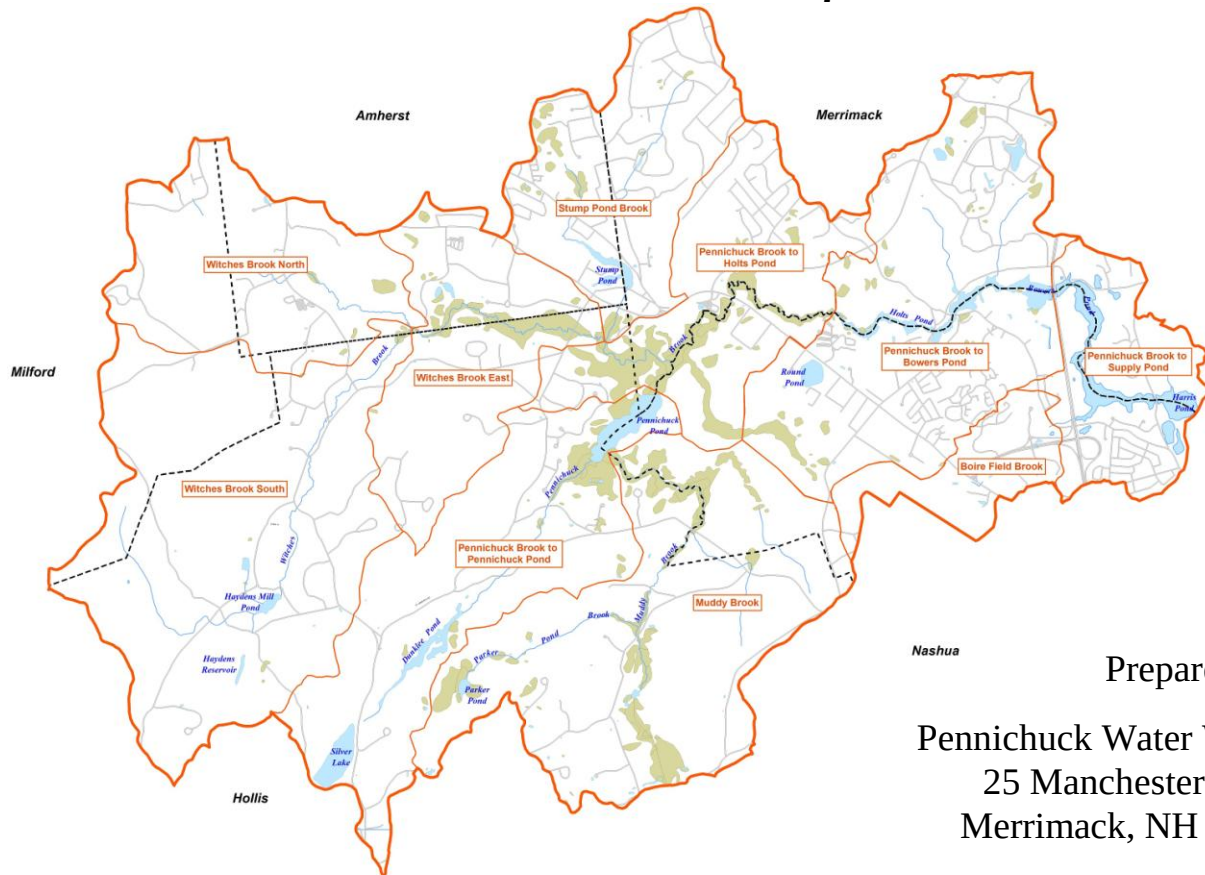


Pennichuck Water Works Pennichuck Brook Watershed Restoration Plan

Final Report: November 2012



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Pennichuck Water Works
Pennichuck Brook Watershed Restoration Plan

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Executive Summary

In this document, the Pennichuck Water Works Corporation (Pennichuck) presents the 2012 Pennichuck Brook Watershed Restoration Plan. This Plan is an update of Pennichuck's 2008 Watershed Restoration Plan. The 2008 Plan presented a quantified approach to setting water quality goals and management actions for protecting the water resources of the Pennichuck Brook system. This 2012 update serves to review and confirm water quality goals established in that earlier document, summarize measures implemented since adoption of that plan, and update recommendations for further actions based on Pennichuck's ongoing evaluation of restoration progress initiated by the 2008 plan.

This Plan puts forth a quantifiable management program to address reduction of pollutant discharges (specifically, phosphorus loading) that enter the Pennichuck Brook system and ultimately affect water quality at Harris Pond, where Pennichuck withdraws water to supply its customers. Based on an ongoing review of the management strategies outlined in the 2008 plan, and continued monitoring of water quality in the watershed, Pennichuck has completed this update of the Watershed Restoration Plan, to maintain a practicable and effective restoration program and protect this water supply.

An effective watershed restoration program involves the characterization of existing water quality issues, the development of goals for addressing those issues, identification of appropriate parameters for measuring progress toward those goals, and development of a management strategy for achieving the goals. This report describes the development of the restoration plan to address these elements.

Pennichuck Brook, with its 17,000+ acre watershed, supports the water supply system operated by the Pennichuck Water Works Corporation located in Merrimack, NH. Extensive development throughout the watershed has resulted in declining yields and water quality, a common phenomenon in urbanizing areas of New Hampshire and elsewhere. Excessive phosphorus loadings associated with this development contribute to algal blooms in Harris Pond, affecting the quality of the water supply.

In conjunction with preparation of the 2008 Watershed Restoration Plan, Pennichuck's consultant, Comprehensive Environmental Inc. (CEI) developed a watershed model to relate land use and other factors to the pollutant concentrations observed within the system of streams and ponds that comprise the water supply. Over a two-year period from 2006 to the end of 2007, the study team collected considerable water quality and flow data throughout the watershed for both dry and wet weather precipitation events. Based on that data and other available historical data, CEI

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compiled and calibrated a model that mimics flow and quality of Pennichuck Brook at various locations throughout the watershed. The model was used to develop an estimate of phosphorus loading from the watershed to the water supply on a watershed-wide and sub-watershed basis. The model included an assessment of current conditions and a projection of loadings at build-out of the entire watershed. Section 2.0 of this document describes the model and its results in greater detail.

The results of that modeling effort provide a quantitative basis for developing and measuring management actions for addressing water quality in the Pennichuck Brook System. Based on this model, this Watershed Restoration Plan presents numeric goals for water quality at Harris Pond (discussed in Section 3.0), targeted reductions in phosphorus loads across contributing sources within the watershed (presented in Section 4.0), and management actions for achieving those reductions (described in Sections 5.0 and 6.0).

Recent water quality data shows a reduction in phosphorus loads and concentrations in tributaries and the water supply ponds, compared to the earlier water quality data used to develop the model. For this update, Pennichuck has not revised the model or the water quality goals and pollutant reduction targets. Rather, the 2008 targets will continue to be used to guide restoration efforts until 10 years of long-term water quality data have been collected, at which time the model will be updated. The continued monitoring and additional data are anticipated to provide a more robust basis than the current data set for updating the water quality model, refining water quality goals, and allocating removal targets across the watershed and across management actions.

Since 2008, Pennichuck has initiated a number of actions to achieve water quality improvements in the watershed. Section 5.0 provides a review of these activities, including a Community Based Social Marketing (CBSM) Education Program for Stump Pond, development of a watershed website, evaluation and conceptual development of Best Management Practices (BMP) retrofits for 10 priority sites in the watershed, implementation of the Tinker Road Detention Basin Retrofit project, evaluation of sediment accumulation in key watershed ponds, operation of the Harris Pond aeration system, and ongoing water quality monitoring.

The end result of the modeling, monitoring, recent watershed management experience, and review of the 2008 Plan is the updated 10-year capital improvement plan presented in Section 6.0. As in the 2008 plan, the capital improvement program is tied to pollutant load reductions. This is unique in that most watershed restoration programs do not take the final step of quantifying potential pollutant removals from various stormwater practices to match the target goal, nor do they tie it into a capital improvement program (CIP) and schedule.

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The capital improvement plan covers a 10-year period from 2013-2022 at a cost of \$5.5 million dollars. These expenditures are estimated to reduce phosphorous loadings by some 2,300 pounds per year, to meet the target goal.

The recommendations under the 10-year program are comprehensive, addressing the significant sources of phosphorus identified in the Plan, including widespread loadings from commercial/industrial parking lots, roadways, residential areas, internal pond loadings, and sediment sources. The plan recommendation include management actions in the following categories:

1. Continue and Expand Public Education
2. Increase Maintenance in Commercial Areas
3. Retrofit Detention Basins & BMPs
4. Encourage Local Adoption of State Stormwater Standards
5. Evaluate Phosphorus in Groundwater
6. Evaluate Sediment Accumulations in Ponds
7. Continue Harris Pond Aeration
8. Continue Long-Term Monitoring Program
9. Update Watershed Restoration Plan Model

The recommended action plan addresses phosphorus reduction benefit, costs (both capital and operating costs), and implementation schedule. In addition recommendations are provided for monitoring and measuring progress for each action proposed under Pennichuck's program.

Pennichuck anticipates continued review and update of this Watershed Restoration Plan once further water quality information is compiled, and as experience with implementing recommended actions is gained. As has been the case since developing its initial Watershed Restoration Plan in 1998, planning for and implementing watershed protection and restoration measures is an ongoing process, involving the revaluation of results, refinement of goals, and adjustments in management measures for further improvements where possible.



1.0 Introduction

This document presents the 2012 Pennichuck Brook Watershed Restoration Plan. In 2008, the Pennichuck Water Works Corporation (Pennichuck) adopted a Watershed Restoration Plan based on an evaluation of the water resources of the Pennichuck Brook system, and on the development of a management program to slow down the eutrophication of the ponds through reduction of pollutant discharges (specifically, phosphorus loading). Based on an ongoing review of the management strategies outlined in that plan, and continued monitoring of water quality in the watershed, Pennichuck has completed this update of the Watershed Restoration Plan, to maintain a practicable and effective restoration program. This report serves to review and confirm water quality goals established in the 2008 document, review and assess measures implemented since adoption of that plan, and update recommendations for further actions based on Pennichuck's ongoing evaluation of restoration progress initiated by the 2008 plan.

The Pennichuck Brook watershed occupies more than 17,000 acres in rapidly urbanizing southern New Hampshire (see Figure 1-1). It provides a major portion of the drinking water supply for Nashua and some surrounding communities, supplied by Pennichuck Water Works Corporation, a private water supply company.

This report describes the results of an evaluation of the Pennichuck Brook Watershed to develop a Watershed Restoration Program to address excess algal growth and cyanobacteria in some of the ponds on Pennichuck Brook, particularly Harris Pond where the water supply intakes are located. The New Hampshire Department of Environmental Services (NHDES) 2010 List of Threatened or Impaired Waters that Require a TMDL (303(d) list) currently lists Harris Pond for cyanobacteria. Cyanobacteria or "blue-green" algae blooms are caused by excessive nutrient loadings into the ponds, particularly phosphorus, which is the limiting nutrient in fresh water systems. As the algae die and decompose, they raise the level of the pond bed, allowing land plants to colonize the edges, and eventually converting the area to dry land and reducing the volume of the water body. This process of filling in is known as eutrophication. While eutrophication is a natural, slow-aging process for a water body, human activity greatly speeds up the process through introduction of higher quantities of nutrients.

This plan focuses on implementation actions to slow the eutrophication process and prevent difficult-to-treat taste and odor problems through the reduction of phosphorus loadings that eventually enter Harris Pond.

The development of an effective watershed restoration program involves the characterization of the existing problem, the development of goals for



addressing that problem along with appropriate parameters for measuring progress toward those goals, and developing a management strategy for achieving the goals. This process is further characterized by the following steps, which are addressed in the remainder of this report:

- 1) Measure or estimate existing water quality and pollutant loadings;
- 2) Identify the most critical measurement point for monitoring water quality and assessing changes in quality that occur as management actions are implemented;
- 3) Identify the appropriate water quality surrogates or indicators¹;
- 4) Identify the desired water quality;
- 5) Compare the existing pollutant loadings to desired water quality goals; and
- 6) Identify how pollutant loads can be addressed to achieve the goals.

The restoration plan is described in six sections beginning with this introduction. Section 2.0 briefly describes the first step listed above, a watershed source analysis of pollutants using a watershed model developed in 2007 to evaluate stormwater impacts and issues. Section 3.0 addresses Steps 2-4, ultimately laying out the numeric targets or goals for water quality and identifying the location and indicator parameters for measuring progress. The Pollutant Load Analysis provided in Section 4.0 addresses Step 4, and describes the necessary load reductions needed by community to achieve the identified goals.

Sections 5.0 and 6.0 address the sixth step. Section 5.0 describes and evaluates actions initiated since the publication of the 2008 Watershed Restoration Plan. Based on the information in Sections 2.0 through 5.0, Section 6.0 presents recommendations for further actions to achieve watershed restoration goals, together with information on associated costs and schedule.

1.1 Background

Pennichuck Brook has long been the primary source of water supply for a significant portion of southern New Hampshire. The water supply is operated by Pennichuck Water Works Corporation located in Merrimack, NH. Peak summer demands are also sometimes supplemented by the Merrimack River. Over the last 100 years, extensive development throughout the 17,000+ acre watershed has resulted in declining yields and water quality, a common phenomenon in urbanizing areas of New Hampshire and elsewhere. Excessive phosphorus loadings associated with this development has caused increased algal blooms in Holts, Bowers and Harris Ponds. Contributing factors include major highways,

¹ A 'surrogate' or 'indicator' parameter is something that represents the general water quality of the stream/ponds and that can be reliably measured and tracked.



urban traffic and dense commercial/industrial land uses that have developed throughout a large segment of the watershed, much of it occurring more than 30 years ago.

In recognition that watershed protection for the five town watershed requires a multi-faceted approach, Pennichuck Water Works Corporation (Pennichuck) developed a Comprehensive Watershed Management Plan in 1998 (CEI, August 1998). Following substantial completion of the recommended measures from the 1998 plan (refer to the graphic representation of implemented watershed management projects in Figure 1-2), Pennichuck updated the Watershed Management Plan, completing the plan in February 2008 (CEI, February 2008). Whereas the 1998 Plan was qualitative in its assessment and recommendations, development of the 2008 plan was based on a quantitative approach. This approach included the development of a computer model to evaluate existing sources of pollution and to further evaluate how proposed watershed restoration actions would affect the total pollution load. This analysis provided the basis for a 10-year capital improvement plan that is tied to quantitative pollutant load reductions.

Pennichuck recently initiated a strategic plan to expand public education and communication outreach programs and other non-structural opportunities to protect the watershed. As a result, Pennichuck initiated a further update of the Watershed Management Plan, reported in this document. This effort has focused on:

- incorporation of long-term operating costs into the evaluation; and
- expansion of the public and communication outreach programs envisioned under the restoration program.

This report presents the findings, modeling results and actions proposed for improving water quality in the watershed. Note that this report does not include an update of the stormwater pollutant load modeling performed for the 2008 report. Updating the model will occur at a future date (as described later in this report) and depends on additional water quality data to be obtained under continued monitoring. However, to provide a complete, stand-alone document that does not require referral back to previous documents, Section 2.0 of this report includes a discussion of the modeling described in the earlier 2008 report.

1.2 General Watershed Information

The Pennichuck Brook Watershed (Figure 1-1) occupies land in five southern New Hampshire towns, including Nashua, Merrimack, Amherst, Milford and Hollis. The primary water supply consists of about 195 acres of water in a series of chain ponds that includes Harris Pond, Bowers Pond and Holts Pond. There are also several other ponds in the watershed that store water upstream from the water supply ponds. Refer to Figure 1-



1 for the locations of lakes and ponds within the watershed boundaries. The overall watershed has an area of 17,300 acres in total, with 10 subwatersheds of roughly 1,200-3,200 acres each (Figure 1-3).

The populations of each of the watershed towns have grown considerably, particularly between the 1960 and 1990 censuses when the population in Nashua alone more than doubled. Table 1-1 shows watershed population by town from 1940 through 2010, showing the dramatic increase in population. Although the watershed is threatened by environmental impacts associated with this continuing rapid growth in population, there are also some conditions that help to minimize the extent of water quality degradation in the near term. These factors include:

- 1) much of the watershed has relatively sandy, well drained soils;
- 2) one of the watershed communities (Hollis) contains a large proportion of the watershed yet is only lightly developed and has land use restrictions intended to maintain this character; and
- 3) Pennichuck has been promoting Low Impact Development (LID) on many projects in the watershed. LID is geared to protect the natural hydrology of each site.

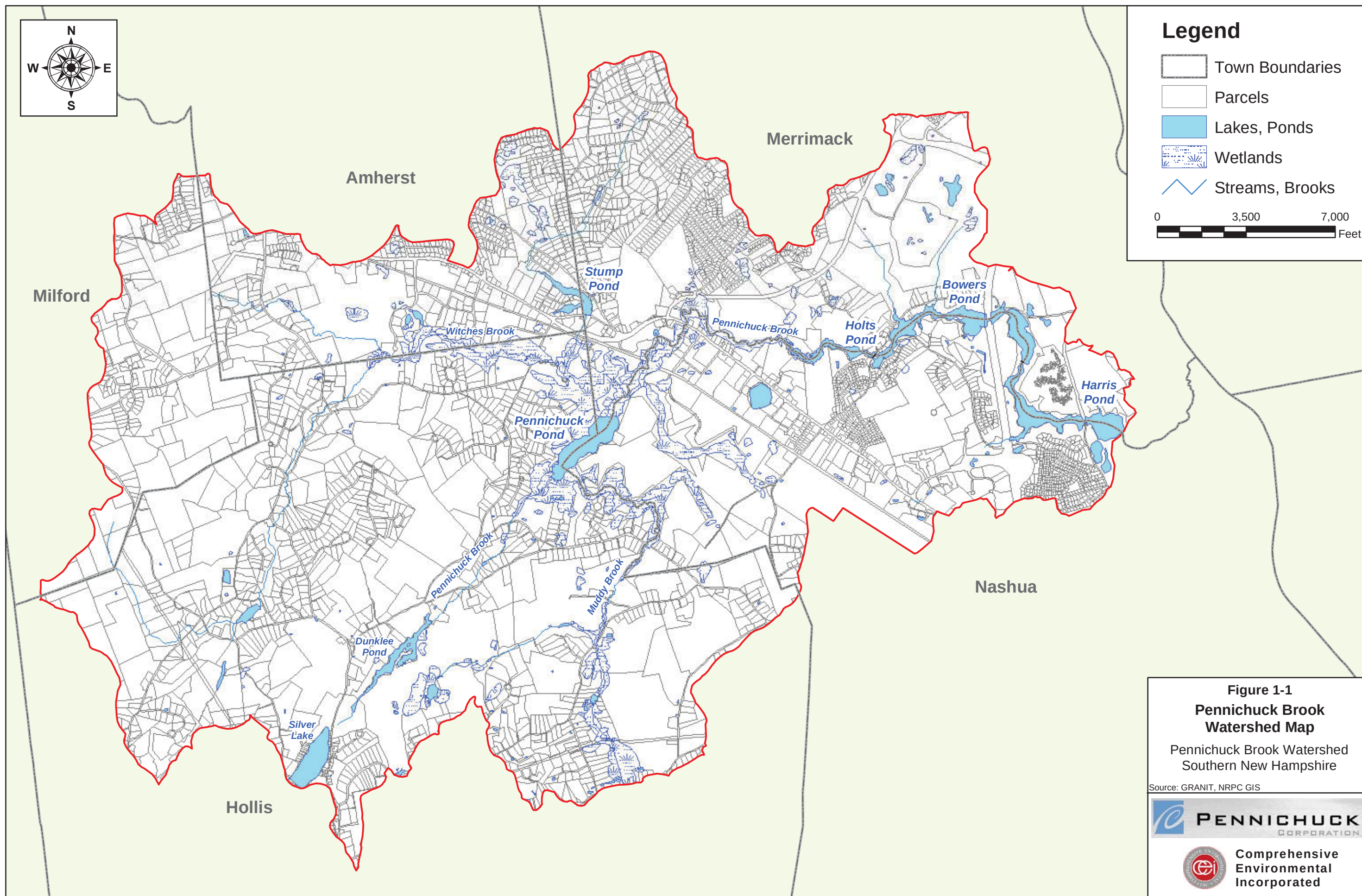
In addition, both water quality and quantity benefit significantly from the large network of wetlands that occur in some areas of the watershed. These wetlands store and purify large quantities of water, providing immense benefits in terms of flood storage, pollutant attenuation, and aquatic habitat. Some of the most significant wetland areas are shown on Figure 1-4. The next section presents a further description of flow and water quality data, as well as a discussion of the development of the water quality model presented in the 2008 report and used to assess pollutant loads and water quality management options.

Table 1-1. Watershed Community Populations 1940-2000²

City/Town	Year							
	1940	1950	1960	1970	1980	1990	2000	2010
Amherst	---	---	2,051	4,605	8,243	9,068	10,769	11,201
Hollis	---	---	1,720	2,616	4,679	5,705	7,015	7,684
Merrimack	---	---	2,989	8,595	15,406	22,156	25,119	25,494
Milford	---	---	4,863	6,622	8,685	11,795	13,535	15,115
Nashua	32,927	34,669	39,096	55,820	67,865	79,662	86,605	86,494

² Note that the data represents each community as a whole and not just the watershed area. Source: [http://www.nh.gov/oep/programs/DataCenter/2010 Census/index.htm](http://www.nh.gov/oep/programs/DataCenter/2010%20Census/index.htm)





Pennichuck Water Works Watershed Management Program



Studies of Urban Non-Point Source Pollution Source Water Protection Grants

- Boire Field Brook: \$14,680
- Pennichuck Brook to Bowers Pond: DES Grant \$13,700
Pennichuck Water Works \$9,200
- Stump Pond Brook: DES Grant \$15,000
Pennichuck Wat

319 Watershed Assistance Grant

- Remaining Five Sunwatersheds:
Muddy Brook,
Pennichuck Brook to Holts Pond,
Pennichuck Brook to Pennichuck Pond,
Pennichuck Brook to Supply Pond,
Witches Brook South
- DES Grant \$19,100
Pennichuck Water Works \$28,600



Provided Guidance to Communities for Developing Stormwater Zoning Criteria



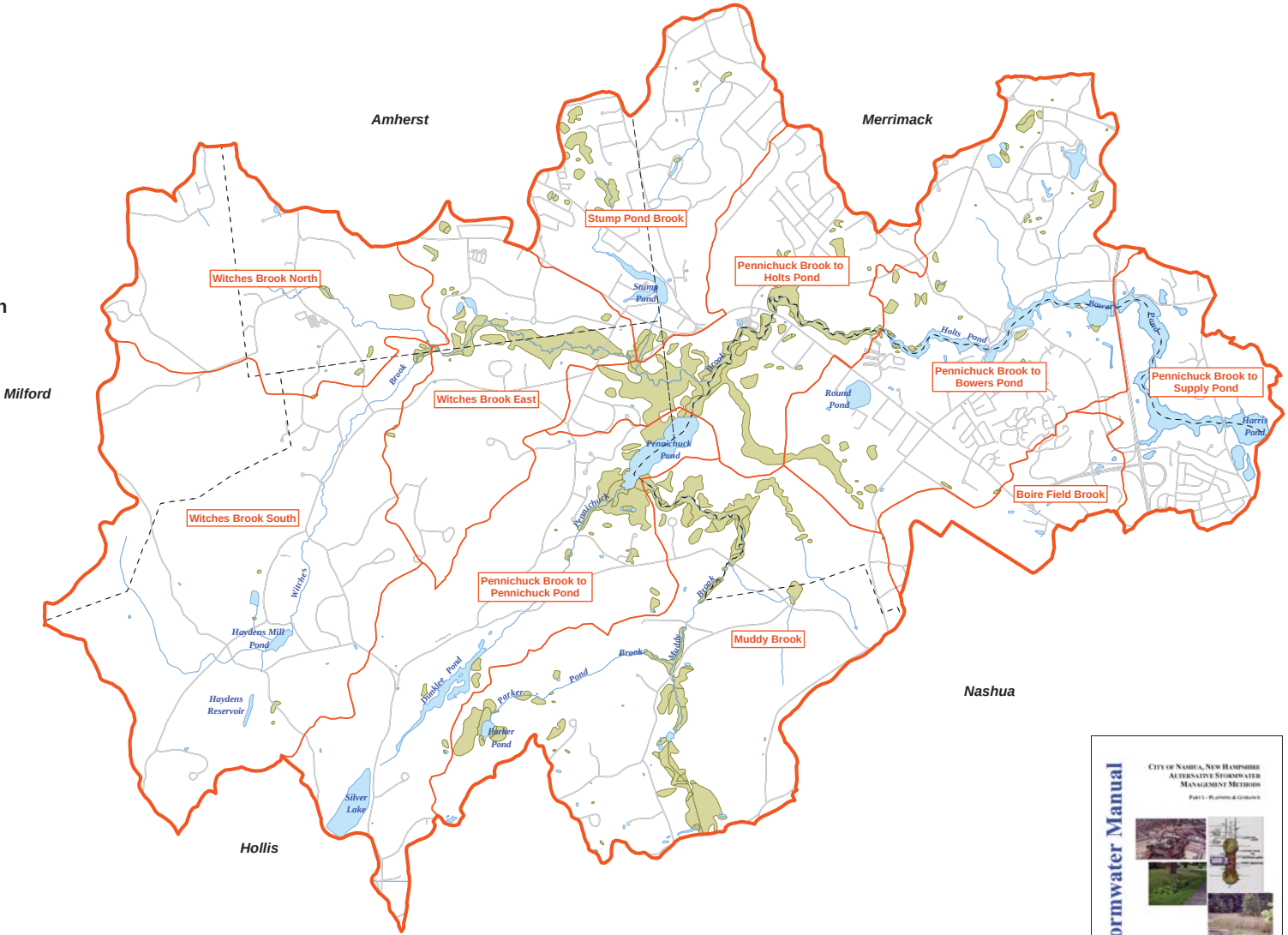
Storm Drain Mapping & Marking Program

Source Water Protection Grant
DES Grant: \$15,000
Pennichuck Water Works: \$19,000



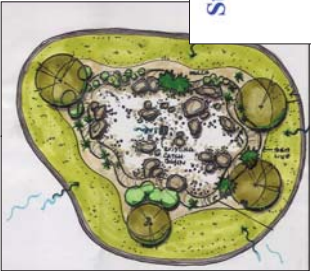
Hot Spots Program

319 Watershed Assistance Grant
DES Grant: \$15,000
Pennichuck Water Works: \$9,300



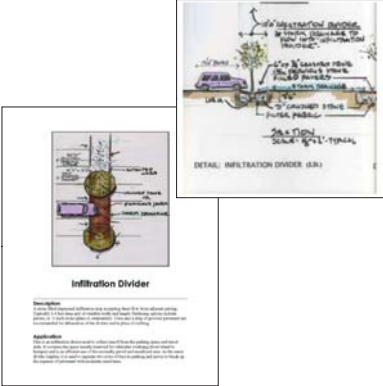
Cornerstone Site Structural BMP/Post Office Treatment Swale & Biolog

319 Watershed Assistance Grant
DES Grant: \$21,000
Pennichuck Water Works: \$14,000



Alternative Stormwater Management Manual

319 Watershed Assistance Grant
DES Grant: \$40,000
Matching Contribution \$58,500 by:
Pennichuck Water Works: \$25,000
City of Nashua: \$25,000
Comprehensive Environmental Inc.: \$8,500



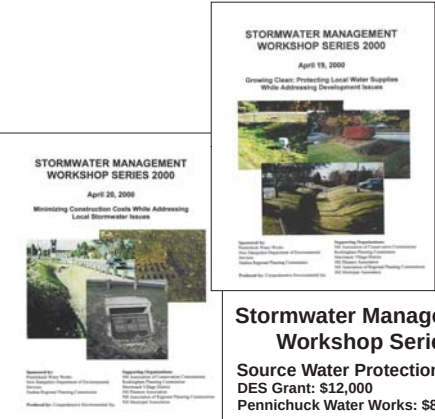
Pennichuck Square and Celina Avenue BMPs

Source Water Protection Grant
DES Grant: \$28,500
Pennichuck Water Works: \$27,500



Nashua Community Technical College Wet Detention

Pennichuck Water Works: \$175,000



Stormwater Management Workshop Series

Source Water Protection Grant
DES Grant: \$12,000
Pennichuck Water Works: \$8,000

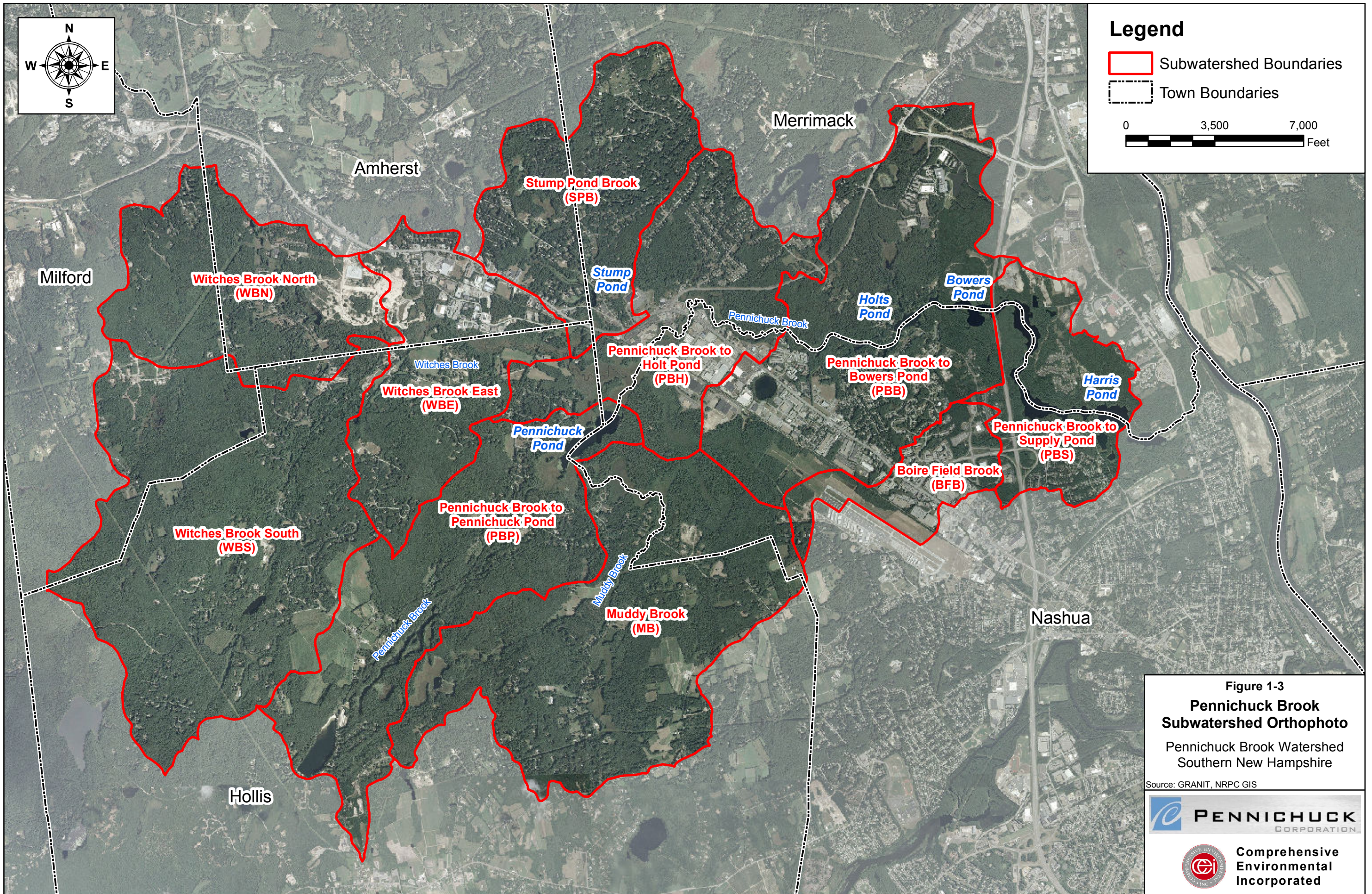
Figure 1-2

Pennichuck Water Works Watershed Management Projects

Pennichuck Brook Watershed
Southern New Hampshire



Comprehensive
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2.0 Source Analysis

This Section describes the analysis of watershed flows and pollutants that affect water quality in the Pennichuck Brook system. This analysis uses a watershed model presented in the 2008 Watershed Restoration Plan, developed to relate watershed land use and other factors to the pollutant concentrations observed within the system of streams and ponds that comprise the water supply. The model was used to develop an estimate of phosphorus loading from the watershed to the water supply on a watershed-wide and sub-watershed basis. The modeling included an assessment of current conditions, and a projection of loadings at build-out of the entire watershed.

