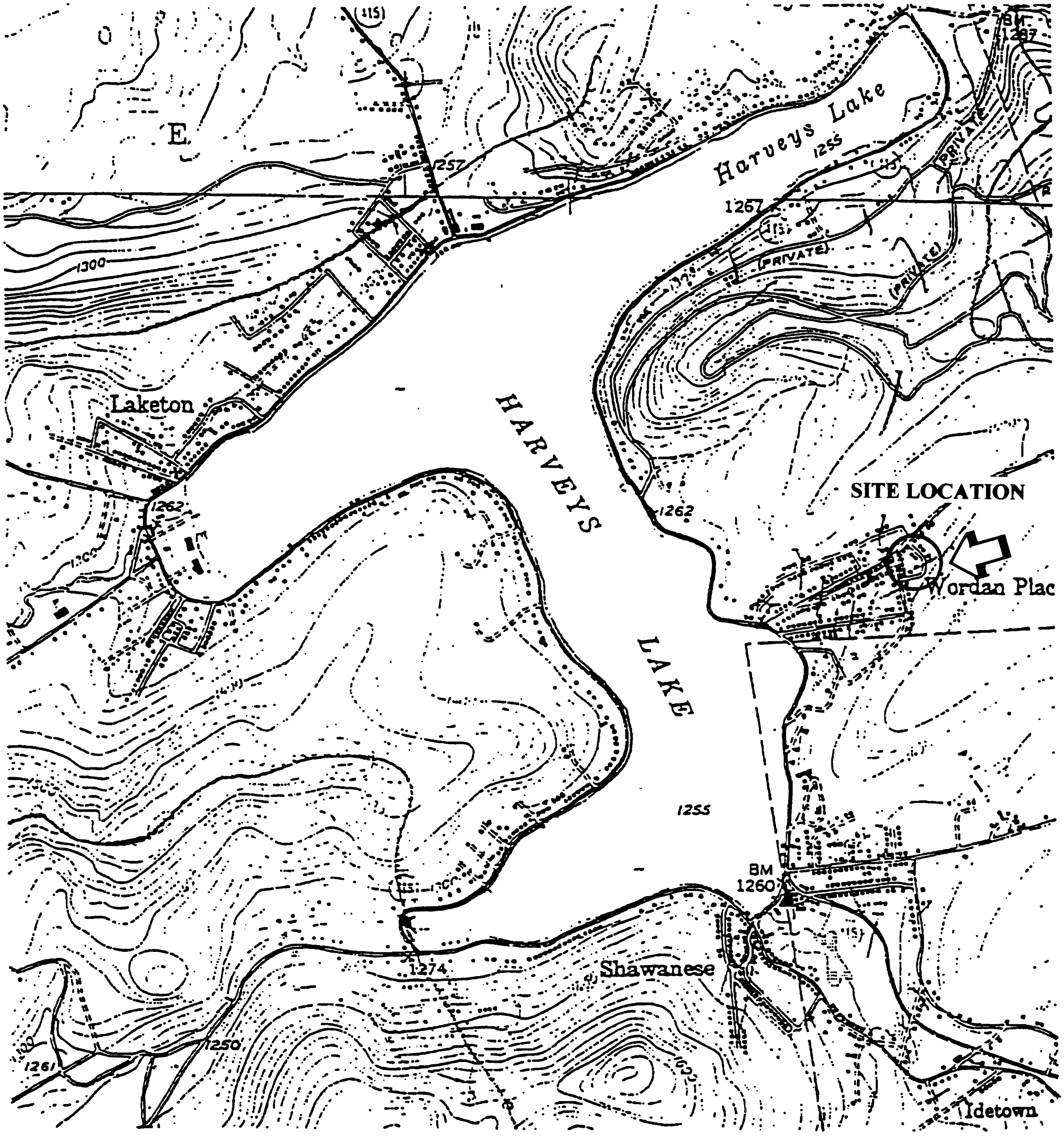
Table 1

Local Contributions Toward the Growing Greener Grant (ME #350385) for Hemlock Gardens, Borough of Harveys Lake, Luzerne County, PA

	Source	Cost
1	Monetary Contribution from Ruckno for roadside swale stabilization	$10,000.00
2	Property Boundary Survey conducted by Michael J. Pasonick, Jr., Inc.	$4,500.00
3	Suntree's **25%** reduction in the material and construction costs of BMP	$7,776.00
4	Mr. Happel's (Suntree) project oversight with construction and installation of BMP	$1,500.00
5	Mr. Sardoni's easement agreement for the BMP outlet pipe (includes legal fees) - *estimated*	$2,000.00
6	Borough of Harveys Lake	
	general project management and oversight	$5,760.00
	administrative / fiscal management	$1,440.00
	review of construction bids	$240.00
	hosting the mandatory bid meeting / other meetings	$720.00
	supplemental oversight at BMP installation	$1,200.00
	supplemental stabilization work upstream of BMP	$1,920.00
	sub-total	*$11,280.00*
7	Additional management and project coordination by the Harveys Lake Environmental Advisory Council	$4,320.00
8	In-kind contributions from the students and staff of Wilkes University for the stormwater monitoring program	$1,740.00
TOTAL		**$54,396.00**

Appendix A

Site Location



SOURCE:

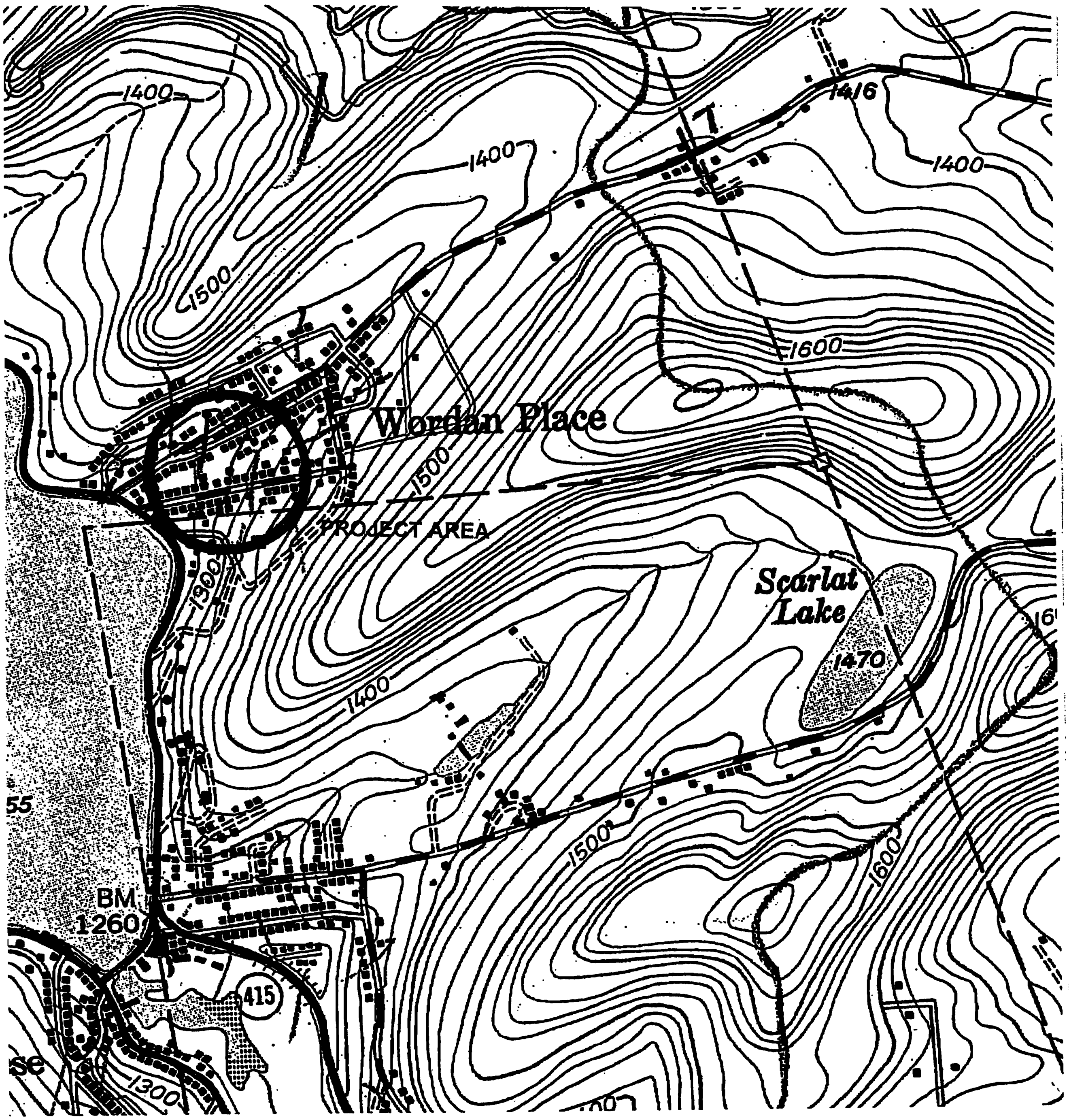
USGS 7.5 minute series quadrangle map
Harveys Lake, PA and Noxen, PA quadrangles
Both photo-revised in 1969

SCALE: 1" = 2,000'

N

FIGURE 1
USGS Topographic Map
Location of Harveys Lake
Borough of Harveys Lake
Luzerne County, PA

pH



SOURCE:

USGS7.5 minute series quadrangle map
HarveysLake, PA and Noxen, PA quadrangles
Both photo-revised in 1969

SCALE: NOT TO SCALE

N

FIGURE 2
USGS Topographic Map
Location of Hemlock Gardens
Site for Proposed Restoration Project
Borough of Harveys Lake
Luzerne County, PA

pH

Appendix B

Project Design and Engineering Report

Princeton Hydro, LLC

1108 Old York Road
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908-237-5660 (P)
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Consulting, Engineering and Planning Services for Water and Wetland Resources

STORMWATER CAPTURE, CONVEYANCE & TREATMENT SYSTEM DESIGN REPORT

Hemlock Gardens Subdivision
Harveys Lake Borough, Luzerne County, Pennsylvania

PREPARED FOR:

Harveys Lake Borough
P.O. Box 60
Harveys Lake, PA 18618

PREPARED BY:

Princeton Hydro, LLC
1108 Old York Road, Suite 1
P.O. Box 720
Ringoes, New Jersey 08551

August 2002
Revised: September 2002

Princeton Hydro, LLC

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Ringoes, New Jersey 08551

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
JOHN A[illegible]R MILLER
ENGINEER
PE-053048-E

August 2002
Revised: September 2002

Princeton Hydro, LLC
1108 Old York Road
Suite 1, P.O. Box 720
Ringoes, NJ 08551

September 16,2002

Mr. Walter Chamberlain
District Manager
Luzerne Conservation District
485 Smith Pond Road
Shavertown, PA 18708

Re: Stormwater Capture, Conveyance and Treatment System Design Report
Revised September 16,2002
Hemlock Gardens Subdivision
Harveys Lake Borough, Luzerne County, Pennsylvania
Princeton Hydro Project No. 156.11

Dear Mr. Chamberlain:

Princeton Hydro, LLC is pleased to provide to you the attached revised Stormwater Capture, Conveyance and Treatment System Design Report for the above referenced project. I have addressed the comments in the review letter dated August 30,2002 by John J. Glushefski, P.E., as discussed with you on the phone on September 13,2002, as follows:

102.4 (b)(3)
- Qualifications and experience of the plan preparer have been added to the report.

102.4 (b) (5) (i)
- Additional contour information has been included in the revised plan.

102.4 (b) (5) (iii)
- The limit of disturbance has been added to the plan and encompasses the staging, access, and stock-pile areas.
- Proposed contours and channel grading have been included in this revision.
- An additional sheet was added to the set entitled "Erosion & Sedimentation Pollution Control Plan" with legend included on this sheet (sheet 3 of 7).

102.4 (b) (5)(v)
- The Chapter 93 classification was mentioned in the revised report.

102.4 (b) (5) (viii)
- The channel calculations were revised and expanded to include actual depth and velocity for all proposed channels. All channels have a minimum one (1) foot of freeboard.
- As we discussed in the phone conversation, I have added rip-rap to the opposite side of the discharge location to provide for slope protection.
- The rock lining thickness has been increased to satisfy the 1.25 x Dmax requirement.
- The apron rip-rap thickness has been increased to satisfy the 1.50 x Dmax requirement.

*102.4 **(b)** (5) (xi)*
- The proposed and graded channels have been numbered and coincide with the detail for same.

Phone: 908.237.5660 ***Fax:*** *908.237.5666*
E-Mail: *info@princetonhydro.com*

- Topsoil stock-piles and temporary material stock-piles have been indicated on the plan bordered on the downslope side with silt fence.
- Silt fence and an additional temporary rock filter has been added below disturbed areas.

I believe that the above reference modifications have satisfied the review comments. If you have any questions, please do not hesitate to contact me at (609) 397-5335.

Sincerely,

John A. Miller, P.E.
Senior Project Engineer

enclosures

c: **Michael Daley, Harveys Lake Borough EAC President**
Edward J. Kelly, Harveys Lake Borough President
Fred Lubnow, Ph.D., Princeton Hydro
file

STORMWATER CAPTURE, CONVEYANCE & TREATMENT SYSTEM

DESIGN REPORT

HEMLOCK GARDENS SUBDIVISION

HARVEYS LAKE BOROUGH
LUZERNE COUNTY, PENNSYLVANIA

Prepared for:

Harveys Lake Borough
P.O. Box 60
Harveys Lake, PA 18618

Prepared by:

Princeton Hydro, LLC
1108 Old York Road, Suite 1
P.O. Box 720
Ringoes, New Jersey 08551

Project No. 156.11

August 2002
Revised: September 2002

TABLE OF CONTENTS

1.0 Introduction

The Hemlock Gardens subdivision is located in the southeastern section (within an area called Wordan Place, Appendix A) of the Harveys Creek Watershed, that drains to Harveys Lake, the largest natural lake, by volume, within the Commonwealth of Pennsylvania. As Hemlock Gardens is a residential subdivision located on steep slopes with unimproved roads, the site generates a substantial hydrologic and non-point source (NPS) pollutant load that eventually flows into Harveys Lake. Runoff generated by storm events flow across and along Second Street (S.R. 1024) and into the unnamed tributary on the opposite side of the road. Currently, the subdivision does not have any improved and stabilized stormwater conveyance system, which hastens the erosion of the unimproved roads within the development.

An Environmental Stewardship and Watershed Protection Grant Application (2000-2001) was submitted and accepted, whereby a Pennsylvania Growing Greener grant was provided to address the problems at Hemlock Gardens. This currently funded phase addresses the design of the project and the construction of the infrastructure for collection and conveyance at the lower elevations of the site. Funding for the second phase to complete the roadside stabilization has not been provided, but the swale and driveway culvert geometries have been assessed and check dams have been designed to provide some reduction of swale flow velocities. Additional boundary survey to determine the right-of-ways and property limits will be necessary before finalizing the second phase design.

Permitting will be required for the proposed construction. A PennDOT Highway Occupancy Permit is required for the installation of the 24 inch reinforced concrete pipe (RCP) pipe under Second Street (S.R. 1024). The Luzerne Conservation District will review for erosion & sediment pollution control adequacy and General Permits (GP-4, 5 and 8) for the 30 inch high density polyethylene (HDPE) discharge pipe on the Sardoni property to the unnamed tributary (easement also required on private property). Chapter **93** describes the Harveys Creek basin (including Harveys Lake and the subject unnamed tributary), from the source to Pikes Creek, as a High Quality-Cold Water Fishery. This state funded project has been designed to enhance the quality of the downstream receiving waterbodies.

PennDOT's County manager has informed Princeton Hydro that resurfacing of Second Street (S.R. 1024) is to commence in the Spring of 2003. In order not to disturb PennDOT's construction schedule and to avoid opening of the roadway after PennDOT's work, the first phase must be completed before the onset of unfavorable weather conditions in the Fall/Winter of 2002.

Mr. John A. Miller, P.E. is the design/project engineer for the project and is a licensed engineer in the Commonwealth of Pennsylvania. Mr. Miller has nine (9) years of experience in stormwater analysis and design of stormwater runoff systems, and erosion and sedimentation pollution control design.

2.0 Stormwater Flow Development

Peak flows for the 10-year frequency, Type II storm to three (3) subareas, were determined (Appendix D) by the NRCS (formerly Soil Conservation Service, SCS) TR-55 method utilizing soil information (Type "B/C" soils) from the Soil Survey of Luzerne County (Appendix C, USDA, 1981, reissued 1992). The land use was considered to be a residential district with an average lot size of 1/2 acre (although some properties in Hemlock Gardens are 113 acre, the balance of larger lots makes the 1/2 acre lot assumption conservative) with future complete development in the drainage area. This was a conservative assumption since full build-out of the entire area is unlikely. The three **(3)** subareas were defined for the distinct major contributions to the existing unimproved/future improved swales (Appendix B). The design considers that the swales may never be improved, although the current phase will fully be effective only if the second phase is implemented. Time of concentration was determined by the Segmental Approach in the TR-55 method.

An analysis (Appendix E) was conducted to support the application for the PennDOT Highway Occupancy Permit. The Rational Method was utilized to determine the 10-year storm runoffpeak flow, following the determination procedures in the Design Manual, Part 2, Chapter 10, Drainage Design. The resulting peak flows were lower than the TR-55 method, therefore the sizing of the conveyance system by the TR-55 method was relatively conservative. A storm sewer computation table was generated with the Rational Method flows.

3.0 Runoff Capture and Conveyance

Various structures and storm sewer pipe will be installed to capture and convey the runoff (including suspended solids) from the Hemlock Gardens subdivision roads. Endwalls will permit the stormwater and sediment to enter the system at locations along the roads (existingunimproved swales). At locations where the alignment of the storm sewer changes, inlets will also permit additional locations of capture. Two (2) 'M' Inlets will be bordered by concrete and connected to a concrete channel on the road to improved capture efficiency. The downstream most inlet will provide a optimum location for pre-treatment sampling. A trench drain with vane grates will be installed across East Hemlock Drive where substantial erosion has been identified in the road and runoff continues downslope.

The crossing under Second Street (S.R. 1024) will be accomplished by a 24 inch RCP within the road right-of-way. A manhole will make a transition of dissimilar materials, provide a change in alignment and will provide a good location for post-treatment sampling. An easement will be established on the Sardoni private lands to permit maintenance and access along the pipe from the PennDOT right-of-way to the discharge location. Due to existing sanitary sewer in close elevation proximity to the proposed storm sewer, several locations will have to be reinforced with a concrete encasement.

The entrances and exists of the storm sewer will be stabilized with rip-rap. A flared end-section (or type 'DW' endwall if necessary) will be constructed in the proximity of the unnamed tributary with a stabilized rip-rap energy dissipator. A temporary rock filter will be constructed in the stream to minimize any sediment runoff downstream.

4.0 Treatment

The Nutrient Separating Baffle Box made of concrete was selected to perform the bulk removal of suspended solids from the conveyance system. The Baffle Box will treat the entire flow from the system and can provide up to 90% collection of suspended solids in three (3) baffle chambers (Suntree Technologies, Inc.) and remove nutrient rich vegetation and capture litter on screens above the unit's static water line. **A** polisher, also constructed of concrete, (larger than, but modeled after the Suntree Technologies Golf Green Water Polisher) will be installed downstream of the Baffle Box to provide secondary treatment after the majority of the large sediment has been removed. The polisher has a nitrate, nitrite, phosphorus, and nitrogen absorbent filter media. If either or both treatment devices reach pollutant capture capacity, design storm flows will not be obstructed, but the system will no longer provide cleaning of the storm water runoff.

Both units are manufactured by Suntree Technologies, Inc. (Suntree) who has offered a *25%* in-kind contribution of the products to the grant (Appendix F). Suntree will also send a representative to the job site to ensure that the devices are correctly installed. The owner of Suntree has provided details, literature and technical guidance during the design process.

5.0 Site Limitations and Erosion and Sediment Pollution Control

Two (2) soils exist in the drainage area: McD (in the first phase work limits) - Mardin very stony silt loam, 8 to *25* percent sloping, and OpD (outside the first phase work limits) - Oquaga and Lordstown extremely stony silt loams, 8 to 25 percent slopes. Both soils have medium to rapid runoff and a slight hazard of erosion. One (1) soil is outside the drainage area to the storm sewer system but in the work area, VrB - Volusia very stony silt loam, 0 to 8 percent slopes, with slow runoff and slight erosion hazard. The McD and VrB soil surface areas are about 3 to 10 percent loose stones which will aid in stabilization. The McD limitations are related to a seasonal high water table, slow to very slow permeability, slope (McD only), and surface stoniness.

To determine the limitations of the site soil, five (5) soil borings were progressed to determine the depth to bedrock and the depth to groundwater (Appendix F). Bedrock was not encountered within the expected excavation limits. The Baffle Box (and storm sewer piping) can not be perforated to permit infiltration, and must be constructed of concrete (versus fiberglass) due to the shallow depth to groundwater realized in the borings.