The results of that modeling effort continue to guide Pennichuck's management actions for addressing water quality in the Pennichuck Brook System. Based on an understanding of the pollutant loading, subsequent Sections of this report describe the setting of targeted reductions in phosphorus loads, and management actions for achieving those reductions.

Setting effective water quality goals for the Pennichuck Watershed and developing action items to achieve those goals requires an understanding of existing pollutant loadings. To account for the multiple parameters involved in estimating pollutant loadings from the watershed, the study team selected EPA's Storm Water Management Model (SWMM) Version 5.0 (Rossman, 2005) to assist with the development of pollutant estimates. The model allows for the evaluation of stormwater practices and their impact on water quality.

Although the primary function of this model for the Pennichuck watershed is to evaluate water quality within the water supply ponds, a detailed flow assessment was also performed to calibrate phosphorus loads to match observed in-pond concentrations. The Reckhow and Vollenweider models were also used to convert pollutant loadings calculated in SWMM to estimated concentrations in the ponds. The model was based on flow data collected between September 2005 and May 2006 and in-pond water quality data collected between November 1995 and October 2006.

As noted in Section 1.0, Pennichuck has not updated the model for this 2012 report. However, the study team recommends bringing the model up to date by 2016 after sufficient data has been collected to support the effort. For reader convenience, the following sub-sections adapt the description of the model development and results from the 2008 report.



2.1 Flow Assessment

The first step in setting up the model comprised the evaluation of tributary flows in the watershed and their response to precipitation events to better quantify flows associated with stormwater runoff and those associated with baseflow.

The model includes a surface runoff/infiltration component and an aquifer/streamflow component (Figure 2-1). Precipitation falls on the ground surface and either evapotranspires, infiltrates or runs off, depending on several variables (e.g., land use, soil type, depression storage). In the model, the study team developed a simple aquifer below the surface of each subwatershed. As configured for this study, the model assumes that this shallow aquifer collects the water that percolates through the surficial soils and conveys this water to the streams as groundwater baseflow.

Deep aquifer recharge is assumed to be insignificant; however, there may be deep aquifer discharge to the streams. The basis for this assumption is: 1) the observed flow data that was collected from the streams for several months in 2005 and 2006 shows that the streams are supported by groundwater discharge as seen by the observed peaks during and after a precipitation event; and 2) using these assumptions, the model predicted less flow in the streams than was observed in the field, which indicates that the deeper aquifer may also be providing water to the streams. An in-depth geological and hydrological analysis would be required to confirm whether this is actually occurring and is well beyond the necessary scope to update the watershed restoration program. The model calibrated well with the existing data and the primary focus of the modeling effort was to characterize the effects of stormwater runoff and the associated pollutants.

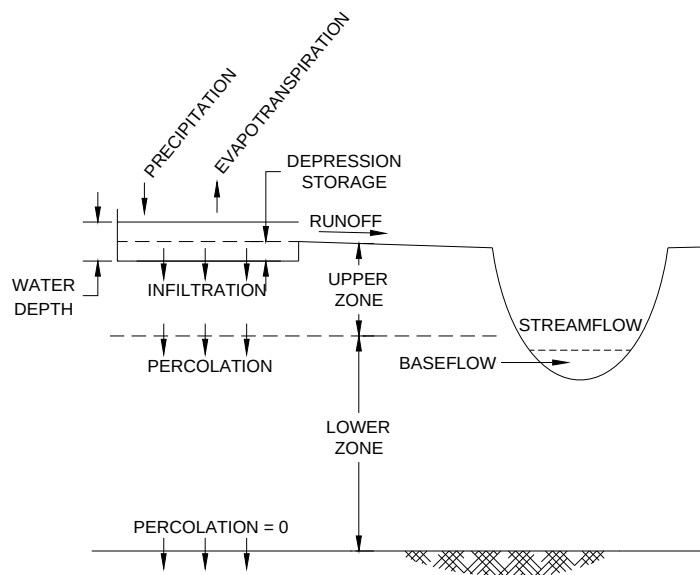


Figure 2-1. EPA SWMM Model Water Balance Schematic

The following summarizes the data used in the model and the results of the flow assessment.

2.1.1 Input Data and Assumptions

The majority of the model input data was available as spatial data in a Geographic Information System (GIS). GIS data was available from NRPC and the State of New Hampshire GIS (GRANIT). The layers available for use, and a description of their purpose in the model, are described in Table 2-1 below.

Table 2-1. Existing GIS Data			
GIS Layer	Model Use	Type	Source
Subwatersheds	Subcatchments	Vector-Polygon	(CEI, 2005)
Parcels	Mapping	Vector-Polygon	(NRPC, 2005)
Land Use	Land Use, Imperviousness	Vector-Polygon	(NRPC, 2005)
Landcover	Evapotranspiration Cover Coefficients	Vector-Polygon	(GRANIT, 2001)
Soils	Infiltration Rates, Soils Parameters	Vector-Polygon	(GRANIT, 2006b)
Hydrography	Streams, Ponds, Reservoirs	Vector-Polygon/Polyline	(GRANIT, 2006a)
Orthophotos	Mapping	Raster-Image	(GRANIT, 2005)
USGS Topographic Maps	Elevation Data	Raster-Image	(GRANIT, 2004)

Subwatersheds

Subwatershed boundaries are natural boundaries dictated by the local topography. A subwatershed boundary generally follows ridgelines or high points and delineates the area that drains to the furthest downgradient point, which is typically chosen where a stream intersects another stream.

The original ten subwatershed boundaries included in the 1998 Watershed Management Plan¹ were divided further into a total of 24 subwatersheds, SUB-1 through SUB-24, for modeling purposes. This allows for evaluation of each subarea for impacts to tributaries and the larger receiving streams and provides a more manageable scale to evaluate the area, providing more localized information on which to base decisions.

In the 2008 Watershed Restoration Plan, these 24 subwatersheds included the Supply Pond subwatersheds, SUB-1 and SUB-2, located at the most downgradient point of the watershed. However, since Supply Pond no

¹ Comprehensive Environmental Incorporated. Pennichuck Water Works Watershed Management Plan. August 1998.



longer serves as part of the water supply, SUB-1 and SUB-2 have been removed from the watershed area. The analysis area now encompasses the remaining 22 subwatersheds, labeled SUB-3 through SUB-24 (Figure 2-2). The original numbering has been maintained for consistency with the model.

USGS topography was used to estimate the average surface slope of each subcatchment area, which is used in runoff estimations in the model.

Hydrography

Hydrography data includes streams, ponds and reservoirs. This information is used to estimate stream lengths and pond areas used in the model. Stream cross-sections were measured in the field for select locations. Hydrography data was obtained from the State of New Hampshire GIS GRANIT database.

Land Use and Landcover

The type of land use within the watershed has a direct relationship with the amount of runoff and pollutant loadings to the water supply. Land uses with greater impervious area will result in greater runoff than forested areas. Generally, the same holds true for pollutant loadings, with greater levels of pollutants associated with more developed areas.

Land use data within the Pennichuck watershed was obtained from NRPC. The NRPC database consisted of multiple land uses throughout the watershed. This data was consolidated into eight land uses as shown in Table 2-2, which also includes the percent impervious area associated with each land use.

The NRPC land use layer is parcel-based, which results in some degree of error in the model because of the assumption that the entire parcel is one consistent land use. For example, a 100-acre lot may have only one house on it, which classifies the parcel as residential, when in actuality the majority of the parcel remains forested. This study assumes that this degree of error would be consistent throughout the model, and since the computed runoff and water quality parameters would be calibrated to measurements of observed conditions, this data constraint is not anticipated to introduce significant error in the model.



Table 2-2. Land Use Types and Parameters		
Model Land Uses	NRPC Land Use	Impervious²
Commercial	Commercial Institutional Municipal Facility School	85%
Forest	Permanent Open Space Recreation Vacant	1.6%
High Density Residential	Multi Family Residential Mixed Use	44%
Industrial	Industrial	72%
Low Density Residential	Single Family Residential Manufactured Housing	19%
Open Space	Agricultural ROW	2.8%
Road	Road	66%
Water	Water	100%

Figure 2-3 shows the existing land uses throughout the watershed. Existing land use within the watershed by town is tabulated in Table 2-3 by acreage and in Table 2-4 as a percentage. This represents the land use in 2005, as obtained from NRPC, to be consistent with the dates of other model inputs.

Table 2-3. Existing Land Use by Town (acres)									
Town	Commercial	Industrial	High Density Residential	Low Density Residential	Open Space	Forest	Road	Water	Total
Amherst	154	366	29	726	23	402	118	-	1,800
Hollis	68	46	22	3,391	647	3,106	230	107	7,600
Merrimack	336	441	208	1,238	0	785	254	100	3,400
Milford	-	-	47	493	-	750	40	-	1,300
Nashua	468	332	329	440	83	1,123	236	172	3,200
Total	1,026	1,186	634	6,289	753	6,166	877	379	17,300

Note: Based on NRPC, 2005.

² Impervious values based on USDA NRCS Technical Release-55 and Sleavin, W.J., Civco, D.L., Prisloe, S., Giannotti, L. 2000. Measuring Impervious Surfaces for Non-Point Source Pollutant Modeling. University of Connecticut.



Table 2-4. Existing Land Use by Town as a Percent of Watershed Area

Town	Commercial	Industrial	High Density Residential	Low Density Residential	Open Space	Forest	Road	Water
Amherst	9%	20%	2%	40%	1%	22%	7%	0%
Hollis	1%	1%	0%	45%	9%	41%	3%	1%
Merrimack	10%	13%	6%	36%	0%	23%	7%	3%
Milford	0%	0%	4%	38%	0%	58%	3%	0%
Nashua	15%	10%	10%	14%	3%	35%	7%	5%

Note: Based on NRPC, 2005.

Soils

Soils data is necessary to estimate percolation rates throughout the watershed. These percolation rates help establish the amount of precipitation that is infiltrated through the soils into the groundwater and the amount that runs off the surface. Soils data was obtained from the U.S. Department of Agriculture, Natural Resources Conservation Service soils layer from GRANIT. Figure 2-4 shows the hydrologic soil groups throughout the watershed.

Precipitation

Precipitation data is necessary for computations of infiltration, runoff and evapotranspiration volumes in the model. SWMM is able to process precipitation data at frequent intervals (e.g., hourly) to simulate individual rain events. This is useful in calibration of the flow data to match modeled flow data with observed flow data.

Precipitation data was obtained from the National Climatic Data Center (NCDC, 2006). This consisted of hourly data for the Concord Municipal Station 271683 from June 1, 1995 through September 29, 2005. This is the closest station with a continuous period of record. The weather station located in Nashua did not have any significant periods of continuous precipitation data available. In addition to this station, data from several personal weather stations in the area were examined. Weather data from KHNASHU10 in South Nashua was also used in the model for the period from October 1, 2005 to May 1, 2006. This station seemed to best fit the runoff events of the watershed and was combined with the Concord precipitation data in an hourly format to form the precipitation inputs for the model. A composite precipitation file was created from these two sources from June 1, 1995 to May 1 2006 (Appendix A).

Snowfall accumulation and snowmelt were not modeled, since there was little snowfall or snow accumulation during the period of the runoff calibration when this could cause significant error. It is noted that spring



snow melt can result in slugs of accumulated pollutant loadings. However, because the study focused on average annual loadings rather than seasonal variations, this phenomenon was not considered to be a relevant factor.

2.1.2 Flow Monitoring and Data Collection

Stream Levels

Nine tributary locations, T-1 through T-9 (Figure 2-5), were monitored for flow to obtain an overall understanding of tributary response to precipitation throughout the watershed. These locations were chosen to represent the major tributaries to Pennichuck's surface water supply and allow for comparison of the impacts of varying levels of development (i.e., ranging from rural to urban areas) on flows.

Staff gages and water level transducers with dataloggers were installed at each of these nine locations during September and October 2005. The Model WL15X dataloggers (Global Water Instrumentation, 2002) are capable of reading depths from zero to 15 feet. The transducer and datalogger are built into the unit and the data can be retrieved using any computer or laptop with the appropriate software. The dataloggers can retain 24,000 readings (Global Water Instrumentation, 2002). The dataloggers are vented, which provides automatic barometric pressure compensation to prevent reading errors. A typical configuration of the staff gage with datalogger installed in the stream channel is shown below in Figure 2-6.

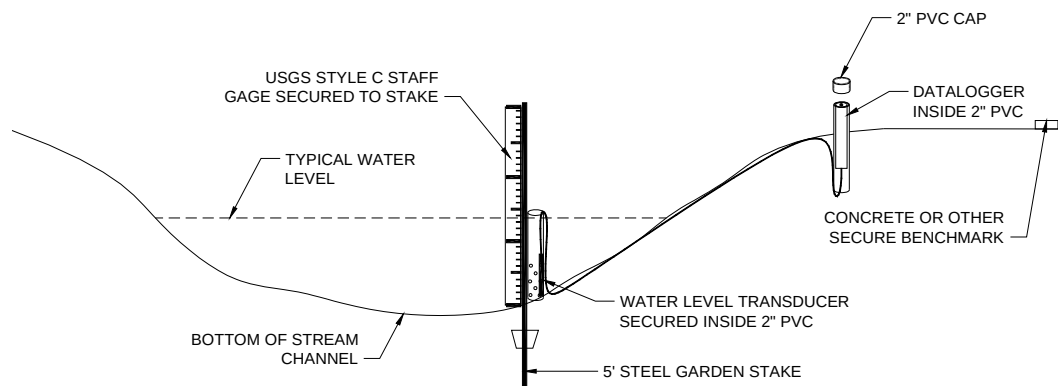


Figure 2-6. Typical Data Logger Installation

Stage-Discharge Curves

Since the data loggers only provide water elevations, stage-discharge curves were developed for each of the nine locations to convert stream elevations into flows. This involved measuring stream cross-sections and flow velocities under multiple flow conditions to establish flows for various water levels in the stream. Nearly all monitoring locations are located at road crossings where defined cross-sections facilitate

streamflow measurements. Based on field observations, it was determined that tailwater effects at the monitoring locations would be insignificant.

The stream bottom cross-section was surveyed using a laser level. The stream bottom was divided into discrete segments and the elevation of each was recorded. A measuring guide was permanently installed at each site to identify where each of these depths were recorded. Each interval was marked for future reference to expedite streamflow measurements. As shown on Figure 2-7, each stream cross-section was divided into about 20 intervals for velocity measurements (Standard Operating Procedure, Flow Measurement, Division of Watershed Management, 2003), with intervals varying from about six inches to two feet depending on the stream width. In some locations, culvert dimensions were used to generate stage-discharge curves. The staff gage, water level, and benchmark were also surveyed. The datalogger water level was recorded during surveying which allowed staff gage readings and/or datalogger readings to be correlated to the geometry of the stream channel.

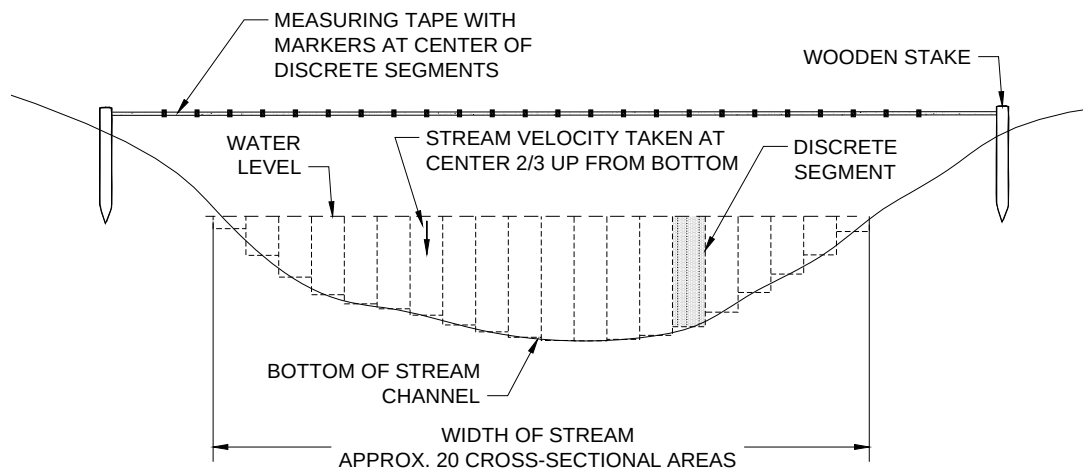


Figure 2-7. Stream Cross-Section Discretization

Stream velocities were measured at each location where the stream elevation was recorded, using a Marsh McBirney 2000 Flo-Mate electromagnetic velocity meter (Marsh-McBirney Incorporated, 1990). A propeller type flow meter could not be used because of the low velocities associated with many of these streams during low flow. The flow meter used has a range of -0.5 to $+19.99$ ft/sec, which is consistent with the observed stream velocities (Marsh-McBirney Incorporated, 1990). Velocities were recorded by standing downstream of the meter and holding it approximately $2/3$ up from the bottom of the stream. Once the velocity stabilized on the meter, the velocity was recorded. This was repeated at each interval at each site. Three to five stream velocity rounds were completed at each site during different stream levels.

The streamflows were determined in accordance with the Quality Assurance Project Plan (QAPP) developed for this project.³ Streamflows were calculated by summing the streamflows at each discrete segment across the stream profile. The width of each segment is defined as the cross-sectional area bound on each side of the vertical velocity measurement by a distance halfway to the preceding vertical and halfway to the following vertical. The stream channel was assumed to remain unchanged while the water level and velocities varied due to time. This was consistent with field observations. The depth of water at each segment and the width of each segment are used to determine the flow area in each section.

The data described above was then used to develop stage-discharge curves so that stream elevations could be converted into flows. A unique curve was developed for each site to correlate stream levels recorded by the data logger to measured streamflows (Appendix B). Using Microsoft Excel 2002, the equation of a best-fit line was obtained for each site. The remaining water levels recorded at each site were then input into this equation to develop a continuous streamflow database (Appendix C). These flows were input into the model where they could be compared directly to modeled results.

2.1.3 Flow Calibration/Validation

Calibration Method

Data loggers were used to record stream elevations and enable estimation of flows at the nine tributary locations between September 29, 2005 and May 4, 2006. This was used to calibrate modeled tributary flow data. The continuous observed flow data for each location was input into the model, allowing for direct comparison of modeled flow to observed flow.

The percent of impervious area directly connected to the drainage system and the groundwater interaction equation parameters, specifically the groundwater flow coefficient and exponent, were the key flow calibration parameters within the model. These parameters had the greatest influence on the peaking of stormwater runoff and the shape of the streamflow curve, to obtain the best match with calibrated flows. Variation of other parameters was determined to have less influence on the model results. To simplify the calibration process, it was assumed that the aquifers are homogeneous throughout each subwatershed; therefore, these parameters were adjusted uniformly to calibrate the model to the measured streamflows. Stream flow lengths were also adjusted where there were extensive wetlands. This adjustment was made to replicate the attenuation provided by the wetlands.

³ Comprehensive Environmental Inc. (January 2006). *Pennichuck Watershed Restoration Project: Water Quality Assessment Quality Assurance Project Plan*. (Report) Merrimack, NH: Comprehensive Environmental Inc.
Pennichuck Brook Watershed Restoration Plan
Final Report: November 2012



Calibration Results

The correlation coefficient represents how well the observed data fits the calibrated data. A value of zero indicates there is no correlation between the data while a value of one represents a perfect correlation between the data. Modeled flows were successfully calibrated to observed flows with a correlation coefficient of 0.86. The results of the calibration for each location are shown graphically in Appendix D.

In the more rural areas, the measured stream flows showed a delay in peak flow of nearly two days from the precipitation event, indicating significant infiltration and contribution by groundwater flow. Some of the more urban areas, such as monitoring station T-1, do not show significant contributions from baseflow, likely due to the large impervious areas in these urban watersheds.

Flow calibration was achieved more easily in the upper watershed, especially for single tributaries. However, as tributaries began to merge and enter large wetland areas, the flows were more difficult to calibrate. This was especially true in the wetlands area that lies over the extensive Silver Lake Fault Zone and the Witches Spring Brook. Figure 2-5 shows tributary monitoring locations and the large expanse of wetlands at the confluence of Pennichuck Brook and Witches Spring Brook. Beginning at monitoring locations T-3 and T-2, the modeled flows were estimated to be significantly higher than the observed flows. This is likely due to the large expanse of wetlands. In reality, these extensive wetlands attenuate flows and result in a slower release than the modeled tributary. The creation of a pond or adjustment of stream flow lengths is required in the model to account for this attenuation. The tributaries feeding location T-3 were lengthened to represent a longer flow path with greater flow attenuation. This allowed for a closer correlation with data measured.

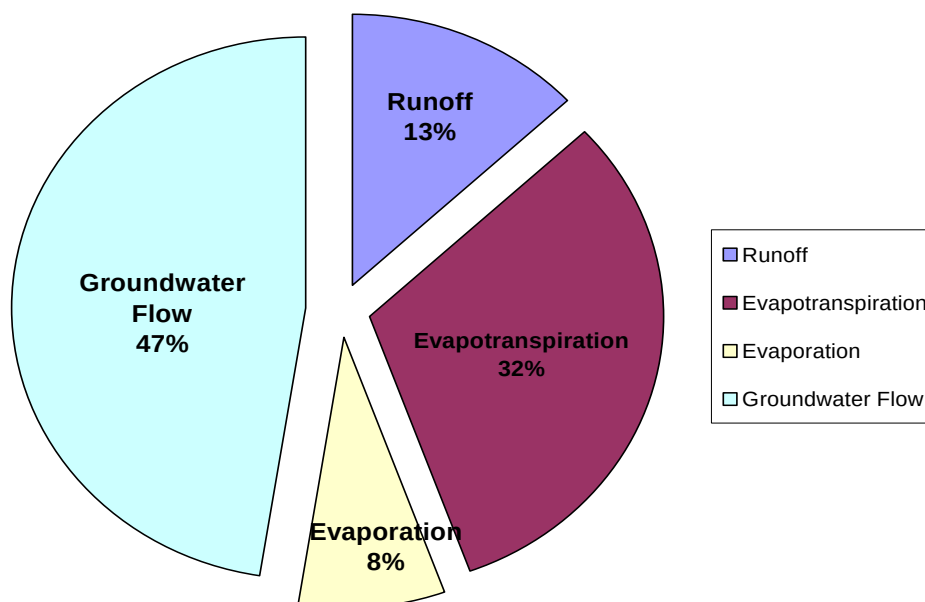
The model also provides estimates of the amount of evapotranspiration; the amount that evaporates from surface depressions and surfaces; the amount that infiltrates through the soils becoming groundwater flow; and the amount that becomes surface runoff. Evaporation is calculated based on a depth of depression in the land surface for water storage, which is entered by the modeler. Evapotranspiration is calculated as a percent of the unsaturated zone that is available for evapotranspiration. This value was adjusted until the combined evapotranspiration and evaporation figures for the entire watershed were 40% of the precipitation budget, which is typical for the Northeast.⁴ Values for individual subwatersheds will vary based on the land cover/infiltration calculations and ponding storage capacity. The adjustment of evapotranspiration is balanced with the groundwater flow. For example, if evapotranspiration is increased,

⁴ Hanson, R.L., 1991, Evapotranspiration and Droughts, in Paulson, R.W., Chase, E.B., Roberts, R.S., and Moody, D.W., Compilers, National Water Summary 1988-89--Hydrologic Events and Floods and Droughts: U.S. Geological Survey Water-Supply Paper 2375, p. 99-104.



groundwater flow is decreased by the same volume. Figure 2-8 on the next page shows the breakdown of the average annual water budget. This budget was used to estimate pollutant loads from runoff and groundwater baseflow. Average annual water budgets by subwatershed are included in Table 2-5.

Figure 2-8. Pennichuck Brook Watershed Average Annual Water Budget



2.2 Water Quality Assessment

Two pollutants, total phosphorus (TP) and total suspended solids (TSS) were modeled within the Pennichuck watershed using the SWMM buildup and washoff functions. Total phosphorus was selected as a key pollutant since the impairment in Harris Pond is ‘excess algal growth’, which is a function of excess nutrient loadings to the ponds. Since phosphorus is the limiting nutrient for algal growth in fresh water systems, often leading to eutrophication and algal blooms, it was selected as the primary pollutant of concern and the basis for setting and implementing water quality goals.

Table 2-5. Water Budget by Subwatershed				
Subwatershed	Runoff	Evapotranspiration	Evaporation	Groundwater Flow
3	33%	17%	10%	41%
4	52%	9%	12%	27%
5	14%	79%	7%	0%
6	26%	17%	10%	47%
7	32%	55%	13%	0%
8	26%	18%	10%	46%
9	26%	18%	10%	46%
10	8%	35%	7%	50%
11	8%	36%	7%	48%
12	5%	40%	6%	49%
13	1%	40%	6%	52%
14	2%	60%	7%	31%
15	1%	32%	6%	60%
16	4%	25%	8%	62%
17	17%	23%	8%	52%
18	21%	21%	9%	49%
19	4%	26%	7%	63%
20	14%	21%	9%	55%
21	6%	19%	10%	65%
22	1%	39%	6%	53%
23	1%	38%	7%	54%
24	2%	34%	7%	57%

The Reckhow and Vollenweider in-pond models were used to approximate modeled in-pond phosphorus concentrations for comparison to observed in-pond concentrations. The models represent an average in-pond concentration that accounts for nutrient cycling within the ponds. The model and in-pond concentration was used to aide in calibrating the TP loads in runoff. Sediment could not be calibrated against observed sediment levels since there was little TSS data available for the watershed. Additionally, SWMM calculates pollutant loads associated with stormwater runoff and there are likely other more significant sources of sediment loadings to the ponds, such as stream bank erosion from large precipitation events and high sediment loadings from construction sites. As a result, the restoration plan focuses on a phosphorus water quality goal, with recommendations that will also help address sediment loadings.

2.2.1 Input Data and Assumptions

Pollutant Loadings

In addition to the input data necessary to model stream flows within the watershed, input on pollutant loading factors was also required. SWMM models pollutants associated with groundwater baseflow and stormwater runoff.

Existing dry weather streamflow data was used to approximate a groundwater baseflow concentration. Based on sampling data available for various locations from July 2004 to August 2006, an average dry weather tributary phosphorus concentration of about 20 ug/l (micrograms per liter) was estimated. For modeling purposes, this was assumed to represent groundwater baseflow and a uniform concentration was applied to all aquifers. However, no groundwater samples were available within the watershed to confirm this assumption.

The dry weather tributary data implies a widespread relatively high groundwater concentration of phosphorus in comparison to what is typical, however, the actual groundwater concentration is unknown as is its' source. Data was found in NHDES's OneStop database for several wells in Milford, NH, outside of the watershed boundaries. The data revealed phosphorus concentrations ranging from 0.001 to 0.351 mg/l with an average of 0.0124 mg/l, indicating that groundwater concentrations could be high in the area. Some possibilities include 1) naturally high levels of phosphorus in the soils in the watershed; 2) gravelly soils that allow high phosphorus stormwater and wastewater to enter groundwater without the typical attenuation of finer soils; and/or 3) some large but yet unknown point source. Further study is recommended to confirm groundwater concentrations and evaluate the source of this phosphorus to determine how it may be addressed.

SWMM offers three options for estimating pollutant loadings associated with stormwater runoff. One is the direct entry of event mean concentrations (EMCs), which can be obtained from literature for various land uses and represent the average concentration of the pollutant in stormwater runoff. The other two methods incorporate pollutant buildup functions, which account for the time between storm events, with pollution accumulating on surfaces during this time. These can be entered as a function of land use (e.g., lb/acre/day) or as a function of curb length (e.g., lb/curb mile/day). A combined land use based with buildup function was used. The power buildup function assumes that the incremental increase in buildup will decrease as the amount of pollutant on the surface increases. An exponential washoff function was assumed to represent the pollutant washoff.

The advantages of the pollutant buildup and washoff functions are that they allow for evaluation of pollutant concentrations through the duration of a storm event and account for actual buildup of pollutants between



storm events rather than just assuming that every precipitation event results in the same concentration of pollutants in the stormwater runoff. This is useful for evaluating the effects of street sweeping at different frequencies. Buildup and washoff functions also allow for evaluation of pollutant concentrations in stormwater throughout the duration of a storm. Table 2-6 shows the initial phosphorus and TSS buildup parameters used in the SWMM model by land use.

Bathymetric Data

Bathymetric data was obtained from a sediment study of the ponds conducted by CEI in 2000⁵. This information is needed to determine the mean depth and water storage capacity of each pond, which is in turn used to determine the in-pond phosphorus concentrations resulting from the estimated phosphorus loadings.

The reservoirs were modeled using their respective surface area and an average depth based on storage capacity.

Table 2-6. Initial Phosphorus and TSS Buildup Parameters Used in SWMM

Land use	Initial Buildup (lb/acre/day)	Source
TP		
Commercial	0.00690	Northern Virginia (Kuo, 1988)
Forest	0.00055	Reckhow
High Density Residential	0.00830	Northern Virginia (Kuo, 1988)
Industrial	0.00580	Northern Virginia (Kuo, 1988)
Low Density Res.	0.00120	Northern Virginia (Kuo, 1988)
Open Space	0.00160	Reckhow Avg. of Ag/Forest
Road	0.03450	Factor * Commercial
Water	0.00000	None (associated with rainfall only)
TSS		
Commercial	2.19	Northern Virginia (Kuo, 1988)
Forest	0.17	Ratio from Com/Forest Above
High Density Res.	3.53	Northern Virginia (Kuo, 1988)
Industrial	1.60	Northern Virginia (Kuo, 1988)
Low Density Res.	1.32	Northern Virginia (Kuo, 1988)
Open Space	0.49	Ratio from Com/Forest Above
Road	10.95	Factor * Commercial
Water	0.00	None (associated with rainfall only)

Very few models are available to estimate in-pond phosphorus concentrations. The most common model, the Reckhow steady-state lake model was used to estimate in-pond concentrations. The most important component of this model is the “apparent settling velocity” of phosphorus within the pond. In actuality, this represents the net effect of phosphorus

⁵ Comprehensive Environmental Incorporated. Sediment Study of Pennichuck Ponds Pennichuck Water Works July 2000.



deposition and resuspension from the bottom surface. To use this model, it is essential that the simulated water body is representative of the basis of the model (Reckhow, 1983), as shown on Table 2-7. This table shows the minimum and maximum data set levels that fit the model, along with the levels of each pond. Holts Pond exceeded the ranges of this model, as it experiences a very large hydraulic loading compared to its overall size, so the generic Vollenweider lake model was used to simulate this pond. This model is more representative because it uses a lower “apparent settling velocity” for phosphorus than the Reckhow model. However, the Reckhow model was used for Bowers and Harris Ponds.

Table 2-7. Reckhow Model Limitations (Reckhow 1979d)				
	Reckhow Acceptable Range	Holts Pond	Bowers Pond	Harris Pond
Phosphorus Concentration – P (ug/l)	4 – 135	47	43	40
Annual Area Phosphorus Loading – L (g/m2-yr)	0.07 – 31.4	19	7	8
Areal Water Loading – qs (m/yr)	0.75 – 187	388	116	146

2.2.2 Monitoring Data

A wide range of samples have been collected in the Pennichuck water supply watershed between 1996 and the present. Data has been collected by the Nashua Regional Planning Commission (NRPC), consultants working for Pennichuck Water Works and by Pennichuck Water Works directly. The focus has been on the tributaries feeding the water supply ponds and on the ponds themselves.

This data has been compiled in a searchable format for use by Pennichuck Water Works and for incorporation by DES into their state database of water quality data. Nearly all of the available data is associated with dry weather sampling events, with a few wet weather-sampling events specifically targeting the performance of stormwater practices within the watershed.

Water quality data collected between November 1995 and October 2006 was used to calibrate the model, representing average pollutant concentrations during the flow period of record (2005 and 2006) and setting the benchmark against which to compare subsequent water quality changes associated with implementation of Watershed Plan recommendations.

Dry-Weather Tributary Sampling

As previously discussed, the data collected from the tributary dry weather sampling events was used to estimate a groundwater baseflow phosphorus contribution. The data also included results from other



nutrient sampling, such as TKN, nitrate-nitrogen and ammonia nitrogen. This data was evaluated to determine whether septic systems may be contributors to the elevated phosphorus concentrations observed in the tributaries. The data revealed non-detect levels of nitrate-nitrogen in all dry weather events at a detection limit of 0.5 to 1.0 mg/l, suggesting that septic systems may not be a major pollutant load since nitrogen is typically quite high from septic systems. However, additional data will be needed in the future to confirm this and to identify source(s) of excess phosphorus in 'baseflow'.

Stormwater Practice Sampling Data

A variety of both common and more innovative stormwater practices in the watershed were sampled under wet weather conditions to assess their performance. Data from other sources was also collected, including:

- an infiltration system at the Department of Transportation Park and Ride Facility off of Somerset Parkway (Exist 8 of the FE Everett Turnpike) on North Southwood Drive;
- a swale located along Amherst Street (Route 101A) in the Somerset Plaza;
- a combination wet pond and constructed wetlands at the Nashua Technical Community College.

In addition, six other stormwater practices were sampled as a part of this study. These included:

- a swale at Conway Office Products in Nashua,
- a grass detention pond at Home Depot in Merrimack,
- Low Impact Development (LID) techniques at Pennichuck Square in Merrimack,
- a sediment forebay at Celina Avenue in Nashua,
- a detention pond with wetland plantings off White Oak Drive near Thornton Road in Nashua, and
- a dry detention basin that is grown in with natural vegetation off White Oak Drive near Tinker Road in Nashua.

The locations of the stormwater practices sampled are shown on Figure 2-9. The purpose of the sampling was to obtain information on the performance of various types of stormwater practices throughout the watershed, to establish whether and to what degree existing stormwater practices were contributing to water quality improvements, as well as obtain some information on loadings from various land use types in the watershed. The information was also used to determine whether there is a need or benefit associated with stormwater practice retrofits in the watershed.

Sampling results showed that most of the traditional practices like detention basins appear to achieve little phosphorus removal and in some cases contributed phosphorus. Most of these stormwater practices are designed for peak control, rather than for water quality treatment, unlike



the newer practices and Low Impact Development practices built by Pennichuck.

Results were highly variable for the two locations sampled by NRPC and the six locations sampled as a part of this study. Four of the six stormwater practices sampled under this study did not have outlet flows with 0.25 inches of precipitation or less, indicating that the smaller storms are typically fully infiltrated due to the high permeability of the soils. The largest stormwater practice in the watershed collects stormwater runoff from the streets, residential neighborhoods and parking lots of roughly 60 businesses located in the approximate 79 acre drainage area. The BMP, which was designed by Pennichuck Water Works Company, incorporates sediment forebays, oil/water separators, wetlands and wet pond treatment and is located on the NH Technical College property. This practice achieved relatively good removal of TSS and phosphorus. Other up-to-date designs such as the LID practices at Pennichuck Square also did quite well at removing all pollutants. A summary of the sampling results is included in Appendix E.

The results of the sampling helped verify that the traditional stormwater practices do not appear to be providing much if any water quality protection. This emphasizes the need to either provide additional stormwater practices or retrofit the existing stormwater practices to obtain some pollutant removal from existing practices such as detention basins.

In-Pond Sampling

Some in-pond data was available, dating as far back as 1996. This data was the most useful for calibrating pollutant loadings calculated in the model as it allowed for a direct comparison of modeled phosphorus concentrations to observed phosphorus concentrations.

The ponds are typically sampled under stratified conditions, with samples collected from the top and bottom water layers of the pond. As expected, the bottom layer has a much higher phosphorus concentration than the top, since low oxygen levels allow for the release of phosphorus from bottom sediments back into the water column. However, this only occurs for a portion of the year. As a result, a representative time-weighted average in-pond concentration was calculated by averaging the top and bottom samples, assuming that the bottom samples only contributed to the in-pond concentration 3 months out of the year and the top samples contributed all 12 months of the year. The average in-pond concentrations for each sampling date, using the method just described is provided in Table 2-8.



Table 2-8. Observed In-Pond Phosphorus Concentrations (ug/l)

Date	Holts Pond	Bowers Pond				Harris Pond	
		08-PEN	07P-PEN	07F-PEN	07-PEN	06-	04-PEN
10/11/2006		26	31	16		16	13
8/8/2006	40						
7/25/2006	40						
6/27/2006	5						
5/9/06-		44	216	28		144	33
9/8/2005		36	47	29		13	13
8/4/2005		15	13	36		22	25
6/23/2005		37	23	28		51	28
8/26/2004		16	15	5		39	73
6/30/2004		17	6	14		14	6
10/28/2003		39	17	35		45	39
7/23/2003		14	019	18		17	13
9/28/1999	110	15			168		158
9/14/1999	5	22			5		5
8/26/1999	14	5			5		5
8/28/1996	130	4,530*			290		120
7/17/1996	49	26			16		46
7/9/1996	210				10		60
6/26/1996	60				60		40
6/13/1996	90						50
5/30/1996	30				12		10
5/15/1996	40						16
5/1/1996	10				254		36
4/18/1996	25						20
11/15/1995	10				20		10
11/14/1995	10				10		20
Station	51	35	43	23	77	40	37
Pond	51	45				38	

* Ignored because value is an outlier that is unreasonably high

Notes: All Phosphorus Concentrations in ug/l

Where top and bottom samples were available, used weighted average for sampling date ($3 \times \text{bottom} + 12 \times \text{top} / 15$). Middle samples were not used.

Where sample was non-detect, 5 ug/l was used.



2.2.3 Pollutant Calibration/Validation

The model was calibrated to the 10-year analysis period from January 1, 1996 through December 31, 2005. The average pollutant loadings, runoff rates, and baseflow from SWMM through this duration were input into the in-pond models. Calibration involved adjusting the pollutant loading factors until estimated in-pond concentrations matched the observed in-pond concentrations with minimal error.

SWMM allows for estimation of pollutant loadings based on either an event mean concentration or a buildup function. The event mean concentration method assumes one stormwater concentration for all storms throughout the duration of the storm. The buildup function represents pollutant buildup on the land surface between precipitation events with a higher initial buildup which levels off to an insignificant buildup rate. The advantage to the buildup function is that it allows for evaluation of pollutant loadings associated with a particular storm event. This would allow for direct comparison to sampled pollutant levels for more detailed calibration. Although this project focused on annual pollutant loadings rather than individual storm events, the buildup function was used to allow more detailed analysis under future modeling efforts if desired.

The initial pollutant buildup coefficients were based on daily accumulation rates since typical values for use in SWMM were not available. These were then adjusted upward to account for the buildup function (e.g., higher initial pollutant buildup). All of the buildup values were adjusted by the same percentage initially, with some additional adjustment, made to specific land uses to achieve good calibration to in-pond concentrations. Since the adjustments primarily focused on normalizing the data set to account for the buildup function, the TSS data set was scaled up by the same percentages. It was assumed that the groundwater baseflow concentrations remained at 20 ug/l throughout the analysis, with adjustments only provided for phosphorus buildup on land surfaces. A comparison of the initial buildup values with the final buildup values to achieve calibration is provided in Table 2-9.



Table 2-9. Phosphorus and TSS Calibrated Buildup Parameters Used in SWMM		
Land use	Initial Buildup (lb/acre/day)	Calibrated Buildup (lb/acre/day)
Total Phosphorus		
Commercial	0.00690	0.0121
Forest	0.00055	0.0010
High Density Residential	0.00830	0.0111
Industrial	0.00580	0.0102
Low Density Res.	0.00120	0.0021
Open Space	0.00160	0.0027
Road	0.03450	0.0604
Water	0.00000	0.0000
Total Suspended Solids		
Commercial	2.19	3.83
Forest	0.17	0.31
High Density Res.	3.53	3.32
Industrial	1.60	2.80
Low Density Res.	1.32	2.31
Open Space	0.49	0.86
Road	10.95	19.16
Water	0.00	0.00

The modeled in-pond concentrations (Appendix F) using the calibrated values above are compared to observed in-pond concentrations in Table 2-10. Water quality goals will focus on Harris Pond, since this is the primary withdrawal point for the water supply system. Note that these calibration runs are based on the larger watersheds contributing to each of the ponds, with calibrated values then applied to estimate loadings for the smaller subwatersheds.

Table 2-10. Calibrated Modeled In-Pond Phosphorus Concentrations vs. Observed In-Pond Phosphorus Concentrations (ug/l)			
	Pond/Reservoir		
	Holts	Bowers	Harris
Calibrated Modeled Concentration	47	43	40
Average Observed Concentration	51	45	38



2.2.4 Pollutant Loadings

Based on the calibrated modeling runs, the phosphorus loadings by subwatershed were estimated. These are presented in Table 2-11 and shown graphically in Figure 2-10.

Table 2-11. Annual Phosphorus Loadings by Subwatershed				
Subwatershed	Existing TP Loading (lbs/year)	Additional TP Load at Buildout (lbs/year)	Total TP Loading (lbs/year)	Tributary to:
Sub 3	642	83	725	Harris Pond
Sub 4	304	18	322	Bowers Pond
Sub 5	10	7	17	Harris Pond
Sub 6	874	81	954	Bowers Pond
Sub 7	433	77	510	Harris Pond
Sub 8	650	59	710	Holts Pond
Sub 9	617	22	639	Holts Pond
Sub 10	71	4	75	Holts Pond
Sub 11	87	8	95	Pennichuck Pond
Sub 12	60	14	74	Pennichuck Pond
Sub 13	27	5	33	Pennichuck Pond
Sub 14	27	2	29	Pennichuck Pond
Sub 15	0	0	0	Holts Pond
Sub 16	2	0	2	Holts Pond
Sub 17	558	24	582	Stump Pond
Sub 18	470	57	526	Holts Pond
Sub 19	20	0	21	Holts Pond
Sub 20	215	12	227	Holts Pond
Sub 21	14	0	14	Holts Pond
Sub 22	23	7	29	Holts Pond
Sub 23	28	8	36	Holts Pond
Sub 24	16	9	25	Holts Pond
Total	5,149	497	5,646	

Phosphorus loadings were also estimated by town to provide a basis for recommendations and to identify responsibility for each action.

Phosphorus loadings by town are included in Table 2-12. Phosphorus loadings by land use are included in Table 2-13.

Table 2-12. Annual Phosphorus Loadings by Source	
Town	Existing TP Loading (lbs/year)
Phosphorus from Stormwater	
Amherst	776
Hollis	345
Merrimack	1988
Milford	53
Nashua	1987
Subtotal Stormwater Contribution	5,149
Phosphorus from Other Sources	
Groundwater	1,523
Merrimack River	288
Subtotal Other Sources	1,812
Total	6,960
Harris In-Pond TP Conc. (ug/l)	40

Table 2-13. Total Phosphorus Loadings by Land Use (lbs/year)	
Land Use	Existing TP Loading
Commercial	1,085
HD Residential	373
Industrial	968
LD Residential	422
Roads	2,107
Forest	27
Open Space	4
Water	163
Total	5,149

2.3 Buildout

A gross buildout evaluation was also performed to determine potential pollutant loadings and in-pond concentrations at buildout. This allows for characterizing potential development impacts, and for planning to prevent or mitigate for loadings associated with new development.

The Region-Wide Buildout Impact Analysis performed by the Nashua Regional Planning Commission in October 2005⁶ was used to evaluate buildout conditions in the Pennichuck Watershed. The NRPC buildout evaluation assumes that all water, wetlands, riparian buffers, 100-year flood plains and slopes greater than 25% are not buildable.

An electronic GIS layer of developable land in the region was obtained from NRPC and used in the Pennichuck watershed analysis. The developable areas were color-coded based on the zoning and type of development that would occur on these lands. This data layer was

⁶ Nashua Regional Planning Commission. (October 2004). Region-Wide Buildout Impact Analysis.



cropped to fit within the Pennichuck watershed and used to determine what a buildout condition would look like in the watershed. Figure 2-11 shows the additional developable land in the watershed. Figure 2-12 shows the total watershed land uses at buildout.

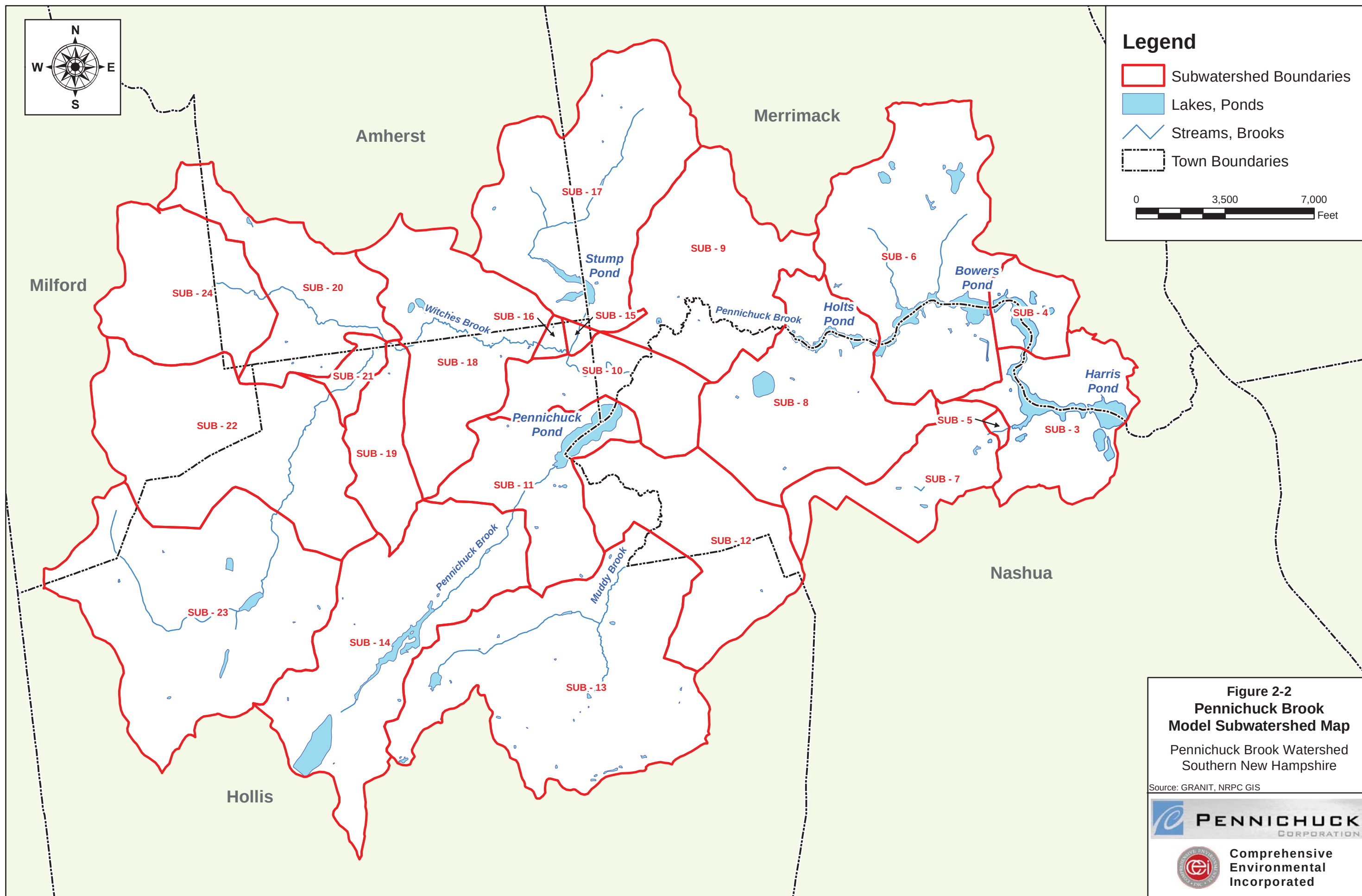
Land uses at buildout for each Town are provided in Table 2-14. Based on the buildout analysis, the additional phosphorus loadings associated with buildout are shown in Table 2-15 by Town and in Table 2-16 by land use.

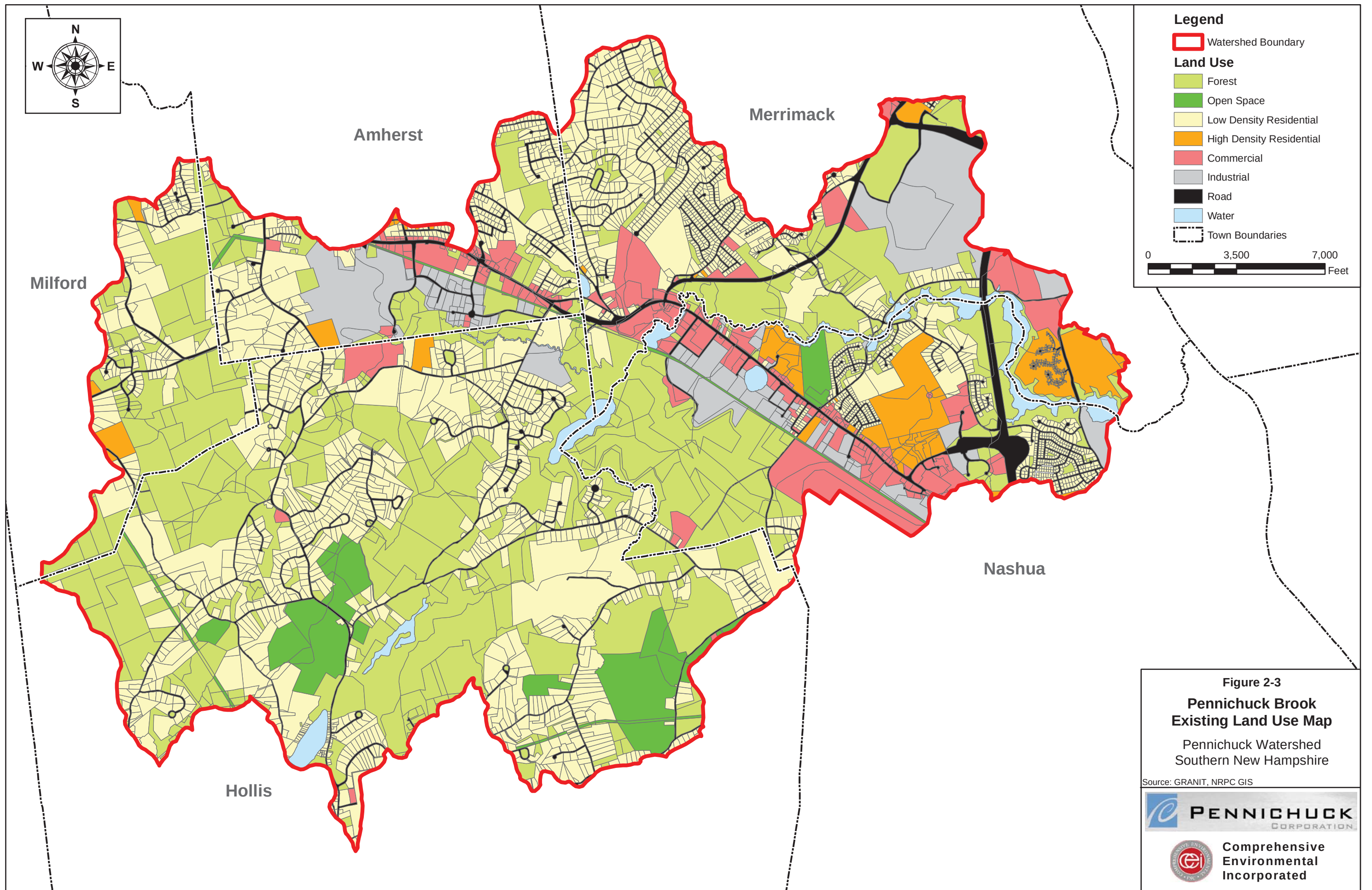
Table 2-14. Land Use at Buildout (acres)									
Town	Commercial	Forest	HD Res	Industrial	LD Res	Open Space	Road	Water	Total
Amherst	178	197	29	393	880	23	118	0	1,800
Hollis	69	2615	23	47	4053	474	230	107	7,600
Merrimack	353	391	208	469	1575	0	254	100	3,400
Milford	0	296	74	0	919	0	40	0	1,300
Nashua	521	845	388	349	568	83	236	172	3,200
Total	1,120	4,345	722	1,258	7,995	580	877	379	17,300

Table 2-15. Total Phosphorus Loadings by Source at Buildout				
Town	Existing TP Loading	Additional TP Loading at Buildout	Total TP Loading at Buildout	Percent of TP Budget
Phosphorus from Stormwater				
Amherst	776	84	861	11%
Hollis	345	29	374	5%
Merrimack	1,988	164	2,151	29%
Milford	53	16	69	1%
Nashua	1,987	205	2,192	29%
Subtotal Stormwater Contribution	5,149	497	5,646	75%
Phosphorus from Other Sources				
Groundwater	1,524	(1)	1,523	20%
Merrimack River	288	---	335	4%
Subtotal Other Sources	1,812	(1)	1,858	25%
Total	6,961	496	7,504	100%
Harris In-Pond TP Conc. (ug/l)	40		43	

Table 2-16. Total Phosphorus Loadings by Land Use (lbs/year)			
Land Use	Existing TP Loading	Additional TP Loading at Buildout	Total TP Loading at Buildout
Commercial	1,085	143	1,228
HD Residential	373	57	430
Industrial	968	96	1,064
LD Residential	422	131	553
Roads	2,107	74	2,182
Forest	27	(9)	19
Open Space	4	0	4
Water	163	6	168
Total	5,149	497	5,646







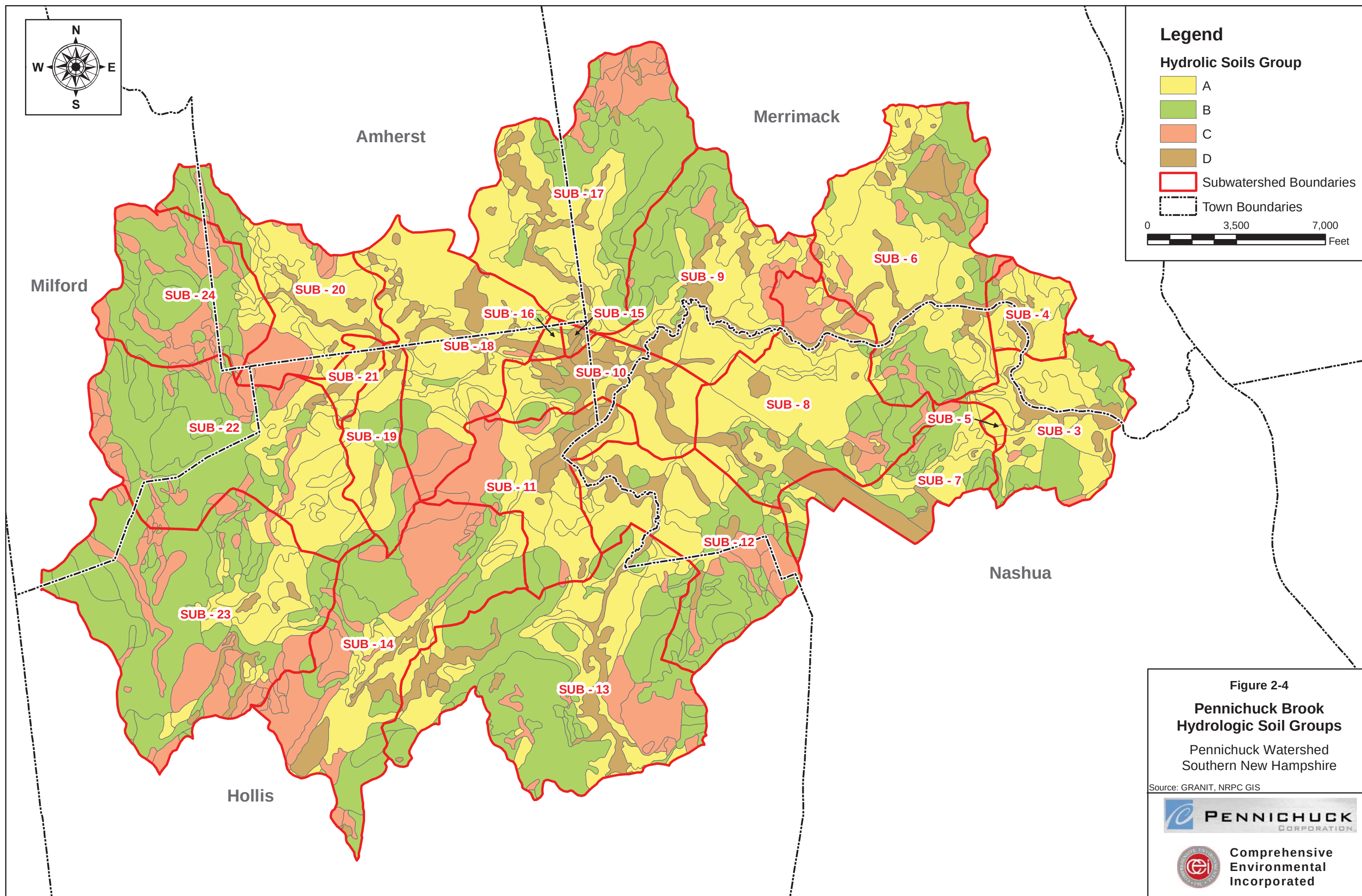
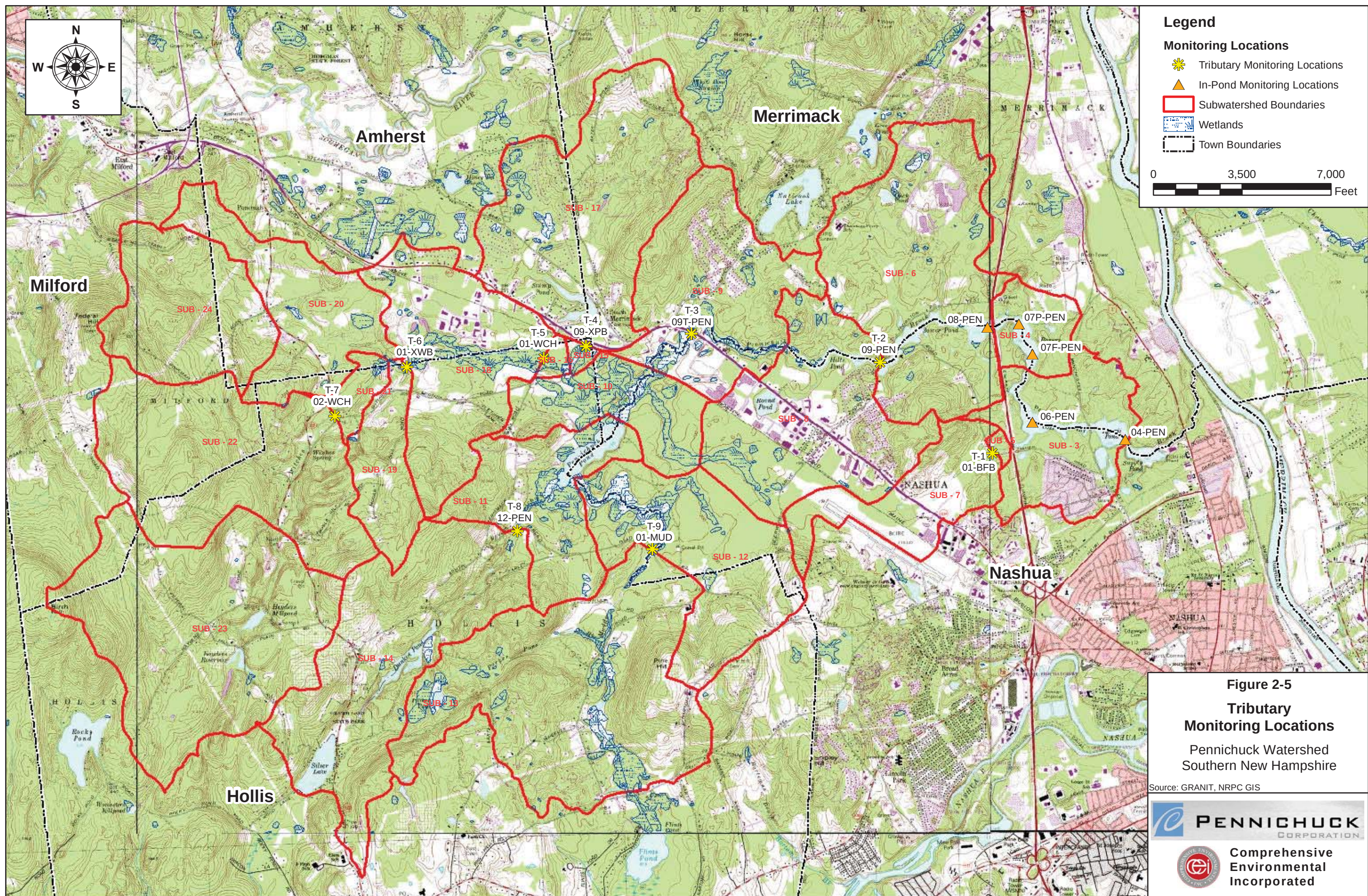