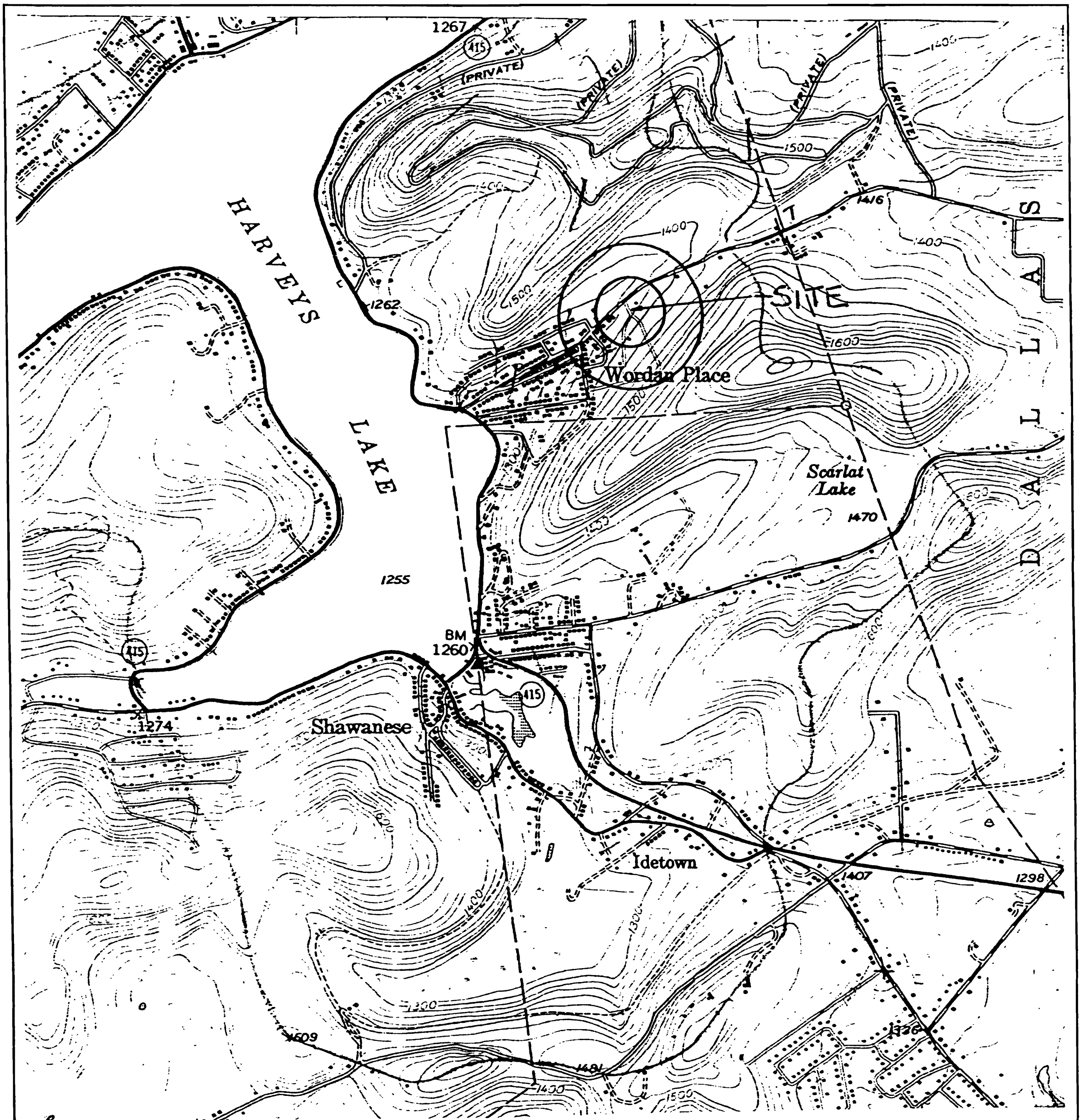
To minimize disturbance during construction, the trench excavation will be backfilled immediately as the pipe is installed. Following the construction sequence (installation from downstream to upstream) will limit the erosion and sediment pollution runoff from the construction activities.

Maintenance and clean-out of the Nutrient Separating Baffle Box and polishing unit will be the responsibility of the Borough of Harveys Lake. Material removed from the units will be transported and stabilized on Borough property as approved by the Luzerne Conservation District.

APPENDICES

APPENDIX A

SITE LOCATION MAP



Legend: Contour Interval 20 feet

SOURCE:

USGS7.5 minute series quadrangle maps: Harveys Lake quadrangle 1946, rev. 1969

SCALE: 1" = *2,000'*

N

APPENDIX A - SITE LOCATION MAP
USGS Topographic Map
Hemlock Gardens subdivision

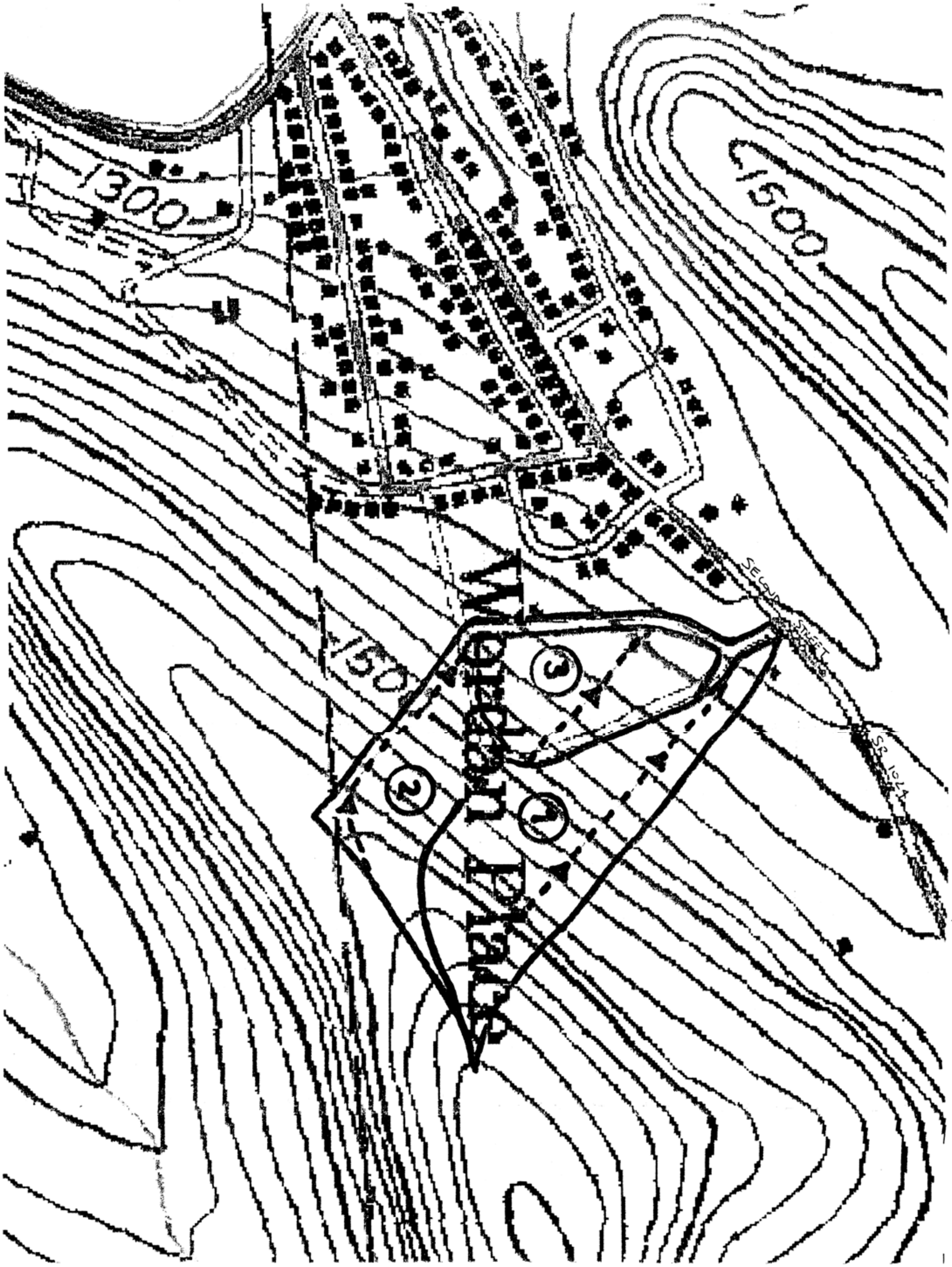
Harveys Lake Borough
Luzeme County, Pennsylvania

Project No. 156.11

pH

APPENDIX B

DRAINAGE AREA / TIME OF CONCENTRATION MAP



APPENDIX B

DRAINAGE AREA / TIME OF CONCENTRATION HARVEYS LAKE 100 0 100 200 300 400 500 Feet SCALE 1"300 Map Projection STATE PLANE PENNSYLVANIA NORTH, FEET, NAD 83	NAD 83, NORTH PA STATE PLANE	SOURCES [illegible] FILE:	NOTES: 1 DATA ACCURACY IS LIMITED TO THE ACCURACY AND SCALE OF THE ORIGINAL DATA SOURCE (MIN.) AREA 1 13.42 Ac, Tc: 24.4 AREA 2: 7.9[illegible] Ac, Tc: 28.[illegible] AREA 3 7.16 Ac, Tc: 1[illegible]	MAP 1: HEMLOCK GARDENS DRAWN BY: CW CHECKED BY: JAM REVISION NO: 2.00 REV DATE: AUGUST 5, 2002 pH Project No 156 01 pH

APPENDIX C

SOIL MAP / SOIL DESCRIPTIONS

SOURCE:

USDA, Luzerne County Soil Survey: 1981, reissued 1992

SCALE: 1: 20,000

N

APPENDIX C - Soil Map
USDA SOIL SURVEY
Hemlock Gardens subdivision

Harveys Lake Borough
Luzerne County, Pennsylvania

Project No 156.11

pH

sides of hills, knolls, and valleys and at the base of the steeper areas of broad, rolling mountaintops and intermountain basins. Runoff is rapid, and the hazard of erosion is moderate.

The profile of this soil is similar to the one described as representative of the series, but the plow layer is about 6 inches thick and depth to the fragipan is about 16 inches. Included in mapping are a few small areas of Mardin very stony silt loam and a few small areas of poorly drained and very poorly drained soils. Also included are a few small areas of Volusia channery silt loam.

This Mardin soil is medium in natural fertility and low in content of organic matter. Erosion is a severe hazard if this soil is used intensively for cultivated crops. Diversion terraces, stripcropping, minimum tillage, and a crop rotation that includes mostly close growing grasses and legumes are needed to control erosion. Artificial drainage is needed to remove excess water and improve use and management.

This soil is suited to most shallow rooted crops commonly grown in the county. Most areas are used for hay and pasture and occasionally for cultivated crops. A few small areas left idle are reverting to brush and trees. Most limitations for nonfarm use are related to the seasonal high water table, the slow permeability, and slope. Capability subclass IVe.

McB---Mardinvery stony silt loam, 3 to 8 percent slopes. This gently sloping soil is on the smooth, slightly concave uplands of broad, rolling mountaintops and intermountain basins. The surface area is about **3** to 10 percent loose stones. Runoff is medium, and the hazard of erosion is slight.

The profile of this soil is similar to the one described as representative of the series, but stones have not been removed from the surface and the soil has no plow layer. Included in mapping are a few small areas of Mardin channery silt loam and a few small areas of poorly drained and very poorly drained soils.

This Mardin soil is medium in natural fertility and moderate in content of organic matter. Because of the surface stones, this soil is not suited to cultivated crops. It is better suited to permanent pasture, woodland, or wildlife habitat. Applying adequate amounts of lime and fertilizer helps to maintain pasture yields.

Most areas of this soil are in woodland. A few small areas have been cleared and are used for permanent pasture. Most limitations for nonfarm use are related to the seasonal high water table, the slow permeability, and the surface stoniness. Capability subclass VIs.

McD---Mardin very stony silt loam, 8 to 25 percent sloping. This sloping and moderately steep soil is on smooth or slightly concave uplands on the crests and sides of hills and knolls and at the base of the steeper areas of broad, rolling mountaintops and intermountain basins. The surface area is about **3** to 10 percent loose stones. Runoff is medium to rapid, and the hazard of erosion is slight.

The profile of this soil is similar to the one described **as** representative of the series, but stones have not been removed from the surface and the soil has no plow layer. Included in mapping are a few small areas of Mardin channery silt loam and a few small areas of poorly drained and very poorly drained soils.

This Mardin soil is medium in natural fertility and moderate in content of organic matter. Because of the surface stones, this soil is not suited to cultivated crops. It is better suited to permanent pasture, woodland, or wildlife habitat. Applying adequate amounts of lime and fertilizer helps to maintain pasture yields.

Most areas of this soil are in woodland. **A** few small areas have been cleared and are used for permanent pasture. Most limitations for nonfarm use are related to the seasonal high water table, the slow permeability, slope, and the surface stoniness. Capability subclass VIs.

Meckesville Series

The Meckesville series consists of deep, well drained, gently sloping to moderately steep soils. These soils are on the uplands of broad, rolling intermountain basins. They formed in thick old glacial till material derived from sandstone, siltstone, and shale.

In a representative profile, the surface layer is dark reddish brown channery silt loam about 8 inches thick. The subsoil to a depth of 60 inches is 27 inches of dark reddish brown and reddish brown silt loam and channery silt loam and 25 inches of firm and brittle, reddish brown channery silt loam.

The fragipan in these soils restricts downward movement of roots. Permeability is moderately slow, and available water capacity is moderate.

Representative profile of Meckesville channery silt loam, **3** to 8 percent slopes, in Black Creek Township about *5-1/2* miles west of Conyngham:

Ap—0 to 8 inches; dark reddish brown (5YR 3/3) channery silt loam; moderate fine and very fine granular structure; very friable, slightly sticky, slightly pastic; many small roots; 15 percent shale fragments; very strongly acid; abrupt smooth boundary.

B21---8 to 15 inches; dark reddish brown (SYR 3/3) silt loam; weak medium and fine blocky structure; friable, slightly sticky, slightly plastic; many small roots; 10 percent shale fragments; very strongly acid; gradual wavy boundary.

B22—15 to 18 inches; reddish brown (5YR 4/3) channery silt loam; weak medium blocky structure; friable, slightly sticky, slightly plastic; common small roots: 20 percent shale fragments; very strongly acid; clear wavy boundary.

B23t—18 to 26 inches: reddish brown (5YR 4/3) silt loam; moderate medium subangular blocky structure parting to very fine angular blocky; friable, slightly sticky, slightly plastic; common small roots; 10 Percent shale fragments; thin patches of clay films on ped faces: strongly acid: gradual wavy boundary.

B24t—26 to 35 inches; reddish brown (2.5YR 4/4) silt loam; moderate medium angular blocky structure; friable, slightly sticky, slightly plastic; few small roots; 10 percent shale fragments; thin patches of clay films on ped faces: strongly acid; clear wavy boundary.

Bx---35 to 60 inches; reddish brown (2.5YR 414) channery silt loam; weak very coarse prismatic structure parting to moderate medium angular blocky; firm, brittle, slightly sticky, slightly plastic: few small roots: 40 percent shale fragments: few black (*N* 2/0) coatings on bedfaces; thick patches of clay films in pores; strongly acid.

Representative profile of Lordstown channery silt loam, in an area of Oquaga and Lordstown channery silt loams, 3 to 8 percent slopes, in Kingston Township about 1-1/2 miles southwest of Dallas:

Ap---0 to 8 inches; dark grayish brown (10YR 4/2) channery silt loam; moderate very fine and fine granular structure; very friable, nonsticky, slightly plastic; many small roots; 15 percent coarse fragments; very strongly acid; gradual wavy boundary.

B21--8 to 18 inches; yellowish brown (10YR 5/4) channery silt loam; weak fine subangular blocky structure; very friable, slightly sticky, slightly plastic; common small roots; 15 percent coarse fragments; strongly acid; gradual wavy boundary.

B22—18 to 27 inches; yellowish brown (10YR 5/4) channery silt loam; weak very fine and fine subangular blocky structure; very friable, slightly sticky. slightly plastic; common small roots; 15 percent coarse fragments: very strongly acid; gradual wavy boundary.

C---27 to 30 inches; yellowish brown (10YR 5/4) very channery silt loam; weak, massive; very friable. slightly sticky, nonplastic; few small roots; 50 percent coarse fragments; very strongly acid; abrupt wavy boundary.

R - 30 inches; olive gray thin bedded sandstone.

Solum thickness and depth to bedrock range from 20 to 40 inches. The content of coarse fragments ranges from 15 to 35 percent in the A and B horizons and from 20 to 60 percent in the C horizon. The fine earth texture throughout the profile is loam or silt loam. Reaction ranges from very strongly acid to slightly acid in the A horizon and from very strongly acid to medium acid in the B and C horizons. Color in the B horizon ranges from dark brown (7.5YR 414) or brown (10YR 4/3) to light olive brown (2.5Y 516). Color in the C horizon ranges from dark brown (7.5YR 3/2) to light olive brown (2.5Y 516).

Lordstown, Oquaga, Mardin, Bath. and Volusia soils formed in similar material. Lordstown soils are similar to Oquaga soils in depth and drainage, but they are yellower.

Mardin Series

The Mardin series consists of deep, moderately well drained, gently sloping to moderately steep soils. These soils are on the smooth, slightly concave uplands of broad, rolling mountaintops and intermountain basins. They formed in thick glacial till material derived from sandstone and shale.

In a representative profile, the surface layer is dark brown channery silt loam about 8 inches thick. The upper 11 inches of the subsoil is light olive brown channery silt loam and channery loam, and the lower 31 inches is firm and brittle, yellowish brown, and dark yellowish brown channery loam. The underlying material to a depth of 64 inches is yellowish brown channery loam.

The fragipan in these soils restricts downward movement of roots and water. Permeability is slow in the fragipan. Available water capacity is low to moderate.

Representative profile of Mardin channery silt loam, 3 to 8 percent slopes, in Union Township about 1-1/2 miles south of Muhlenburg:

Ap---0 to 8 inches; dark brown (10YR 4/3) channery silt loam; weak fine granular structure; very friable, nonsticky, nonplastic; many small roots; 20 percent coarse fragments; medium acid; abrupt smooth boundary.

B21---8 to 17 inches; light olive brown (2.5Y 5/4) channery silt loam: weak very fine and fine subangular blocky structure; friable, slightly sticky, slightly plastic; common roots; 25 percent coarse fragments; medium acid; gradual wavy boundary.

B22—17 to 19 inches; light olive brown (2.5Y 514) channery loam; many medium and coarse distinct light gray (10YR 7/2) and strong brown (7.5YR 516) mottles; weak very fine and fine subangular blocky structure; friable, slightly sticky, slightly plastic; few roots; 15 percent coarse fragments; medium acid; clear broken boundary.

Bx1—19 to 26 inches; yellowish brown (10YR 5/4) channery loam, light gray (2.5Y 712) prism faces; few fine faint mottles, dark brown (7.5YR 4/4) prism interior; weak very coarse prismatic structure parting to weak fine and medium subangular blocky; firm. brittle, slightly sticky. slightly plastic; few roots; 20 percent coarse fragments: medium acid; gradual wavy boundary.

Bx2—26 to 39 inches; brown (10YR 5/3) channery loam, light gray (N 7/0) prism faces; many medium prominent light gray (1OYR 7/1) and strong brown (7.5YR 5/6) streaks and mottles; moderate very coarse prismatic structure parting to weak fine and medium blocky; firm, brittle, sticky, plastic; few roots along prism faces; common fine black (N 2/0) coatings on ped faces and a yellowish brown (10YR 5/4) horizontal streak at the base of the horizon; 20 percent coarse fragments; medium acid; gradual wavy boundary.

Bx3—39 to 43 inches; yellowish brown (10YR 5/4) channery loam, light gray (10 YR 7/1) prism faces; weak very coarse prismatic structure parting to weak fine medium subangular blocky; firm, brittle, slightly sticky, slightly plastic; 5-millimeter thick strong brown (7.5YR 5/6) horizontal streak across the horizon; 20 percent coarse fragments; medium acid; gradual wavy boundary.

Bx4---43 to 50 inches; dark yellowish brown (10YR 414) channery loam, light gray (N 7/0) prism faces; common coarse distinct strong brown (7.5YR 5/6) mot. tles; weak very coarse prismatic structure parting tc weak fine and medium subangular blocky; firm. brit. tle, slightly sticky, slightly plastic; common fine black (N 2/0) coatings on ped faces; thin clay films arounc pores; 25 percent coarse framents; medium acid gradual wavy boundary.

IIC—50 to 64 inches; yellowish brown (10 YR 514) chan nery loam; massive; friable, nonsticky, nonplastic 30 percent coarse fragments; medium acid.

Solum thickness ranges from 40 to 70 inches. Depth t the Bx horizon ranges from 16 to 26 inches. Depth to bed rock is 6 feet or more. The content of coarse fragment ranges from 10 to 35 percent above the Bx horizon and from 20 to 50 percent in the Bx and C horizons. Reaction ranges from very strongly acid to medium acid above th Bx horizon and from very strongly acid to slightly acid in the Bx horizon. Color in the B2 horizon ranges from stron brown (7.5YR 5/6) to olive brown (2.5Y 4/4) an brown (10YR 5/3). This horizon has high and low chrom mottles between depths of 15 and 26 inches. The fine eart texture of the B2 horizon ranges from loam to silt loan Color in the Bx and C horizons ranges from dark brow (7.5YR 312) to light olive brown (2.5Y 514). These hor zons have faint to prominent mottles and streaks. The fin earth texture of the Bx horizon is silt loam or loam. Th fine earth texture of the C horizon ranges from silt loam to loam.

Mardin. Bath. Lordstown. Volusia. and Chippewa soi formed in similar material. Mardin soils are deep and moderately well drained. Bath sails are deep and well drained Lordstown soils are moderately deep and well drained Volusia soils are deep and somewhat poorly drained, ar Chippewa soils are deep and poorly drained and vel poorly drained.