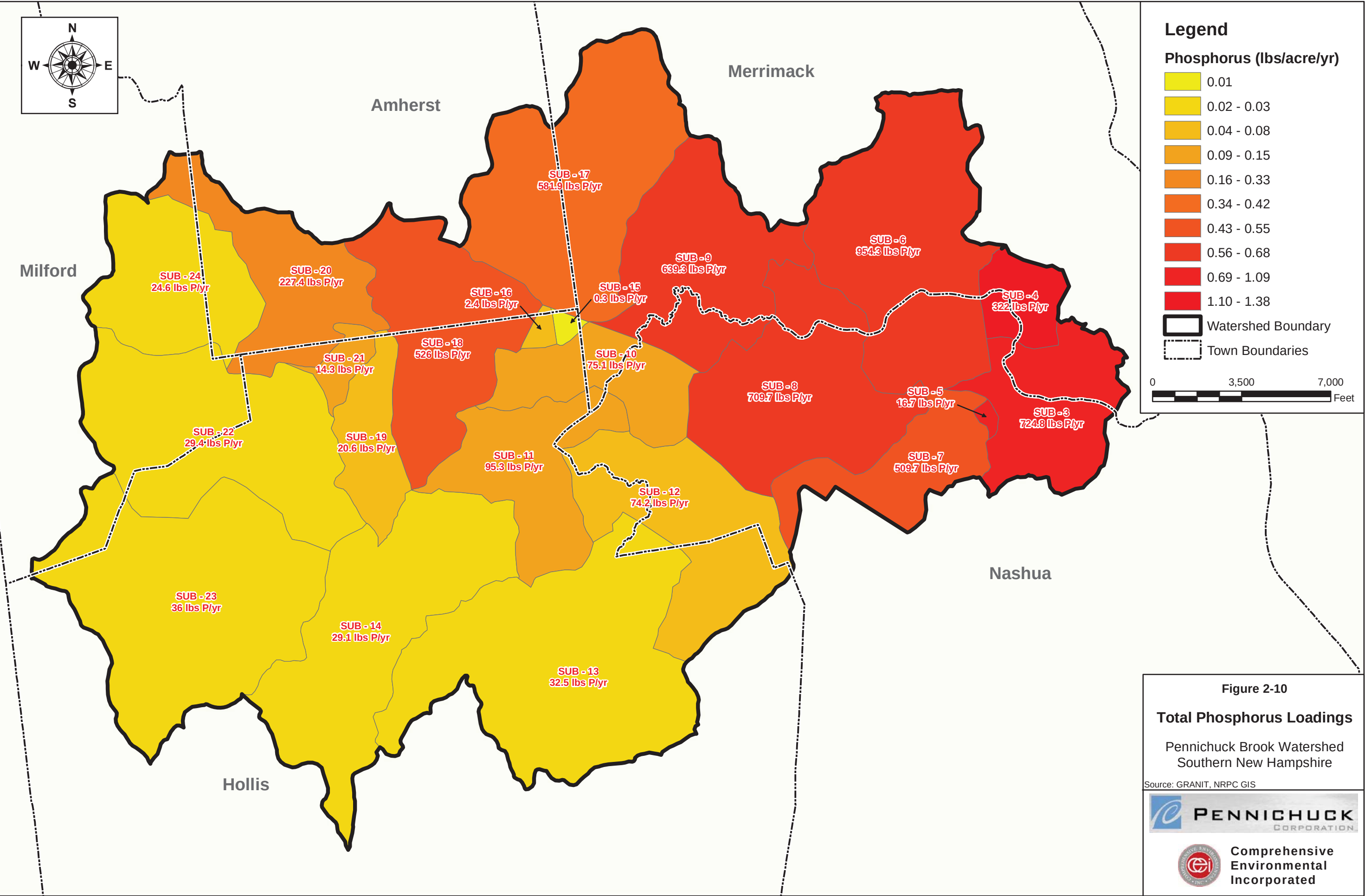
Figure 2-4
**Pennichuck Brook
Hydrologic Soil Groups**
Pennichuck Watershed
Southern New Hampshire
Source: GRANIT, NRPC GIS

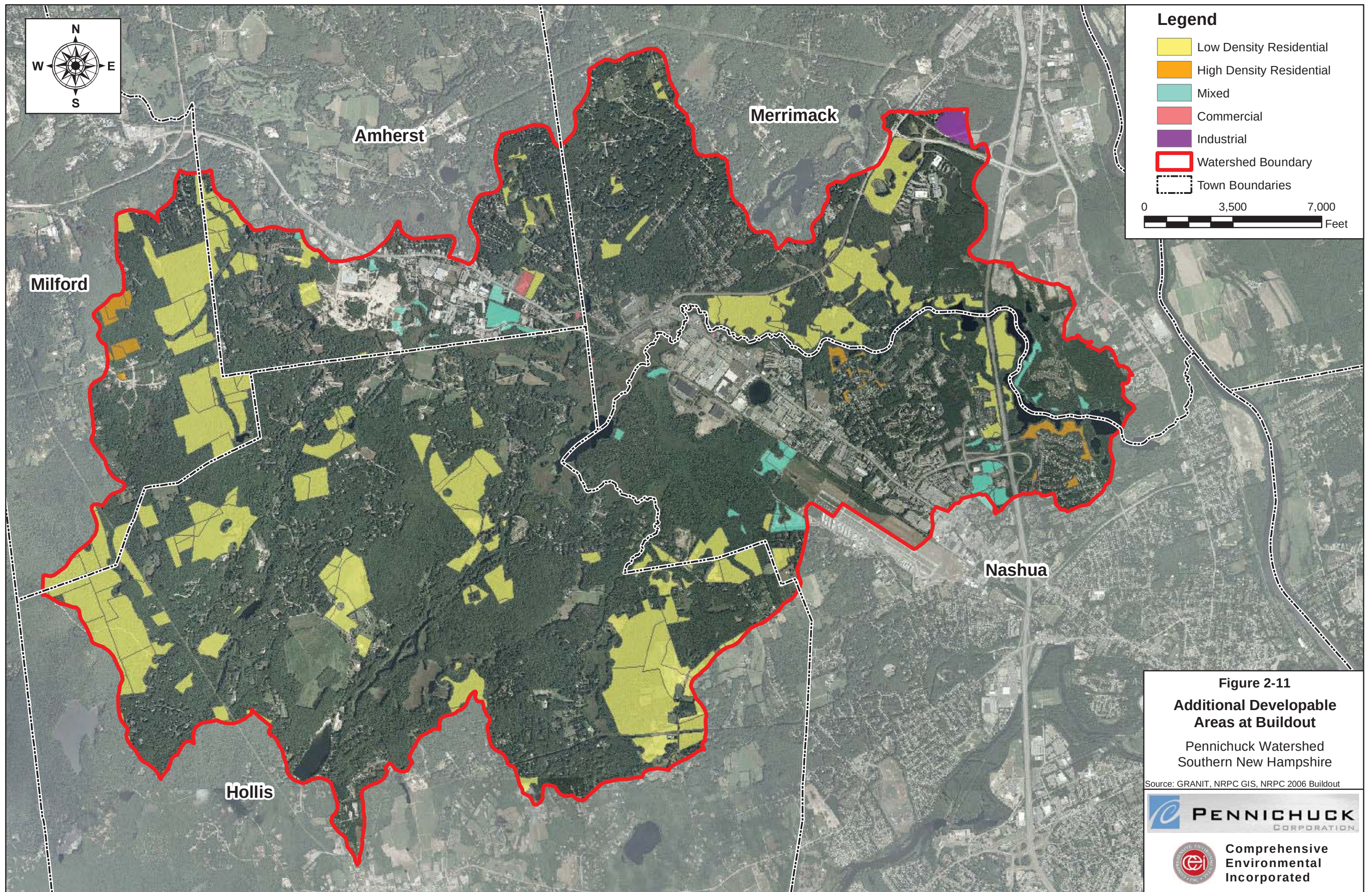

PENNICHUCK
CORPORATION

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Environmental
Incorporated**









Legend

- Low Density Residential
- High Density Residential
- Mixed
- Commercial
- Industrial
- Watershed Boundary
- Town Boundaries

0 3,500 7,000 Feet

Figure 2-11
Additional Developable Areas at Buildout
Pennichuck Watershed
Southern New Hampshire
Source: GRANIT, NRPC GIS, NRPC 2006 Buildout

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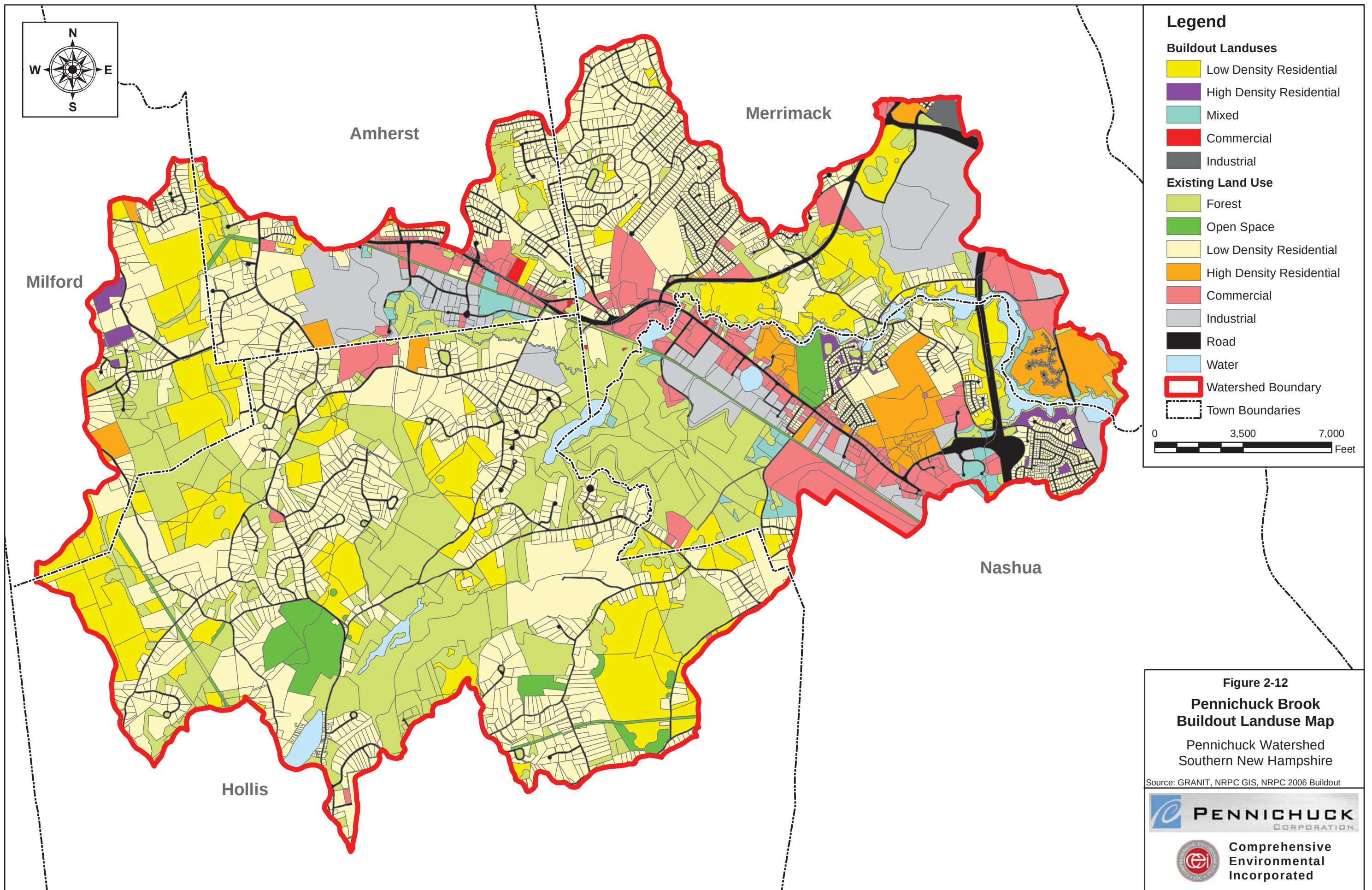


Figure 2-12
Pennichuck Brook
Buildout Landuse Map
Pennichuck Watershed
Southern New Hampshire

Source: GRANIT, NRPC GIS, NRPC 2006 Buildout

3.0 Numeric & Other Targets

This Section of the Watershed Restoration Plan discusses water quality goals for the watershed. Objectives to be achieved by water quality management actions include identifying the critical location where measurement of progress will be conducted, selecting the water quality parameter(s) to serve as indicators of overall water quality, and defining the desired water quality criteria that those water quality parameters should meet.

The purpose of setting numeric targets or goals for water quality is to use achievable, measurable benchmarks to promote the desired outcomes over time. As noted in Section 1, there are several steps to developing effective water quality goals and implementing management actions for their achievement. Section 2.0 discussed the monitoring and modeling effort for the initial step to estimate existing water quality and pollutant loadings. This Section describes the identification of the most critical measurement point, the appropriate water quality surrogates or indicators¹ and the desired water quality goals.

Section 4.0 compares the loadings to the goals. The alternative strategies to address loadings and a recommended overall strategy are considered in Sections 5.0 and 6.0.

3.1 Critical Measurement Point

For the Pennichuck Brook system, the Watershed Restoration Plan identifies Harris Pond as the critical analysis point for establishing and measuring water quality goals, because the drinking water supply intakes are located at this pond. Although water quality data has been collected throughout the watershed in connection with this project and others, it is important to identify one critical point where watershed efforts can be measured. Consistent monitoring at such a point allows a clear indication of how much progress has been made towards a water quality goal; although in reality reaching the goals may take years and can vary widely from year to year due to climatic and other factors.

3.2 Water Quality Surrogates & Indicators

Pollutant loadings from the watershed were estimated using the modeling protocol described in Section 2.0. As discussed in that section, phosphorus was chosen as the primary indicator of overall water quality because it is considered a limiting nutrient for plant life in fresh water systems. Excess phosphorus can cause excess algae blooms and die-off, which can lead to taste and odor problems in drinking water. In addition, the blooms, die-off, and resulting organic material deposition may cause

¹ A 'surrogate' or 'indicator' parameter is something that represents the general water quality of the stream/ponds and that can be reliably measured and tracked.



anaerobic conditions and filling in of ponds over time. Generally, phosphorus levels under 20-30² ug/l will not lead to eutrophication or algae blooms, although this tends to vary with different water bodies. While this range of concentration is often considered in setting water quality goals, as discussed below, other factors about the water bodies and the watershed setting need to be considered in establishing effective, achievable goals. In other words, what is achievable in some water bodies may not be realistic for others due to existing land uses, geologic or soil pre-conditions, or other factors.

Another frequently used indicator of water quality is total suspended solids (TSS). In a riverine system, TSS loadings typically represent erosion of the streambed or streambanks, with lesser loads associated with runoff from various land uses and roadways. Elevated levels of TSS could also be caused by uncontrolled construction sites. TSS was not used as a surrogate for this watershed because it is not readily calibrated with in-pond data, since particle size and settling play a large role in the resultant in-pond concentrations. However, some of the control strategies described in Sections 5.0 and 6.0 do address streambank and other erosion.

3.3 Desired Water Quality

Streams and rivers typically have phosphorus levels that depend on their urbanization level, and may range from 20 - 40 ug/l or even higher if there are wastewater discharges in proximity. Large lakes and ponds tend to have lower phosphorus levels since they have longer residence times and fewer point sources. Oligotrophic lakes, characterized by great depth, cold water and purity, may have levels as low as 5-10 ug/l, while small shallow ponds with a short residence time are typically on the higher side, with levels greater than 30 ug/l more typical. The highest levels occur in urban ponds. For example, Dorrs Pond in Manchester, a small urbanized pond, had average phosphorus levels ranging between 23 and 45 ug/l between 2000 and 2006.³

Based on the accumulated data (described in Section 2.0), the average phosphorus level in Harris Pond between 1995 and 2006 was 38 ug/l. The pond is shallow, about 20 feet deep with an average depth of 13 feet and a volume of 340 million gallons (MG). The residence time of only 10 days suggests it is more riverine than pond-like in character, in

² Vollenweider, R. A. 1975. Input-Output Models with Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-83.

³ City of Manchester, New Hampshire. *Biological and Water Quality Monitoring*. Retrieved October 3, 2007 from the World Wide Web: <http://www.manchesternh.gov/CityGov/DPW/EPD/SEPP/Pond/Quality.html>



comparison to a lake such as Sebago Lake (in Maine) where the residence time is about 5.1 years and total volume is 995 billion gallons.⁴

Harris Pond is not a deep, coldwater lake and the watershed is far from undeveloped as major highways and intense commercial development lie along the brook and throughout much of the 17,000+ acres of land. The brook and ponds are essentially a river run reservoir system characterized by rapid turnover rates and shallow conditions. Based on these characteristics and the water quality data available for the 2008 Watershed Restoration Plan model, it was anticipated that Harris Pond might realistically achieve 30+ ug/l, which represents a 21% decrease from the 2008 estimated average levels. Identifying this concentration as a goal is supported, in part, by observations that Pennichuck Brook appeared to have a rather high level of phosphorus in the groundwater baseflow that discharges into the stream.⁵

The study team used the modeling data to analyze whether a benefit would be realized if treatment removed 65% of phosphorus in stormwater runoff from all existing developments. The results indicated that in-pond concentration would decrease to roughly 25 ug/l. However, that level of retrofit was deemed to be unrealistic.

As a further check on whether the 30 ug/l goal is within a realistically achievable range, the study team noted data from a study⁶ of in-pond lake phosphorus concentrations. The study findings are summarized as shown on Figure 3-1, and suggest that regional in-lake total phosphorus concentrations are in the range of 30 to 50 µg/l.

Based on this information, this report recommends an in-pond water quality target for phosphorus concentrations of 30 ug/l. Although this target is in the higher end of the so-called eutrophication range based on the Vollenweider analysis, it is on the lower end of the regional concentrations range. Note that these numbers are not hard and fast but are instead general indications of the health of the water body. What is more important is that the watershed is gradually improving instead of worsening over time.

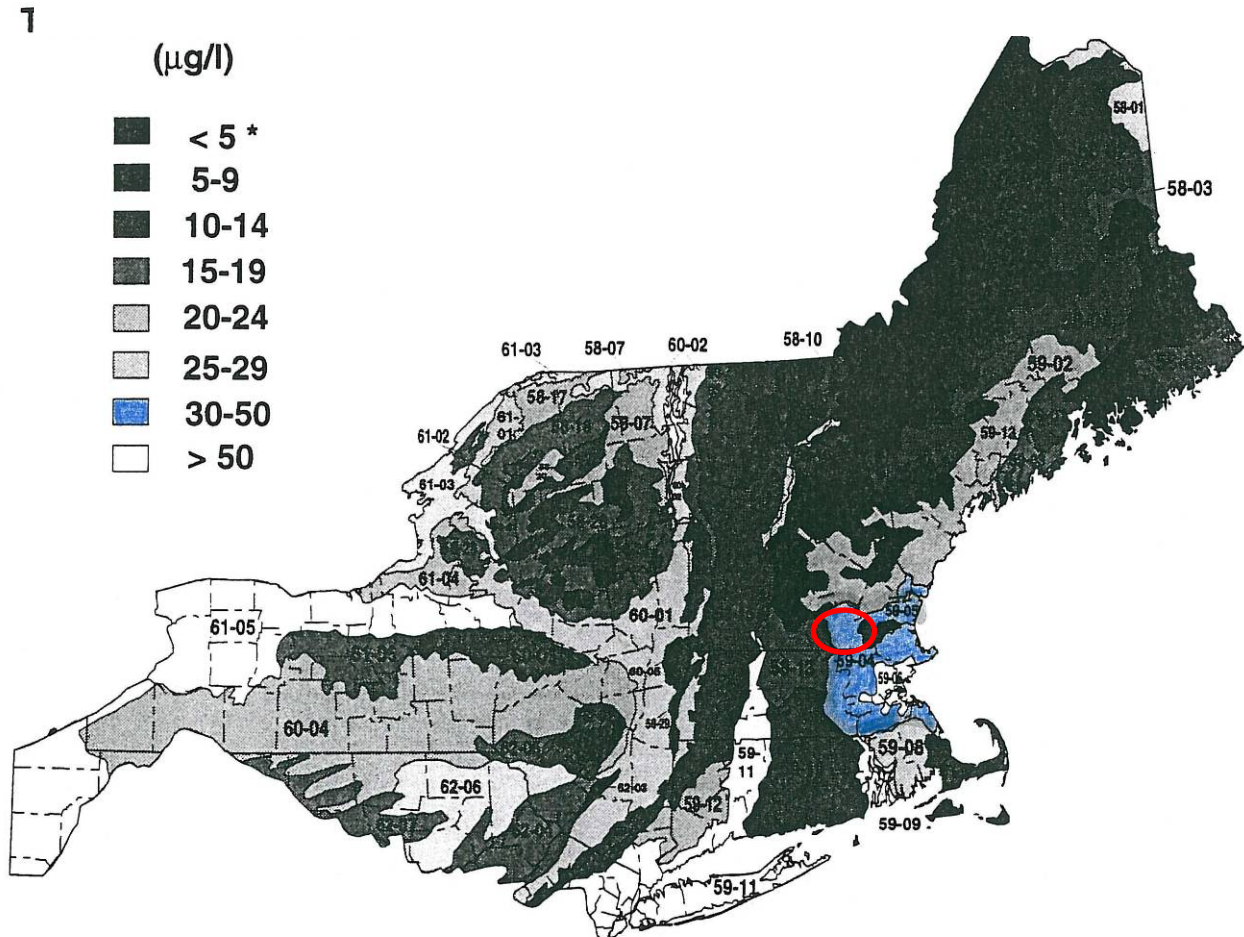
⁴ Portland Water District. *Sebago Lake Facts*. Retrieved October 3, 2007 from the World Wide Web: <http://www.pwd.org/environment/sebago/facts.php>

⁵ The levels in the stream baseflow, assumed to be from groundwater, were in the range of non-detect (detection limit of 10) to 55 ug/l. It is not known whether the source of this phosphorus is from human development, from soils/geologic conditions, or from some other source. Phosphorus is rarely sampled in groundwater, so without comparative data to suggest otherwise, it is also possible that the elevated concentrations are not so unusual.

⁶ Rohm, C. M., J. M. Omernik and C. W. Kiilsgaard. Regional Patterns of Total Phosphorus in Lakes of the Northeastern United States. *Lake and Reservoir Management* 11(1):1-14.



Figure 3-1. Regional Total Phosphorus Concentrations for Lakes in Northeastern United States¹



As discussed in Section 5, recent data collected between 2007 and the present shows a decreasing trend in phosphorus loads to the ponds and in in-pond phosphorus concentration. If continued monitoring shows that phosphorus levels have declined, then the water quality goal should be revisited. This can occur with the recommended model update after 10 years of water quality have been collected.

The study team also analyzed pollutant concentrations for TSS for stormwater runoff. However, stormwater-borne TSS load is likely only a portion of the total sediment loading to the ponds. Winter sanding, streambank erosion, and construction-site erosion likely contribute significant quantities of additional sediment. Since TSS settles in the pond, an in-pond concentration target is not a reasonable goal. A more important concern is the filling in of the pond by sediments over time, with the attendant potential for release of phosphorus from the sediments themselves as decomposition of entrapped organic materials occurs. Rather than setting a separate goal for sediment in the pond, Pennichuck can anticipate that the same techniques employed for the control of phosphorus will also prove effective at TSS reduction.. Nearly all of the proposed stormwater practices for phosphorus removal will also remove significant quantities of sediment. Further, other recommendations in

Section 6.0 particularly focus on addressing stream channel protection and sediment accumulation (for example, Recommendation 4 - Encourage Local Adoption of State Stormwater Standards and Recommendation 6 - Evaluate Sediment Accumulations).



4.0 Pollutant Load Analysis

Section 2.0 presented information to quantify existing phosphorus loads in the Pennichuck Brook watershed, as well as anticipated loads at full build-out. Section 3.0 described the development of the water quality goal desired at Harris Pond, based on phosphorus concentration. Using the model described in Section 2.0, this restoration plan has developed an estimate of the pollutant load reduction necessary to achieve that water quality goal. This Section presents the results of that analysis.

The model was used to estimate the total reduction in phosphorus load required to achieve an in-pond concentration of 30 ug/l of total phosphorus at Harris Pond. This represents approximately 40% reduction in phosphorus load across the watershed. Since the Pennichuck water supply watershed encompasses several communities, phosphorus loadings and needed removals were estimated by community instead of by subwatershed to encourage local control and coordination. Removals were apportioned in proportion to the estimated load for each community.

Table 4-1 shows phosphorus loadings under buildout conditions and the amount of phosphorus that needs to be removed to achieve the water quality goal of 30 ug/l by each of the five communities within the watershed. As explained in Section 3.0, the target of 30 ug/l was used because it is just below the range of concentrations generally associated with pond eutrophication. This goal is aggressive but appears achievable.

As outlined in previous sections, the model used to develop the pollutant loads should be updated by 2016. At that time, the allocations of phosphorus removals may require adjustment to reflect the new analysis.

Sections 5.0 and 6.0 discuss experience to date in the implementation of phosphorus reduction actions and the development of further management actions for moving toward the water quality goal.



Table 4-1: Proposed Total Phosphorus Loading Goals

Community	Existing TP Loading	Additional TP Load at Buildout	Total TP Loading	Percent of TP Budget	Target TP Removal	Target TP Loading
Phosphorus from Stormwater						
Amherst	776	84	861	11%	344	516
Hollis	345	29	374	5%	149	224
Merrimack	1,988	164	2,151	29%	861	1,291
Milford	53	16	69	1%	28	41
Nashua	1,987	205	2,192	29%	877	1,315
Subtotal Stormwater Contribution	5,149	497	5,646	75%	2,258	3,388
Phosphorus from Other Sources						
Groundwater	1,524	(1)	1,523	20%	---	---
Merrimack River	288	---	335	4%	---	---
Subtotal Other Sources	1,812	(1)	1,858	25%	---	---
Total	6,961	496	7,504	100%	2,258	3,388
Harris In-Pond TP Conc. (ug/l)	40		43			30

The distribution of the pollutant loads by land use is shown on Table 4-2.