MaB—Mardin channery silt loam, 3 to 8 percent

better suited to woodland, wildlife habitat, recreation, or esthetic use. The extremely stony surface layer and rock outcrop restrict the use of some woodland equipment.

Most areas of this mapping unit are used for woodland. A few small areas have been cleared and are used for permanent pasture. Most limitations for nonfarm use are related to the depth to bedrock and the surface stoniness. Capability subclass VIIs.

OpD---Oquaga and Lordstown extremely stony silt loams, **8** to **25** percent slopes. This sloping and moderately steep mapping unit is on the convex, rounded tops, crests, and sides of hills; on knolls; and on the mountain ridges of broad, rolling mountains and intermountain basins. About 55 percent of the total acreage is Oquaga soil and 30 percent is Lordstown soil. Some mapped areas are entirely Oquaga soil. Some are Lordstown soil. Loose stones cover about 15 to 25 percent of the surface. Runoff is medium to rapid, and the hazard of erosion is slight.

The Lordstown soil has a profile similar to the one described as representative of the Lordstown series, but stones have not been removed from the surface. The Oquaga soil has the profile described as representative of the Oquaga series.

Included with this unit in mapping are a few small areas of a deep, moderately well drained soil without a fragipan; a few small areas of Oquaga and Lordstown channery silt loams; and a few small wet areas. Also included is rock outcrop, which in places makes up about 5 to 15 percent of the surface area.

Natural fertility is medium, and content of organic matter is moderate. Because of the surface stones, this unit is not suited to cultivated crops or to pasture. It is better suited to woodland, wildlife habitat, recreation, or esthetic use. The extremely stony surface layer and rock outcrop restrict the use of some woodland equipment.

Most areas of this mapping unit are used for woodland. A few small areas have been cleared and are used for permanent pasture. Most limitations for nonfarm use are related to the depth to bedrock, the surface stoniness, and slope. Capability subclass VIIs.

OXF—Oquaga and Lordstown extremely stony silt loams, steep. This steep and very steep mapping unit is on the sides of hills, mountain ridges, and valleys of broad, rolling mountaintops and intermountain basins. About 55 percent of the total acreage is Oquaga soil, and **30** percent is Lordstown soil. Some mapped areas are entirely Oquaga soil. Some are Lordstown Soil. Loose stones cover about 5 to 30 percent of the surface. Runoff is rapid to very rapid, and the hazard of erosion is slight.

The Lordstown soil has a profile similar to the one described as representative of the series, but stones have not been removed from the surface. The Oquaga soil has a profile similar to the one described as representative of the series. Depth to bedrock is about 24 inches in both soils.

Because of the steep and very steep dopes, this mapping unit has not been investigated as thoroughly as most areas in the county, and it contains more inclusions than the less sloping Oquaga and Lordstown extremely stony silt loams mapping units. The most common inclusions are a few small areas of a deep, moderately well drained soil without a fragipan. Also included is rock outcrop, which in places makes up about 5 to 15 percent of the surface area.

Natural fertility is medium, and content of organic matter is moderate. Because of the steep and very steep slopes, this unit is not suited to cultivated crops. It is better suited to woodland, wildlife habitat, recreation, or esthetic use. The steep and very steep slopes and stones restrict the use of most woodland equipment.

Most areas of this mapping unit are used for woodland. Most limitations for nonfarm use are related to slope, the depth to bedrock, and the surface stoniness. Capability subclass VIIs.

Pocono Series

The Pocono series consists of deep, well drained, gently sloping to moderately steep soils. These soils are on the smooth, convex uplands of broad, rolling mountaintops and mountainsides. They formed in thick glacially influenced material derived from sandstone, conglomerate, and shale.

The top inch in a representative profile is an organic layer of partly decomposed leaf litter. The surface layer is about 1 inch of very dark brown gravelly loam. The subsurface layer is pinkish gray gravelly sandy loam about 4 inches thick. The subsoil to a depth of 65 inches is strong brown gravelly loam.

Permeability is moderate, and available water capacity is moderate to high.

Representative profile of Pocono gravelly sandy loam, in a wooded area of Pocono extremely stony sandy loam, 8 to 25 percent slopes, in Hazle Township about three-quarters of a mile southwest of the village of Japan along a coal haul road east of Legislative route 40004:

02—1 inch to 0; black (N 210) partly decomposed organic material.

A1—0 to 1 inch; very dark brown (10YR 212) gravelly loam; moderate fine granular structure; very friable. nonsticky, nonplastic; many roots; 30 percent coarse fragments: very strongly acid; abrupt wavy boundary.

A2—1 to 5 inches; pinkish gray (7.5YR 612) gravelly sandy loam; weak coarse granular structure; very friable, nonsticky, nonplastic; many roots; 35 percent coarse fragments; very strongly acid; clear wavy boundary.

B21t—5 to 11 inches; strong brown (7.5YR 516) gravelly loam; weak fine subannular blocky structure; very friable, slightly sticky, slightly plastic; many roots; some clay bridging sand grains; 40 percent coarse fragments; very strongly acid; clear wavy boundary.

B22t-11 to 24 inches; strong. brown (7.5YR 516) gravelly loam; weak fine subangular blocky structure; friable. slightly sticky, plastic; common roots: few thin clay films in pores and bridging sand grains: few thin black coatings; 50 percent coarse fragments: very strongly acid; gradual wavy boundary.

B23t—24 to 36 inches; strong brown (7.5YR 5/6) gravelly loam; weak fine and medium subangular blocky structure; friable. slightly sticky. plastic: common roots; common thin clap films in pores and bridging positions in drainageways or at the base of steeper, better drained soils on broad, rolling mountaintops and in intermountain basins. The surface area is about 3 to 10 percent loose stones. Runoff is medium, and the hazard of erosion is slight.

Included with this soil in mapping are a few small areas of Morris channery silt loam and a few small areas where stones cover more than 10 percent of the surface.

This Morris soil is medium in natural fertility and moderate in content of organic matter. Because of the surface stones, this soil is not suited to cultivated crops. It is better suited to permanent pasture, woodland, or wildlife habitat. Applying adequate amounts of lime and fertilizer helps to maintain pasture yields. The seasonal high water table restricts the use of some woodland equipment.

Most areas of this soil are in woodland. A few small areas have been cleared and are used for permanent pasture. Most limitations for nonfarm use are related to the slow permeability, the seasonal high water table, slope, and the surface stoniness. Capability subclass VIIs.

Muck

Mu—Muck consists of very poorly drained, level and nearly level organic soils. These soils are in low lying, concave depressions of broad, rolling mountaintops and intermountain basins. They formed in decaying organic deposits 5 to 30 feet thick. Runoff is slow, and ponding is common. The hazard of erosion is slight.

These organic soils have a black surface layer. The underlying organic layers are very dark gray, very dark grayish brown, dark brown, very dark brown, and dark reddish brown. The material is fibric, hemic, or sapric.

Included with Muck in mapping are a few small areas of Muck that is 10 to 36 inches thick over contrasting mineral soils or bedrock.

Permeability is moderately rapid, and available water capacity is high. Natural fertility is medium to low, and content of organic matter is extremely high. Because of the high water table, these soils are generally not suited to cultivated crops. If drained, however, they are suited to certain high cash value truck crops.

Most areas of Muck are in woodland or wetland Shrubs. Organic material from several of the larger bogs is sold commercially for mushroom culture and landscaping purposes. Most limitations for nonfarm Use are related to the high water table, ponding, the difficultyin locating suitable drainage outlets, and the possibility of subsidence if the material is excessively drained and as it continues to decay.

Oquaga Series

The Oquaga series consists of moderately deep, well drained, gently sloping to very steep soils. These soils are on the convex tops and sides of hills, knolls, and mountain ridges of broad, rolling mountaintops and intermountain basins. They formed in moderately thick glacial till material weathered from sandstone, shale, and conglomerate.

The top 3 inches in a representative profile is an organic layer of recently deposited and partly decomposed leaf litter. The surface layer is 4 inches of dark reddish brown channery silt loam. The subsoil is dark reddish brown and dark red channery silt loam, channery loam, and very channery loam about 26 inches thick. The underlying material to a depth of 35 inches is dark reddish brown very channery loam. Shale bedrock is at a depth of 35 inches.

These soils have bedrock within a depth of 40 inches. Permeability is moderate: and available water capacity is moderate to low.

Representative profile of Oquaga channery silt loam, in an area of Oquaga and Lordstown extremely stony silt loams, 8 to 25 percent slopes, in Bear Creek Township about 2 miles south of the Wilkes-Barre interchange of Northeast Pennsylvania Turnpike along State Route 115:

O1---3 to 2 inches; recently deposited leaf litter.

02—2 inches to 0; black (5YR 211) partly decomposed organic material.

Al—0 to 4 inches; dark reddish brown (2.5YR 314) channery silt loam; weak and very fine granular structure; friable, nonsticky, nonplastic; many small roots; 15 percent coarse fragments; very strongly acid; clear wavy boundary.

B1-4 to 9 inches; dark reddish brown (2.5YR 3/4) channery silt loam; weak very fine subangular blocky structure; friable. slightly sticky. slightly plastic; many small roots; 20 percent coarse fragments: strongly acid; clear wavy boundary.

B21—9 to 18 inches; dark red (2.5YR 3/6) channery silt loam; weak very fine subangular blocky structure; friable, slightly sticky, slightly plastic; common small roots; 30 percent coarse fragments; strongly acid; clear wavy boundary.

B22—18 to 26 inches; dark reddish brown (2.5YR 3/4) channery loam; weak very fine and fine subangular blocky structure; friable, slightly sticky, nonplastic; few small roots; 40 percent coarse fragments; strongly acid; clear wavy boundary.

B3—26 to 30 inches: dark reddish brown (2.5YR 3/4) very channery loam; weak very fine and fine subangular blocky structure; friable, slightly sticky. nonplastic; few small roots; 60 percent coarse fragments: strongly acid; clear wavy boundary.

C--30 to 35 inches; dark reddish broun (2.5YR 3/4) very channery loam; massive. silt within interstices of the shale fragments; friable. slightly sticky, nonplastic 85 percent shale fragments; very strongly acid abrupt wavy boundary.

R—35 inches; dark reddish gray shale.

Solum thickness ranges from 15 to 35 inches. Depth to bedrock ranges from 20 to 40 inches. The content of coarse fragments ranges from 15 to 50 percent in the solum and from 60 to 90 percent in the C horizon. In unlimed area reaction is very strongly acid or strongly acid throughout the profile. Color in the B horizon ranges from dark red dish brown (2.5YR 3/4) to strong brown (7.5YR 5/6) The fine earth texture in the B and C horizons is silt loar or loam. In some pedons faint mottles are at the point o contact with bedrock.

Oquaga. Arnot, Lackawanna. and Wellsboro soils forme in similar rnaterial. Oquaga soils are moderately deep an well drained. Arnot soils are shallow and well drained Lackawanna soils are deep and well drained. and Well: boro soils are deep and moderately well drained.

01B---Oquaga and Lordstown channery silt loams

and a crop rotation that includes close growing grasses and legumes are needed to control erosion in steeper areas.

This soil is suited to most shallow rooted crops commonly grown in the county. Most areas are in hap or permanent pasture. A few small areas are used for cultivated crops, and some areas left idle are reverting to brush and trees. Most limitations for nonfarm use are related to the seasonal high water table and the very slow permeability. Capability subclass IIIw.

VoC---Volusia channery silt loam, 8 to 15 percent slopes. This sloping soil is in smooth, concave upland positions in drainageways or at the base of steeper, better drained soils of broad, rolling mountaintops and intermountain basins. Runoff is medium, and the hazard of erosion is moderate.

In most areas the profile of this soil is similar to the one described as representative of the series, but the Volusia soils near Wurtsboro soils are slightly coarser textured throughout the profile than those near Mardin soils. Included in mapping are a few small areas of Volusia very stony silt loam and a few small areas of poorly drained and very poorly drained soils.

This Volusia soil is medium in natural fertility and low in content of organic matter. Erosion is a moderate hazard if this soil is used for cultivated crops. Diversion terraces, stripcropping, minimum tillage, and a crop rotation that includes close growing grasses and legumes are needed to control erosion. Artificial drainage is needed to remove excess water and improve use and management.

This soil is suited to most shallow rooted crops commonly grown in the county. Most areas are in hay or permanent pasture. A few small areas are in cultivated crops, and some areas left idle are reverting to brush and trees. Most limitations for nonfarm use are related to slope, the seasonal high water table, and the very slow permeability. Capability subclass IIIe.

Vrb---Volusia very stony silt loam, 0 to 8 percent slopes. This nearly level to gently sloping soil is in the smooth, concave depressions and drainageways of broad, rolling mountaintops and intermountain basins. The surface area is about 3 to 10 percent loose stones. Runoff is slow, and the hazard of erosion is slight.

The profile of this soil is similar to the one described as representative of the series, but stones have not been removed from the surface and the soil has no plow layer. The Volusia soils near Wurtsboro soils are slightly coarser textured throughout the profile than those near Mardin soils. Included in mapping are a few small areas of Volusia channery silt loam and a few small areas of poorly drained and very poorly drained soils.

This Volusia soil is medium in natural fertility and moderate in content of organic matter. Because of the surface stones, this soil is not suited to cultivated crops. It is better suited to permanent pasture, woodland, or wildlife habitat. Applying adequate amounts of lime and fertilizer helps to maintain pasture yields. The seasonal high water table restricts the use of some woodland equipment.

Most areas of this soil are in woodland. A few small areas have been cleared and are used for permanent pasture. Most limitations for nonfarm use are related to the seasonal high water table, the very slow permeability, and the surface stoniness. Capability subclass VIIs.

VrC---Volusia very stony silt loam, 8 to 15 percent slopes. This sloping soil is in smooth, concave upland positions in drainageways or at the base of steeper, better drained soils of broad, rolling mountaintops and intermountain basins. The surface area is about 3 to 10 percent loose stones. Runoff is medium, and the hazard of erosion is slight.

The profile of this soil is similar to the one described as representative of the series, but stones have not been removed from the surface and the soil has no plow layer. The Volusia soils near Wurtsboro soils are slightly coarser textured throughout the profile than those near Mardin soils. Included in mapping are a few small areas of Volusia channery silt loam and a few small areas of poorly drained and very poorly drained soils.

This Volusia soil is medium in natural fertility and moderate in content of organic matter. Because of the surface stones, this soil is not suited to cultivated crops. It is better suited to permanent pasture, woodland, or wildlife habitat. Applying adequate amounts of lime and fertilizer helps to maintain pasture yields. The seasonal high water table restricts the use of some woodland equipment.

Most areas of this soil are in woodland. A few small areas have been cleared and are used for permanent pasture. Most limitations for nonfarm use are related to the seasonal high water table, the very slow permeability, slope, and the surface stoniness. Capability subclass VIIs.

Wayland Series

The Wayland series consists of deep, very poorly drained, nearly level soils on flood plains. These soils formed in mixed alluvial material deposited by streams.

In a representative profile, the surface layer is very dark grayish brown silt loam about 3 inches thick. The substratum to a depth of 60 inches is mottled gray and olive gray silty clay loam and heavy silty clay loam.

Permeability is slow, and available water capacity is high. The water table is at or near the surface during wet periods.

Representative profile of Wayland silt loam, in Lake Township about 1-1/4 miles northeast of the village of Pike's Creek. Slope is less than 1 percent:

Alg---0 to 3 inches; very dark grayish brown (1OYR 3/2) silt loam, gray (10YR 511) rubbed and dry; moderate very fine granular structure; very friable, nonstick~.nonplastic: neutral: abrupt wavy boundary.

Clg-3 to 35 inches; gray (5Y 6/1) siity clayloam; many medium prominent yellowish brown (10YR 5/8) and strong brown (7.5YR 5/6) mottles; weak stratification or weak medium and thick platy structure; friable, sticky. plastic; thin continuous clay films in pores; neutral; gradual wavy boundary.

C2g--35 to 42 inches: pray (5Y 511) silty clay loam; few fine prominent yellowish red (5YR 416) mottles and stains around old root channels; massive; friable, sticky. plastic; neutral; gradual wavy boundary.

Urban Land

Urban land is a nearly level to moderately steep mixture of soil, rock, and miscellaneous manmade material. It is in industrial, commercial, and some residential areas where urban structures and works so obscure the land surface that identification of the soils is not practical. Most areas are on uplands or terraces, but some are on flood plains.

In many places the original soil profile has been completely destroyed, but in some scattered areas the soils remain intact. Urban land is used as sites for shopping centers, schools, factories, railroads, homes, and other urban and industrial facilities. The largest areas are between West Pittston and Nanticoke near the Susquehanna River and, in the southern part of the county, in Hazleton.

Ub---Urban land is on smooth or slightly convex uplands. It is nearly level to moderately steep. Runoff is slow to rapid. The surface layer in most areas is stabilized artificially or with vegetation. If the surface cover is inadequate, the hazard of erosion is severe.

Included with Urban land in mapping are a few areas of Mine dump, Strip mine, and Cut and Fill land and a few small areas of soils adjacent to Urban land.

Most areas of Urban land are in the closely built-up sections of communities. Onsite investigation is needed to determine the suitability, hazards, and degree of limitations before selecting an area for a specific use.

Uf— Urban land, rarely flooded, is on smooth or slightly concave flood plains. It is nearly level to gently sloping. The soil material consists of water-laid sediments. Color and texture are variable. Runoff is slow to rapid. The surface layer in most areas is stabilized artificially or with vegetation. If the surface cover is inadequate, the hazard of erosion is moderate.

Included with Urban land, rarely flooded, in mapping are a few areas of Mine dump, some areas of Pope and Basher soils, and a few small sand and gravel quarries that have been filled with trash.

Onsite investigation is needed to determine the flooding frequency before selecting an area for a specific use.

Volusia Series

The Volusia series consists of deep, somewhat poorly drained, nearly level to sloping soils. These soils are in the smooth, concave depressions and drainageway of broad, rolling mountaintops and intermountain basins. They formed in thick glacial till material weathered from sandstone and shale.

In a representative profile, the surface layer is dark grayish brown channery silt loam about 9 inches thick. The subsoil to a depth of 60 inches is 11 inches of mottled pale olive and light olive gray channery silt loam and channery heavy silt loam and 40 inches of very firm and brittle, olive channery loam.

The fragipan in these soils restricts downward movement of roots and water. Permeability is very slow in the fragipan. Available water capacity is moderate.

Representative profile of Volusia channery silt loam, 0 to 8 percent slopes, in Union Township about three-quarters of a mile southwest of Muhlenburg:

Ap—0 to 9 inches; dark grayish brown (10YR 4/2) channery silt loam; moderate very fine and fine granular structure; very friable, nonsticky, slightly plastic; many small roots; 25 percent coarse fragments; slightly acid; abrupt smooth boundary.

B21—9 to 15 inches; pale olive (5Y 613) channery silt loam; few medium distinct yellowish brown (10YR 5/8) mottles and dark grayish brown (10YR 4/2) stains in earthworm channels; weak fine and medium subangular blocky structure: friable, nonsticky, slightly plastic; common small roots; 30 percent coarse fragments; thin continuous clay films in root pores and earthworm channels; slightly acid; gradual wavy boundary.

B22--5 to 20 inches; light olive gray (5Y 612) channery heavy silt loam; common coarse and medium distinct yellowish brown (10YR 5/81 and gray (5Y 6/) mottles: weak fine and medium angular blocky structure; friable to slightly firm, slightly sticky. plastic; few small roots; 15 percent coarse fragments; thin continuous clay films in root pores and earthworm channels; strongly acid: clear wavy boundary.

Bx—20 to 60 inches; olive (5Y 5/3) channery loam, light gray (5Y 6/1) prism faces: many medium prominent yellowish brown (10YR 5/8) mottles; moderate very coarse prismatic structure parting to weak medium and coarse angular blocky; very firm, brittle, nonstickp. nonplastic; few fine roots along prism faces: 30 percent coarse fragments; few thin clay films on prism faces and around pores and stone faces: slightly acid.

Solum thickness ranges from 40 to 72 inches. Depth to the Bx horizon ranges from 10 to 20 inches. In unlimed areas reaction ranges from very strongly acid to slightly acid above the Bx horizon and from medium acid to slightly acid in the Bx horizon. The content of coarse fragments ranges from 15 to 30 percent in the solum and from 30 to 60 in the C horizon. The fine earth texture in the solum is loam or silt loam. The B2 horizon ranges from light yellowish brown (10YR 6/4) to olive gray (5Y 4/2). but a chroma of 2 or less is dominant in the lower part of the B2 horizon, just above the Bx horizon. Color in the Bx horizon ranges from very dark grayish brown (10YR 3/2) to olive (5Y 5/4).

Volusia. Chippewa, Mardin, Wurtsboro. and Bath soils formed in similar material. Volusia soils are somewhat poorly drained. Chippewa soils are poorly drained and very poorly drained, Mardin and Wurtsboro soils are moderately well drained. and Rath soils are well drained.

VoB---Volusia channery silt loam, 0 to 8 percent slopes. This nearly level and gently sloping soil is in the smooth, concave depressions and drainageways of broad, rolling mountaintops and intermountain basins. Runoff is slow to medium, and the hazard of erosion is moderate.

In most areas this soil has the profile described as representative of the series, but the Volusia soils near Wurtsboro soils are slightly coarser textured throughout the profile than those near Mardin soils. Included in mapping are a few small areas of Volusia very stony silt loam and a few small areas of poorly drained and very poorly drained soils.