Table 4-2. Total Phosphorus Loadings by Land Use (lbs/year)

Land Use	Existing TP Loading	Additional TP Loading at Buildout	Total TP Loading at Buildout
Commercial	1,085	143	1,228
HD Residential	373	57	430
Industrial	968	96	1,064
LD Residential	422	131	553
Roads	2,107	74	2,182
Forest	27	(9)	19
Open Space	4	0	4
Water	163	6	168
Total	5,149	497	5,646



5.0 Past Actions

Based on the analysis presented in Sections 2.0 through 4.0, this Watershed Restoration Plan includes the development of recommendations for management actions designed to achieve the desired reduction in watershed phosphorus loading to the Pennichuck Brook system. These recommendations comprise an update of the 2008 Watershed Restoration Plan. To provide a basis for these updated recommendations, the study team has summarized and reviewed the actions completed since 2008. This Section presents a summary of that review. A full list of recommendations and their status beginning with the 1998 Watershed Management Plan is included in Appendix G.

5.1 Introduction

The Pennichuck Water Works water supply pond network has moderate phosphorus concentrations associated with phosphorus loadings, largely from stormwater runoff and to some degree groundwater baseflow. Average phosphorus concentrations near the intake in Harris Pond between 1995 and 2006 and used in model calibration were 38 ug/l. This concentration is associated with a total estimated average annual phosphorus loading of 6,960 lbs from the watershed from the following sources:

- 5,149 lbs from stormwater runoff,
- 1,523 lbs from groundwater baseflow, and
- 288 lbs from the Merrimack River.

Using this same model, at buildout the in-pond phosphorus concentration in Harris Pond could increase to 43 ug/l if no actions are taken. This projection suggests that water quality could become significantly worse over time if measures are not taken to address these loadings, particularly those from future development. The projected future load at buildout (without new measures) could be 7,504 lbs deriving from the various sources as follows:

- 5,646 lbs from stormwater runoff,
- 1,523 lbs from groundwater baseflow, and
- 335 lbs from the Merrimack River (accounting for a slight increase associated with a greater withdrawal at buildout).

Based on the analysis conducted for the 2008 planning document, the target in-pond water quality goal of 30 ug/l was established. As explained in Section 3.0, identification of this goal included consideration of the typical regional in-pond phosphorus concentrations and what can realistically be achieved through the implementation of effective stormwater practices with a Margin of Safety.



Section 4 described how much phosphorus needs to be removed to protect the Pennichuck ponds and watershed from further eutrophication, presenting the removals required in each of the watershed communities to meet the in-pond water quality goal. To get to this goal, a total of 2,258 pounds of phosphorus needs to be prevented from entering the ponds over the entire watershed under buildout conditions. Stormwater treatment is targeted for phosphorus removal since it is easier to address than groundwater baseflow and because it represents about 75% of the total loadings. Flow from the Merrimack River does not present a significant loading and would also be difficult to address due to the large watershed, so it is not addressed herein.

This section describes the actions that have been taken since the February 7, 2008 Watershed Restoration Plan. It also summarizes current water quality trends within the ponds and tributaries. Recommendations are presented in Section 6.0.

5.2 Actions Implemented Between 2008 and Present

Pennichuck Water Works has been working on implementing the recommendations from the 2008 Watershed Restoration Plan. Items that have been completed or are in progress include:

1. Part 2 of Community Based Social Marketing (CBSM) Education Program for Stump Pond – The Stump Pond Brook subwatershed was selected to serve as a pilot area for developing and implementing a CBSM program. General field observations within the watershed noted manicured lawns to the edges of waterbodies, illegal dumping in tributaries and pet waste along roadsides, all of which can have negative impacts on the water quality of the water supply. The purpose of the CBSM program was to assess why residents are choosing certain behaviors, to identify barriers and competing behaviors, and to develop an education action plan to reduce residential land use impacts.

Pennichuck formed a working group that conducted an initial survey to collect information from residents on what they felt were the most significant activities that contribute to water pollution. A 39% return response rate was received. The working group decided to focus educational activities on proper application of lawn fertilizer within the watershed. A “Put Your Lawn on a Diet” campaign was developed and implemented to encourage residents to minimize non-point source pollution associated with lawn care. The campaign was conducted over a 6-month period and incorporated the following:

- Postcard announcement of free soil test
- Distribution of free soil test kits with cover letter from towns



- Postcard announcement of free lawn and garden event
- Master gardener lawn and garden event
- Lawn and garden tip postcard #1
- Vivid message postcard
- Lawn and garden tip postcard #2
- Distribution of “Put Your Lawn on a Diet” lawn flags
- Lawn and garden tip postcard #3
- Distribution of UNH Cooperative Extension magnet and cover letter from towns
- Farmer’s Market table with outreach material
- Survey announcement postcard with pledge and incentive offer
- Distribution of the “Put Your Lawn on a Diet: The 5-Minute Survey”

The intent of the followup survey was to measure resident awareness and behavior changes since beginning the CBSM activities. An 18% return response rate was received. 88% of the survey respondents were familiar with the “Put Your Lawn on a Diet” campaign and/or logo. 89% of respondents that fertilize their lawn indicated that they used or planned on using less fertilizer.

2. Watershed Website – Pennichuck has now updated its website to include a section specific to the Pennichuck Brook watershed. The materials have been developed and a website developer is working on incorporating these into Pennichuck’s existing website.

The website includes an interactive map of the watershed that allows visitors to the site to view sampling locations and data, locations of best management practices implemented by Pennichuck, and a map showing land uses within the watershed. Additional information on past and ongoing watershed initiatives and resources is also provided, allowing visitors to download past study reports. Links are provided to other useful websites where users can learn more about watershed protection.

3. Evaluate and Prioritize Retrofits for Existing BMPs – Previous work in the watershed revealed over 85 stormwater best management practices (BMPs) in the watershed, ranging from the latest high performance practices such as those used at the Pennichuck Square Pilot project and the Celina Avenue plunge pool, to older detention basins that are full of sediment, to small swales constructed as part of various developments over the years. Many of these BMPs offer little water quality improvement due to lack of maintenance or simply because the design focused on flood control rather than water quality.



Pennichuck used interns and contracted with CEI to evaluate these BMPs and identify the top 10 sites needing improvements that would help to improve water quality within the Pennichuck Brook water supply system. Sites were selected based on:

- proximity to the water supply
- size of the contributing drainage area and the amount of impervious area
- land uses
- the condition of the BMP
- current BMP performance

Conceptual design improvements were prepared for each of the 10 identified sites, along with estimated pollutant removal and stormwater recharge volumes. Ownership information was also identified. Refer to Appendix H for more detailed information for each location and for conceptual design drawings for each location.

4. Tinker Road Detention Basin Retrofit – The 2004 watershed study of Pennichuck Brook¹ identified an existing detention pond off Tinker Road and Exit 8 of the F.E. Everett Turnpike as a potential stormwater practice retrofit area. The 2008 Watershed Restoration Plan also included this recommendation. Tinker Pond collects stormwater runoff from about 150 acres of mixed commercial, residential and transportation uses. Retrofits were proposed to address threat of spills from local roads and the Everett Turnpike, sediments from road sanding and erosion; and phosphorus inflows from stormwater runoff.

Retrofits were completed in the summer of 2011 and included:

- Modifications to the inlet and outlet structures in the Tinker Road detention pond to extend the flow length and detention time;
- Construction of forebays, treatment ponds and exfiltration berms to treat highway runoff before it discharges into Harris Pond; and
- Construction of oil/water separation structures and oil sorbent booms within the proposed treatment ponds.

The Tinker Road retrofits are estimated to remove about 70 pounds of phosphorus per year and 140,000 pounds of sediment per year that would otherwise enter Harris Pond.

5. Evaluate Sediment Accumulation Rates in Ponds – Pennichuck completed a sediment impact study for the Pennichuck chain pond

¹ Comprehensive Environmental Incorporated. (Spring 2004). Study of Urban Non-Point Source Pollution PBS, PBH, PBP, WBS & MB Subwatersheds. Merrimack, NH.



system in 2000 that evaluated the quantity and quality of sediments in the four chain ponds. The study was conducted to determine the loss of capacity resulting from sediment deposition and how these sediments were contributing to water quality degradation.

Sediment depths were resurveyed in 2010 and showed additional sediment deposition, including the development of “land” areas within the ponds. Sediment also appears to have moved throughout the pond chain since the 2000 study. The 2010 study recommended further investigations to evaluate:

- Whether the sediment is accumulating faster than expected. If the sediment is accumulating faster than what is expected based on typical sediment loads for the watershed land uses and development, then it may indicate other sources, such as streambank erosion, that should be addressed.
- What is the source of the sediment accumulation? Knowing the source of the sediment will help direct actions to reduce sediment loads. Sediment cores can help identify the source of the sediment (e.g., road sanding and stormwater inputs vs. plant die-off and decay);
- What are the accumulation rates through annual measurements? This requires a consistent method for measuring sediment accumulation in the ponds.

6. Harris Pond Aeration – Pennichuck has been operating a hypolimnetic aeration system in Harris Pond since June 2005. The system aerates the bottom layer of the water column in the pond without destratifying it. The aeration system prevents anoxic conditions from occurring in the hypolimnion layer of Harris Pond, which will prevent phosphorus from being released from the bottom sediments back into the pond. The result is a reduction in in-pond phosphorus concentrations. Data from the ongoing long-term monitoring program supports this conclusion.
7. Long-Term Monitoring Program – Pennichuck has been actively monitoring the in-pond water quality and tributary streams since 2007. Both the in-pond and tributary stream water quality data have shown a decreasing trend in phosphorus concentrations since 2007. Refer to Figure 5-1 for tributary data between May 2007 and April 2012 and Figure 5-2 for in-pond data between May 2007 and August 2011. The concentrations were also converted to phosphorus loads by multiplying the concentration by the recorded flow on the same day. This allows for better comparison of phosphorus inputs considering the amount of flow in the stream, as the concentration may reflect diluted results under high flow conditions. This data also shows an overall reduction in phosphorus loads (refer to Figure 5-3).



Figure 5-1. Total Phosphorus Concentrations in Pennichuck Brook Watershed Tributaries

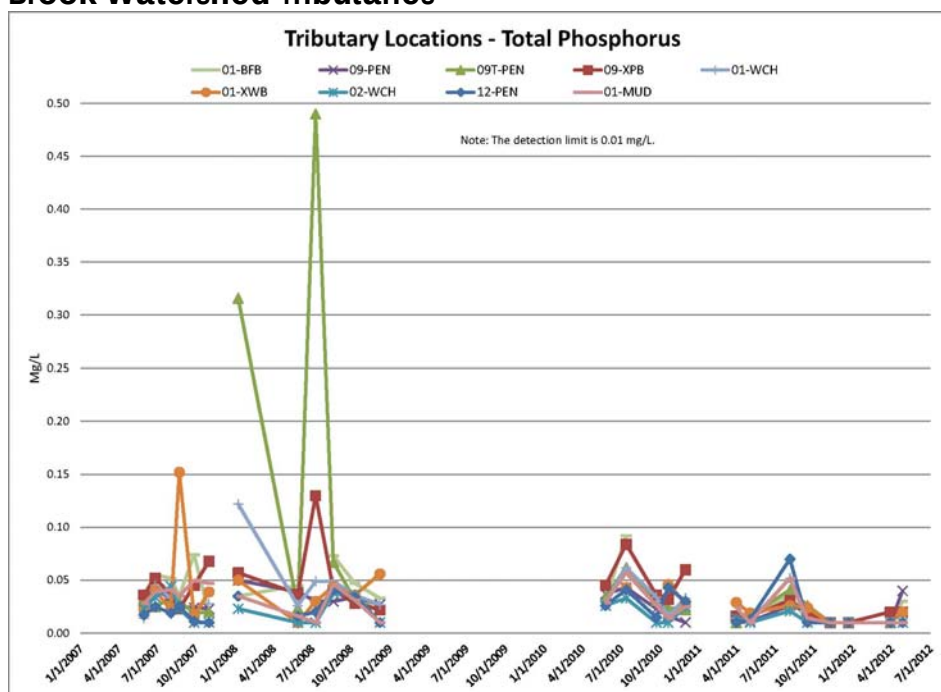
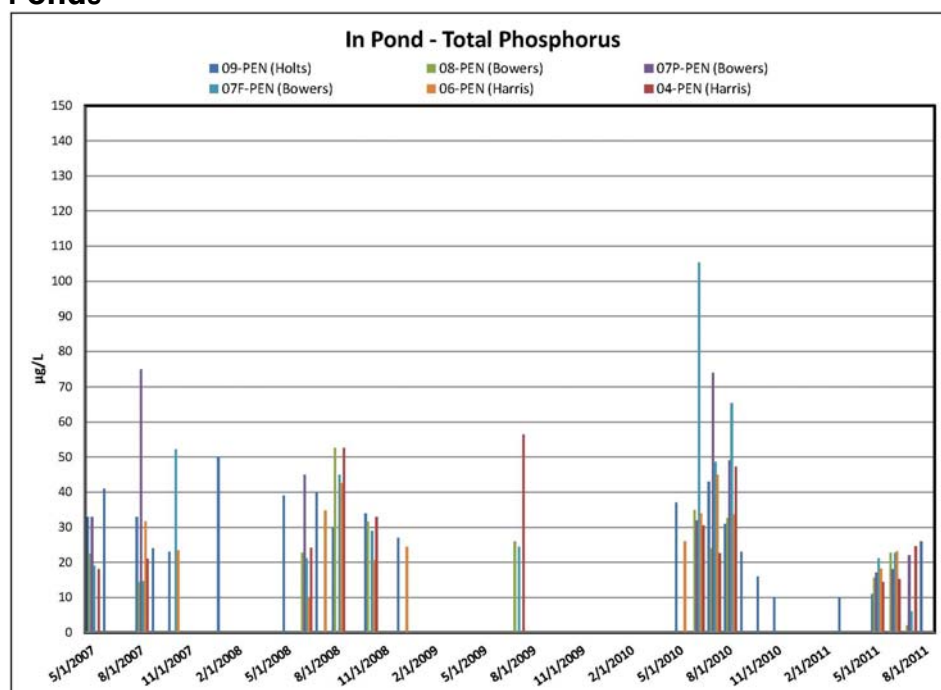
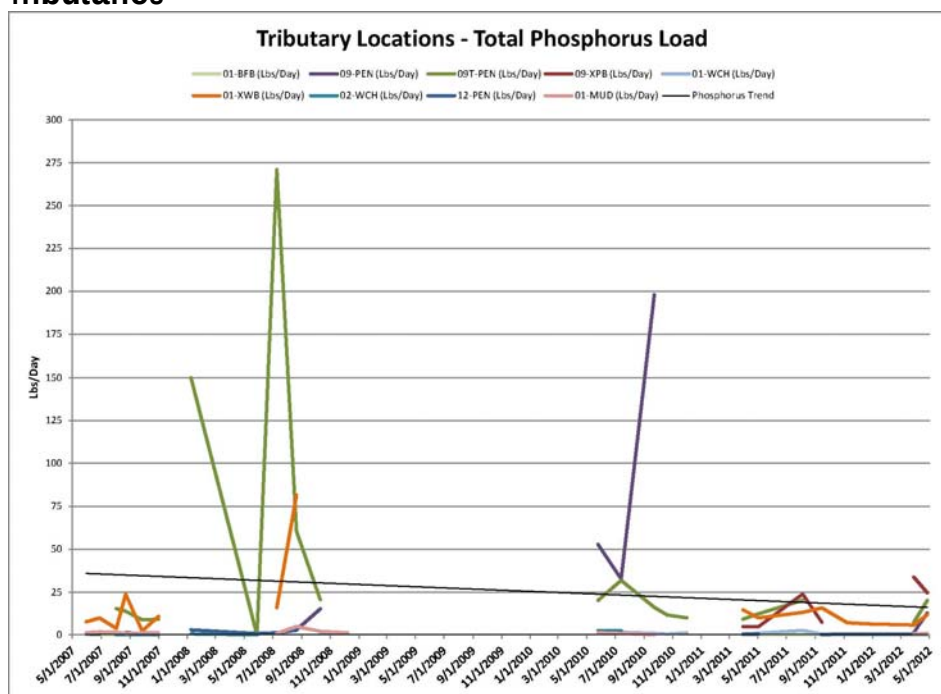


Figure 5-2. Total Phosphorus Concentrations in Water Supply Ponds



Note: Data represents a time-weighted average in-pond concentration calculated by averaging the top and bottom samples, assuming that the bottom samples only contributed to the in-pond concentration 3 months out of the year and the top samples contributed all 12 months of the year $((3 \times \text{bottom} + 12 \times \text{top})/15)$.

Figure 5-3. Total Phosphorus Loads in Pennichuck Brook Tributaries



The average phosphorus concentration in Harris Pond during this time was 26 ug/l, compared to 38 ug/l between November 1995 and October 2006. However, as shown on Figure 5-2, concentrations can vary significantly from year to year as evidenced by higher concentrations in 2010 than in previous and later years.

The observed reductions may be the result of several factors including:

- Operation of the aeration system and curtains in Bowers and Harris Pond prevents or minimizes the release of phosphorus from bottom sediments, with a notable reduction in bottom phosphorus concentrations.
- Actions implemented under the watershed management program and by cities/towns under the NPDES MS4 program remove phosphorus loads into the stream and ponds.
- Changes in climate can influence water quality results, with concentrations varying with the amount and frequency of precipitation and resulting stream flow.
- Fewer spikes in phosphorus concentrations than in previous years, bringing average values down.
- The water quality database is much more extensive between May 2007 and August 2011 than what was available during the 2008 Watershed Restoration Plan development. This helps offset higher values that may occur periodically and may provide a more accurate picture of actual conditions than the limited previous data set.

Based on the preliminary assessment of the recent water quality data, water quality looks better than the historic 1995 to 2006 period included in the 2008 Watershed Restoration Plan. Based on these results, Pennichuck should continue the aggressive monitoring program to provide the basis for a robust modeling effort in 2014 to 2016, and to provide the basis for setting a more aggressive water quality goal. In the meantime, Pennichuck should strive for the load reductions currently reported in Section 4.0.



6.0 Recommendations

6.1 Introduction

This Section presents recommendations for continued watershed management actions to achieve reductions in phosphorus loading to the Pennichuck Brook system. The modeling and analysis provided in Sections 2.0 through 4.0 provide the basis for developing and implementing such actions to achieve quantifiable results. Therefore, the recommended actions in this Watershed Restoration Plan have been developed with estimates of phosphorus and sediment removal achievable by each measure, as shown in Table 6-1 including capital and annual operating costs.

As discussed in Section 5.0, a total of 2,258 pounds of phosphorus needs to be prevented from entering the ponds under buildout conditions to reach the water quality goal of 30 ug/l. Although more recent data shows a significant reduction in phosphorus loads and concentrations in tributaries and the water supply ponds, CEI recommends continuing with watershed restoration efforts based on the 2,258 pound reduction goal, until 10 years of long-term water quality data is collected and the model is updated using this new data. While recent data suggests that revising water quality goals and removal targets may be warranted, the continued monitoring and additional data would be anticipated to provide a more robust basis upon which to update the water quality model, refine water quality goals, and allocate removal targets across the watershed and across management actions.

Section 6.2 presents recommendations in a standardized format, including a description of the action, statement of its objectives (including phosphorus removal target), schedule, implementing partners, costs of implementation, and means for measuring results. Note that the costs of implementation included for each recommendation do not include administrative costs for Pennichuck staff, unless otherwise noted. Major subcategories for these recommendations include:

1. Public Education
2. Increased Maintenance in Commercial Areas
3. Retrofit Detention Basins & BMPs
4. Encourage Local Adoption of State Stormwater Standards
5. Evaluate Phosphorus in Groundwater
6. Evaluate Sediment Accumulations
7. Harris Pond Aeration
8. Continue Long-Term Monitoring Program
9. Update Watershed Restoration Plan Model



Table 6-1 shows both capital and annual operating costs broken out by year, showing which year capital expenditures are scheduled for and the annual operational costs. In some cases, alternative approaches to achieve the same goal are provided, weighing the benefits and differences between them so Pennichuck Water Works can make sound decisions for implementation. Note that although most recommendations relate to phosphorus and sediment removal, some recommendations are critical even though they do not directly remove phosphorus.

The success of the recommendations in achieving water quality improvement must be measurable to ensure the plan is working and to make adjustments as needed to achieve the desired results. Section 6.3 concludes this report with a discussion of the recommended monitoring program and success indicators.

6.2 Recommendations

#1. Public Education

Public education and outreach is an important component of any watershed management program. It connects citizens and businesses to the water supply and watershed. With this connection and knowledge, individuals are more likely to make good decisions regarding their habits and practices to help protect the water supply and watershed, and are more likely to support policies that support watershed protection.

Existing residential neighborhoods in the Pennichuck Brook watershed produce some 795 pounds of phosphorus (estimated at 983 lbs at buildout), largely through activities such as yard waste dumped in wetlands; uncontrolled pet wastes; lawn and garden fertilizers; erosion from recreational vehicles; car washing and uncontrolled runoff. To raise awareness and foster individual efforts to reduce activities that contribute to phosphorus loading, the following educational program components are proposed.

1A. Maintain Watershed Website. Pennichuck is in the process of implementing and publishing the watershed website. As outlined in Section 5.0, the new website materials provide information on the watershed and actions that Pennichuck is taking to protect the watershed. The website should be updated annually to reflect new data collected by Pennichuck (e.g., updated water quality monitoring, and additional projects implemented by Pennichuck).

Recommendation: Update the website annually with new data collected by Pennichuck, including:

- Additional phosphorus and flow data for all monitoring locations;



- New best management practices (BMPs) implemented by Pennichuck;
- Additional watershed initiatives; and
- Additional links to guides, brochures and factsheets.

Actions:

- 1) Annually review website content and evaluate changes to data since the last update;
- 2) Update website with new information;
- 3) Contact the five communities in the watershed to notify them of changes to the website.

Objectives: Increase awareness of residents of more environmentally friendly practices that will be more protective of water quality. In combination with Recommendations 1B through 1D, the collective reduction in phosphorus loadings from residential areas is about 30%.

Schedule: Refer to Table 6-1.

Partners: NHDES

Capital Costs: Completed

Annual O&M Costs: \$5,000

Associated Recommendations: 1B Develop & Print Door Hangers, 1C Develop Targeted School Education Program, 1D Roof Leader Disconnection Pilot Program, 2 Maintenance Program through Vendors, 3 Retrofit Detention Basins & BMPs, 4 Encourage Local Adoption of State Stormwater Standards, 5 Evaluate Phosphorus in Groundwater, 6 Evaluate Sediment Accumulations, 7 Harris Pond Aeration, 8 Continue Long-Term Monitoring Program

Measurement: The number of hits to the website, indicating how often the site is visited.

1B. Develop & Print Door Hangers. The development and distribution of door hangers will help increase the awareness of residents of more environmentally friendly practices that will be more protective of water quality.

Recommendation: Develop and place door hangers in specific residential areas of the watershed. The door hangers should highlight the water supply and environmentally friendly practices that residents and businesses can implement to help protect the water supply. The door hangers should also include a link to the watershed website for further information.



Actions:

- 1) Identify residential areas of the watershed to receive door hangers.
- 2) Create and print door hangers.
- 3) Place door hangers in identified neighborhoods. This could be performed by a summer intern through the use of local volunteers.

Objectives: Increase awareness of residents of more environmentally friendly practices that will be more protective of water quality. In combination with Recommendations 1A, 1C and 1D collectively reduce phosphorus loadings from residential areas by 30%.

Schedule: Refer to Table 6-1.

Partners: NHDES

Capital Costs: \$5,000 initially for creation and printing of door hangers.

Annual Costs: \$5,000 every other year to continue with printing and distribution throughout the watershed.

Associated Recommendations: 1A Maintain Watershed Website, 1D Roof Leader Disconnection Pilot Program

Measurement: Percentage of watershed covered by the program. The number of hits to the website which residents will be directed to by the door hangers.

1C. School Education Program

Educating children brings the public education process full circle. Children bring home and share information and concerns with their parents. Parents will learn more and likely reinforce the lessons taught to children at school through example. As children mature into young adults, the hope is that they will retain the lessons and habits instilled by teachers and parents and pass these along to their children.

Key elements of a strong school based education program should include:

- A consistent presence – Annual visits and presentations to the selected schools to help encourage the schools to incorporate watershed protection specific to the Pennichuck Brook Watershed each year.
- A good fit with the existing NH school curriculum – Ensure the proposed program fits into the current NH school curriculum and is targeted at the appropriate grades.
- Make learning fun – Presentations should be performed by someone that can engage children and use props, games and experiments to pique their interest.



The education program may also include information on overall impacts of stormwater on water quality, to help meet city/town requirements for education under the EPA Phase II Stormwater (NPDES) program if the watershed towns wish to participate.

Recommendation: Develop a school education program. This can be targeted at all of the elementary schools within the five communities that make up the watershed, or select schools based on location within the watershed or proximity to the watershed. Pennichuck also has options for developing and implementing a targeted school education program. For example, Pennichuck could hire a contractor to develop and implement a school education program or hire a full time educator as part of its staff to develop and implement this program.

One approach to an education program is described below. Please note, however, this may change depending on the feedback received from participating schools and teachers:

1. Present Proposed School Education Program at Teacher's Workshops

The first step in establishing a school education program is to “sell” the idea to the schools and get permission to come in and implement the program. Each of the five watershed communities has a separate school administrative unit (SAU). Pennichuck could contact the Superintendents of each SAU and request the opportunity to present the proposed program at a scheduled teacher's workshop and offer continuing education credits. Teachers are required to attend teacher's workshops to obtain continuing education credits.

The key to selling the program is to “wow” the teachers and highlight the benefits to the teachers. For example, demonstrate how the proposed program fits into the existing curriculum, that no extra work is required of the teachers, and how Pennichuck will make the program fun and exciting for kids, including some of the props that may be used. Provide lunch for the workshops.

2. Develop Water Education Program Guide, Presentations & Potentially Contests

Target 3rd and 4th grade students through classroom presentations, a 3rd grade poster contest and a 4th grade water science fair.

Develop a water education program guide for distribution to 3rd and 4th grade teachers in the selected elementary schools in the five watershed communities. The program may include a letter to the teachers outlining the program and information on selecting dates, a form for teachers to fill out and send back indicating which programs they would like to participate in (e.g., class presentation, 3rd grade



poster contest, 4th grade science fair, tour of water treatment plant), the theme and rules for a poster contest if that is to be held, the rules and entry form for the water science fair, the presentation outlines for the 3rd and 4th grade presentations, a project review form for teachers to provide feedback on the education program, a list of reference materials available to the schools through Pennichuck (e.g., books and videos the teachers can borrow for use in their classrooms, website references for more information), and activities for the teachers to use in class.

After sending the curriculum guides, follow-up with classroom teachers to promote participation and confirm presentation dates.

3. Perform Classroom Presentations and Coordinate Contests

Present to all participating 3rd and 4th grade classes in the selected elementary schools in the watershed communities. Coordinate the activities and school fair.

For the science fair, Pennichuck could coordinate selection of judges, photographing of students who enter projects and prizes for each participant and winners. Each school could be asked to host their own science fair. The top projects from each school could be selected and the students and families invited to a Pennichuck Water Fair for presentation and award of prizes.

4. Coordinate Local Pennichuck Water Fair

Pennichuck could coordinate a local Pennichuck Water Fair to be held on Pennichuck Water Works property (e.g., Water Treatment Facility). Pennichuck could contact various vendors to request donations for prize awards for poster contest and science fair winners and coordinate food, games and activities for the fair.

Actions:

1. Present proposed school education program at Teacher's Workshops.
2. Develop water education program guide, presentations & contests.
3. Perform classroom presentations and coordinate contests.
4. Coordinate local Pennichuck Water Fair.
5. Modify proposed program as needed based on the feedback received from participating schools and teachers.

Objectives: Educate students about the watershed/water supply and on more environmentally friendly practices that are protective of water quality. In combination with Recommendations 1A through 1C, collectively reduce phosphorus loadings from residential areas by 30%.

Schedule: Refer to Table 6-1.



Partners: Local schools

Capital Costs: Costs will vary depending on how many schools are included in the program, whether Pennichuck contracts a consultant to prepare and implement the program or hires in-house staff to perform the work. Several cost options are provided considering these options:

- Option 1. \$65,000 – All watershed communities (22 schools). Costs include labor and supplies for consultant to develop and implement program (e.g., supplies include workshop food, presentation props, games and science kits, water fair food, games, activities and prizes).
- Option 2. \$45,000 – Nashua and Amherst (14 schools, 12-Nashua, 2-Amherst) – target rate paying communities. Costs include labor and supplies for consultant to develop and implement program.
- Option 3. \$37,000 – Schools in proximity to watershed (8 schools, 2-Hollis, 1-Merrimack, 5-Nashua) – target schools closest to the watershed boundaries. Costs include labor and supplies for consultant to develop and implement program.
- Option 4. \$29,000 – Nashua pilot (5 schools) – target the closest schools to the watershed located in Nashua, since they are primary consumers of water supply. This would target Nashua schools on the north side of the Nashua River. Costs include labor and supplies for consultant to develop and implement program.
- Option 5. \$51,000 – Train Pennichuck Staff – Consultant would develop the curriculum and presentation materials and train Pennichuck staff on its content and presentation. Pennichuck staff would be responsible for school coordination, implementation of program and all supplies (recommend \$7,000 for supplies). \$11,000 is for consultant and supply costs, with \$40,000 to cover the salary of a new Pennichuck employee hired to implement the education program and other public relation activities.

Annual O&M Costs:

- Option 1. \$47,500 – All watershed communities (22 schools). Labor and supplies for consultant.
- Option 2. \$34,500 – Nashua and Amherst (14 schools, 12-Nashua, 2-Amherst) – target rate paying communities. Labor and supplies for consultant.



- Option 3. \$26,500 – Schools in proximity to watershed (8 schools, 2-Hollis, 1-Merrimack, 5-Nashua) – target schools closest to the watershed boundaries. Labor and supplies for consultant.
- Option 4. \$22,500 – Nashua pilot (5 schools) – target the closest schools to the watershed located in Nashua, since they are primary consumers of water supply. This would target Nashua schools on the north side of the Nashua River. Labor and supplies for consultant.
- Option 5. \$46,000-\$51,000 – for supplies (\$6,000-\$11,000), depending on how many schools are included, and employee salary (\$40,000) to implement the program each year (assuming new hire).