This Volusia soil is medium in natural fertility and low in content of organic matter. The seasonal high water table delays tillage in spring and during wet periods. Diversion terraces or artificial drainage is needed to remove excess water and improve use and management. Contour stripcropping, minimum tillage

APPENDIX D

TR-55 TRAVEL TIME CALCULATIONS / STORM FLOWS / SWALE CALCULATIONS / STORM SEWER DESIGN / OUTLET PROTECTION CALCULATIONS

Chapter 3 Time of concentration and travel time

Travel time (T_t) is the time it takes water to travel from one !ocation to another in a watershed. T_t is a component of time of concentration (T_c), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system.

T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

Factors affecting time of concentration and travel time

Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics. runoff flow velocity increases and travel time decreases.

Slope

Slopes may be increased or decreased by urbanization. depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers. street gutters, and diversions.

Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600V} \qquad \text{[eq. 3-1]}$$

where:

T_t = travel time (hr)
L = flow length (ft)
V = average velocity (ft/s)
3600 = conversion factor from seconds to hours.

Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t1} + T_{t2} + \dots T_{tm} \qquad \text{[eq. 3-2]}$$

where:

T_c = time of concentration (hr)
m = number of flow segments

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks: and erosion and transportation of sediment. These n values are for very shallow flow depths of about **0.1** foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

Table 3-1 Roughness coefficients (Manning's n) for sheet flow

Surface description	n [1]
Smooth surfaces (concrete. asphalt. gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover 120%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods: [3]	
Light underbrush	0.40
Dense underbrush	0.80

1 **The n values are a composite of information compiled by Engman (1986).**
2 **Includes species such as weeping lovegrass. bluegrass. buffalo grass. blue grama grass. and native grass mixtures.**
3 **When selecting n. consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.**

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \quad \text{[eq. 3-3]}$$

where:

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
P_2 = 2-year. 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow. (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

Provide 3 alternates

TABLE 2.10.15.2
SUGGESTED GUIDES FOR CORROSION PROTECTION
BASED ON pH VALUES OF WATER

Guide for the selection of pipe based on pH values of the water the installation is expected to carry.

	pH Values of *Water* or Soil
pH—3.5 or less	—Stainless Steel, Vitrified Clay, Coal Tar Epoxy Lined Reinforced Cement Concrete Pipe. Coated Corrugated Galvanized Steel Pipe. Coated Aluminum Alloy Pipe.
pH—3.5 to 5.0	—Coated Corrugated Galvanized Steel Pipe. P.I.C.C. Pipe (24" Max.). Reinforced Cement Concrete Pipe or Coated Aluminum Alloy Pipe.
pH—5.0 to 8	--Corrugated Galvanized Steel Pipe. P.I.C.C. Pipe (24" Max.). Reinforced Cement Concrete Pipe. or Aluminum Alloy Pipe.
pH--8 and above	Coated Corrugated Galvanized Steel Pipe. Coated Aluminum Alloy Pipe. Reinforced Cement Concrete Pipe or P.I.C.C. Pipe (24" Max.).

High Sulphur Content---Same as **3.5** or less.

Note: In areas where highly abrasive conditions may exist, the metal pipe. should have a Type A polymeric coating.

Requisitions for pipe should be supported with the pH of the affluent.

For design purposes; the pH of water at a future construction site shall be determined, in the field, by PTM **208.** If the pH is found to be below 5.0 a one (1) quart sample shall be furnished to the Materials and Testing Division for exact identificatibn, Such testing should be done seasonally. if possible, and the worst set of conditions used in making determination of proper type of pipe.

Further. at the discretion of the District Soils Engineer. if a site is considered to have exceptionally acidic or alkaline conditions. a six (6) to eight (8) pound sample of the site soil should be sent to the Materials and Testing Division for determination of soil pH and resistivity(pp).

Selection of the type of polymeric coating required shall be made as per the following:

Type A

Water pH of less than 5.0 or greater than 8 combined with a soil pH of 5.0 to 8 and/or a soil resistivity if 6000 ohmlcm or greater.

Type B

Water pH of less than 5.0 or greater than 8 combined with a soil pH of 3.5 to 5.0 and/or a soil resistivity of 2000 to 6000 ohm/cm. A Type B polymeric coating shall be used for water with a pH **of** 3.5 to **5.0 of** soil conditions are not being tested.

Type C

Water pH of less than 5.0 or greater than 8 combined with a soil pH less than 3.5 or greater than **8** and/or **a soil** resistivity of less **than 2000** ohm/cm.

TABLE 2.10.13.1
ROUGHNESS COEFFICIENT "n"
FOR MANNING'S EQUATION

Description	"n"
Concrete Pipe	.012
Annular Corrugated Steel and Alum. Alloy Pipe or Pipe Arch + (plain or coated)	.024
Vitrified Clay Pipe	.012
Cast Iron Pipe	.013
Brick Sewer	.015
Asphalt Pavement	.015
Concrete Pavement	.014
Grass Medians	.05
Earth	.02
Gravel	.02
Rock	.035
Cultivated Areas	.03 - .05
Dense Brush	.07 - .14
Heavy Timber—Little Undergrowth	.10 - .15
Streams	
a. some grass and weeds--little or no brush	.03 - .035
b. dense growth of weeds	.035- .05
c. some weeds—heavy brush on banks	.05 - .07

Note: In considering each factor more critical judgment will be exercised if it is kept in mind that any condition that causes turbulence and retards flow results in a greater value of "n".

+ Roughness Coefficient (n) for Helical Corrugated Steel and Alum. Alloy Pipe

Corruqations	$2\frac{2}{3}" \times \frac{1}{2}"$								$3" \times 1"$
Diameters	18"	24"	36"	48"	60"	72"	84"	96"	ALL DIA.
Plain or Coated	.014	.016	.019	.020	.021	.021	.021	.021	.024

TABLE 2.10.13.2:
CAPACITY OF TYPE C INLET
OR TYPE M INLET (MOUNTABLE CURB)

SLOPE LONGITUDINAL (%)	***SWALE****	***CAPACITY*** (cfs)**
0.5	12:1	1.5
0.5	16:1	1.5
0.5	24:1	0.3
0.5	48:1	0.2.
2.0	12:1	2.8
2.0	16:1	2.1
2.0	24:1	1.8
2.0	48:1	0.6
4.0	12:1	3.4
4.0	16:1	2.6
4.0	24:1	1.2
4.0	48:1	0.4
8.0	12:1	2.4
8.0	16:1	2.0
8.0	24:1	1.2
8.0	48:1	0.5

*Pavement cross slope

**100% EFFICIENCY

```
*****************************************************************
* TRAVEL TIME CALCULATIONS - SCS Segmental Approach, TR-55 (1986) *
*****************************************************************

SUMMARY for Area 1

Segment 1: OVERLAND FLOW
     L = 100 ft, S = .1 ft/ft, n = .8, P(2yr/24hr) = 2.9 in
     Travel Time = 20.6 minutes

 Segment 2: CONCENTRATED FLOW
     L = 1500 ft, S = .19 ft/ft, UNPAVED surface
     Travel time = 3.6 minutes

 Segment 3: CHANNEL FLOW
     A = 3 ft^2, P = 5 ft, L = 100 ft, S = .1 ft/ft, n = .04
     Travel Time = .2 minutes

TOTAL TRAVEL TIME = 24.4 min.
```

Table 2-2a Runoff curve numbers for urban areas 1/

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area 2/	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns. parks, golf courses, cemeteries. etc.) 3/:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs. driveways. etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) J		63	77	85	88
Artificial desert landscaping (impervious weed barrier. desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
118 acre or less (town houses)	65	77	85	90	92
114 acre	38	61	75	83	87
113 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) 5/	77	86	91	94	
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.

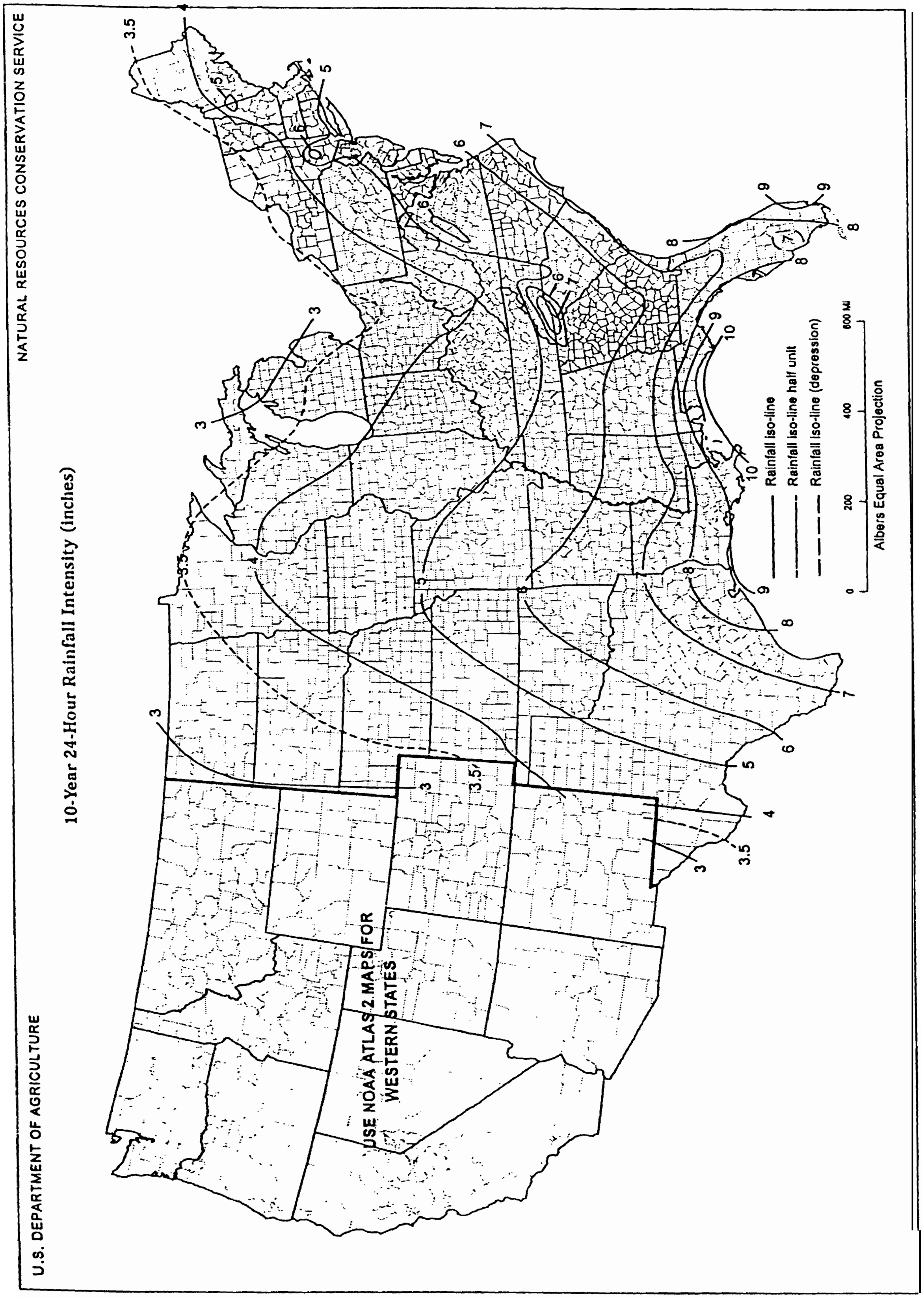
2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98. and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Figure B-5 **Ten-year, 24-hr rainfall**



Princeton Hydro, LLC
Ringoes, NJ
AUGUST 6, 2002

HYDROLOGIC REPORT FOR

Hemlock Gardens (Harveys Lake)

24 HOUR S. C. S. HYDROGRAPH

BASIN IDENTIFICATION Area 1
BASIN DISCHARGES INTO Swale East

BASIN AREA	=	13.42	ACRES		
BASIN CURVE NUMBER	=	75.00			
24-HOUR PRECIPITATION	=	4.50	INCHES		
24-HOUR RUNOFF	=	2.05	INCHES		
AVERAGE BASIN SLOPE	=	18.00	%		
HYDRAULIC LENGTH	=	1,700.00	FEET		
BASIN LAG, (Tc)	=	0.24	HOURS ,	0.40	HOURS
UNITPEAK COEFFICIENT	=	484.00			
RAINFALL DISTRIBUTION	=	TYPE II			

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.
8.67	0.0	8.75	0.0	8.83	0.0	8.92	0.0
9.00	0.0	9.08	0.0	9.17	0.0	9.25	0.0
9.33	0.0	9.42	0.0	9.50	0.0	9.58	0.0
9.67	0.0	9.75	0.1	9.83	0.1	9.92	0.1
10.00	0.1	10.08	0.1	10.17	0.1	10.25	0.2
10.33	0.2	10.42	0.2	10.50	0.2	10.58	0.3
10.67	0.3	10.75	0.4	10.83	0.4	10.92	0.5
11.00	0.6	11.08	0.6	11.17	0.7	11.25	0.8
11.33	0.9	11.42	1.0	11.50	1.2	11.58	1.4
11.67	2.0	11.75	3.3	11.83	5.2	11.92	8.4
12.00	14.1	12.08	20.9	12.17	25.3	12.25	24.5
12.33	20.0	12.42	15.1	12.50	11.3	12.58	8.8
12.67	7.1	12.75	6.0	12.83	5.2	12.92	4.6
13.00	4.2	13.08	3.8	13.17	3.5	13.25	3.2
13.33	3.0	13.42	2.8	13.50	2.6	13.58	2.5
13.67	2.4	13.75	2.3	13.83	2.2	13.92	2.1
14.00	2.0	14.08	1.9	14.17	1.8	14.25	1.8
14.33	1.7	14.42	1.7	14.50	1.6	14.58	1.5
14.67	1.5	14.75	1.4	14.83	1.4	14.92	1.3
15.00	1.3	15.08	1.3	15.17	1.3	15.25	1.3
15.33	1.3	15.42	1.2	15.50	1.2	15.58	1.2
15.67	1.1	15.75	1.1	15.83	1.1	15.92	1.1
16.00	1.1	16.08	1.1	16.17	1.1	16.25	1.1
16.33	1.1	16.42	1.1	16.50	1.1	16.58	1.1
16.67	1.1	16.75	1.1	16.83	1.0	16.92	1.0

Princeton Hydro, LLC
Ringoes, NJ
AUGUST 6, 2002

HYDROLOGIC REPORT FOR

Hemlock Gardens (Harveys Lake)

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY (CONT'D)

TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.
17.00	1.0	17.08	0.9	17.17	0.9	17.25	0.9
17.33	0.9	17.42	0.9	17.50	0.9	17.58	0.9
17.67	0.9	17.75	0.9	17.83	0.9	17.92	0.9
18.00	0.9	18.08	0.8	18.17	0.8	18.25	0.8
18.33	0.8	18.42	0.8	18.50	0.7	18.58	0.7
18.67	0.7	18.75	0.7	18.83	0.7	18.92	0.7
19.00	0.7	19.08	0.7	19.17	0.7	19.25	0.7
19.33	0.7	19.42	0.7	19.50	0.7	19.58	0.7
19.67	0.7	19.75	0.7	19.83	0.7	19.92	0.7
20.00	0.7	20.08	0.7	20.17	0.6	20.25	0.6
20.33	0.6	20.42	0.6	20.50	0.6	20.58	0.6
20.67	0.6	20.75	0.6	20.83	0.6	20.92	0.6
21.00	0.6	21.08	0.6	21.17	0.6	21.25	0.6
21.33	0.6	21.42	0.6	21.50	0.6	21.58	0.6
21.67	0.6	21.75	0.6	21.83	0.6	21.92	0.6
22.00	0.6	22.08	0.6	22.17	0.6	22.25	0.6
22.33	0.6	22.42	0.6	22.50	0.6	22.58	0.6
22.67	0.6	22.75	0.6	22.83	0.6	22.92	0.6
23.00	0.6	23.08	0.6	23.17	0.6	23.25	0.6
23.33	0.6	23.42	0.6	23.50	0.6	23.58	0.6
23.67	0.6	23.75	0.6	23.83	0.6	23.92	0.6
24.00	0.5	24.08	0.5	24.17	0.4	24.25	0.3
24.33	0.2	24.42	0.1	24.50	0.1	24.58	0.0
24.67	0.0	24.75	0.0	24.83	0.0	24.92	0.0
25.00	0.0	25.08	0.0	25.17	0.0	25.25	0.0
25.33	0.0	25.42	0.0	25.50	0.0	25.58	0.0
25.67	0.0	25.75	0.0	25.83	0.0	25.92	0.0

TIME TO PEAK = 12.17 HOURS
PEAK RUNOFF = 25.26 C.F.S.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name:

Comment: SWALE TO EW1

Solve For Discharge

Given Input Data:

Bottom Width.....	1.00 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n......	0.040
Channel Slope....	0.1500 ft/ft
Depth............	1.00 ft

Computed Results:

Discharge........	**28.91** cfs
Velocity.........	9.64 fps
Flow Area........	3.00 sf
Flow Top Width...	5.00 ft
Wetted Perimeter.	5.47 ft
Critical Depth...	1.44 ft
Critical Slope...	0.0282 ft/ft
Froude Number....	2.19 (flow is Supercritical)

```
**********************************************************************
* TRAVEL TIME CALCULATIONS - SCS Segmental Approach, TR-55 (1986) *
**********************************************************************
```

SUMMARY for Area 2

Segment 1: OVERLAND FLOW
L = 100 ft, S = .06 ft/ft, n = .8, P (2yr/24hr) = 2.9 in
Travel Time = 25.3 minutes

Segment 2: CONCENTRATED FLOW
L = 800 ft, S = .18 ft/ft, UNPAVED surface
Travel time = 1.9 minutes

Segment 3: CHANNEL FLOW
A = 6 ft^2, P = 7 ft, L = 1000 ft, S = .07 ft/ft, n = .035
Travel Time = 1.6 minutes

TOTAL TRAVEL TIME = *28.9* min.

HYDROLOGIC REPORT FOR

Hemlock Gardens (Harveys Lake)

24 HOUR S. C. S. HYDROGRAPH

BASIN IDENTIFICATION Area 2
BASIN DISCHARGES INTO Swale West

BASIN AREA = 7.91 ACRES
BASIN CURVE NUMBER = 75.00
24-HOUR PRECIPITATION = 4.50 INCHES
24-HOUR RUNOFF = 2.05 INCHES
AVERAGE BASIN SLOPE = 12.00 %
HYDRAULIC LENGTH = 1,900.00 FEET
BASIN LAG , (Tc) = 0.29 HOURS , 0.48 HOURS
UNITPEAK COEFFICIENT = 484.00
RAINFALL DISTRIBUTION = TYPE I I

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.
8.67	0.0	8.75	0.0	8.83	0.0	8.92	0.0
9.00	0.0	9.08	0.0	9.17	0.0	9.25	0.0
9.33	0.0	9.42	0.0	9.50	0.0	9.58	0.0
9.67	0.0	9.75	0.0	9.83	0.0	9.92	0.0
10.00	0.1	10.08	0.1	10.17	0.1	10.25	0.1
10.33	0.1	10.42	0.1	10.50	0.1	10.58	0.1
10.67	0.2	10.75	0.2	10.83	0.2	10.92	0.3
11.00	0.3	11.08	0.3	11.17	0.4	11.25	0.4
11.33	0.5	11.42	0.6	11.50	0.6	11.58	0.7
11.67	1.0	11.75	1.4	11.83	2.3	11.92	3.8
12.00	6.2	12.08	9.4	12.17	12.3	12.25	13.5
12.33	12.7	12.42	10.6	12.50	8.4	12.58	6.6
12.67	5.3	12.75	4.4	12.83	3.7	12.92	3.2
13.00	2.8	13.08	2.6	13.17	2.3	13.25	2.1
13.33	1.9	13.42	1.8	13.50	1.7	13.58	1.6
13.67	1.5	13.75	1.4	13.83	1.3	13.92	1.3
14.00	1.2	14.08	1.2	14.17	1.1	14.25	1.1
14.33	1.0	14.42	1.0	14.50	1.0	14.58	0.9
14.67	0.9	14.75	0.9	14.83	0.8	14.92	0.8
15.00	0.8	15.08	0.8	15.17	0.8	15.25	0.8
15.33	0.7	15.42	0.7	15.50	0.7	15.58	0.7
15.67	0.7	15.75	0.7	15.83	0.7	15.92	0.7
16.00	0.7	16.08	0.6	16.17	0.6	16.25	0.6
16.33	0.6	16.42	0.6	16.50	0.6	16.58	0.6
16.67	0.6	16.75	0.6	16.83	0.6	16.92	0.6

HYDROLOGIC REPORT FOR

Hemlock Gardens (Harveys Lake)

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY (CONT'D)

TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.
17.00	0.6	17.08	0.6	17.17	0.6	17.25	0.6
17.33	0.5	17.42	0.5	17.50	0.5	17.58	0.5
17.67	0.5	17.75	0.5	17.83	0.5	17.92	0.5
18.00	0.5	18.08	0.5	18.17	0.5	18.25	0.5
18.33	0.5	18.42	0.5	18.50	0.4	18.58	0.4
18.67	0.4	18.75	0.4	18.83	0.4	18.92	0.4
19.00	0.4	19.08	0.4	19.17	0.4	19.25	0.4
19.33	0.4	19.42	0.4	19.50	0.4	19.58	0.4
19.67	0.4	19.75	0.4	19.83	0.4	19.92	0.4
20.00	0.4	20.08	0.4	20.17	0.4	20.25	0.4
20.33	0.4	20.42	0.3	20.50	0.3	20.58	0.3
20.67	0.3	20.75	0.3	20.83	0.3	20.92	0.3
21.00	0.3	21.08	0.3	21.17	0.3	21.25	0.3
21.33	0.3	21.42	0.3	21.50	0.3	21.58	0.3
21.67	0.3	21.75	0.3	21.83	0.3	21.92	0.3
22.00	0.3	22.08	0.3	22.17	0.3	22.25	0.3
22.33	0.3	22.42	0.3	22.50	0.3	22.58	0.3
22.67	0.3	22.75	0.3	22.83	0.3	22.92	0.3
23.00	0.3	23.08	0.3	23.17	0.3	23.25	0.3
23.33	0.3	23.42	0.3	23.50	0.3	23.58	0.3
23.67	0.3	23.75	0.3	23.83	0.3	23.92	0.3
24.00	0.3	24.08	0.3	24.17	0.3	24.25	0.2
24.33	0.2	24.42	0.1	24.50	0.1	24.58	0.1
24.67	0.0	24.75	0.0	24.83	0.0	24.92	0.0
25.00	0.0	25.08	0.0	25.17	0.0	25.25	0.0
25.33	0.0	25.42	0.0	25.50	0.0	25.58	0.0
25.67	0.0	25.75	0.0	25.83	0.0	25.92	0.0
26.00	0.0	26.08	0.0	26.17	0.0	26.25	0.0

TIME TO PEAK = 12.25 HOURS
PEAK RUNOFF = 13.47 C.F.S.

****
* **TRAVEL TIME CALCULATIONS - SCS Segmental Approach, TR-55 (1986)** *
****

SUMMARY for Area 3

Segment 1: OVERLAND FLOW
L = 100 ft, S = .2 ft/ft, n = .35, P (2yr/24hr) = 2.9 in
Travel Time = 8.1 minutes

Segment 2: CONCENTRATED FLOW
L = 450 ft, S = .13 ft/ft, UNPAVED surface
Travel time = 1.3 minutes

04
Segment 3: CHANNEL FLOW
A = 1.5 ft^2, P = 3.5 ft, L = 250 ft, S = .08 ft/ft, n =
Travel Time = .7 minutes

TOTAL TRAVEL TIME = 10.1 min.

Princeton Hydro, LLC
Ringoes, NJ
AUGUST 6, 2002

HYDROLOGIC REPORT FOR

Hemlock Gardens (Harveys **Lake)**

24 HOUR S. C. S. HYDROGRAPH

BASIN IDENTIFICATION Area 3
BASIN DISCHARGES INTO Swale Inside

BASIN AREA	-	7.16	ACRES
BASIN CURVE NUMBER	-	75.00	
24-HOUR PRECIPITATION	=	4.50	INCHES
24-HOUR RUNOFF	-	2.05	INCHES
AVERAGE BASIN SLOPE	=	12.00	%
HYDRAULIC LENGTH	-	800.00	FEET
BASIN LAG , **(Tc)**	-	0.10	HOURS , 0.17 HOURS
UNITPEAK COEFFICIENT	=	484.00	
RAINFALL DISTRIBUTION	=	TYPE I I	

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY

TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.
8.67	0.0	8.75	0.0	8.83	0.0	8.92	0.0
9.00	0.0	9.08	0.0	9.17	0.0	9.25	0.0
9.33	0.0	9.42	0.0	9.50	0.0	9.58	0.0
9.67	0.0	9.75	0.1	9.83	0.1	9.92	0.1
10.00	0.1	10.08	0.1	10.17	0.1	10.25	0.1
10.33	0.1	10.42	0.2	10.50	0.2	10.58	0.2
10.67	0.2	10.75	0.3	10.83	0.3	10.92	0.4
11.00	0.4	11.08	0.5	11.17	0.5	11.25	0.6
11.33	0.6	11.42	0.8	11.50	0.9	11.58	1.3
11.67	3.1	11.75	4.4	11.83	6.6	11.92	13.3
12.00	18.2	12.08	18.5	12.17	10.0	12.25	5.6
12.33	4.2	12.42	3.1	12.50	2.6	12.58	2.5
12.67	2.2	12.75	2.1	12.83	2.0	12.92	1.8
13.00	1.7	13.08	1.6	13.17	1.5	13.25	1.4
13.33	1.4	13.42	1.3	13.50	1.2	13.58	1.2
13.67	1.1	13.75	1.0	13.83	1.0	13.92	1.0
14.00	1.0	14.08	0.9	14.17	0.9	14.25	0.9
14.33	0.8	14.42	0.8	14.50	0.8	14.58	0.8
14.67	0.7	14.75	0.7	14.83	0.7	14.92	0.7
15.00	0.7	15.08	0.7	15.17	0.7	15.25	0.7
15.33	0.7	15.42	0.6	15.50	0.6	15.58	0.6
15.67	0.6	15.75	0.6	15.83	0.6	15.92	0.6
16.00	0.6	16.08	0.6	16.17	0.6	16.25	0.6
16.33	0.6	16.42	0.6	16.50	0.6	16.58	0.6
16.67	0.5	16.75	0.5	16.83	0.5	16.92	0.5

HYDROLOGIC REPORT FOR

Hemlock Gardens (Harveys Lake)

HYDROGRAPH RUNOFF VALUES
10 YEAR STORM FREQUENCY (CONT'D)

TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.	TIME HOUR	RUNOFF C.F.S.
17.00	0.5	17.08	0.5	17.17	0.5	17.25	0.5
17.33	0.5	17.42	0.5	17.50	0.5	17.58	0.5
17.67	0.5	17.75	0.5	17.83	0.5	17.92	0.4
18.00	0.4	18.08	0.4	18.17	0.4	18.25	0.4
18.33	0.4	18.42	0.4	18.50	0.4	18.58	0.4
18.67	0.4	18.75	0.4	18.83	0.4	18.92	0.4
19.00	0.4	19.08	0.4	19.17	0.4	19.25	0.4
19.33	0.4	19.42	0.4	19.50	0.4	19.58	0.4
19.67	0.4	19.75	0.4	19.83	0.4	19.92	0.3
20.00	0.3	20.08	0.3	20.17	0.3	20.25	0.3
20.33	0.3	20.42	0.3	20.50	0.3	20.58	0.3
20.67	0.3	20.75	0.3	20.83	0.3	20.92	0.3
21.00	0.3	21.08	0.3	21.17	0.3	21.25	0.3
21.33	0.3	21.42	0.3	21.50	0.3	21.58	0.3
21.67	0.3	21.75	0.3	21.83	0.3	21.92	0.3
22.00	0.3	22.08	0.3	22.17	0.3	22.25	0.3
22.33	0.3	22.42	0.3	22.50	0.3	22.58	0.3
22.67	0.3	22.75	0.3	22.83	0.3	22.92	0.3
23.00	0.3	23.08	0.3	23.17	0.3	23.25	0.3
23.33	0.3	23.42	0.3	23.50	0.3	23.58	0.3
23.67	0.3	23.75	0.3	23.83	0.3	23.92	0.2
24.00	0.2	24.08	0.2	24.17	0.1	24.25	0.0
24.33	0.0	24.42	0.0	24.50	0.0	24.58	0.0
24.67	0.0	24.75	0.0	24.83	0.0	24.92	0.0

TIME TO PEAK - 12.08 HOURS
PEAK RUNOFF - 18.50 C.F.S.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: HEMLOCK GARDENS

Comment: CHANNEL TO EW1 (C1)

Solve For Depth

Given Input Data:

Bottom Width.....	1.50 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n......	0.040
Channel Slope....	0.3300 ft/ft
Discharge........	25.30 cfs

Computed Results:

Depth............	0.82 ft< 2.0 ✓ (>1' freeboard)
Velocity.........	13.38 fps R-6 Rip-rap (D_{50}=12")
Flow Area........	1.89 sf
Flow Top Width...	3.13 ft
Wetted Perimeter.	3.81 ft
Critical Depth...	1.49 ft
Critical Slope...	0.0323 ft/ft
Froude Number....	3.03 (flow is Supercritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: HEMLOCK GARDENS

Comment: CHANNEL BETWEEN EW2-EW3 (C2)

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.......	0.040
Channel Slope....	0.0750 ft/ft
Discharge........	43.80 cfs

Computed Results:

Depth............	1.20 ft < 2.5' ✓ & > 1' freeboard
Velocity.........	8.68 fps R-4 riprap (D_{50} = 6")
Flow Area........	5.04 sf
Flow Top Width...	5.40 ft
Wetted Perimeter.	6.40 ft
Critical Depth...	1.57 ft
Critical Slope...	0.0286 ft/ft
Froude Number....	1.58 (flow is Supercritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: HEMLOCK GARDENS

Comment: CHANNEL BETWEEN EW4-EW5 (C3)

Solve For Depth

Given Input Data:

Bottom Width.....	2.00 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n......	0.040
Channel Slope....	0.0630 ft/ft
Discharge........	63.31 cfs

Computed Results:

Depth............	1.50 ft < 2.5' ✓ = 1' freeboard
Velocity.........	8.44 fps Req'd RIP-RAP (Dn = 6")
Flow Area........	7.50 sf
Flow Top Width...	8.00 ft
Wetted Perimeter.	8.71 ft
Critical Depth...	1.85 ft
Critical Slope...	0.0253 ft/ft
Froude Number....	1.54 (flow is Supercritical)

Princeton Hydro, LLC
1108 Old York Road
Suite 1, P.O. Box 720
Ringoes, NJ 08551

project: Hemlock Gardens
Sheet No: 1 of 1
By: JHM *Date: 811912002*

COMPUTATION TABLE - STORM SEWER DESIGN

DESIGN STORM: 10 **YEARS** (TR-55)

INLET NO.	DISCHARGE Q PIPE	LENGTH OF PIPE	SLOPE OF PIPE	TYPE OF PIPE	MANNINGS 'n' VALUE	SIZE OF PIPE	MEAN VELOCITY	CAPACITY OF PIPE, FULL SLOPE
	CFS	FEET	FT/FT			IN	FPS	CFS
EW1								
EW1-I1	25.26	20	0.15	HDPE	0.012	18	25.76	44.03
I1								
I1-EW2 (including trench drain)	25.26	27	. 0.093	HDPE (concrete)	0.012	18	21.48	34.67
EW3								
EW3-EW4	43.76	39	0051	HDPE	0.012	**24**	1965	55.34
EW5								
EW5-I2	57.23	70	0.097	HDPE	0.012	24	26.78	76.32
I2								
I2-I3	57.23	51	0.063	HDPE	0.012	24	22.66	61.51
I3								
13-BB	57.23	18	0.055	HDPE	0.012	24	21.49	57.47
Polisher								
Polisher-MH1	57.23	50	0.055	RCP	0.012	24	21.49	57 47
MH1								
MH1-EW6	57.23	103	0017	HDPE	0012	30	13.85	57 97

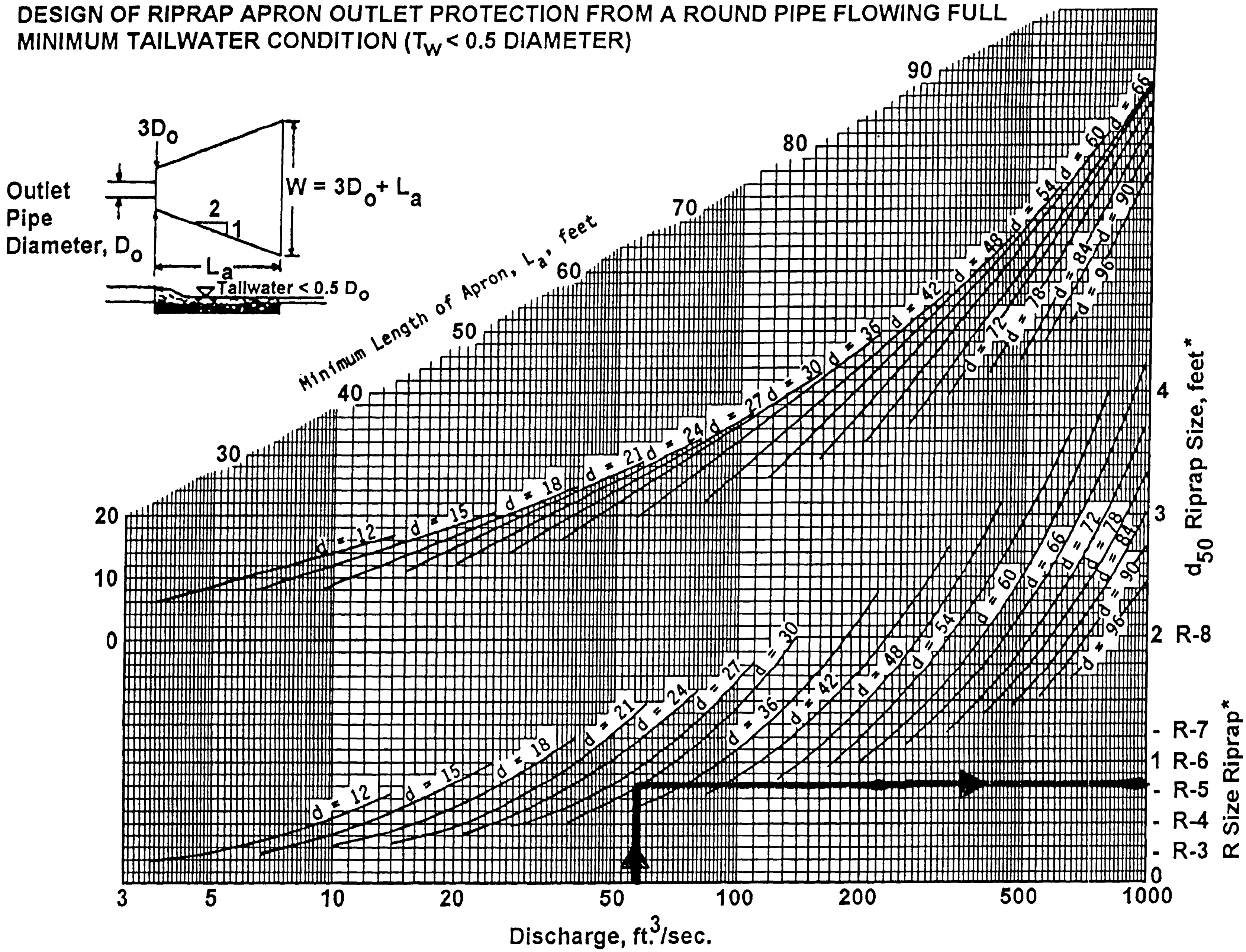


FIGURE 21
Riprap Apron Design, Minimum Tailwater Condition

* For discharge velocities exceeding Maximum Allowable for Riprap indicated, increase d_{50} stone size and/or provide velocity reduction device.

Princeton Hydro, LLC
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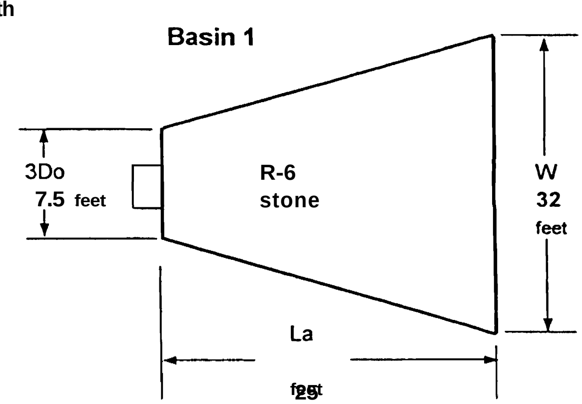
Project: Hemlock Gardens
Sheet No: 1 **of** 1
By: JAM Date: 8/6/2002

OUTLET PROTECTION CALCULATIONS

ENDWALL Basin 1 outlet

Do	30 inches 2.5 feet	maximum inside culvert width
3Do	7.5 feet	width at pipe outlet
Q	57.23 cfs	pipe discharge
	TW less than	112 Do
La	25 feet 24 inches	length of apron apron thickness
W	32 feet	width of the outlet
Rip-Rap		
d50	0.80 feet 9.60 inches	
stone	R-6	Figure 21



APPENDIX E

PENNDOT-RATIONAL TIME OF CONCENTRATION / STORM FLOWS / STORM SEWER DESIGN

TABLE 2.10.12.1
RUNOFF FACTORS FOR THE RATIONAL EQUATION

Type of Drainage Area or Surface	Runoff Factor "C" Minimum	Maximum
Pavements, concrete or bituminous concrete	0.75	0.95
Pavements, bituminous macadam or surface-treated gravel	0.65	0.80
Pavements. gravel, macadam. etc.	0.25	0.60
Sandy soil. cultivated or light growth	0.15	0.30
Sandy soil. woods, or heavy brush	0.15	0.30
Gravel. bare or light growth	0.20	0.40
Gravel. woods or heavy brush	0.15	0.35
Clay soil, bare or light growth	0.35	0.75
Clay soil. woods or heavy growth	0.25	0.60
City business sections	0.60	0.80
Dense residential sections	0.50	0.70
Suburban. normal residential areas	0.35	0.60
Rural areas. parks. golf courses	0.15	0.30

NOTE: Higher values are applicable to denser soils and steep slopes.
Consideration should be given to future land use changes in the drainage area in selecting the "C" factor.
For drainage area containing several different types of ground cover. a weighted value of "C" must be used.
In special situations where sinkholes, stripped abandoned mines, etc. exist. careful evaluation shall be given to the selection of a suitable runoff factor with consideration given to possible reclamation of the land in the future.

TABLE 2.10.12.2
RECOMMENDED AVERAGE VELOCITIES OF OVERLAND FLOW
FOR DETERMINING **TIME** OF CONCENTRATION

Description of Course of Runoff Water	Velocities in feetlsecond — Slope in Percent						
	0-3	4-7	*8-10*	*11-15*	*16-20*	*21-25*	*26-30*
Woodland	0.5	1.0	1.5	1.7	2 0	2.7	3.5
Pasture	0.8	1.5	2.2	2.6	3.0	4.1	4.5
Cultivated (Row Crop)	1.0	2.0	3.0	3.5	4.0	4.5	5.0
Pavement	5.0	12.0	15.5	18.0	—	—	—
Natural Draw(Not Well Defined)	0.8	2.5	4.0	6.0	—	—	—

Princeton Hydro, LLC
1108 Old York Road
Suite 1, P.O. Box 720
Ringoes, NJ 08551

Project: Hemlock Gardens
Sheet No: ______ of 1
By: JAM Date: 8/5/2002

TIME OF CONCENTRATION

PennDOT Design Manual, Part 2

AREA 1	slope	0.180	Wft
	length	1700	feet
	velocity	2.0	Wsec
	tc =	**14.2**	**minutes**
AREA 2	slope	0.120	ft/ft
	length	1900	feet
	velocity	1.7	ft/sec
	tc =	**18.6**	**minutes**
AREA 3	slope	0.120	ft/ft
	length	800	feet
	velocity	1.7	ft/sec
	tc =	**7.8**	**minutes**

RAINFALL INTENSITY– DURATION–FREQUENCY CURVES

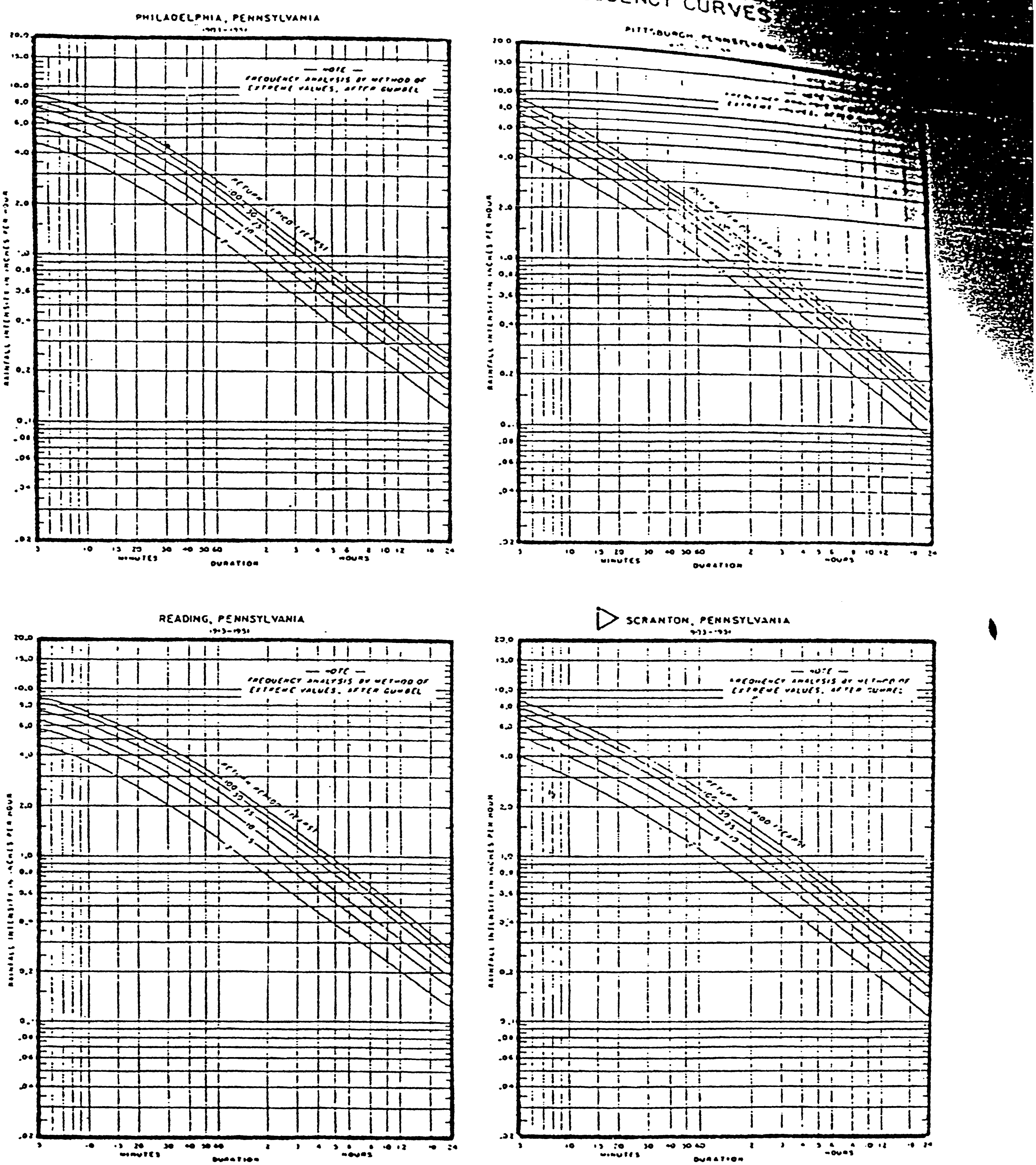


FIGURE 2.10.12.1

Princeton Hydro, LLC
Ringoes, NJ
AUGUST 5, 2002

HYDROLOGIC REPORT FOR

HEMLOCK GARDENS (pH #156.11)