Associated Recommendations: 1A Maintain Watershed Website, 1D Roof Leader Disconnection Pilot Program, 4 Encourage Local Adoption of State Stormwater Standards, 8 Continue Long-Term Monitoring Program

Measurement: Copy of the curriculum developed for the schools. Identify the number of schools and classes participating in the program, and the number of students involved. Percent of students served by water supply based on the watershed and school district boundaries.

1D. Roof Leader Disconnection Program. There are many urbanized, impervious areas within the Pennichuck Brook watershed. Many homes and businesses have roof leaders that are connected to the storm drainage system. This creates large volumes of stormwater runoff that discharge quickly and directly to city/town drainage systems and Pennichuck's water supply (e.g., directly to the water supply ponds or their tributaries). This makes the watershed more "flashy" and increases erosion and sedimentation by increasing flood volumes. In most cases, there is opportunity to handle and maintain roof runoff at the site where it is generated. This can be accomplished through a roof leader disconnection program, but requires education and participation of the cities/towns and its citizens.

Such a program would allow communities to take credit for 'disconnecting' impervious area. Such disconnection practices are receiving more attention from EPA and DES under the NPDES Phase II Stormwater program. The draft NPDES Phase II MS4 permit includes requirements for regulated communities to begin tracking their impervious and disconnected impervious areas and this program can be used to show progress towards disconnecting existing connected impervious areas.



Recommendation: Initiate a roof leader disconnection program in the watershed as follows:

1. Coordinate with Towns

A successful disconnection program will require participation by local city/town officials. Highlighting the benefits of such a program can provide an incentive for participation. Pennichuck should research existing disconnection programs and benefits to highlight successes in other locations and estimate the potential recharge and pollutant removal capable in each community with a disconnection program. Application towards meeting the EPA NPDES Phase II stormwater program should also be highlighted. This information can be used to help ‘sell’ the program to the watershed communities.

Pennichuck should meet with each of the watershed communities to discuss the proposed program and gauge the communities’ interest in participating.

2. Select a Neighborhood for a Disconnection Pilot Program

Upon meeting with the communities, select a neighborhood to perform a pilot disconnection program. The selection should be based on housing density, drainage infrastructure and soil types. Present the pilot program to town officials and determine level of community participation. Work with the community to assign responsibilities for implementing various components of the pilot program.

Prepare *typical* details for each type of disconnection (e.g., to a dry well or gravel pit, rain barrel, vegetative strip) for the community to use in its communication with residents. It is anticipated that in most cases, an existing roof drain downspout would be connected to a dry well or gravel well placed away from the house’s foundation, with other options suggested for areas with tight, impermeable soils). Materials being developed under the NH DES’s “Soak up the Rain NH” program may be used or adapted for this purpose. The “Soak up the Rain NH” program is striving to achieve voluntary reductions in stormwater runoff and pollution from private, residential and small commercial properties through a coordinated statewide outreach and local capacity building campaign to install small-scale BMPs. Materials developed under this program may include examples of do-it-yourself installations and multi-media resources to complete site assessments, develop site plans, and install homeowner scale stormwater treatment practices.

Draft a letter for the community to mail to property owners in the identified neighborhood, requesting their participation in the project.



3. *Site Visits and Disconnection Plan*

Mark the selected neighborhood for Digsafe to identify the locations of existing utilities. Conduct followup site visits to consider applicable disconnection options and locations considering utilities and lot configurations. Based on this information, identify the best practicable disconnection option for the participating residence. Prepare a general site plan using available GIS and assessor's information to identify the proposed location of the disconnection technique. Provide this plan to the community's town staff or other designated program representatives for implementation by the Town.

4. *Report on Pilot*

Prepare a brief report summarizing the program and its results. Include information on each of the techniques used to handle roof runoff, including a typical detail, suitable applications, construction costs and benefits, to readily allow application to other watershed neighborhoods. Discuss the "lessons learned" and use that experience to develop an outline protocol for implementing similar programs in other neighborhoods. Provide a copy of this protocol to watershed communities, and post it on the website.

Actions:

- 1) Coordinate with Towns and select a pilot neighborhood for disconnections. Develop typical roof leader disconnection plans and/or use/adapt materials developed under the "Soak up the Rain NH" program as they become available.
- 2) Coordinate with Town to determine how the pilot will get implemented.
- 3) Implement pilot.
- 4) Prepare a report on the pilot to allow easy application at other locations.

Objectives: Encourage and provide the tools to implement roof disconnection programs in relevant areas of the watershed. Increase recharge to baseflow. In combination with Recommendations 1A through C, collectively reduce phosphorus loadings from residential areas by 30%.

Schedule: Refer to Table 6-1.

Partners: Watershed communities

Capital Costs: \$19,000 to coordinate with watershed communities and to develop *typical* plans for disconnection option and a general plan for the selected pilot neighborhood.



Annual O&M Costs: \$5,000 to annually meet with watershed communities to discuss progress of roof leader disconnection program and encourage continued implementation.

Associated Recommendations: 1A Maintain Watershed Website, 1B Develop & Print Door Hangers, and 1C Develop Targeted School Education Program, 4 Encourage Local Adoption of State Stormwater Standards

Measurement: Number of homes disconnected and associated reduction in “effective impervious cover” (allowing for an estimate of stormwater runoff volume reduction).

#2. Increased Maintenance in Commercial Areas

Commercial and industrial properties comprise about 13% of the watershed. With their large impervious areas, these properties are anticipated to contribute about 40% of the phosphorus pollutant load at buildout. Commercial areas also contribute to high sediment loads due to sanding of parking lots.

Street and parking lot sweeping and catch basin cleaning, along with regular maintenance of stormwater practices, has been found to remove phosphorus from watersheds quite effectively if the best equipment is used – namely either vacuum sweepers and/or regenerative air sweepers for sweeping, vacuum trucks for cleaning of catch basins and other stormwater practices such as the plunge pool at Celina Avenue and detention basins.

Although the watershed communities sweep the roadways and streets, private parking lots and commercial driveways are likely not swept as frequently or thoroughly as they could be, at least not on a widespread basis. To evaluate the potential effectiveness of increased sweeping and maintenance of commercial and industrial properties, CEI modeled watershed commercial and industrial parking areas to determine the phosphorus reduction that could be achieved. For the purposes of the analysis, we assumed the use of a regenerative air sweeper that would go over the most critical areas near the brook six times per year, and over less critical areas 2 times per year. Two alternative recommendations are provided to promote increased sweeping. These include:

- Option 1. Maintenance by Pennichuck – Pennichuck to purchase a street sweeper and vacuum truck and perform street sweeping and maintenance activities for commercial and industrial properties for a fee.
- Option 2. Maintenance Program through Vendors – Develop a commercial/industrial maintenance program through



existing street sweeping and catch basin cleaning vendors to offer discounted services to businesses.

Each is discussed further below:

Option 1. Maintenance by Pennichuck

Recommendation: Continuously sweep private parking lots and commercial driveways between April and November, sweeping critical areas near the brook more frequently (e.g., 6 times a year) and less critical areas 2 times a year. Clean private catch basins and stormwater practices twice a year.

Actions:

- 1) Investigate the feasibility of Pennichuck performing maintenance activities (Option 1) vs. Pennichuck establishing an agreement with maintenance vendors (Option 2). The feasibility should include:
 - a. Identify the number of private properties and their associated parking lot areas and drainage infrastructure to estimate costs with both programs.
 - b. Identify private property managers and existing practices.
 - c. Estimate pollutant loads and reductions.
 - d. Contact local maintenance vendors for possible participation.
 - e. Develop report and determine most appropriate course of action.
- 2) If Option 1 is selected:
 - a. Sweep continuously between April and November and clean private catch basins and stormwater practices associated with commercial and industrial development twice a year. Track sediment collected from sweeping/cleaning operations and adjust efforts as necessary, based on accumulations.

Objectives: Reduction of 96 pounds per year of phosphorus to the water supply associated with sweeping.¹ Reduction of 280 pounds of phosphorus per year (7.5%² assuming catch basins are cleaned twice a year) to the water supply associated with cleaning private catch basins and stormwater practices.

¹ Street sweeping assumes Pennichuck would buy a street sweeper and run it continuously in the watershed to sweep roadways and commercial parking lots. Further evaluation would be necessary to prioritize areas for sweeping, such that higher loading areas could be addressed more frequently.

² State of Wisconsin Department of Transportation. (January 24, 1997) Facilities Development Manual



Schedule: Refer to Table 6-1.

Partners: Private commercial and industrial property owners.

Capital Costs: \$34,000 to perform feasibility study, \$200,000 to purchase a street sweeper, \$120,000 to purchase a Vac Truck.

Annual O&M Costs: \$70,000 per year for each street sweeper and the vacuum truck for an operator, gasoline, maintenance and sediment disposal.

Associated Recommendations: 4 Encourage Local Adoption of State Stormwater Standards, 6 Evaluate Sediment Accumulations.

Measurement: Amount of sediment swept from designated areas.
Amount of sediment removed from catch basins and stormwater BMPs.

Option 2. Maintenance Program through Vendors

Recommendation: Establish an agreement with street sweeping and catch basin cleaning vendors to offer discounted services to businesses within the watershed that use the vendor's services. Use an advertising program to get businesses to participate.

The goal is to obtain discounted "bulk" services rates, which could benefit the property owners and water quality. Participating businesses will then be promoted as watershed stewards, providing positive press releases and signage. Components to establish agreements would include the following:

1. *Contact Street Sweeping and Catch Basin Cleaning Contractors*
Contact local street sweeping and catch basin cleaning vendors to gauge their interest in participating in a watershed program. Solicit bids to obtain the best "bulk" service rates. The bid package should outline specifications for sweeping/cleaning equipment and be sent to selected vendors and advertised locally.

2. *Advertise the Proposed Program*
Meet with the five watershed communities and local Chambers of Commerce to present and discuss the proposed program, how they can participate, and to obtain a list of businesses and contacts.

Prepare a draft letter for the communities and Chambers to mail to businesses, advertising the proposed program, benefits to the watershed and businesses, and contact information for businesses to get more information. If the community has a local stormwater bylaw that requires sweeping and cleaning, the letter could explain how



compliance can be achieved through participation in the program. Place an article in local newspapers with similar content.

3. *Promotional Advertising*

Upon final selection and pricing with the vendor, generate an additional letter and article advertising the participating vendors and their contact information.

After program startup, obtain a list of participating businesses from the contracted vendor and develop news articles to promote participating vendors and businesses. Provide participating businesses with signs advertising them as watershed stewards and promote the businesses on the watershed website. The promotional advertising will encourage other businesses to contact the vendors for their services and to participate in the program.

Follow-up with the vendors annually to determine growth of the program and additional promotional needs.

Actions:

- 1) Investigate the feasibility of Pennichuck performing maintenance activities (Option 1) vs. Pennichuck establishing an agreement with maintenance vendors (Option 2). The feasibility should include:
 - a. Identify the number of private properties and their associated parking lot areas and drainage infrastructure to estimate costs with both programs.
 - b. Identify private property managers and existing practices.
 - c. Estimate pollutant loads and reductions.
 - d. Contact local maintenance vendors for possible participation.
 - e. Develop report and determine most appropriate course of action.
- 2) If Option 2 is selected:
 - a. Contact street sweeping and catch basin cleaning contractors and solicit bids for “bulk” service rates. Meet with five watershed communities and local Chambers of Commerce to engage them to participate and advertise the proposed program.
 - b. Prepare promotional advertising for participating businesses.

Objectives: Reduction of 96 pounds per year of phosphorus to the water supply associated with sweeping.³ Reduction of 280 pounds per year of

³ Street sweeping assumes Pennichuck would buy a street sweeper and run it continuously in the watershed to sweep roadways and commercial parking lots. Further



phosphorus (7.5%⁴ assuming catch basins are cleaned twice a year) to the water supply associated with cleaning private catch basins and stormwater practices. Actual removal will depend on the number of businesses participating and the frequency of sweeping and maintenance activities.

Schedule: Refer to Table 6-1.

Partners: Street sweeping and maintenance vendors, watershed communities, Chambers of Commerce

Capital Costs: \$34,000 to perform feasibility study. \$21,500 to coordinate with vendors, watershed communities, and Chambers of Commerce, and to solicit bids and advertise the program.

Annual O&M: \$10,000 to followup with vendors and businesses, and to rebid

Associated Recommendations: 1A Maintain Watershed Website, 4 Encourage Local Adoption of State Stormwater Standards, 6 Evaluate Sediment Accumulations

Measurement: Number of businesses that participate. Amount of sediment swept from designated areas. Amount of sediment removed from catch basins and stormwater BMPs.

#3. Retrofit Detention Basins & BMPs

As described in Section 5.0, Pennichuck has investigated and identified the top 10 existing BMP sites for retrofits to improve water quality. Conceptual designs for improvements have been prepared as summarized in Table 6-2 and included in Appendix H. Additional data is needed to increase the success of the renovations, specifically, ownership information and cooperation, and additional data to prepare preliminary designs for the purpose of pursuing grant funds.

evaluation would be necessary to prioritize areas for sweeping, such that higher loading areas could be addressed more frequently.

⁴ State of Wisconsin Department of Transportation. (January 24, 1997) Facilities Development Manual



Table 6-2. Proposed BMP Retrofits			
BMP #	BMP Description	Proposed Retrofit	Estimated BMP Retrofits Cost¹
1	PC Connection Wet Pond	Add forebay & flow through berm, regrade & stabilize bank erosion, install vegetated parking lot dividers & porous pavement	\$525,000
2	Northwest Blvd/ RR-Xing Wetland Polishing Pond & Swale	Add sediment trap to pond, add sediment trap, bioretention area, & vegetated treatment swale with sediment plunge pool	\$91,100
3	Abandoned Saturn Dealership Swale	Install vegetated parking lot dividers & porous pavement, install depressed vegetated buffer zone pockets, add forebays, check dams & vegetated treatment swale	\$200,000
4	Post Office Detention Basin	Add forebays, vegetation	\$32,300
5	Ford Dealership Swale & Detention Basin	Add forebays & check dams to swale, add riprap apron & install pocket wetland, install vegetated buffer zone at basin	\$172,200
6	Blackstone Apartment Complex Wet Pond & Amherst Park Stream Channel	Install gravel wetland, add forebays & deep sump catch basins with perforated pipe for infiltration, add pretreatment sediment forebays at swale	\$457,000
7	White Oak Drive Residential Detention Basin 1	Add sediment forebay, raise low flow outlet to increase WQv treatment, install gravel flow through channel	\$42,900
	White Oak Drive Residential Detention Basin 2	Add sediment forebay, raise low flow outlet to increase WQv treatment, install gravel flow through channel	
8	Kessler Farms Detention Basin	Retrofit existing basin into sediment forebay, install pocket wetland	\$174,600
9	Somerset Plaza Swale	Install vegetated parking lot dividers & porous pavement, add sediment trap at culverts	\$428,700
10	Crowne Plaza Wet Pond & Swale	Add forebays & vegetated treatment swale to pond, install vegetated parking lot dividers & porous pavement	\$445,600

¹Costs include permitting, engineering and construction. Cost for legal agreements is not included.

Further work is required to develop partnerships with the owners of properties within which the above listed improvements are proposed. The willingness of property owners to participate in the program will



affect whether and to what degree Pennichuck will be able to advance these improvements.

Recommendation: Contact property owners to determine willingness to participate. Initial review of available assessor information on community websites indicated that the top 10 BMP sites involve 16 potential property owners.

Recommended approach for involving the property owners is for Pennichuck personnel to meet with them to discuss the proposed project and provide them with a copy of the conceptual site plan for review.

Based on owner cooperation, prioritize sites for design and construction.

Actions:

- 1) Contact property owners for the 10 BMP sites to discuss proposed projects and determine owner interest in participating.
- 2) Prioritize BMP sites based on owner cooperation.
- 3) Design and construct BMP retrofits. Target one BMP every two years.

Objectives: Prevent 75 pounds of phosphorus per year from entering the water supply through construction of 10 BMP retrofits. Prevent sediment from entering the water supply. Provide storage and infiltration for stormwater.

Schedule: Refer to Table 6-1.

Partners: Private landowners, watershed communities

Capital Costs: \$26,000 to contact property owners for all 10 sites and to prepare 30% preliminary design plans for one selected site. \$500,000 budget allowance per BMP retrofit for final design and construction. This equates to \$2,500,000 during the 10-year implementation period for design and construction of 5 BMP; \$5,000,000 over 20-years for the design and construction of 10 BMPs. Design includes surveying and permitting.

Annual O&M Costs: \$1,000 per BMP per year for annual maintenance including cleanout and disposal of sediment

Associated Recommendations: 1A Maintain Watershed Website, 4 Encourage Local Adoption of State Stormwater Standards

Measurement: Number and types of retrofits. Revised pollutant removals based on actual area treated and type of BMP installed. Measured quantities of sediments removed from retrofits during annual cleaning.



#4. Encourage Local Adoption of State Stormwater Standards

The implementation of consistent, well-designed stormwater regulations and standards is an important element of watershed management. With five communities in the watershed, Pennichuck also considers it highly important that such regulations should be consistently applied across the watershed, requiring communication and coordination among the affected municipalities. Therefore, this watershed restoration plan recommends a coordinated effort to encourage and facilitate the adoption of state stormwater standards at the local level.

One of the biggest threats in the watershed consists of the discharge of uncontrolled stormwater runoff from older commercial and industrial land uses that were developed without stormwater treatment measures. Vast parking lots, in particular, pose a hazard to the water quality of Pennichuck Brook. In addition, runoff from these properties during high intensity storm events contributes to flooding in the host communities, with associated damages to private property and public infrastructure.

There is an opportunity to reduce the impact of existing and future development through regulatory requirements for new and redevelopment projects to meet specific stormwater design standards. Specifically, local municipalities can adopt the Alteration of Terrain (AoT) regulations, requiring their application to lower development thresholds than currently required by NHDES, to help reduce the impacts of stormwater runoff from new and redevelopment projects.

The AoT Program requires that entities disturbing more than 100,000 square feet apply for a State level permit through NHDES. Applying a lower threshold at the local level would provide better protection and help communities meet federal NPDES Phase II requirements, which require regulation of disturbances greater than one acre (43,560 square feet).

While Pennichuck Water Company has the technical knowledge and resources to assist in the development of local regulations, regulatory authority resides with the communities within the watershed. Therefore, Pennichuck seeks to work in cooperation with the watershed communities to promote the creation of a regulatory system for better development and management of stormwater runoff, to prevent pollution of the water supply.

Additionally, this coordinated effort between Pennichuck Water Works and the communities can enhance the effectiveness of other watershed protection actions, to benefit both the water supply and the communities. For example, all of the watershed communities are subject to the federal Phase II Stormwater Program and must implement measures to address non-point source pollution. Required measures include public education, illicit discharge programs, stormwater regulatory controls,



implementation of stormwater best management practices and improved housekeeping. Many of these requirements either overlap or have common elements with Pennichuck's watershed protection efforts and the associated goals. Thus coordination of these efforts can serve to meet Phase II compliance and protect the Pennichuck Brook watershed and water supply.

Recommendation: Continue coordination with watershed communities including planning boards and public works to:

- Encourage adoption of AoT standards from NHDES. Work with community departments to encourage adoption of these standards and to present other ongoing watershed protection efforts and how these may also fit into Phase II Stormwater Management Programs.
- Keep community representatives informed of ongoing watershed protection efforts and obtain their input. Highlight the benefits of these efforts to both the communities and the water supply (e.g., Phase II compliance for communities and watershed protection for the water supply) and discuss opportunities to work together to accomplish these activities. Continued coordination can help gain the support of these communities for future activities.

Actions:

- 1) Identify potential areas of collaboration between Phase II and watershed problems. Examples include roof leaders that discharge directly to driveways and then to street drainage systems; dumping of leaves, grass and other yard waste in ditches and streams; wetland buffer zone disturbances; open dumping and dumping of waste materials in catch basins; control of stormwater runoff from existing and future development.
- 2) Contact and meet with planning boards and public works in the five watershed communities at least annually to discuss ongoing projects and potential collaboration, including benefits of adopting the AoT standards for new and redevelopment projects at the local level.

Objectives: Adoption of AoT standards at the local level for new and redevelopment projects with a threshold of one acre or less. Coordinate watershed protection efforts with Phase II efforts to provide an incentive to local communities to implement measures that will be protective of the water supply. This could ultimately result in the reduction of phosphorus loads by 252 pounds per year by applying these standards to new development projects and 685 pounds of phosphorus per year by applying these standards to redevelopment projects.

Note that the projected phosphorus reductions assume application at all new development and redevelopment projects. The rate of development



and redevelopment to achieve these reductions is expected to take longer than the 10-year implementation period of this plan.

Schedule: Refer to Table 6-1.

Partners: Watershed communities

Capital Costs: None

Annual O&M Costs: \$7,200 for annual coordination/meeting with all five communities

Associated Recommendations: 1A Maintain Watershed Website, 1C Develop Targeted School Education Program, 2 Develop Commercial/Industrial Maintenance Program, 3 Retrofit Detention Basins & BMPs

#5. Evaluate Phosphorus in Groundwater

As described in Section 2.0, about 20% of the total phosphorus load at buildout was attributed to phosphorus levels in groundwater. This was based on a groundwater phosphorus concentration of 0.02 mg/l, as observed in dry weather flow concentrations in the tributaries.

Preliminary groundwater data was found in NHDES's OneStop database. OneStop did not include any groundwater data within the watershed, but did provide groundwater phosphorus concentrations for several wells in Milford, NH, outside of the watershed. The results from the OneStop database revealed phosphorus concentrations ranging from 0.001 to 0.351 mg/l with an average of 0.0124 mg/l. This data indicates that groundwater could be a source of phosphorus loads, however, additional data is needed to determine its contribution in the watershed.

Recommendation: Investigate groundwater phosphorus levels in the watershed to evaluate groundwater's role as a source of phosphorus load and whether additional recommendations to address this load are warranted. Perform the following tasks:

1. Install Wells/Piezometers

Install nine groundwater monitoring wells/piezometers near the stream gauging/sampling locations. Obtain permission to install these wells/piezometers from the affected landowners and contact Digsafe prior to installing the wells/piezometers.

Based on the results of the collected data, future additional groundwater monitoring wells/piezometers could be installed to target areas where there might be greater phosphorus contributions such as near nurseries or large commercial septic systems near the water supply or its tributaries.



2. Sample Soils and Groundwater

Collect soil samples during the installation of the wells/piezometers for laboratory analysis of Total Phosphorus, Total Nitrogen, TKN and Nitrates/Nitrites. Collect two rounds of groundwater samples, representing varying groundwater levels, for laboratory analysis of Total Phosphorus, Sodium, Chloride, Total Nitrogen, TKN and Nitrates/Nitrites from all of the newly installed wells.

3. Analyze Laboratory Results and Prepare Report

Review data against regional groundwater data compiled by NHDES (typical “background” levels). Review the data against the assumptions used in the Pennichuck model.

Determine the need for further actions, including recommendations for modification of the SWMM model in conjunction with updated data from continuing surface water quality monitoring in the watershed.

Actions:

- 1) Install piezometers at nine tributary locations.
- 2) Collect soil and groundwater samples.
- 3) Assess the sampling results, comparing them with typical “background” levels suggested by published regional groundwater data.
- 4) Determine the need for further actions.

Objectives: Determine whether additional recommendations are needed to address phosphorus loads associated with groundwater. Additional recommendations may include better controls on large septic systems or additional measures for treating recharged stormwater.

Schedule: Refer to Table 6-1.

Partners: None

Capital Costs: \$17,700 to install piezometers, sample soils and groundwater and prepare a report of findings and recommendations.

Annual O&M Costs: \$4,700 for repeat sampling two times a year

Associated Recommendations: 1A Maintain Watershed Website, 6 Evaluate Sediment Accumulations, 7 Harris Pond Aeration, 8 Continue Long-Term Monitoring Program

Measurement: Final report with recommendations.



#6. Evaluate Sediment Accumulations

Sediment discharge and deposition within the watersheds streams and ponds can result in infill, reducing the physical storage capacity of the supply. In addition, depending on the characteristics of the sediment, it can impact water quality; for example, organic materials in deposited sediment can result in an internal source of phosphorus load in the ponds. An understanding of the location, depth, and characteristics of sediment accumulation is a key element of the ongoing monitoring, analysis, and planning efforts for the management of the water supply.

CEI resurveyed sediment depths in the Pennichuck Brook Watershed water supply ponds in August 2010 for comparison with the July 2000 Sediment Study of the ponds. The results of the investigation showed that sediment is accumulating throughout the water supply pond system. However, further study is required to determine whether infill is occurring faster than expected or is typical given the surrounding land uses.

Recommendation:

- 1) Identify and estimate expected sediment loadings to the ponds from roadway sanding, runoff from surrounding land uses, die-off of algal and aquatic plant biomass, and channel erosion and deposition. Developing this estimate will serve as a loading rate baseline for comparison with future measurements.
- 2) Collect sediment core samples in Harris and Bowers Pond for gradation analysis and quantification of organic content. The cores will be used to identify natural pond bottom materials and the types and percentage of materials entering the pond (e.g. road sand vs. organic materials from internal die-off of plant material). This information can be compared with estimated sediment loadings from each source, to help assess the source(s) of continued sediment accumulation.
- 3) Install sediment depth sampling gages within Harris and Bowers Ponds. These can be used to measure sediment accumulation at fixed locations in the future.
- 4) Measure sediment accumulations using acoustic echosounding (sonar) measurement of bottom sediments as outlined in the 2011 Sediment Impact Study with direct measurement at the fixed installed staff gages to monitor sediment depths on an annual basis.

Actions:

- 1) Estimate anticipated sediment loadings and sources based on “desk top” values for land uses, sand application, and stream erosion.
- 2) Collect sediment core samples in Harris and Bowers Ponds and characterize for organic content and gradation.
- 3) Install sediment depth gages within Harris and Bowers Ponds.



- 4) Measure sediment accumulations annually, using acoustic echosounding and sediment depth gages.

Objectives: Track the rate of infill of the ponds to help direct future actions designed to minimize loadings, and to assess the need for remediation of sediment deposition.

Schedule: Refer to Table 6-1.

Partners: None

Capital Costs: \$6,800 to calculate estimated sediment loads. \$33,100 to collect sediment samples, install gages, develop sampling protocol and purchase equipment for measurements.

Annual O&M Costs: \$18,000 to annual measure sediment depths in ponds and prepare report.

Associated Recommendations: 1A Maintain Watershed Website, 5 Evaluate Phosphorus in Groundwater, 7 Harris Pond Aeration, 8 Continue Long-Term Monitoring Program

Measurement: Installation of sediment measurement devices and annual sediment readings.

#7. Harris Pond Aeration

Some internal loading of phosphorus is anticipated in the ponds. Reduced loading from the watershed may eventually lead to reduced internal loading, but such a reduction is not expected to happen shortly after stormwater practice implementation. Aeration may be used to prevent the recycling of phosphorus from bottom sediments into the water column in the short term.

Pennichuck Water Works began operating a hypolimnetic aeration system in Harris Pond in 2005, along with flow routing elements in Bowers Pond. The flow routing influences how water moves through the ponds in depth layers. The Bowers Pond system imports water from the Merrimack River, introducing it in the deeper layer of the pond to subsidize oxygen input to maintain better water quality. A combination of submerged weir partitions, baffle “stilling basin” booms, and containment partitions in Bowers and Harris Pond are used to achieve the flow routing.

The hypolimnetic aeration system used in Harris Pond aerates the bottom layer of the pond without destratifying it. The aeration system prevents anoxic conditions from occurring in the hypolimnion layer of Harris Pond, which in turn prevents phosphorus release from the bottom sediments into the pond.



Pennichuck has observed lower and more consistent in-pond phosphorus concentrations since the aeration system has been in operation than previously, as shown in Figure 5-2.

Recommendation: Continue operation of the flow routing and aeration system in Bowers Pond and Harris Pond.

Actions:

- 1) Continue operation of the flow routing and aeration system in Bowers Pond and Harris Pond.

Objectives: Reduce treatment costs of raw water by preventing the release of phosphorus and other contaminants from the bottom sediments into the pond. For phosphorus load reduction purposes, it was assumed that the aeration system will reduce the average phosphorus concentration to 33.5 ug/l near the intake in Harris Pond, which is equivalent to about 1,160 pounds of phosphorus annually. However, actual internal loading is unknown and there may be some variability in phosphorus reduction associated with aeration due to weather conditions. Thus, for a conservative estimate for the restoration plan, the equivalent phosphorus reduction associated with aeration is estimated at 696 pounds (60% of that predicted based on concentration) removal annually.

Schedule: Refer to Table 6-1.

Partners: None

Capital Costs: The system is already in place.

Annual O&M Costs: Yearly operational costs are not included since the system is already in place to improve the raw water quality entering the treatment plan and is covered in the ongoing operating budget.

Associated Recommendations: 1A Maintain Watershed Website, 5 Evaluate Phosphorus in Groundwater, 6 Evaluate Sediment Accumulations, 8 Continue Long-Term Monitoring Program

Measurement: Operation of the aeration system. Raw water quality at the intake before and after aeration.

#8. Continue Long-Term Monitoring Program

Long-term monitoring of the in-pond water quality and tributary streams provides information about water quality trends. Coupled with an analysis of precipitation trends and management activities within the watershed (i.e., development, implementation of BMPs), monitoring data can provide the basis for assessing progress toward achieving water quality goals, and can also inform decisions to refine those goals and the



allocation of pollutant load reductions among contributing sources. This restoration plan recommends continuing the monitoring program.

As discussed under Section 5.2, water quality data collected between 2007 and the present has shown an overall declining trend in phosphorus concentrations in both tributaries and in the ponds. As further data is obtained in the coming years, it should be supplemented by compiling further information on stormwater retrofits, landscape management practices, stormwater system maintenance practices, and public education activities, to help inform Pennichuck's understanding of how the water quality trends correlate with stormwater management activities.