UNIVERSAL RATIONAL HYDROGRAPH

Q(PEAK) = C*I*A
10 YEAR STORM FREQUENCY

BASIN IDENTIFIER AREA 1
DISCHARGES INTO EW1

BASIN AREA	-	13.42	ACRES
RUNOFF COEFF.	=	0.30	
RAINFALL INT.	=	4.08	IN/HR
TIME OF CONC.	=	14.20	MINUTES
VOLUME	-	35841.66	CUBIC FEET

TIME (MIN)	RUNOFF (C.F.S.)
0.0	0.0
7.1	1.1
14.2	2.3
21.3	3.1
28.4	4.0
35.5	10.2
42.6	16.4
49.7	11.7
56.8	6.9
63.9	5.7
71.0	4.4
78.1	3.9
85.2	3.4
92.3	2.8
99.4	2.2
106.5	1.8
113.6	1.4
120.7	1.2
127.8	1.1
134.9	0.5
142.0	0.0
149.1	0.0
156.2	0.0
163.3	0.0
170.4	0.0
177.5	0.0
184.6	0.0
191.7	0.0
198.8	0.0
205.9	0.0

Princeton Hydro, LLC
Ringoes, NJ
AUGUST 5, 2002

HYDROLOGIC REPORT FOR

HEMLOCK GARDENS (pH #156.11)

UNIVERSAL RATIONAL HYDROGRAPH

Q(PEAK) = C*I*A
10 YEAR STORM FREQUENCY

BASIN IDENTIFIER AREA 3
DISCHARGES INTO EW3

BASIN AREA	=	7.16	ACRES
RUNOFF COEFF.	=	0.40	
RAINFALL INT.	=	5.20	IN/HR
TIME OF CONC.	=	7.80	MINUTES
VOLUME	=	20483.26	CUBIC FEET

TIME (MIN)	RUNOFF (C.F.S.)
0.0	0.0
3.9	1.5
7.8	3.1
11.7	3.4
15.6	3.8
19.5	9.3
23.4	14.9
27.3	11.3
31.2	7.7
35.1	6.4
39.0	5.2
42.9	4.3
46.8	3.4
50.7	2.9
54.6	2.4
58.5	2.1
62.4	1.7
66.3	1.7
70.2	1.6
74.1	0.8
78.0	0.0
81.9	0.0
85.8	0.0

Princeton Hydro, LLC
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Ringoes, NJ 08551

Project: Hemlock Gardens
Sheet No: 1 of 1
By: JMM Date: 8/19/2002

COMPUTATION TABLE - STORM SEWER DESIGN

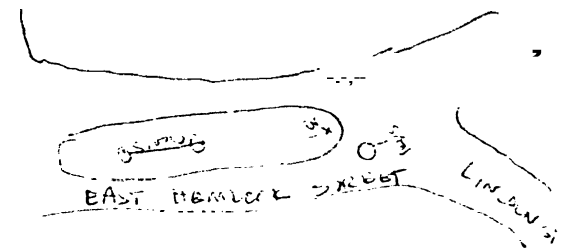
DESIGN STORM: 10 YEARS **(PennDOT)**

INLET NO.	DISCHARGE Q PIPE CFS	LENGTH OF PIPE FEET	SLOPE OF PIPE FT/FT	TYPE OF PIPE	MANNINGS 'n' VALUE	SIZE OF PIPE IN	MEAN VELOCITY FPS	CAPACITY OF PIPE, FULL SLOPE CFS
EW1								
EW1-I1	16.40	20	0.15	HDPE	0.012	18	23.01	44.03
I1								
I1-EW2 (including trench drain)	16.40	27	0.093	HDPE (concrete)	0.012	18	19.31	34.67
EW3								
EW3-EW4	25.00	39	0.051	HDPE	0.012	24	17.14	55.34
EW5								
EW5-I2	39.90	70	0.097	HDPE	0.012	24	24.54	76.32
I2								
I2-I3	39.90	51	0.063	HDPE	0.012	24	20.85	61.51
I3								
I3-BB	39.90	18	0.055	HDPE	0.012	24	19.80	57.47
Polisher								
Polisher-MH1	39.90	50	0.055	RCP	0.012	24	19.80	57.47
MH1								
MH1-EW6	39.90	103	0.017	HDPE	0.012	30	12.76	57.97

APPENDIX F

BORING LOGS / SUNTREE TECHNOLOGIES, INC. LITERATURE

LOCATION OF BORING	JOB NO.	CLIENT	LOCATION
	1564.11	Hemlock Gardens	[illegible]



DRILLING METHOD:	2½" Hollow (A size auger)			BORING NO.	B1
SAMPLING METHOD:	Split spoon			SHEET 1 OF 1	
WATER LEVEL	15'	14'	9.9'	DRILLING START DATE 5/6	FINISH DATE 5/6
TIME	9:30	1:17		START TIME 7am	FINISH TIME 10am
DATE	5/6/02	5/6/02	5/6/02		
CASING DEPTH	-0-	-0-	-0-		

DATUM ELEVATION

SAMPLER TYPE	INCHES DRIVEN / INCHES RECVD	DEPTH OF CASING	SAMPLE NO. / DEPTH	BLOWS/6" SAMPLER		DEPTH (FEET)	SOIL GRAPH	SURFACE CONDITIONS
								Lawn; 2" Topsoil
	24" / 12"			3 / 6		0		Brown Silt w/ organic / Fine Sand (Fill) - some fragments (bricks/brick) & [illegible]
			1 / 2'	10 / 8	2'	1		
	24" / 14"			5 / 5	2'	2		
			2 / 4'	13 / 12	4'	3	3'4"	
	24" / 6"			21 / 18	4'	4		Brown Fine Silt - Sand & stains (Fill) (Damp)
			3 / 6'	10 / 13	6'	5		
	24" / 14"		4 / 7'	10 / 9	7'	6	6'6"	Spoon wet @ 5'0"; Rotten Brown F-Sand & Little Silt (Fill)
			5 / 8'	10 / 21	8'	7		7½ spoon [illegible] to Boulder
	24" / 16"			7 / 10	8'	8	8'	Orange Brown / Brown Silt w/ Fine Sand (Fill)
			6 / 10'	12 / 9	10'	9		
	24 / 18		7 / 11'	6 / 7	12'	0	10'	Brown Silt w/ trace organic (Old Topsoil?) trace clay, Damp Brown
			8 / 12'	9 / 9	12'	1	11'	Brown - LF Sand & Silt
	24 / 17			16 / 11	12'	2		
			9 / 14'	11 / 10	14'	3	13½	Wet, Damp
	24 / 9			7 / 14	14' wet	4	14'	wet
			10 / 16'	13 / 16	16'	5		
	24 / 20			19 / 33	16' wet	6	16'6"	16'6" spoon [illegible]; Trace gray stratified - very wet
			11 / 18'	33 / 35	18	7		
						8		18'
						9		
						0		Terminated Boring @ 20' -

DRILLER/HELPER Eric / Tom

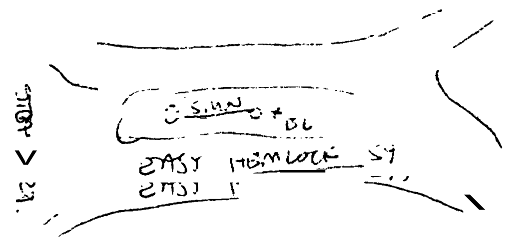
CONTRACTOR SJB Drilling Co.

DATE 5/6/03

BY Keith Merl

Bond 1-600 | Dietrich

LOCATION OF BORING



JOB NO.	CLIENT	LOCATION
156.11	Hemlock Gardens	Hemlock

DRILLING METHOD: 2 1/2" Hollow Auger (ASIZE)

SAMPLING METHOD: Split Spoon

BORING NO. B2 — **SHEET** 1 OF 1

WATER LEVEL	12'	7'	4'8"
TIME	11:40	1:16p	4:00p
DATE	5/6/02	5/6/02	5/6/02
CASING DEPTH	-0-	-0-	-0-

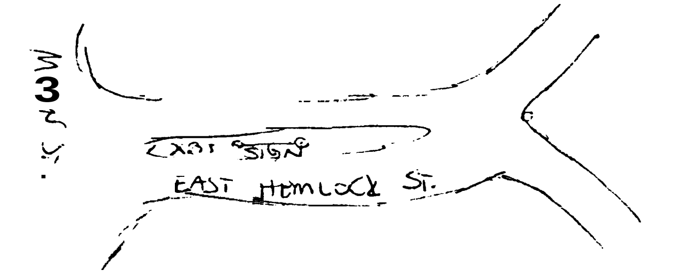
DRILLING	START	FINISH
DATE	5/6	5/6
TIME	10:05	11:55

DATUM ELEVATION

DRILLER/HEL — CONTRACTOR SJF Drilling — DATE 5/6/02 — BY

SAMPLER TYPE	INCHES DRIVEN / INCHES RECVD	DEPTH OF CASING	SAMPLE NO. / DEPTH	BLOWS/6" SAMPLER		DEPTH (FEET)	SOIL GRAPH	SURFACE CONDITIONS: Lawn.
	24" / 20"			3 / 2		0		0' - Peat - Topsoil - clayey silt w/ organics
			1 / 2'	5 / 9	2	1	1'	Brown Fine Sand & Silt w/ [illegible] fragments
	24" / 18"			5 / 10		2		mixed w/ R.B. - Gray & Black Sand & Silt. (Fill)
			2 / 4'	18 / 12	9	3	2'	Reddish Brown Silt F-Sand w/ shale frag.
	24 / 22"			8 / 8		4	2'3"	Brown / Lt. Brown F. Sand & Silt - mixed with Frag. / Mot. Sand & Silt.
			3 / 6'	11 / 13	6	5		5'0" Auger [illegible] on Boulders
	24" / 18"			13 / 14		6		6' Sample wet
			4 / 8'	13 / 11	8	7		7' Sample Moist
	24 / 18			8 / 11		8		
			5 / 10'	14 / 30	10	9		Spoon [illegible] on Boulder @ 9'11" - Black Sand, Dk. Red Br.
	24 / 10			18 / 6		0	10'	Brown Sandy Silt w/ trace organics
				9 / 12	12	1	11.5'	Samples damp from 10.
	24 / 20			12 8 / 9	12	2		1' Sample wet (saturated)
			7 / 14'	15 / 16	14	3		Brown Fine Sand & Silt w/ some Lt. Frag. R.B. Shale, Gray Br. Sandstone (micaceous) Dk. Br. Frag.)
	24 / 15			9 / 14	4	4		
			8 / 16'	16 / 15	16	5		
	24 / 21			20 / 20	16	6		Sat. @ 18' [?] — GW 18' wet from sample
			9 / 18'	24 / 27	18	7		~~End Boring Spoon~~ [illegible]
						8		
						9		23' Boulder
						0		Terminated @ 25'

LOCATION OF BORING	JOB NO.	CLIENT	LOCATION
	isc...11	Barclay : N.L.	Hemlock G



1 3

DRILLING METHOD: 2 1/4" Hollow Aug.

SAMPLING METHOD: Split Spoon

BORING NO. 133

SHEET 1 OF 1

WATER LEVEL	4'			
TIME	4:55p			
DATE	5/6/02			
CASING DEPTH	-0-			

DRILLING	START	FINISH
DATE	5/6	5/6
TIME	1:20p	3p

DATUM   ELEVATION

SURFACE CONDITIONS: Lawn.

SAMPLER TYPE	INCHES DRIVEN / INCHES RECVD	DEPTH OF CASING	SAMPLE NO. / DEPTH	BLOWS/6" SAMPLER		DEPTH (FEET)	SOIL GRAPH	DESCRIPTION
	— / NR		1 / NR	2/15		0		0 Topsoil to 3". Auger to 1' - Re started sampling. Spoon bouncing on boulder. @ 3" R.B. same
	24" / 20"		2 / 2'	6 / 6	1	1	3"	Brown F. sand & silt w/ no frags
			3 / 3'	25 / 21	3	2	9"	Br - L.Br. F.S. & silt - wet.
	24" / 6"			11 / 12	3	3	30"	Brown (light) silt w/ F.S. & trace clay.
			3 / 5'	13 / 10	5	4	3'6"	Brown/tan silty sand w/ ~~[illegible]~~ gravel rx. fragments. (clump) Medium to fine sand
	24" / 20"			11 / 12	5	5		
			4 / 7'	11 / 12	7	6		
	24" / 1"			12 / 9	7	7		Possibly rock fragment? Auger to 10' - cont. sampling.
			5 / 9'	8 / 9	9	8		~~[illegible]~~
						9		
	24" / 1"		6	8 / 15	10	0		(Sample wet.)
			6 / 12'	16 / 12	12	1		12' GW encountered.
	18 / 10"			13 / 10		2		12 1/3" Augers rubbing on boulder.
			7 / 14'	50/6"		3		1 1/2' spoon bouncing on boulder. (wet)
						4		14' Bouncing on boulder
				[illegible]		5		
				[illegible]		6		
	[illegible]			50/1"		7		Spoon: bouncing. Auger refusal 17' (boulder)
						8		
						9		
						0		

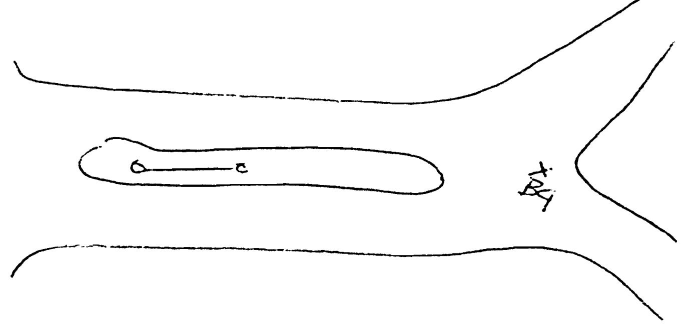
DRILLER/HELPER Greg / Todd

CONTRACTOR SJF Drilling

DATE 5/6/02

BY Keith M.

LOCATION OF BORING	JOB NO.	CLIENT	LOCATION
	156.11	Bur. of H.L.	Hemlock Gar.



DATUM ELEVATION

DRILLING METHOD:	BORING NO.
2½" Power Augers	B4

SHEET 1 OF 1

SAMPLING METHOD:
SPLIT SPOON.

WATER LEVEL	5'9"			
TIME	4:05			
DATE	5/6			
CASING DEPTH	-0-			

DRILLING	START	FINISH
DATE	5/6	5/6
TIME	3:10p	4:05

DRILLER/HELPER Eric / Tom

CONTRACTOR SIE Drilling

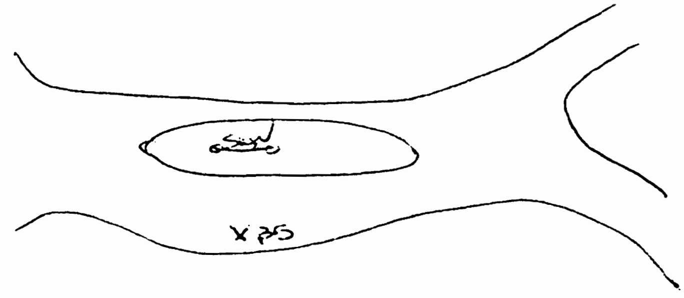
DATE 5/6/02

BY Keith J Merl

SURFACE CONDITIONS: Gravel Road - Ballast Size Mixed w/ 2A Mod

SAMPLER TYPE	INCHES DRIVEN / INCHES RECVD	DEPTH OF CASING	SAMPLE NO. / DEPTH	BLOWS/6" SAMPLER		DEPTH (FEET)	SOIL GRAPH	
	24" / 22"		1	16 / 22	0	0	0	Gray Sandy Gravel w/ Cobbles. Disintg Rx. Frag.
			2'	15 / 8	2	1	6"	Brown Sandy Silt w/ Rx Frag.
	24" / 7.5"			4 / 8	2	2		
			2 / 4'	27 / 39	9	3		
				- / -		4	4'	Light Brown Silty Sand w/ Gravel (Medium)
	24" / 14"			9 / 8	5	5	6'	Brown Sandy Silt w/ some Clay - Trace
			3 / 7'	9 / 11	7	6	6'6"	Brown Sand w/ some Silt & Gravel (Rx Frag) (Damp)
	24 / 16"			15 / 17	7	7		
			4 / 9'	17 / 23	9	8		Hard Augering @ 8'6"
				- / -		9		
	24 / 20"			9 / 13	10	10		
			5 / 12'	16 / 16	12	11		(Moist)
	24 / 20			12 / 14	13	12		
			6 / 13'	16 / 13	14	13		Top of Sample Saturated (wet)
						14		Terminated @ 14' — Bottom Wet
						5		
						6		
						7		
						8		
						9		
						0		

LOCATION OF BORING	JOB NO.	CLIENT	LOCATION
	156.11	Boro of H.L.	Hemlock Cr.



DRILLING METHOD:	BORING NO.
2¼" HD. Aug.	B5
SAMPLING METHOD:	SHEET
2in S.S.	1 OF

WATER LEVEL	~~9'~~	9'	8'6"
TIME	~~[illegible]~~	5:10	5:17
DATE	5/6	5/6	5/6
CASING DEPTH	-	-	-

DRILLING	
START	FINISH
DATE 5/6	DATE 5/6
TIME ~~[illegible]~~	TIME 4:55

DATUM ELEVATION

SURFACE CONDITIONS: Gravel Road - 2A Mod. w/ Ballast.