The existing monitoring program should continue to evaluate the watershed and track the progress of the proposed improvements. Data collected under a monitoring program can also be used for future modeling efforts, anticipated for future updates of the watershed plan. CEI recommends the following monitoring program in the watershed. This program should be reevaluated annually based on the results of the data and need for additional information.

8A. Tributary Sampling and Flow Monitoring

Tributary sampling is useful to monitor water quality and quantity impacts to the streams from various areas of the watershed. Water quantity measurements will help develop trendlines that show how streams respond to precipitation and how this is changing over time as more development occurs. Water quality measurements will also help develop trendlines that show how water quality is responding to development and which areas of the watershed need more attention.

Recommendation:

- 1) Sample nine tributaries under dry weather conditions.

Locations:

02-WCH	12-PEN	09T-PEN
01-XWB	01-MUD	01-WCH
09-PEN	09-XPB	01-BFB

Dry Weather Sampling Schedule:

February	August
March	September
April	October
July	



Sampling Parameters:

All samples should be analyzed for:

E. coli	pH
Ammonia-N	temperature
TKN	DO
Total Phosphorus	conductivity
TSS	

2) Download tributary elevation data collected by the data loggers about every six weeks. This allows for inspection of the data loggers on a frequent basis to ensure they are operating properly and to allow for corrections as needed without losing large batches of data.

Actions:

- 1) Sample water quality in tributaries throughout the year under dry weather conditions.
- 2) Download tributary elevation data from data loggers about every six weeks and convert to flow data.
- 3) Add the sampling results to the water quality database.
- 4) Evaluate long-term water quality trends to help determine the success of the Watershed Restoration Plan.

Objectives: Establish long-term trends of water quality data in the tributaries to help determine the success of the Watershed Restoration Plan.

Schedule: Refer to Table 6-1.

Partners: None

Capital Costs: This is an annual operating cost.

Annual O&M Costs: \$35,000 for outside consultant to perform monitoring program.

Associated Recommendations: 1A Maintain Watershed Website, 5 Evaluate Phosphorus in Groundwater, 6 Evaluate Sediment Accumulations, 7 Harris Pond Aeration

Measurement: Increasing water quality database and decreasing phosphorus concentration trends in tributary samples. Long term increase in baseflows as evidenced through the flow monitoring program.

8B. Pond Sampling

In-pond sampling is useful to monitor the ponds' response to pollutant loadings from the watershed and the effects of aeration on water quality at the intake. This information is useful to develop trendlines of the health



of the ponds and determine the impacts resulting from development and from the implementation of BMPs. The information can also be used for future modeling efforts to help calibrate loadings to the pond.

Recommendation: Perform in-pond sampling at five locations under dry weather conditions.

Locations:

08-PEN
07P-PEN
07F-PEN
06-PEN
04-PEN

Temperature and DO should be measured at ½ meter intervals throughout the water column to define where the pond stratifies. Ponds should be sampled at the top (three feet below the surface) and the bottom (three feet above the bottom).

Dry Weather Sampling Schedule:

End of March/Beginning of April
July
September/October

Sampling Parameters:

E. coli	pH
Nitrate-N	temperature
Ammonia-N	DO
TKN	conductivity
Total Phosphorus	turbidity
Chlorophyll-a	
TSS	

Actions:

- 1) Sample ponds during critical periods of the year.
- 2) Add the sampling results to the water quality database.
- 3) Evaluate long-term water quality trends to help determine the success of the Watershed Restoration Plan.

Objectives: Establish long-term trends of water quality data in the ponds to help determine the success of the Watershed Restoration Plan.

Schedule: Refer to Table 6-1.

Partners: NHDES, Watershed communities



Capital Costs: The system is already in place.

Annual O&M Costs: Yearly operational costs are not included since the system is already in place to improve the raw water quality entering the treatment plant and is covered in the ongoing operating budget.

Capital Costs: This is an annual operating cost.

Annual O&M Costs: Yearly operational costs are not included since the in-pond monitoring is performed as part of Pennichuck's routine operations.

Associated Recommendations: 1A Maintain Watershed Website, 5 Evaluate Phosphorus in Groundwater, 6 Evaluate Sediment Accumulations, 7 Harris Pond Aeration

Measurement: Increasing water quality database and decreasing phosphorus concentration trends in Harris Pond.

#9. Update Watershed Restoration Plan Model

As cited throughout this report, recent water quality data is showing a trend of decreasing phosphorus concentrations and loads in tributaries and ponds. Based on these decreasing trends, the model should be updated to reflect more recent water quality data and to adjust water quality and phosphorus reduction goals.

Recommendation: Update the watershed restoration plan model after 10 years of data has been collected. The update should begin in 2014 for completion by 2016. The results should be used to refine the water quality and phosphorus reduction goals.

Actions:

- 1) Update and calibrate SWMM model with new water quality data.
- 2) Update water quality goals based on modeling results.
- 3) Update watershed restoration plan with new modeling results, water quality goals, and reduction allocations among contributing sources. Modify or refine recommendations for watershed-specific actions to address the new goals.

Objectives: Adjust the model and restoration plan to reflect actual water quality conditions and to establish a plan to meet water quality goals to advance the protection of the water supply. A current plan also supports future funding of recommendations through NHDES.

Schedule: Refer to Table 6-1.



Partners: None

Capital Costs: \$65,000

Annual O&M Costs: None.

Associated Recommendations: 8 Continue Long-Term Monitoring Program.

6.3 Overall Plan Success Indicators

The success of the recommendations in achieving improvements to water quality must be measurable to ensure the plan is working and to make adjustments as needed to achieve the desired results. The following monitoring program and success indicators are proposed:

1. The long-term monitoring program outlined above will be used to assess improvements in water quality in the water supply ponds and their tributaries. As previously discussed, a significant decrease in phosphorus concentrations in Harris Pond is already evident based on the 2007 through 2011 data, compared to the 1995 through 2006 data on which the 2008 watershed restoration plan was based. This may be partially attributed to the operation of the aeration system, and stormwater improvements made in the watershed over the last several years under the NPDES Phase II MS4 permit and by Pennichuck Water Works.

The long-term monitoring program will continue to be used to assess long-term trendlines and the apparent decreasing trendlines in average in-pond concentrations. This will be the primary measurement to assess the program as it will reflect actual water quality improvements.

Based on these decreasing trends, CEI recommends that the model be updated and the water quality goal be adjusted after 10 years of water quality data has been collected.

2. The long-term tributary streamflow measurements outlined above will be used to assess changes in water quantity in the tributaries. Several recommendations focus on infiltration for both water quantity and quality reasons. The data will be used to assess long-term trendlines that will help in evaluating the impacts of increased infiltration from existing developments, as well as impacts from new developments (e.g., whether a greater emphasis on stormwater infiltration is required). If the data were to show that tributary base flows are decreasing, then this condition would



warrant evaluation of the causes (e.g., new development) and development of actions to maintain or restore flows.

3. An in-pond sediment depth measurement program will be developed and used to assess the sediment loadings into the pond from tributaries and stormwater. This will provide some information on the rate that sediment is entering the pond, with an anticipated decrease in sediment loadings as the recommendations are implemented.
4. The amount of sediment removed from catch basin cleaning, street sweeping and BMP maintenance should be tracked by the entity performing the activities. This will allow for prioritization of areas for more frequent cleaning to better use existing resources to achieve the greatest removal. Pennichuck should survey the watershed communities annually to document changes in existing practices (e.g., road sanding, landscape maintenance, catch basin and BMP maintenance, street sweeping) for correlation with the restoration program and monitoring results.
5. Conduct an update of total impervious coverage at the time the model is updated, so that the effect of ongoing development can be included in the newly calibrated model.
6. The number of new and redevelopment projects constructed should be tracked by the watershed communities including the total and impervious acreage of the site, the “effective impervious coverage” (accounting for infiltration BMPs and disconnection practices), and the controls implemented at each site with estimated phosphorus removals. This information would provide a tally of anticipated loading reductions that can be compared with the in-pond monitoring program results to draw a correlation between structural stormwater practices improvements and water quality improvements.
7. Track and document all management actions performed by Pennichuck and others over the 10-year implementation period to allow correlation with noted water quality changes.



Table 6-1: 10-Year Watershed Restoration Program Capital Improvement Program Budget																					
Option	Capital Cost ¹	Annual O&M Cost ¹	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 1-10 Costs	Lbs Phosphorus Removed per Year	Lbs Phosphorus Removed Over 10 Years	\$/lb Phosphorus	Lbs Sediment Removed per Year	Lbs Sediment Removed Over 10 Years	\$/lb Sediment	Million Gallons (MG) Recharged per Year	MG Recharged Over 10 Years
1. Public Education																					
1A. Maintain Watershed Website	Complete	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$50,000								
1B. Develop & Print Door Hangers	\$5,000	\$5,000	\$5,000		\$5,000		\$5,000		\$5,000		\$5,000		\$25,000								
1C. Develop Targeted School Education Program																					
Option 1. All Watershed Communities (22 schools)	\$65,000	\$47,500	\$65,000	\$47,500	\$47,500	\$47,500	\$47,500	\$47,500	\$47,500	\$47,500	\$47,500	\$47,500	\$492,500								
Option 2. Nashua and Amherst (14 schools)	\$45,000	\$34,500	\$45,000	\$34,500	\$45,000	\$34,500	\$45,000	\$34,500	\$45,000	\$34,500	\$45,000	\$34,500	\$397,500								
Option 3. Schools in proximity to watershed (8 schools)	\$37,000	\$26,500	\$37,000	\$26,500	\$37,000	\$26,500	\$37,000	\$26,500	\$37,000	\$26,500	\$37,000	\$26,500	\$317,500								
Option 4. Nashua Pilot (5 schools)	\$29,000	\$22,500	\$29,000	\$22,500	\$29,000	\$22,500	\$29,000	\$22,500	\$29,000	\$22,500	\$29,000	\$22,500	\$257,500								
Option 5. Train Pennichuck Staff ²	\$51,000	\$46,000-\$51,000	\$51,000	\$46,000-\$51,000	\$46,000-\$51,000	\$46,000-\$51,000	\$46,000-\$51,000	\$46,000-\$51,000	\$46,000-\$51,000	\$46,000-\$51,000	\$46,000-\$51,000	\$46,000-\$51,000	\$51,000								
1D. Roof Leader Disconnection Pilot Program ³	\$19,000	\$5,000	\$19,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$64,000							11.5	115
Total ⁴	\$89,000	\$62,500	\$94,000	\$57,500	\$62,500	\$57,500	\$62,500	\$57,500	\$62,500	\$57,500	\$62,500	\$57,500	\$631,500	285	2,846	\$222					
2. Develop Commercial/Industrial Maintenance Program																					
Perform Feasibility of Option 1 vs. Option 2	\$34,000		\$ 34,000										\$34,000								
Option 1. Maintenance by Pennichuck ⁵																					
Purchase Street Sweeper for Prioritized Operations 2-6x/year	\$200,000	\$70,000	\$200,000	\$70,000	\$70,000	\$70,000	\$70,000	\$70,000	\$70,000	\$70,000	\$70,000	\$70,000	\$830,000								
Purchase Vac Truck for Prioritized Cleanouts in Private Areas	\$120,000	\$70,000	\$120,000	\$70,000	\$70,000	\$70,000	\$70,000	\$70,000	\$70,000	\$70,000	\$70,000	\$70,000	\$750,000								
Option 1. Total	\$320,000		\$320,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$1,580,000								
Option 2. Maintenance Program through Vendors	\$21,500	\$10,000	\$21,500			\$10,000			\$10,000			\$10,000	\$51,500								
Removal													\$0								
Parking Lot Sweeping 2-6x/year (assumes 2,378 acres swept)													\$0	96	959		24,814	248,144			
Catch Basin Cleanouts for Commercial/Industrial													\$0	135	1,353		42,719	427,192			
Total ⁴	\$354,000	\$140,000	\$354,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$1,614,000	231	2,312	\$698	67,534	675,336	\$1.87		

Table 6-1: 10-Year Watershed Restoration Program Capital Improvement Program Budget																					
Option	Capital Cost ¹	Annual O&M Cost ¹	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 1-10 Costs	Lbs Phosphorus Removed per Year	Lbs Phosphorus Removed Over 10 Years	\$/lb Phosphorus	Lbs Sediment Removed per Year	Lbs Sediment Removed Over 10 Years	\$/lb Sediment	Million Gallons (MG) Recharged per Year	MG Recharged Over 10 Years
3. Retrofit Detention Basins & BMPs																					
Contact Site Owners & Preliminary Design of One Site	\$26,000		\$26,000																		
Design & Construct BMPs for One Site Every Other Year ⁶	\$2,500,000			\$500,000		\$500,000		\$500,000		\$500,000		\$500,000	\$2,500,000								
Blackstone Apartment Complex Wet Pond & Amherst Park Stream Channel														11	111	\$ 4,109	33,533	335,334	\$ 1.36		
Somerset Plaza Swale														9	94	\$ 4,566	29,689	296,893	\$ 1.44	8.8	88.5
Crowne Plaza Wet Pond & Swale														19	190	\$ 2,349	13,582	135,817	\$ 3.28	8.4	83.8
PC Connection Wet Pond														15	153	\$ 9,307	42,367	423,675	\$ 1.24	9.1	90.9
Abandoned Saturn Dealership Swale														2	25	\$ 8,004	6,578	65,779	\$ 3.04	1.3	13.4
Post Office Detention Basin														2	16	\$ 2,035	15,317	153,172	\$ 0.21		
Northwest Blvd/RR-X-ing Wetland Polishing Pond & Swale														2	24	\$ 3,868	7,553	75,533	\$ 1.21	0.3	3.4
Ford Dealership Swale & Detention Basin														6	55	\$ 3,111	22,610	226,100	\$ 0.76		
White Oak Drive Residential Detention Basin 1 & 2														5	46	\$ 930	18,774	187,737	\$ 0.23	1.7	17.5
Kessler Farms Detention Basin														4	38	\$ 4,592	14,712	147,122	\$ 1.19		
Annual Maintenance		\$1,000 per BMP per year				\$1,000	\$1,000	\$2,000	\$2,000	\$3,000	\$3,000	\$4,000	\$16,000								
Total ³	\$2,526,000	\$4,000	\$26,000	\$500,000	\$0	\$501,000	\$1,000	\$502,000	\$2,000	\$503,000	\$3,000	\$504,000	\$2,542,000	75	752		238,250	2,382,496		30	297
4. Encourage Local Adoption of State Stormwater Standards																					
Coordinate with Watershed Communities ⁷	In Progress	\$7,200	\$7,200	\$7,200	\$7,200	\$7,200	\$7,200	\$7,200	\$7,200	\$7,200	\$7,200	\$7,200	\$72,000								
Removal																					
Impacts on Redevelopment Sites ⁸														685	6,845		117,429	1,174,287		268	2,682
Impacts on New Development ⁹														252	2,515		52,869	528,688		183	1,827
Total ⁴	\$0	\$7,200	\$7,200	\$7,200	\$7,200	\$7,200	\$7,200	\$7,200	\$7,200	\$7,200	\$7,200	\$7,200	\$72,000	936	9,361	\$8	170,297	1,702,974	\$0.04	451	4,509
5. Evaluate Phosphorus in Groundwater																					
Piezometer Installation and Monitoring	\$17,700		\$17,700										\$17,700								
Annual Monitoring and Report		\$4,700		\$4,700	\$4,700	\$4,700	\$4,700	\$4,700	\$4,700	\$4,700	\$4,700	\$4,700	\$42,300								
Total ⁴	\$17,700	\$4,700	\$17,700	\$4,700	\$4,700	\$4,700	\$4,700	\$4,700	\$4,700	\$4,700	\$4,700	\$4,700	\$60,000								
6. Evaluate Sediment Accumulations																					
Identify & Estimate Expected Sediment Loadings	\$6,800		\$6,800										\$6,800								
Collect Sediment Cores Samples, Install Gages & Equipment for Long-Term Measurement	\$33,100		\$33,100										\$33,100								
Annual Sediment Measurement & Report		\$18,000		\$18,000	\$18,000	\$18,000	\$18,000	\$18,000	\$18,000	\$18,000	\$18,000	\$18,000	\$162,000								
Total ⁴	\$39,900	\$18,000	\$39,900	\$18,000	\$18,000	\$18,000	\$18,000	\$18,000	\$18,000	\$18,000	\$18,000	\$18,000	\$201,900								
7. Harris Pond Aeration ¹⁰														696	6,960						

Table 6-1: 10-Year Watershed Restoration Program Capital Improvement Program Budget																					
Option	Capital Cost ¹	Annual O&M Cost ¹	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 1-10 Costs	Lbs Phosphorus Removed per Year	Lbs Phosphorus Removed Over 10 Years	\$/lb Phosphorus	Lbs Sediment Removed per Year	Lbs Sediment Removed Over 10 Years	\$/lb Sediment	Million Gallons (MG) Recharged per Year	MG Recharged Over 10 Years
8. Continue Long-Term Monitoring Program																---					
Ongoing Monitoring		\$35,000	\$35,000	\$35,000	\$35,000	\$35,000	\$35,000	\$35,000	\$35,000	\$35,000	\$35,000	\$35,000	\$350,000								
9. Update Watershed Restoration Plan Model																---					
Update Model	\$65,000			\$65,000									\$65,000								
Total for All Recommendations ⁴	\$3,091,600	\$271,400	\$573,800	\$827,400	\$267,400	\$763,400	\$268,400	\$764,400	\$269,400	\$765,400	\$270,400	\$766,400	\$5,536,400	2,223	22,231	\$249.04					
Capital Costs			\$526,600	\$565,000	\$0	\$500,000	\$0	\$500,000	\$0	\$500,000	\$0	\$500,000	\$3,091,600								
Annual O&M Costs			\$47,200	\$262,400	\$267,400	\$263,400	\$268,400	\$264,400	\$269,400	\$265,400	\$270,400	\$266,400	\$2,444,800								
Completed Since 2008 Watershed Restoration Plan																					
Tinker Road Detention Basin Retrofit														68			140,277	1,402,770			
Total Removal - Completed & Recommended ¹¹														2,291							
Removal Goal														2,258							
Notes																					
¹ Unless, otherwise stated, all costs represent the cost for a consultant to perform the work and do not include costs for Pennichuck staff to administer/coordinate/perform the work.																					
² Training Pennichuck staff includes costs for consultant to prepare materials and train staff and \$40,000 for new Pennichuck staff member to perform public education tasks. New staff member could be placed in charge of all public relations activities.																					
³ Recharge assumes half of the estimated 2,264 high density residential properties in Amherst, Merrimack and Nashua will be disconnected.																					
⁴ Some recommendations include multiple options, with varying costs. In these cases, the most expensive option is carried in the total cost.																					
⁵ Annual operating costs include operator labor, gas, vehicle maintenance and sediment disposal.																					
⁶ Annual budget allowance based on the highest design and construction costs for the top 10 BMP sites. This allows flexibility in selecting sites from year to year based on owner participation, funding, etc. Costs per pounds of pollutant removal are based on estimated costs for each BMP as included in Appendix H.																					
⁷ Includes annual budget to follow-up with watershed communities on progress of incorporating and enforcing AoT regulations at the local level.																					
⁸ Assumes 25 sites redeveloped per year; average parcel size is 3.73 acres; 0.5 inch design storm captured for recharge (the standard requires 1" recharge - 0.5" was used to account to allow a factor of safety for parcels that may have tight soils, high groundwater or other restrictions) includes annual budget to follow-up with watershed communities on progress of incorporating and enforcing AoT regulations at the local level.																					
⁹ Removals are for incorporation of regulatory changes on all new development to achieve buildout, including the following additional impervious areas: 80 acres commercial, 39 acres high density residential, 52 acres industrial, 324 acres low density residential.																					
¹⁰ The costs of aeration and in-pond sampling are covered under other Pennichuck initiatives.																					
¹¹ The phosphorus and sediment removals include reductions associated with all recommended BMPs, however, not all of these recommendations are scheduled to occur over the 10-year implementation period. Specifically, Recommendation 3 - Retrofit Detention Basins & BMPs, is scheduled to occur over a 20 year period, however, the removals associated with all BMPs are provided. Likewise, Recommendation 4 - Encourage Local Adoption of State Stormwater Standards, assumes redevelopment of 25 sites per year. Actual redevelopment will vary with the real-estate market and it may take longer than 10 years to achieve these removals.																					

Appendix A

Precipitation Data File

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1995	06	03	0.090
South_Nash_Concord	1995	06	04	0.140
South_Nash_Concord	1995	06	07	0.170
South_Nash_Concord	1995	06	08	0.070
South_Nash_Concord	1995	06	11	0.200
South_Nash_Concord	1995	06	12	0.240
South_Nash_Concord	1995	06	14	0.240
South_Nash_Concord	1995	06	15	0.120
South_Nash_Concord	1995	06	25	0.090
South_Nash_Concord	1995	07	01	0.020
South_Nash_Concord	1995	07	08	0.130
South_Nash_Concord	1995	07	11	0.070
South_Nash_Concord	1995	07	15	0.220
South_Nash_Concord	1995	07	17	0.980
South_Nash_Concord	1995	07	18	0.040
South_Nash_Concord	1995	07	23	0.020
South_Nash_Concord	1995	07	24	0.050
South_Nash_Concord	1995	07	26	1.450
South_Nash_Concord	1995	07	28	0.900
South_Nash_Concord	1995	07	29	0.130
South_Nash_Concord	1995	08	02	0.530
South_Nash_Concord	1995	08	03	0.590
South_Nash_Concord	1995	08	04	0.490
South_Nash_Concord	1995	08	05	0.150
South_Nash_Concord	1995	08	06	0.540
South_Nash_Concord	1995	08	12	0.010
South_Nash_Concord	1995	08	27	0.110
South_Nash_Concord	1995	09	07	0.100
South_Nash_Concord	1995	09	09	0.070
South_Nash_Concord	1995	09	13	0.050
South_Nash_Concord	1995	09	14	0.110
South_Nash_Concord	1995	09	17	1.130
South_Nash_Concord	1995	09	22	0.890
South_Nash_Concord	1995	09	25	0.010
South_Nash_Concord	1995	09	26	0.340
South_Nash_Concord	1995	10	04	0.310
South_Nash_Concord	1995	10	05	0.510
South_Nash_Concord	1995	10	06	1.170
South_Nash_Concord	1995	10	07	0.030
South_Nash_Concord	1995	10	14	0.830
South_Nash_Concord	1995	10	15	0.550
South_Nash_Concord	1995	10	16	0.010
South_Nash_Concord	1995	10	21	1.710
South_Nash_Concord	1995	10	28	2.190
South_Nash_Concord	1995	11	01	0.140
South_Nash_Concord	1995	11	02	0.990
South_Nash_Concord	1995	11	07	0.700
South_Nash_Concord	1995	11	08	0.040
South_Nash_Concord	1995	11	09	0.050
South_Nash_Concord	1995	11	11	0.030
South_Nash_Concord	1995	11	12	1.580
South_Nash_Concord	1995	11	13	0.080
South_Nash_Concord	1995	11	14	0.860
South_Nash_Concord	1995	11	15	0.550
South_Nash_Concord	1995	11	18	0.050

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1995	11	19	0.300
South_Nash_Concord	1995	11	20	0.020
South_Nash_Concord	1995	11	29	0.190
South_Nash_Concord	1995	12	01	0.180
South_Nash_Concord	1995	12	02	0.020
South_Nash_Concord	1995	12	03	0.050
South_Nash_Concord	1995	12	04	0.010
South_Nash_Concord	1995	12	06	0.250
South_Nash_Concord	1995	12	09	0.450
South_Nash_Concord	1995	12	10	0.010
South_Nash_Concord	1995	12	14	0.250
South_Nash_Concord	1995	12	15	0.070
South_Nash_Concord	1995	12	16	0.280
South_Nash_Concord	1995	12	17	0.050
South_Nash_Concord	1995	12	19	0.090
South_Nash_Concord	1995	12	20	0.180
South_Nash_Concord	1995	12	21	0.020
South_Nash_Concord	1995	12	24	0.040
South_Nash_Concord	1996	01	02	0.090
South_Nash_Concord	1996	01	03	0.410
South_Nash_Concord	1996	01	04	0.020
South_Nash_Concord	1996	01	08	0.080
South_Nash_Concord	1996	01	10	0.140
South_Nash_Concord	1996	01	12	0.360
South_Nash_Concord	1996	01	13	0.010
South_Nash_Concord	1996	01	16	0.010
South_Nash_Concord	1996	01	19	1.170
South_Nash_Concord	1996	01	21	0.040
South_Nash_Concord	1996	01	24	0.710
South_Nash_Concord	1996	01	27	1.700
South_Nash_Concord	1996	01	29	0.110
South_Nash_Concord	1996	01	30	0.020
South_Nash_Concord	1996	02	03	0.080
South_Nash_Concord	1996	02	08	0.060
South_Nash_Concord	1996	02	09	0.010
South_Nash_Concord	1996	02	11	0.040
South_Nash_Concord	1996	02	14	0.110
South_Nash_Concord	1996	02	15	0.010
South_Nash_Concord	1996	02	16	0.250
South_Nash_Concord	1996	02	17	0.030
South_Nash_Concord	1996	02	20	0.100
South_Nash_Concord	1996	02	21	1.400
South_Nash_Concord	1996	02	22	0.210
South_Nash_Concord	1996	02	24	0.270
South_Nash_Concord	1996	02	28	0.010
South_Nash_Concord	1996	03	02	0.300
South_Nash_Concord	1996	03	03	0.010
South_Nash_Concord	1996	03	05	0.340
South_Nash_Concord	1996	03	06	0.010
South_Nash_Concord	1996	03	07	0.340
South_Nash_Concord	1996	03	08	0.060
South_Nash_Concord	1996	03	15	0.060
South_Nash_Concord	1996	03	20	0.340
South_Nash_Concord	1996	03	21	0.070
South_Nash_Concord	1996	04	02	0.380

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1996	04	07	0.250
South_Nash_Concord	1996	04	08	0.230
South_Nash_Concord	1996	04	09	0.150
South_Nash_Concord	1996	04	10	0.290
South_Nash_Concord	1996	04	13	0.170
South_Nash_Concord	1996	04	14	0.430
South_Nash_Concord	1996	04	16	2.400
South_Nash_Concord	1996	04	22	0.410
South_Nash_Concord	1996	04	23	0.380
South_Nash_Concord	1996	04	26	0.080
South_Nash_Concord	1996	04	27	0.020
South_Nash_Concord	1996	04	29	0.500
South_Nash_Concord	1996	04	30	0.280
South_Nash_Concord	1996	05	01	0.290
South_Nash_Concord	1996	05	03	0.140
South_Nash_Concord	1996	05	04	0.310
South_Nash_Concord	1996	05	06	0.210
South_Nash_Concord	1996	05	10	0.710
South_Nash_Concord	1996	05	11	0.890
South_Nash_Concord	1996	05	12	0.360
South_Nash_Concord	1996	05	16	0.370
South_Nash_Concord	1996	05	17	0.020
South_Nash_Concord	1996	05	18	0.270
South_Nash_Concord	1996	05	19	0.090
South_Nash_Concord	1996	05	24	0.010
South_Nash_Concord	1996	05	29	0.290
South_Nash_Concord	1996	05	30	0.710
South_Nash_Concord	1996	06	03	0.440
South_Nash_Concord	1996	06	04	0.090
South_Nash_Concord	1996	06	07	0.360
South_Nash_Concord	1996	06	08	0.130
South_Nash_Concord	1996	06	09	0.030
South_Nash_Concord	1996	06	10	0.160
South_Nash_Concord	1996	06	13	0.590
South_Nash_Concord	1996	06	14	0.310
South_Nash_Concord	1996	06	15	0.010
South_Nash_Concord	1996	06	20	0.030
South_Nash_Concord	1996	06	21	0.200
South_Nash_Concord	1996	06	22	0.270
South_Nash_Concord	1996	06	25	0.030
South_Nash_Concord	1996	06	27	0.190
South_Nash_Concord	1996	06	30	0.310
South_Nash_Concord	1996	07	04	0.220
South_Nash_Concord	1996	07	08	0.030
South_Nash_Concord	1996	07	09	0.230
South_Nash_Concord	1996	07	13	2.200
South_Nash_Concord	1996	07	14	0.690
South_Nash_Concord	1996	07	15	0.200
South_Nash_Concord	1996	07	16	0.090
South_Nash_Concord	1996	07	19	0.100
South_Nash_Concord	1996	07	20	0.020
South_Nash_Concord	1996	07	23	0.100
South_Nash_Concord	1996	07	26	0.240
South_Nash_Concord	1996	07	31	0.020
South_Nash_Concord	1996	08	21	0.020

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1996	09	02	0.210
South_Nash_Concord	1996	09	07	0.130
South_Nash_Concord	1996	09	08	0.110
South_Nash_Concord	1996	09	10	0.050
South_Nash_Concord	1996	09	16	0.180
South_Nash_Concord	1996	09	17	0.370
South_Nash_Concord	1996	09	18	0.360
South_Nash_Concord	1996	09	22	0.510
South_Nash_Concord	1996	09	23	0.150
South_Nash_Concord	1996	09	24	0.140
South_Nash_Concord	1996	09	25	0.140
South_Nash_Concord	1996	09	28	0.160
South_Nash_Concord	1996	09	29	0.300
South_Nash_Concord	1996	10	02	0.050
South_Nash_Concord	1996	10	08	0.410
South_Nash_Concord	1996	10	09	0.850
South_Nash_Concord	1996	10	10	0.180
South_Nash_Concord	1996	10	14	0.050
South_Nash_Concord	1996	10	16	0.030
South_Nash_Concord	1996	10	20	3.190
South_Nash_Concord	1996	10	21	2.480
South_Nash_Concord	1996	10	23	0.050
South_Nash_Concord	1996	10	24	0.120
South_Nash_Concord	1996	10	28	0.140
South_Nash_Concord	1996	10	30	0.090
South_Nash_Concord	1996	11	07	0.130
South_Nash_Concord	1996	11	08	0.040
South_Nash_Concord	1996	11	09	0.520
South_Nash_Concord	1996	11	19	0.030
South_Nash_Concord	1996	11	25	0.190
South_Nash_Concord	1996	11	26	0.950
South_Nash_Concord	1996	12	01	0.320
South_Nash_Concord	1996	12	02	0.990
South_Nash_Concord	1996	12	06	0.180
South_Nash_Concord	1996	12	07	0.550
South_Nash_Concord	1996	12	08	0.780
South_Nash_Concord	1996	12	12	0.350
South_Nash_Concord	1996	12	14	0.110
South_Nash_Concord	1996	12	15	0.020
South_Nash_Concord	1996	12	17	0.800
South_Nash_Concord	1996	12	19	0.360
South_Nash_Concord	1996	12	23	0.040
South_Nash_Concord	1996	12	24	0.610
South_Nash_Concord	1996	12	25	0.050
South_Nash_Concord	1996	12	28	0.130
South_Nash_Concord	1996	12	29	0.280
South_Nash_Concord	1997	01	02	0.030
South_Nash_Concord	1997	01	03	0.090
South_Nash_Concord	1997	01	04	0.010
South_Nash_Concord	1997	01	05	0.200
South_Nash_Concord	1997	01	09	0.070
South_Nash_Concord	1997	01	10	0.450
South_Nash_Concord	1997	01	16	0.680
South_Nash_Concord	1997	01	24	0.260
South_Nash_Concord	1997	01	25	0.600