SAMPLER TYPE	INCHES DRIVEN / INCHES RECVD	DEPTH OF CASING	SAMPLE NO. / DEPTH	BLOWS/6" SAMPLER		DEPTH (FEET)	SOIL GRAPH	DESCRIPTION
	24 / 8"			25 / 29		0	0'	Road Base - 2A Mod. w/ Rock Fragments.
			1 / 2'	24 / 9		1	6" / 1'	Brn & Blk F. Sand & Silt ... Pumping 2x Frag. PEAT
	24" / 20"			4 / 3		2	1'6" / 2'	Brown & Lt Gr. Silty Sand w/ Gravel. (F→M) (Sample Moist)
			2 / 3'	17 / 23		3		
						4		Augered to 5' & cont. sampling.
	24 / 18"		~~[illegible]~~	8 / 11		5		Trace Clay (Sample Damp)
			3 / 6'	13 / 10		6		
	24 / 20"		4 / 8'	9 / 12		7	8'	Brown & Tan Silty Sand w/ Rock Frag. (Coarse Gravel - Cobbles)
			5 / 9'	11 / 10		8		
						9		(Augered to 10' cont. samp.)
	24 / 20"			4 / 7		0	~~[illegible]~~	~~[illegible]~~ Sample Wet.
			6 / 11.5'	8 / 8		1		
	24 / 24			8 / 11		2		
			7 / 14'	13 / 12		3		Sample Wet - Saturated
						4		
	18 / 12			8 / 14 / 50/6"		5		Auger Boring in Boulders. Sample Wet.
						6		
						7		
						8		
						9		
						0		

DRILLER/HELPER Eric / Tom

CONTRACTOR SJF Drilling

DATE 5/6/02

BY Keith Moore

THE EVALUATION OF SUNTREE TECHNOLOGIES, INC. GRATE INLET SKIMMER BOXES FOR DEBRIS, SEDIMENT, AND OIL & GREASE REMOVAL

1 of 2

Reedy Creek Improvement District
Planning & Engineering Department
Eddie Snell, Compliance Specialist

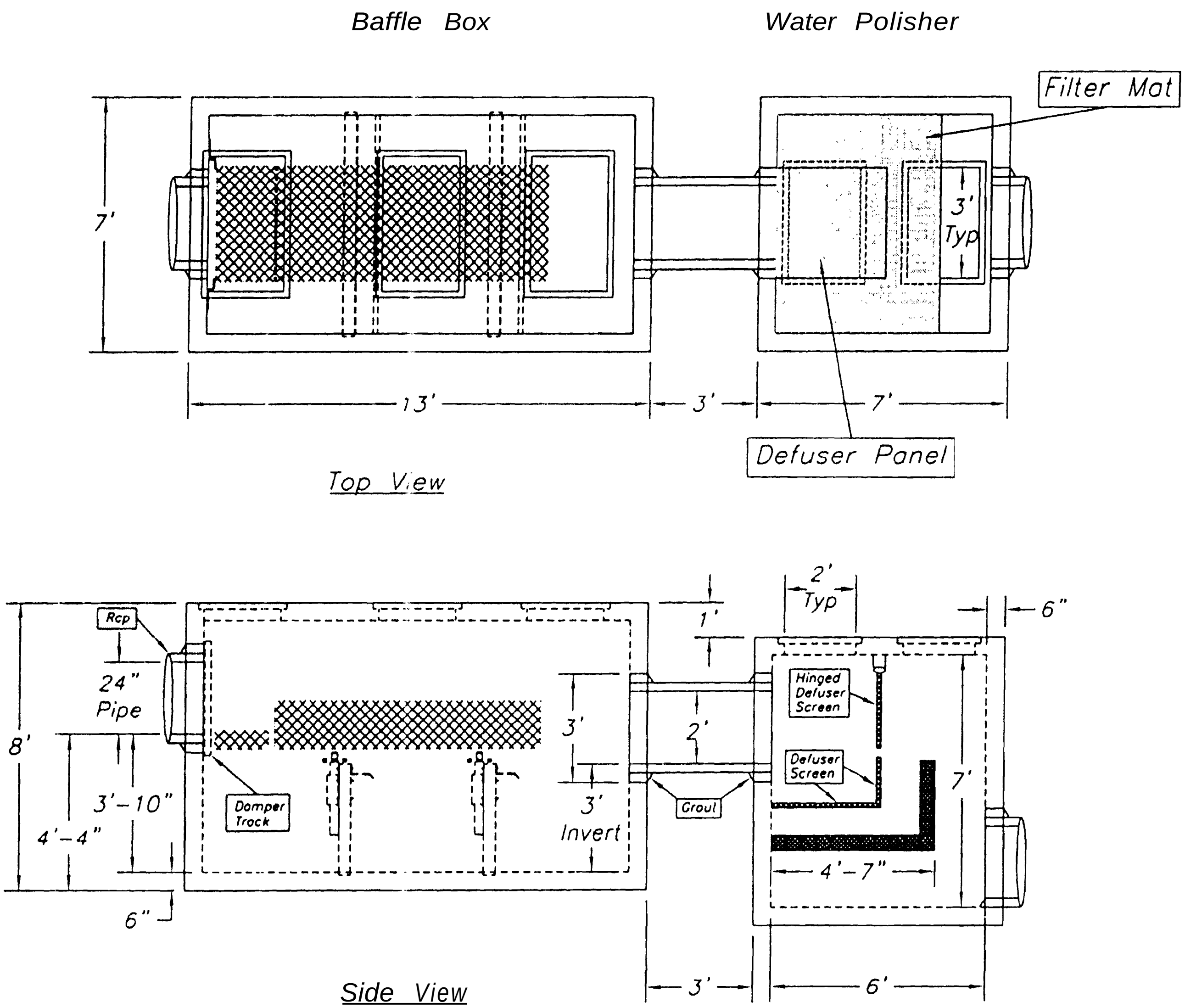
rmwater is now recognized as the leading source of pollution to our remaining natural er bodies in the United States. Development and urbanization have removed most of natural filtration and sediment trapping systems provided by the environment. Current elopment must address this need through the implementation of stormwater atments systems in the project design. Most of these systems perform reasonably well, properly designed, constructed, and maintained.

rofit of older urban areas lacking these modem stormwater systems is a continually ensive challenge. The Downtown Disney complex, formerly' the Lake Buena Vista opping Village, has several drainage basins with 1970's stormwater systems. These er systems discharge directly into the adjacent drainage canal with no pollutant atment. Over time the accumulation of sediments, nutrients, intensive development, l recreational/entertainment pressures are contributing to water quality degradation.

ienever new development or redevelopment occurs, the stormwater system is brought current code/permit requirements. In the interim, several areas are m need for rapid ective, and economical improvement in the quality of its stormwater discharge.

ntree Technologies Incorporated, located in Cape Canaveral, FL, manufactures rmwater grate inlet skimmer boxes They are made of a high quality fiberglass frame, th stainless steel filter screens backed by heavy-duty aluminum grating. Each unit is stom made to accommodate various inlet sizes. A hydrocarbon absorption boom is ached to the top of the skimmer box for petroleum, oil, and grease removal.

iese devices fit below the grate and catch sediment, debris. and petroleums, oils & eases. Clean-out, maintenance, and performance reporting is provided by Suntree on a



Note:

All Pips Openiongs in Bores ore 36"

Drawn By: R. DeMeulenaere	Date: 8/24/02
Checked:	Date:
Customer Sig	Date:
Revision:	Date:
Revision:	Date:

Nutrient Separating Baffle Box used in series with on enlarged version of the Suntree Golf Green Water Polisher

www.sunlrselach.com

Pat. pending

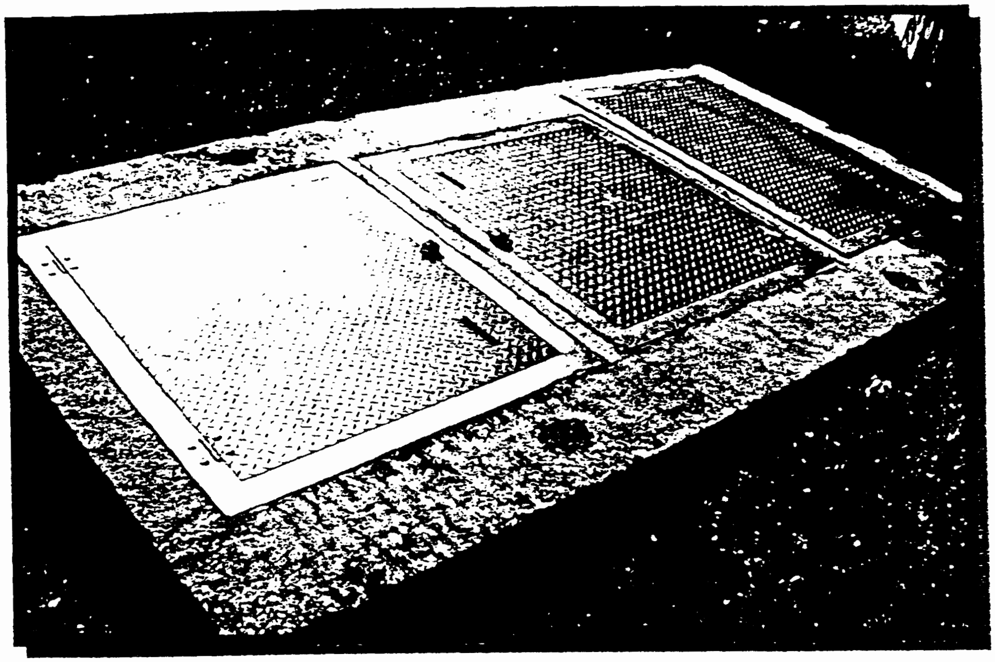
Suntree Technologies
720 Mullet Rood, Cope Conoverol, Florida 32920
PH: 321-799-0001 Fox: 321-799-1245

Drawing: Nutrient Separating & Polishing Unit

Sheet: 1 of 1

Scale: Custom

Available In Concrete Or Fiberglass



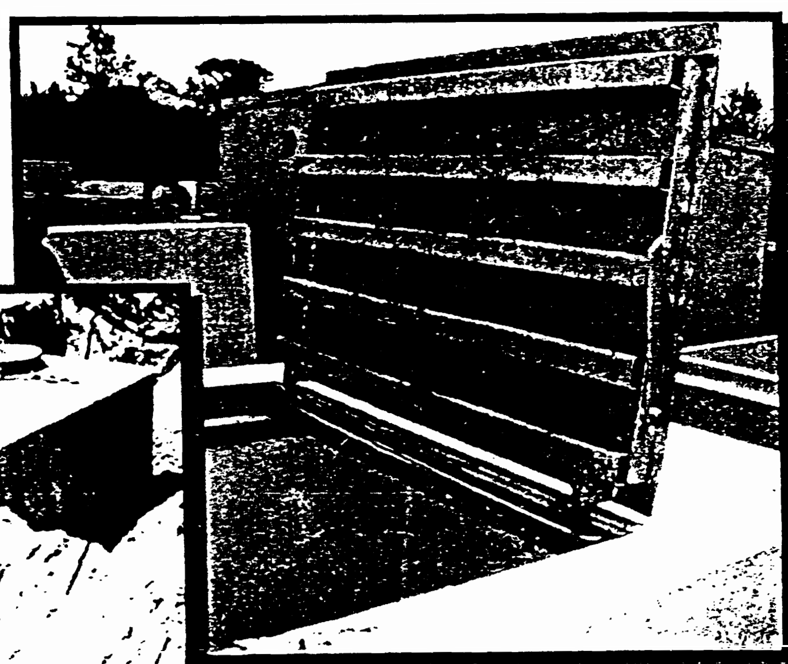
Available In Any Load Rating

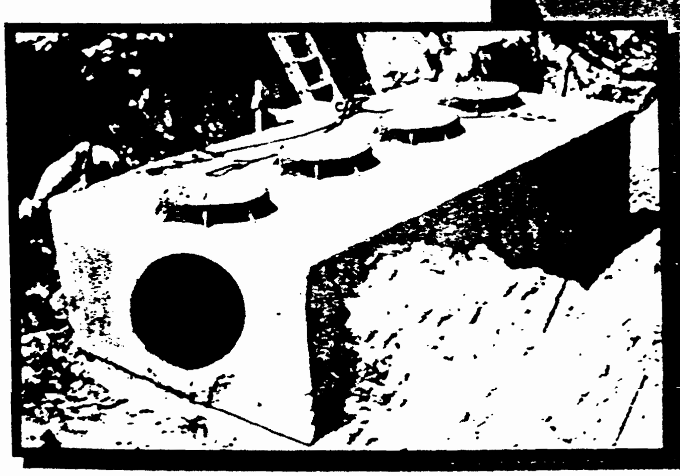
Easily Retrofits To Existing Pipes

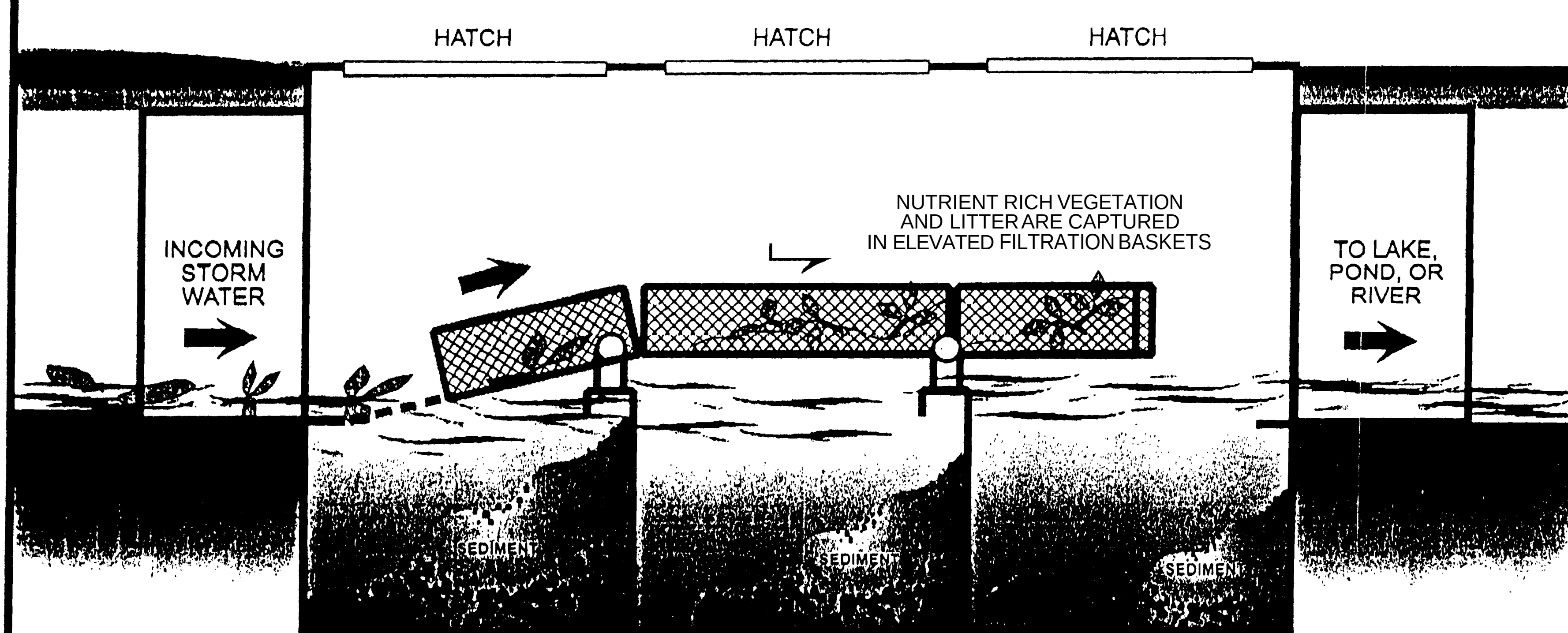
Available In Any Size

Up To 90% Removal Of Total Suspended Solids

Customize With Large Load Rated Access Lids or Manhole Lids







Advanced Baffle Box With Nutrient/Vegetation/Litter Separation

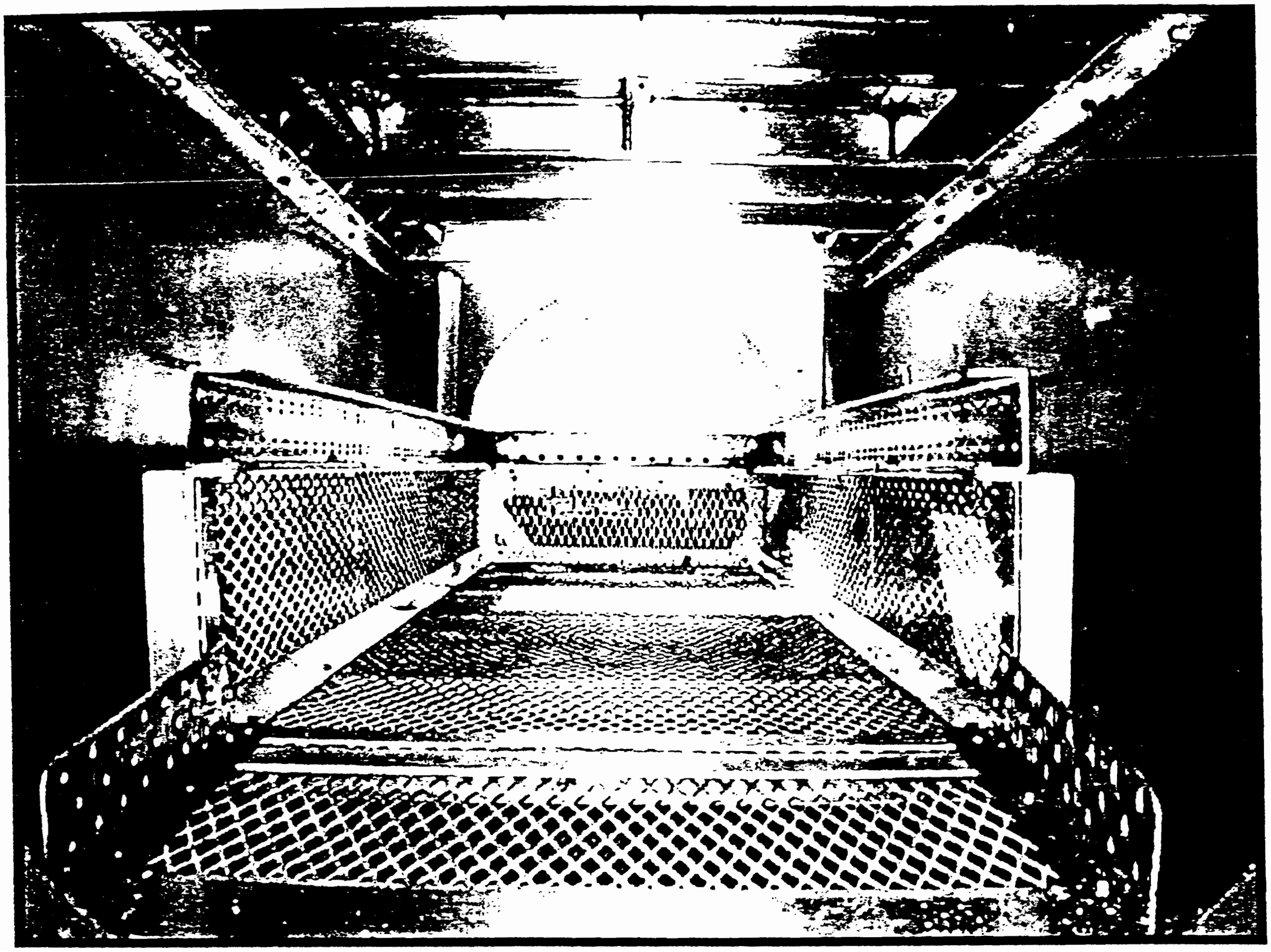
HEAVIER SEDIMENT GETS SEPARATED OUT AND FALLS TO BOTTOM

Our BaffleBox design captures sediment, nutrient rich vegetation, and litter without head loss, and can treat the entire maximum flow of the drain pipe. Requires no additional land acquisition, and can be installed in existing easements in line with existing pipes. Because of the high strength and lightweight design, our fiberglass baffle box can be easily transported, lifted, and lowered into place without heavy equipment. Available In concrete too.

Suntree Technologies Inc.
720 Mullet Road, Suite "H"
Cape Canaveral, FL 32920
Phone (321) 799-0001 Fax 321) 799-1245
www.suntreetech.com Happel@suntreetech.com

Patented with Patents Pending

Inside Baffle Box



The baffled chambers measure 36" deep and are spaced to create **3** equally sized chambers. The tops of the baffles are below the incoming and outflow openings in the ends of the box. The screens elevate the foliage and other debris 4" above the baffles. This separates the foliage from the water, capturing foliage and preventing nutrient loss to the water flow. The screens are hinged and can easily swing out of the way to give a vacuum truck access to the lower chambers.

The screens measure approximately **3'** wide, 18" tall, and run the length of the box stopping 20" short of the outflow opening This allows for 12 horizontal inches of unobstructed flow over the baffles along each side of the screens. In addition, the screens are elevated 4" above the baffles allowing unobstructed flow over the baffles and under the screens.

In order to prevent water flowing into the baffle box during cleaning, a damper is built into each end of the baffle box, The access lids in the top of the box will slide down an aluminum track built into the ends of the baffle box to make a damper. This will stop the **water** flow from either or both ends, allowing faster, more effective cleaning.

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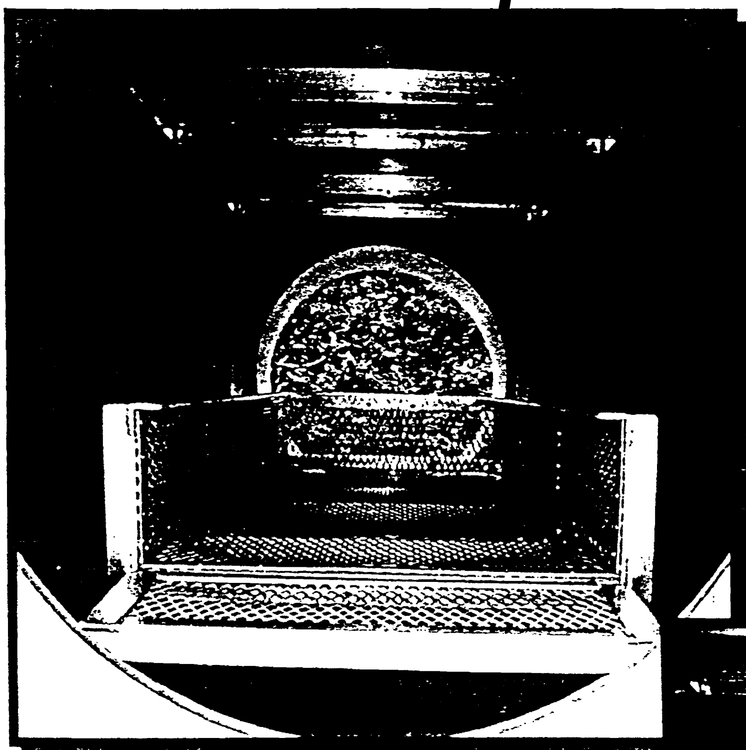
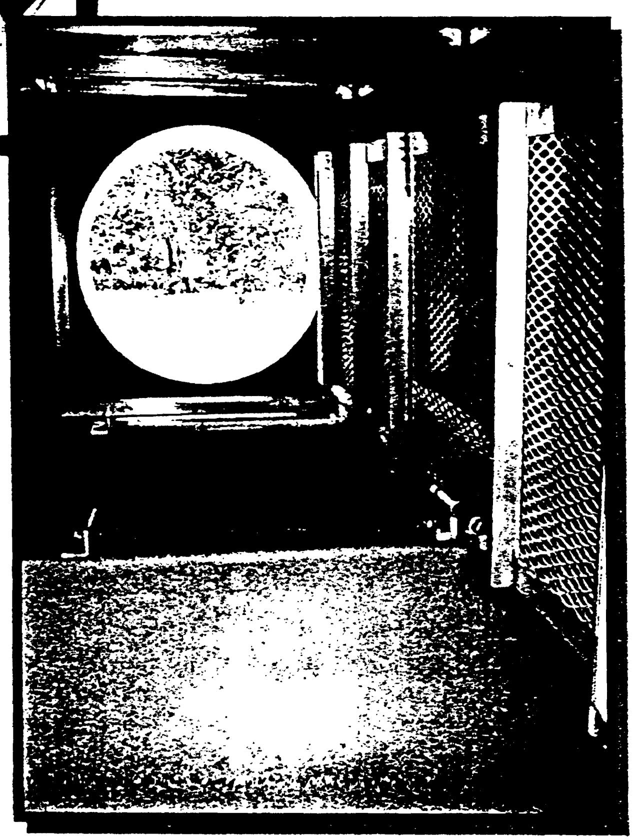
Nutrient Separating Baffle Box



Left: Inside the Nutrient Separating Baffle Box, the filtration screens are in the down, working position. Foliage and liter is captured and separated from the lower sediment chambers. During servicing, the captured foliage and litter is removed by a vacuum truck.



Right: The filtration screens are hinged up, exposing the lower sediment chambers for easy clean out by a vacuum truck.

Entry Is Not Required For Servicing

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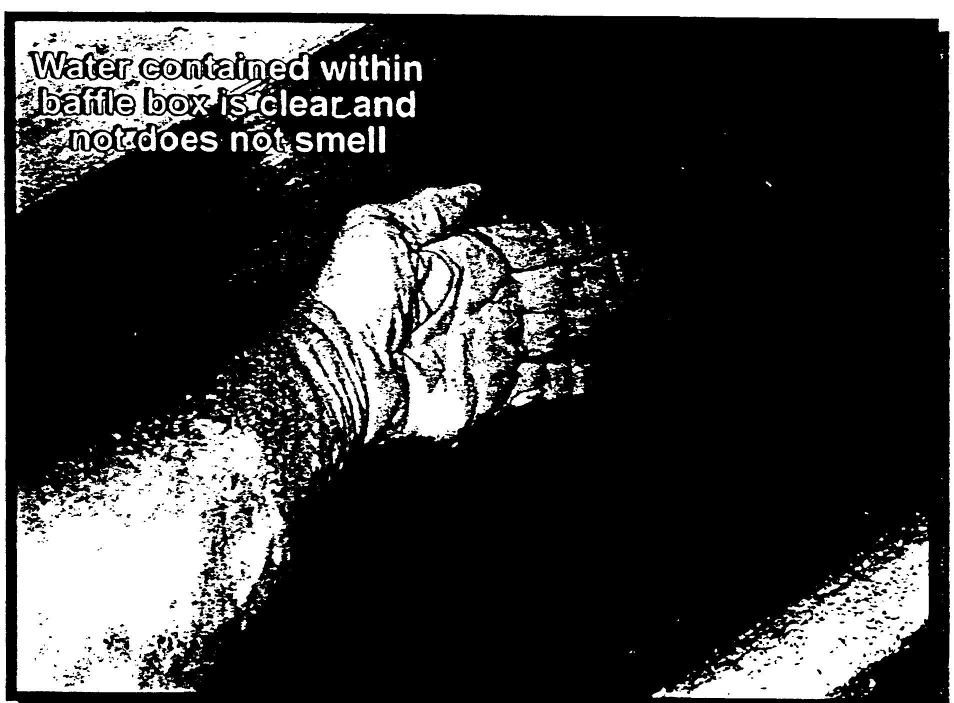
Nutrient Separating Baffle Box



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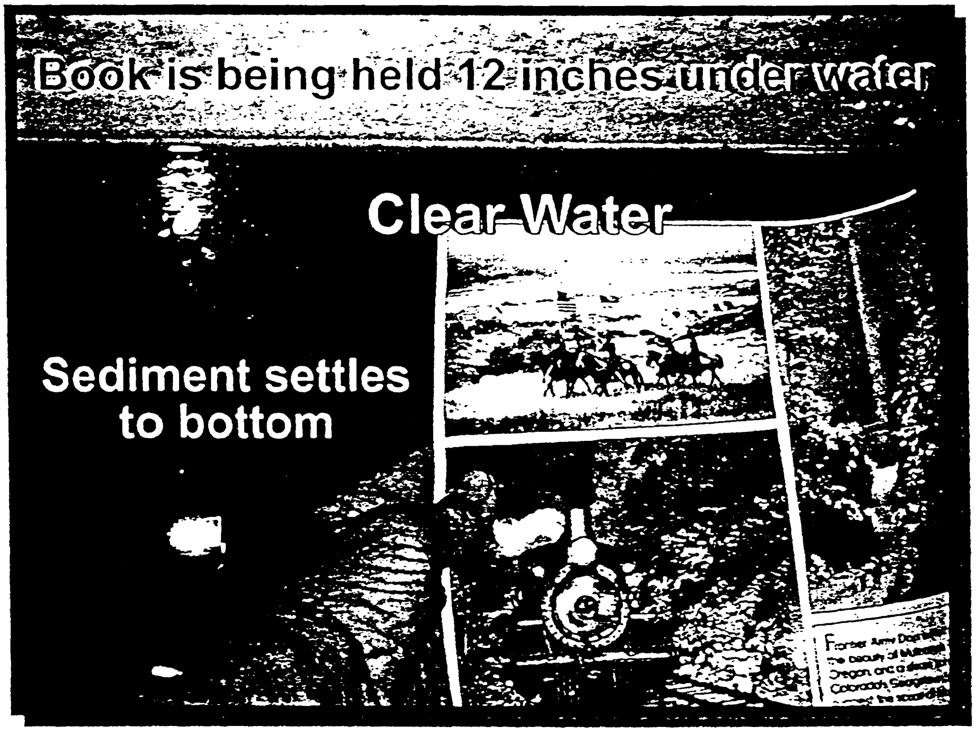
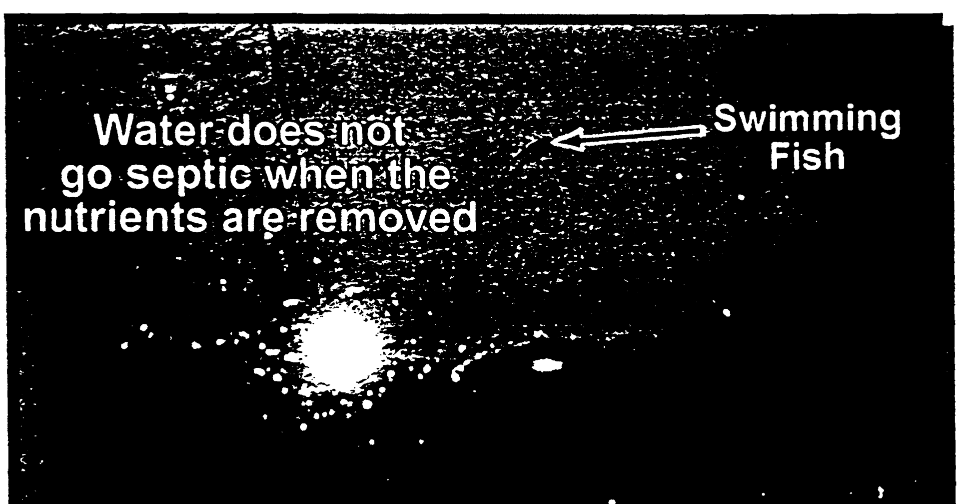
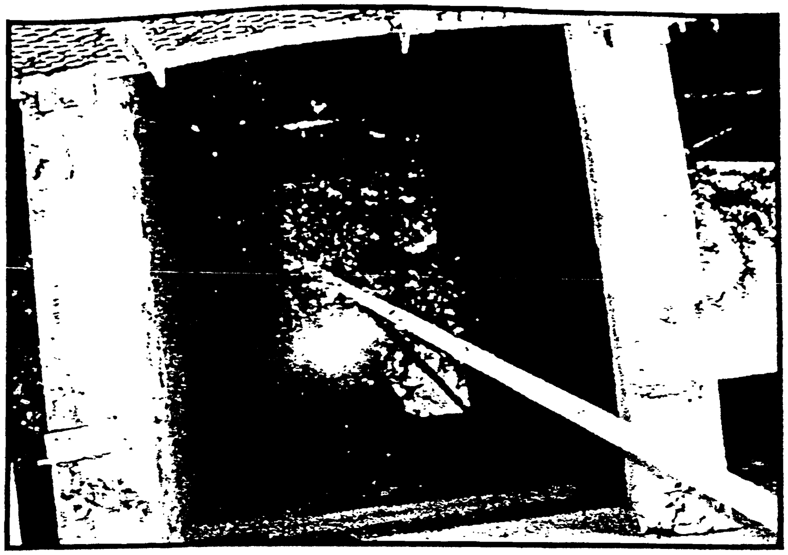
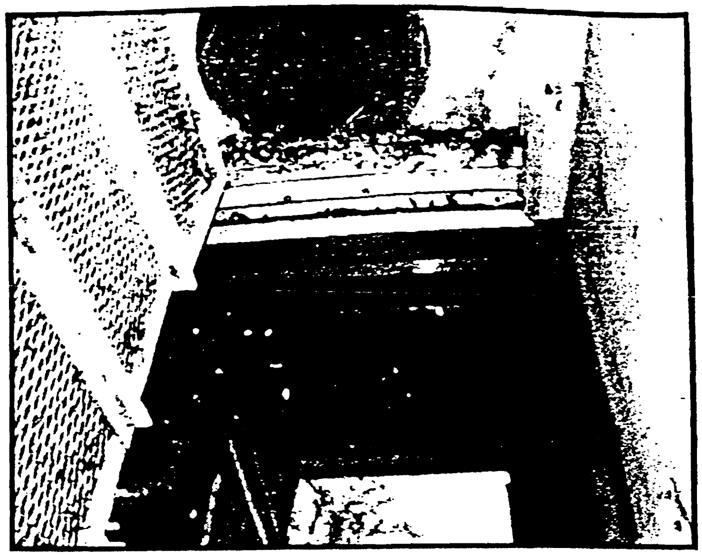
Nutrient Separating Baffle Box



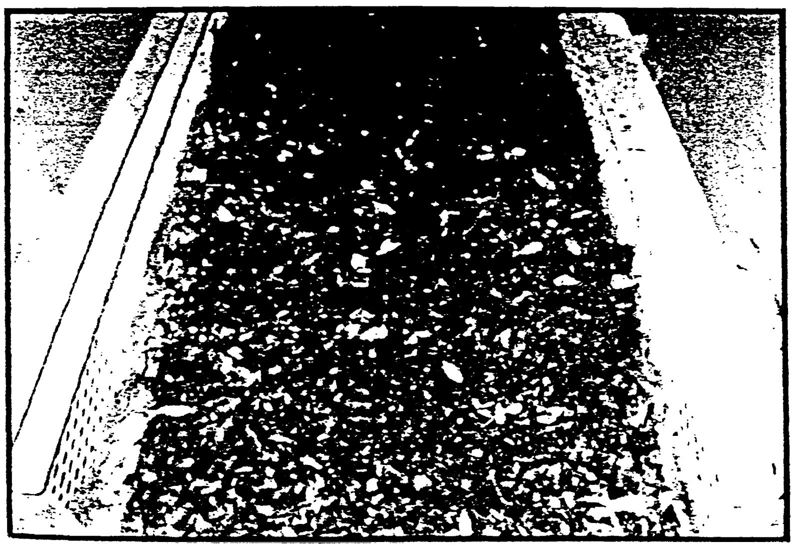


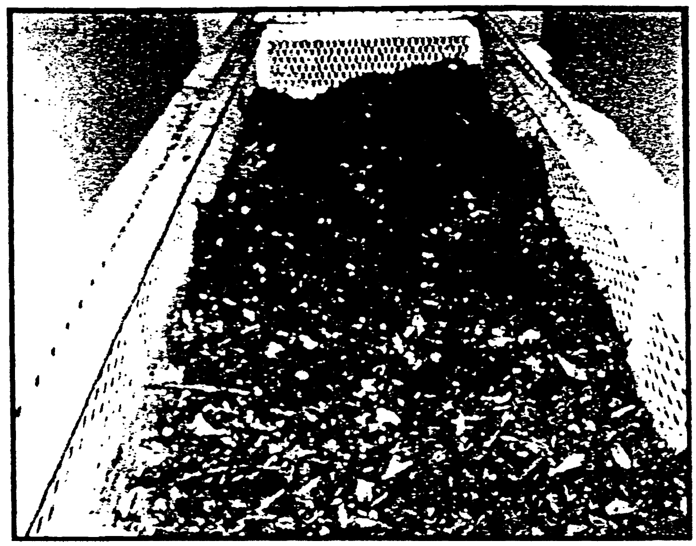
The Nutrient Separating Baffle Box by Suntree Technologies inc 321-799-0001





Above, Basket folded up reveals clear water and sediment in lower baffle





Approximately 250 pounds of leaves and grass in nutrient collecting basket.

Patent Pending. This instillation is on Orange St. in Sarasota Florida. Aprox. 1 month old.

Appendix C

Project Documentation

Prior to Installation

Photo 1: Stormwater conveyance system at Hemlock Gardens, prior to the installation of the BMP.

Photo 2: Stormwater conveyance system at Hemlock Gardens, prior to the installation of the BMP.

Hemlock Gardens
Borough of Harveys Lake
Luzerne County, Pennsylvania
Growing Greener grant (ME #350385)
Funded by PA DEP

Princeton Hydro pH

Photo 1: Roadside swales at Hemlock Gardens prior to the installation of the structural BMP.

Photo 2: Roadside swales at Hemlock Gardens prior to the installation of the structural BMP.

Hemlock Gardens
Borough of Harveys Lake
Luzerne County, Pennsylvania
Growing Greener grant (ME #350385)
Funded by PA DEP

Princeton Hydro

Installation of the BMP

Photo 1: Installation of part of the outflow pipe for the Hemlock Gardens BMP in the fall of 2002.

Photo 2: Installation of part of the outflow pipe for the Hemlock Gardens BMP in the fall of 2002.

Hemlock Gardens
Borough of Harveys Lake
Luzerne County, Pennsylvania
Growing Greener grant (ME #350385)
Funded by PA DEP

Princeton Hydro

Photo 1: Excavation of the site where the structural BMP will be installed at Hemlock Gardens.

Photo 2: Installation of the Water Polishing Unit section of the structural BMP.

Hemlock Gardens
Borough of Harveys Lake
Luzerne County, Pennsylvania
Growing Greener Grant (ME #350385)
Funded by PA DEP

Princeton Hydro

Photo 1: Installation of the Nutrient Separating Baffle Box section of the structural BMP.

Photo 2: Installation of the Nutrient Separating Baffle Box section of the structural BMP.

Hemlock Gardens
Borough of Harveys Lake
Luzerne County, Pennsylvania
Growing Greener grant (ME #350385)
Funded by PA DEP

Princeton Hydro pH

Photo 1: Completed installation of the Nutrient Separating Baffle Box section of the structural BMP.

Photo 2: Inside of the first chamber of the Nutrient Separating Baffle Box.

Hemlock Gardens
Borough of Harveys Lake
Luzerne County, Pennsylvania
Growing Greener grant (ME #350385)
Funded by PA DEP

Princeton Hydro

Completed Project

Photo 1: Some of the roadside swale stabilization work that was completed as part of the project.

Photo 2: The structural BMP after it was installed at Hemlock Gardens.

Hemlock Gardens
Borough of Harveys Lake
Luzerne County, Pennsylvania
Growing Greener grant (ME #350385)
Funded by PA DEP

Princeton Hydro

Photo 1: Additional stabilization work completed as part of the Hemlock Gardens project.

Photo 2: Vane grate trench drain which was installed as part of the Hemlock Gardens project.

Hemlock Gardens
Borough of Harvey Lake
Luzerne County, Pennsylvania
Growing Greener grant (ME #350385)
Funded by PA DEP

Princeton Hydro

Photo 1: Gravel that has accumulated within the baffle box over the course of two and a half months.

Photo 2: Stormwater flowing through the first chamber of the baffle box and into the polishing unit.

Hemlock Gardens
Borough of Harveys Lake
Luzerne County, Pennsylvania
Growing *Greener* grant (ME #350385)
Funded by PA DEP

Princeton Hydro pH

Appendix D

Raw Water Quality Data

Hemlock Gardens
Storrnwater Monitoring Program
Raw Water Quality Data

Date	Sampling Label	TP mg/L	TSS mg/L
14-May-01	SS-2	0.14	40
25-May-01	SS-2	0.14	35
7-Aug-01	SS-2	0.12	42
24-Aug-02	SS-2	0.01	137
24-Aug-02	HG-1	0.01	7.6
24-Aug-02	HG-2	0.03	5.5
24-Aug-02	HG-3	0.02	190.4
29-Aug-02	SS-2	< 0.01	12
29-Aug-02	HG-1	0.011	4
29-Aug-02	HG-2	0.07	1062
29-Aug-02	HG-3	0.08	1178
29-Aug-02	SS-2B	0.05	47
29-Aug-02	SS-2C	< 0.01	14
27-Sep-02	SS-2	0.061	46
27-Sep-02	HG-1	0.03	13
27-Sep-02	HG-2	0.05	34
27-Sep-02	HG-3	0.06	54
27-Sep-02	SS-2B	0.04	27
27-Sep-02	SS-2C	0.01	9

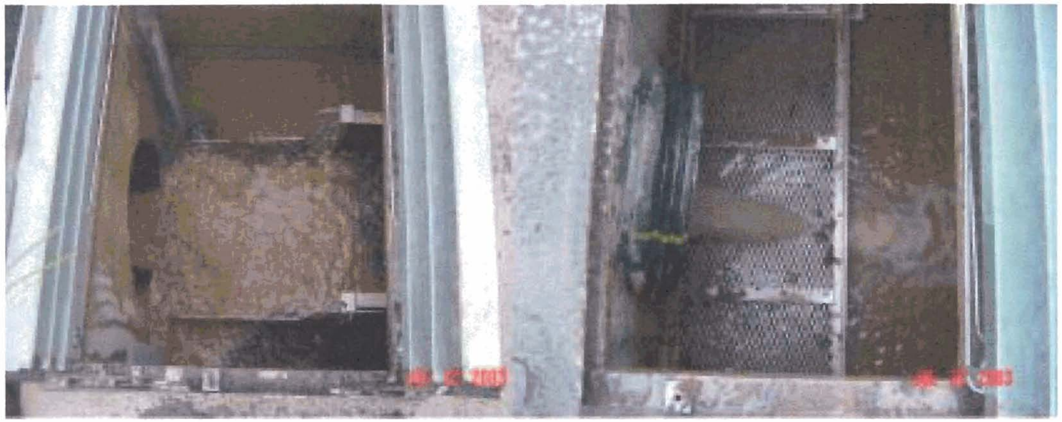
Appendix E

Summary Sheet

Project: Hemlock Gardens Collection, Conveyance and Treatment System
Harveys Lake, Pennsylvania

Client: Borough of Harveys Lake

Harveys Lake is the largest natural lake, by volume, within the Commonwealth of Pennsylvania. As a result of an increase in the frequency and magnitude of algal blooms, as well as near shore sedimentation and an increase in elevated counts of fecal coliform, the Borough of Harveys Lake and the Harveys Lake Environmental Advisory Council was awarded funding in 1993 to conduct a US EPA Phase I Diagnostic / Feasibility Study on the lake. Staff of Princeton Hydro conducted the technical components of the Study, such as the development of the pollutant (nitrogen, phosphorus, sediments) budget, and the long-term Management Plan.



INFLOW → → *OUTFLOW*

COMPLETED BMP

Through the use of State-based Growing Greener funds, engineering services were provided for the design and implementation of a stormwater Best Management Practices (BMP) project for an approximately 30-acre portion of the Harveys Lake watershed. This section of watershed, known as Hemlock Gardens, has steep slopes with exposed dirt roads and had no existing stormwater conveyance system. This stormwater BMP project included the installation of a large baffle box / sedimentation chamber and nutrient absorption polishing unit. The baffle box collects trash and allows particulate matter to settle, while the polishing unit inactivates or "collects" incoming phosphorus before it can enter the stream that discharges into Harveys Lake. Thus, this BMP treats the stormwater before it enters the stream.

1108 **Old York Road, Suite 1, P.O. Box 720**
Ringoes, New Jersey 08551
908.237.5660 (p), 908.237.5666 (f),info@princetonhydro.com

Project: Hemlock Gardens Collection, Conveyance and Treatment System
Harveys Lake, Pennsylvania
Client: Borough of Harveys Lake

TP (mg/L)

Date	Inflow	Outflow
4-Aug-04	0.659	0.524
12-Aug-04	0.214	0.201
21-Aug-04	0.537	0.251

TP (kg)

Date	Inflow	Outflow	Net Removal (kg)	pounds
4-Aug-04	1.0196	0.8108	0.2089	0.459533926
12-Aug-04	1.0058	0.9447	0.0611	0.13442411
21-Aug-04	1.5677	0.7328	0.8349	1.836851194
				2.430809231

Phosphorus removed per inch of rain	0.76125027
total annual rain	36.74
Annual removal	27.97
2003 removal	44.5 lbs
2004 removal	28 lbs
Mean Removal of TP (lbs)	**36.25** lbs

TSS (mg/L)

Date	Inflow	Outflow
4-Aug-04	1527	167
12-Aug-04	768	55
21-Aug-04	459	158

TSS (kg)

Date	Inflow	Outflow	Net Removal (kg)	Net Removal lbs
4-Aug-04	2362.6542	258.3911	2104.2631	4629.378815
12-Aug-04	3609.7104	258.5079	3351.2025	7372.645425
21-Aug-04	1339.9789	461.2563	878.7225	1933.189544
				13935.213784

Phorphorus removed per inch of rain	3993.542028
total annual rain	36.74
Annual removal	146723 lbs
in 2004	73.4 tonnes

Raw data collected by:
Dr. Fred Lubnow [flubnow@princetonhydro.com]

Jen-Hill 2005