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1997	01	27	0.110
South_Nash_Concord	1997	01	28	0.580
South_Nash_Concord	1997	01	31	0.090
South_Nash_Concord	1997	02	01	0.030
South_Nash_Concord	1997	02	03	0.200
South_Nash_Concord	1997	02	04	0.080
South_Nash_Concord	1997	02	05	0.950
South_Nash_Concord	1997	02	12	0.010
South_Nash_Concord	1997	02	14	0.380
South_Nash_Concord	1997	02	16	0.020
South_Nash_Concord	1997	02	17	0.010
South_Nash_Concord	1997	02	21	0.050
South_Nash_Concord	1997	02	27	0.410
South_Nash_Concord	1997	03	02	0.020
South_Nash_Concord	1997	03	04	0.010
South_Nash_Concord	1997	03	05	0.170
South_Nash_Concord	1997	03	06	0.650
South_Nash_Concord	1997	03	08	0.150
South_Nash_Concord	1997	03	10	0.200
South_Nash_Concord	1997	03	11	0.100
South_Nash_Concord	1997	03	14	0.910
South_Nash_Concord	1997	03	15	0.010
South_Nash_Concord	1997	03	20	0.100
South_Nash_Concord	1997	03	21	0.060
South_Nash_Concord	1997	03	22	0.220
South_Nash_Concord	1997	03	25	0.250
South_Nash_Concord	1997	03	26	0.470
South_Nash_Concord	1997	03	29	0.240
South_Nash_Concord	1997	03	31	0.450
South_Nash_Concord	1997	04	01	0.040
South_Nash_Concord	1997	04	06	0.110
South_Nash_Concord	1997	04	12	0.290
South_Nash_Concord	1997	04	13	0.060
South_Nash_Concord	1997	04	17	0.110
South_Nash_Concord	1997	04	18	1.270
South_Nash_Concord	1997	04	19	0.600
South_Nash_Concord	1997	04	25	0.010
South_Nash_Concord	1997	04	28	0.800
South_Nash_Concord	1997	05	01	0.060
South_Nash_Concord	1997	05	03	0.370
South_Nash_Concord	1997	05	06	0.340
South_Nash_Concord	1997	05	09	0.070
South_Nash_Concord	1997	05	10	0.130
South_Nash_Concord	1997	05	13	0.050
South_Nash_Concord	1997	05	14	0.010
South_Nash_Concord	1997	05	15	0.050
South_Nash_Concord	1997	05	16	0.110
South_Nash_Concord	1997	05	17	0.010
South_Nash_Concord	1997	05	19	0.640
South_Nash_Concord	1997	05	20	0.230
South_Nash_Concord	1997	05	21	0.030
South_Nash_Concord	1997	05	25	0.160
South_Nash_Concord	1997	06	01	0.080
South_Nash_Concord	1997	06	13	0.010
South_Nash_Concord	1997	06	18	0.530

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1997	06	19	0.080
South_Nash_Concord	1997	07	03	1.200
South_Nash_Concord	1997	07	04	0.010
South_Nash_Concord	1997	07	08	0.240
South_Nash_Concord	1997	07	09	1.550
South_Nash_Concord	1997	07	10	0.030
South_Nash_Concord	1997	07	13	0.010
South_Nash_Concord	1997	07	14	0.100
South_Nash_Concord	1997	07	15	0.460
South_Nash_Concord	1997	07	16	0.020
South_Nash_Concord	1997	07	17	0.050
South_Nash_Concord	1997	07	18	0.110
South_Nash_Concord	1997	07	21	0.030
South_Nash_Concord	1997	08	03	0.030
South_Nash_Concord	1997	08	04	0.030
South_Nash_Concord	1997	08	05	0.110
South_Nash_Concord	1997	08	11	0.110
South_Nash_Concord	1997	08	12	0.010
South_Nash_Concord	1997	08	13	0.770
South_Nash_Concord	1997	08	15	0.010
South_Nash_Concord	1997	08	18	0.040
South_Nash_Concord	1997	08	21	0.820
South_Nash_Concord	1997	08	22	0.120
South_Nash_Concord	1997	08	23	0.020
South_Nash_Concord	1997	08	27	0.350
South_Nash_Concord	1997	08	28	0.100
South_Nash_Concord	1997	08	29	1.170
South_Nash_Concord	1997	09	01	0.030
South_Nash_Concord	1997	09	03	0.080
South_Nash_Concord	1997	09	06	0.060
South_Nash_Concord	1997	09	07	0.460
South_Nash_Concord	1997	09	08	0.060
South_Nash_Concord	1997	09	11	0.400
South_Nash_Concord	1997	09	12	0.160
South_Nash_Concord	1997	09	18	0.020
South_Nash_Concord	1997	09	20	0.060
South_Nash_Concord	1997	09	23	0.010
South_Nash_Concord	1997	09	29	0.340
South_Nash_Concord	1997	10	03	0.150
South_Nash_Concord	1997	10	05	0.370
South_Nash_Concord	1997	10	09	0.010
South_Nash_Concord	1997	10	10	0.010
South_Nash_Concord	1997	10	15	0.010
South_Nash_Concord	1997	10	16	0.090
South_Nash_Concord	1997	10	25	0.320
South_Nash_Concord	1997	10	27	0.480
South_Nash_Concord	1997	11	01	1.850
South_Nash_Concord	1997	11	02	0.410
South_Nash_Concord	1997	11	04	0.470
South_Nash_Concord	1997	11	08	0.050
South_Nash_Concord	1997	11	09	0.870
South_Nash_Concord	1997	11	10	0.010
South_Nash_Concord	1997	11	14	0.480
South_Nash_Concord	1997	11	15	0.010
South_Nash_Concord	1997	11	16	0.120

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1997	11	22	0.650
South_Nash_Concord	1997	11	23	0.030
South_Nash_Concord	1997	11	26	0.110
South_Nash_Concord	1997	11	27	0.020
South_Nash_Concord	1997	11	28	0.060
South_Nash_Concord	1997	11	30	0.470
South_Nash_Concord	1997	12	01	0.240
South_Nash_Concord	1997	12	04	0.040
South_Nash_Concord	1997	12	14	0.010
South_Nash_Concord	1997	12	23	0.410
South_Nash_Concord	1997	12	25	0.570
South_Nash_Concord	1997	12	29	0.030
South_Nash_Concord	1997	12	30	0.170
South_Nash_Concord	1998	01	04	0.060
South_Nash_Concord	1998	01	05	0.010
South_Nash_Concord	1998	01	06	0.070
South_Nash_Concord	1998	01	07	0.350
South_Nash_Concord	1998	01	08	1.020
South_Nash_Concord	1998	01	09	0.090
South_Nash_Concord	1998	01	13	0.110
South_Nash_Concord	1998	01	15	0.060
South_Nash_Concord	1998	01	16	0.170
South_Nash_Concord	1998	01	18	0.100
South_Nash_Concord	1998	01	20	0.030
South_Nash_Concord	1998	01	23	0.710
South_Nash_Concord	1998	01	24	0.470
South_Nash_Concord	1998	01	30	0.080
South_Nash_Concord	1998	02	12	0.270
South_Nash_Concord	1998	02	18	0.910
South_Nash_Concord	1998	02	19	0.250
South_Nash_Concord	1998	02	24	0.490
South_Nash_Concord	1998	02	25	0.260
South_Nash_Concord	1998	03	01	0.010
South_Nash_Concord	1998	03	05	0.010
South_Nash_Concord	1998	03	07	0.020
South_Nash_Concord	1998	03	08	0.200
South_Nash_Concord	1998	03	09	1.870
South_Nash_Concord	1998	03	10	0.010
South_Nash_Concord	1998	03	14	0.100
South_Nash_Concord	1998	03	18	0.030
South_Nash_Concord	1998	03	19	0.610
South_Nash_Concord	1998	03	21	0.060
South_Nash_Concord	1998	03	22	0.500
South_Nash_Concord	1998	03	23	0.010
South_Nash_Concord	1998	04	01	0.200
South_Nash_Concord	1998	04	02	0.150
South_Nash_Concord	1998	04	03	0.020
South_Nash_Concord	1998	04	16	0.200
South_Nash_Concord	1998	04	17	0.100
South_Nash_Concord	1998	04	19	0.480
South_Nash_Concord	1998	04	20	0.500
South_Nash_Concord	1998	04	23	0.320
South_Nash_Concord	1998	04	24	0.020
South_Nash_Concord	1998	04	25	0.150
South_Nash_Concord	1998	05	02	0.260

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1998	05	03	0.020
South_Nash_Concord	1998	05	04	0.160
South_Nash_Concord	1998	05	05	0.150
South_Nash_Concord	1998	05	06	0.930
South_Nash_Concord	1998	05	07	0.230
South_Nash_Concord	1998	05	10	0.180
South_Nash_Concord	1998	05	11	0.050
South_Nash_Concord	1998	05	17	0.140
South_Nash_Concord	1998	05	20	0.020
South_Nash_Concord	1998	05	21	0.020
South_Nash_Concord	1998	05	31	1.790
South_Nash_Concord	1998	06	01	0.100
South_Nash_Concord	1998	06	02	0.130
South_Nash_Concord	1998	06	03	0.030
South_Nash_Concord	1998	06	07	0.180
South_Nash_Concord	1998	06	08	0.470
South_Nash_Concord	1998	06	12	0.400
South_Nash_Concord	1998	06	13	2.340
South_Nash_Concord	1998	06	14	0.740
South_Nash_Concord	1998	06	15	0.460
South_Nash_Concord	1998	06	16	1.050
South_Nash_Concord	1998	06	17	0.820
South_Nash_Concord	1998	06	18	0.010
South_Nash_Concord	1998	06	19	0.250
South_Nash_Concord	1998	06	20	0.020
South_Nash_Concord	1998	06	21	0.010
South_Nash_Concord	1998	06	24	0.030
South_Nash_Concord	1998	06	25	0.310
South_Nash_Concord	1998	06	26	0.240
South_Nash_Concord	1998	06	27	0.210
South_Nash_Concord	1998	06	30	0.120
South_Nash_Concord	1998	07	01	0.670
South_Nash_Concord	1998	07	05	0.150
South_Nash_Concord	1998	07	20	0.460
South_Nash_Concord	1998	07	23	0.630
South_Nash_Concord	1998	08	06	0.260
South_Nash_Concord	1998	08	07	0.030
South_Nash_Concord	1998	08	11	0.370
South_Nash_Concord	1998	08	12	0.010
South_Nash_Concord	1998	08	17	0.170
South_Nash_Concord	1998	08	18	0.070
South_Nash_Concord	1998	08	21	0.010
South_Nash_Concord	1998	08	23	0.170
South_Nash_Concord	1998	08	24	0.140
South_Nash_Concord	1998	08	25	0.160
South_Nash_Concord	1998	08	31	0.020
South_Nash_Concord	1998	09	02	0.070
South_Nash_Concord	1998	09	07	0.260
South_Nash_Concord	1998	09	09	0.130
South_Nash_Concord	1998	09	15	0.340
South_Nash_Concord	1998	09	16	0.220
South_Nash_Concord	1998	09	22	0.370
South_Nash_Concord	1998	09	26	0.010
South_Nash_Concord	1998	09	27	0.240
South_Nash_Concord	1998	10	01	0.020

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1998	10	08	0.660
South_Nash_Concord	1998	10	09	0.160
South_Nash_Concord	1998	10	10	1.660
South_Nash_Concord	1998	10	11	0.210
South_Nash_Concord	1998	10	14	0.670
South_Nash_Concord	1998	10	15	0.020
South_Nash_Concord	1998	10	28	0.180
South_Nash_Concord	1998	11	11	0.560
South_Nash_Concord	1998	11	14	0.010
South_Nash_Concord	1998	11	15	0.070
South_Nash_Concord	1998	11	16	0.020
South_Nash_Concord	1998	11	17	0.120
South_Nash_Concord	1998	11	19	0.050
South_Nash_Concord	1998	11	20	0.160
South_Nash_Concord	1998	11	21	0.020
South_Nash_Concord	1998	11	24	0.010
South_Nash_Concord	1998	11	26	1.180
South_Nash_Concord	1998	12	08	0.210
South_Nash_Concord	1998	12	17	0.110
South_Nash_Concord	1998	12	19	0.040
South_Nash_Concord	1998	12	21	0.020
South_Nash_Concord	1998	12	22	0.270
South_Nash_Concord	1998	12	29	0.110
South_Nash_Concord	1998	12	30	0.090
South_Nash_Concord	1999	01	03	1.050
South_Nash_Concord	1999	01	08	0.250
South_Nash_Concord	1999	01	09	0.390
South_Nash_Concord	1999	01	12	0.090
South_Nash_Concord	1999	01	13	0.160
South_Nash_Concord	1999	01	14	0.230
South_Nash_Concord	1999	01	15	1.000
South_Nash_Concord	1999	01	18	0.850
South_Nash_Concord	1999	01	19	0.010
South_Nash_Concord	1999	01	22	0.080
South_Nash_Concord	1999	01	23	0.040
South_Nash_Concord	1999	01	24	0.510
South_Nash_Concord	1999	01	27	0.120
South_Nash_Concord	1999	01	28	0.180
South_Nash_Concord	1999	01	29	0.040
South_Nash_Concord	1999	02	02	0.940
South_Nash_Concord	1999	02	03	0.030
South_Nash_Concord	1999	02	04	0.180
South_Nash_Concord	1999	02	12	0.130
South_Nash_Concord	1999	02	17	0.130
South_Nash_Concord	1999	02	18	0.490
South_Nash_Concord	1999	02	19	0.010
South_Nash_Concord	1999	02	28	0.700
South_Nash_Concord	1999	03	01	0.440
South_Nash_Concord	1999	03	03	0.310
South_Nash_Concord	1999	03	04	0.230
South_Nash_Concord	1999	03	06	0.170
South_Nash_Concord	1999	03	07	0.030
South_Nash_Concord	1999	03	11	0.010
South_Nash_Concord	1999	03	12	0.030
South_Nash_Concord	1999	03	14	0.020

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1999	03	15	0.220
South_Nash_Concord	1999	03	21	0.120
South_Nash_Concord	1999	03	22	0.710
South_Nash_Concord	1999	03	24	0.010
South_Nash_Concord	1999	03	28	0.460
South_Nash_Concord	1999	04	03	0.020
South_Nash_Concord	1999	04	04	0.010
South_Nash_Concord	1999	04	07	0.010
South_Nash_Concord	1999	04	16	0.280
South_Nash_Concord	1999	04	17	0.200
South_Nash_Concord	1999	04	20	0.380
South_Nash_Concord	1999	04	23	0.030
South_Nash_Concord	1999	04	26	0.020
South_Nash_Concord	1999	05	04	0.220
South_Nash_Concord	1999	05	05	0.350
South_Nash_Concord	1999	05	06	0.060
South_Nash_Concord	1999	05	08	0.130
South_Nash_Concord	1999	05	09	0.030
South_Nash_Concord	1999	05	19	1.260
South_Nash_Concord	1999	05	20	0.080
South_Nash_Concord	1999	05	23	0.070
South_Nash_Concord	1999	05	24	0.490
South_Nash_Concord	1999	05	25	0.040
South_Nash_Concord	1999	05	26	0.060
South_Nash_Concord	1999	06	02	0.030
South_Nash_Concord	1999	06	08	0.050
South_Nash_Concord	1999	06	09	0.010
South_Nash_Concord	1999	06	14	0.030
South_Nash_Concord	1999	06	15	0.010
South_Nash_Concord	1999	06	17	0.090
South_Nash_Concord	1999	06	18	0.010
South_Nash_Concord	1999	06	21	0.750
South_Nash_Concord	1999	06	23	0.040
South_Nash_Concord	1999	06	25	0.040
South_Nash_Concord	1999	06	28	0.380
South_Nash_Concord	1999	06	29	0.500
South_Nash_Concord	1999	07	01	0.020
South_Nash_Concord	1999	07	02	0.830
South_Nash_Concord	1999	07	03	0.010
South_Nash_Concord	1999	07	04	0.030
South_Nash_Concord	1999	07	06	0.310
South_Nash_Concord	1999	07	08	0.070
South_Nash_Concord	1999	07	09	0.130
South_Nash_Concord	1999	07	19	0.880
South_Nash_Concord	1999	07	22	0.460
South_Nash_Concord	1999	07	24	0.730
South_Nash_Concord	1999	07	25	0.320
South_Nash_Concord	1999	07	26	0.410
South_Nash_Concord	1999	07	27	0.180
South_Nash_Concord	1999	07	29	0.010
South_Nash_Concord	1999	08	01	0.010
South_Nash_Concord	1999	08	05	0.050
South_Nash_Concord	1999	08	06	0.130
South_Nash_Concord	1999	08	08	0.610
South_Nash_Concord	1999	08	11	0.140

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1999	08	14	0.350
South_Nash_Concord	1999	08	15	0.190
South_Nash_Concord	1999	08	17	0.110
South_Nash_Concord	1999	08	21	0.690
South_Nash_Concord	1999	08	22	0.020
South_Nash_Concord	1999	08	27	1.110
South_Nash_Concord	1999	08	29	0.030
South_Nash_Concord	1999	09	06	0.550
South_Nash_Concord	1999	09	08	0.020
South_Nash_Concord	1999	09	10	2.690
South_Nash_Concord	1999	09	15	0.160
South_Nash_Concord	1999	09	16	1.900
South_Nash_Concord	1999	09	17	0.320
South_Nash_Concord	1999	09	21	0.780
South_Nash_Concord	1999	09	22	0.420
South_Nash_Concord	1999	09	23	0.140
South_Nash_Concord	1999	09	29	0.010
South_Nash_Concord	1999	09	30	0.710
South_Nash_Concord	1999	10	04	0.640
South_Nash_Concord	1999	10	09	0.130
South_Nash_Concord	1999	10	10	0.170
South_Nash_Concord	1999	10	14	0.160
South_Nash_Concord	1999	10	18	0.340
South_Nash_Concord	1999	10	20	0.470
South_Nash_Concord	1999	10	23	0.570
South_Nash_Concord	1999	11	02	0.360
South_Nash_Concord	1999	11	03	0.530
South_Nash_Concord	1999	11	10	0.340
South_Nash_Concord	1999	11	11	0.090
South_Nash_Concord	1999	11	12	0.080
South_Nash_Concord	1999	11	13	0.020
South_Nash_Concord	1999	11	14	0.130
South_Nash_Concord	1999	11	20	0.190
South_Nash_Concord	1999	11	23	0.010
South_Nash_Concord	1999	11	24	0.080
South_Nash_Concord	1999	11	25	0.030
South_Nash_Concord	1999	11	26	0.190
South_Nash_Concord	1999	11	27	0.610
South_Nash_Concord	1999	12	04	0.090
South_Nash_Concord	1999	12	06	0.250
South_Nash_Concord	1999	12	07	0.250
South_Nash_Concord	1999	12	10	0.070
South_Nash_Concord	1999	12	15	0.100
South_Nash_Concord	1999	12	16	0.050
South_Nash_Concord	1999	12	20	0.460
South_Nash_Concord	1999	12	21	0.080
South_Nash_Concord	2000	01	02	0.010
South_Nash_Concord	2000	01	03	0.110
South_Nash_Concord	2000	01	04	0.480
South_Nash_Concord	2000	01	05	0.010
South_Nash_Concord	2000	01	10	0.600
South_Nash_Concord	2000	01	11	0.070
South_Nash_Concord	2000	01	16	0.070
South_Nash_Concord	2000	01	20	0.020
South_Nash_Concord	2000	01	25	0.410

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2000	01	26	0.090
South_Nash_Concord	2000	01	31	0.310
South_Nash_Concord	2000	02	07	0.010
South_Nash_Concord	2000	02	11	0.130
South_Nash_Concord	2000	02	14	1.170
South_Nash_Concord	2000	02	16	0.010
South_Nash_Concord	2000	02	18	0.270
South_Nash_Concord	2000	02	19	0.180
South_Nash_Concord	2000	02	24	0.140
South_Nash_Concord	2000	02	25	0.730
South_Nash_Concord	2000	02	26	0.020
South_Nash_Concord	2000	02	28	0.160
South_Nash_Concord	2000	03	02	0.010
South_Nash_Concord	2000	03	09	0.120
South_Nash_Concord	2000	03	11	0.850
South_Nash_Concord	2000	03	12	0.360
South_Nash_Concord	2000	03	16	0.270
South_Nash_Concord	2000	03	17	0.400
South_Nash_Concord	2000	03	25	0.020
South_Nash_Concord	2000	03	26	0.030
South_Nash_Concord	2000	03	28	1.220
South_Nash_Concord	2000	03	29	0.060
South_Nash_Concord	2000	04	02	0.030
South_Nash_Concord	2000	04	03	0.350
South_Nash_Concord	2000	04	04	0.410
South_Nash_Concord	2000	04	08	0.010
South_Nash_Concord	2000	04	09	1.030
South_Nash_Concord	2000	04	11	0.090
South_Nash_Concord	2000	04	12	0.040
South_Nash_Concord	2000	04	19	0.050
South_Nash_Concord	2000	04	20	0.010
South_Nash_Concord	2000	04	21	1.060
South_Nash_Concord	2000	04	22	0.560
South_Nash_Concord	2000	04	23	0.480
South_Nash_Concord	2000	04	26	0.500
South_Nash_Concord	2000	04	27	0.080
South_Nash_Concord	2000	04	28	0.120
South_Nash_Concord	2000	05	02	0.090
South_Nash_Concord	2000	05	06	0.010
South_Nash_Concord	2000	05	08	0.010
South_Nash_Concord	2000	05	09	0.010
South_Nash_Concord	2000	05	10	0.780
South_Nash_Concord	2000	05	11	0.240
South_Nash_Concord	2000	05	13	0.140
South_Nash_Concord	2000	05	14	0.020
South_Nash_Concord	2000	05	18	0.450
South_Nash_Concord	2000	05	19	0.120
South_Nash_Concord	2000	05	20	0.010
South_Nash_Concord	2000	05	21	0.120
South_Nash_Concord	2000	05	23	0.020
South_Nash_Concord	2000	05	24	0.600
South_Nash_Concord	2000	05	25	0.210
South_Nash_Concord	2000	06	02	0.090
South_Nash_Concord	2000	06	06	0.690
South_Nash_Concord	2000	06	07	0.550

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2000	06	08	0.010
South_Nash_Concord	2000	06	09	0.020
South_Nash_Concord	2000	06	11	0.050
South_Nash_Concord	2000	06	12	0.400
South_Nash_Concord	2000	06	13	0.080
South_Nash_Concord	2000	06	14	0.030
South_Nash_Concord	2000	06	17	0.320
South_Nash_Concord	2000	06	18	0.140
South_Nash_Concord	2000	06	21	0.140
South_Nash_Concord	2000	06	22	0.220
South_Nash_Concord	2000	06	25	0.100
South_Nash_Concord	2000	06	26	0.020
South_Nash_Concord	2000	06	27	0.010
South_Nash_Concord	2000	06	29	0.260
South_Nash_Concord	2000	07	03	0.030
South_Nash_Concord	2000	07	04	0.020
South_Nash_Concord	2000	07	09	0.640
South_Nash_Concord	2000	07	10	0.080
South_Nash_Concord	2000	07	14	0.040
South_Nash_Concord	2000	07	15	0.010
South_Nash_Concord	2000	07	16	1.200
South_Nash_Concord	2000	07	17	0.070
South_Nash_Concord	2000	07	18	0.010
South_Nash_Concord	2000	07	21	0.030
South_Nash_Concord	2000	07	22	0.010
South_Nash_Concord	2000	07	26	0.270
South_Nash_Concord	2000	07	27	0.800
South_Nash_Concord	2000	07	30	0.590
South_Nash_Concord	2000	07	31	0.530
South_Nash_Concord	2000	08	01	0.020
South_Nash_Concord	2000	08	03	0.090
South_Nash_Concord	2000	08	06	0.180
South_Nash_Concord	2000	08	07	0.630
South_Nash_Concord	2000	08	09	0.020
South_Nash_Concord	2000	08	10	0.080
South_Nash_Concord	2000	08	14	0.460
South_Nash_Concord	2000	08	16	0.200
South_Nash_Concord	2000	08	18	0.060
South_Nash_Concord	2000	08	23	0.120
South_Nash_Concord	2000	09	02	0.120
South_Nash_Concord	2000	09	04	0.070
South_Nash_Concord	2000	09	13	0.590
South_Nash_Concord	2000	09	15	0.930
South_Nash_Concord	2000	09	19	0.680
South_Nash_Concord	2000	09	20	0.420
South_Nash_Concord	2000	09	23	0.550
South_Nash_Concord	2000	09	24	0.150
South_Nash_Concord	2000	09	26	0.030
South_Nash_Concord	2000	10	05	0.380
South_Nash_Concord	2000	10	06	0.670
South_Nash_Concord	2000	10	16	0.320
South_Nash_Concord	2000	10	18	0.580
South_Nash_Concord	2000	10	29	0.010
South_Nash_Concord	2000	10	30	0.290
South_Nash_Concord	2000	10	31	0.040

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2000	11	05	0.480
South_Nash_Concord	2000	11	06	0.010
South_Nash_Concord	2000	11	10	1.280
South_Nash_Concord	2000	11	11	0.190
South_Nash_Concord	2000	11	13	0.010
South_Nash_Concord	2000	11	14	0.580
South_Nash_Concord	2000	11	15	0.140
South_Nash_Concord	2000	11	26	0.660
South_Nash_Concord	2000	11	27	0.010
South_Nash_Concord	2000	11	29	0.010
South_Nash_Concord	2000	11	30	0.050
South_Nash_Concord	2000	12	12	0.220
South_Nash_Concord	2000	12	14	0.610
South_Nash_Concord	2000	12	16	0.180
South_Nash_Concord	2000	12	17	0.800
South_Nash_Concord	2000	12	19	0.020
South_Nash_Concord	2000	12	20	0.180
South_Nash_Concord	2000	12	30	0.280
South_Nash_Concord	2000	12	31	0.060
South_Nash_Concord	2001	01	05	0.070
South_Nash_Concord	2001	01	06	0.110
South_Nash_Concord	2001	01	08	0.040
South_Nash_Concord	2001	01	09	0.020
South_Nash_Concord	2001	01	15	0.060
South_Nash_Concord	2001	01	16	0.010
South_Nash_Concord	2001	01	19	0.110
South_Nash_Concord	2001	01	21	0.030
South_Nash_Concord	2001	01	30	0.530
South_Nash_Concord	2001	01	31	0.310
South_Nash_Concord	2001	02	05	0.500
South_Nash_Concord	2001	02	06	0.020
South_Nash_Concord	2001	02	09	0.270
South_Nash_Concord	2001	02	10	0.020
South_Nash_Concord	2001	02	14	0.110
South_Nash_Concord	2001	02	16	0.060
South_Nash_Concord	2001	02	22	0.010
South_Nash_Concord	2001	02	23	0.020
South_Nash_Concord	2001	02	25	0.510
South_Nash_Concord	2001	03	05	0.240
South_Nash_Concord	2001	03	06	0.420
South_Nash_Concord	2001	03	09	0.210
South_Nash_Concord	2001	03	10	0.090
South_Nash_Concord	2001	03	13	0.420
South_Nash_Concord	2001	03	18	0.010
South_Nash_Concord	2001	03	22	1.980
South_Nash_Concord	2001	03	23	0.100
South_Nash_Concord	2001	03	30	1.080
South_Nash_Concord	2001	04	06	0.070
South_Nash_Concord	2001	04	08	0.190
South_Nash_Concord	2001	04	09	0.040
South_Nash_Concord	2001	04	12	0.460
South_Nash_Concord	2001	04	21	0.020
South_Nash_Concord	2001	04	22	0.060
South_Nash_Concord	2001	05	05	0.070
South_Nash_Concord	2001	05	12	0.030

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2001	05	15	0.070
South_Nash_Concord	2001	05	16	0.020
South_Nash_Concord	2001	05	23	0.040
South_Nash_Concord	2001	05	24	0.060
South_Nash_Concord	2001	05	26	0.080
South_Nash_Concord	2001	05	27	1.310
South_Nash_Concord	2001	05	28	0.610
South_Nash_Concord	2001	05	30	0.040
South_Nash_Concord	2001	06	02	1.620
South_Nash_Concord	2001	06	03	0.600
South_Nash_Concord	2001	06	10	0.420
South_Nash_Concord	2001	06	11	1.090
South_Nash_Concord	2001	06	17	1.030
South_Nash_Concord	2001	06	20	0.430
South_Nash_Concord	2001	06	21	0.010
South_Nash_Concord	2001	06	23	0.340
South_Nash_Concord	2001	06	24	0.160
South_Nash_Concord	2001	06	30	0.030
South_Nash_Concord	2001	07	01	0.490
South_Nash_Concord	2001	07	05	0.240
South_Nash_Concord	2001	07	08	0.070
South_Nash_Concord	2001	07	09	0.390
South_Nash_Concord	2001	07	10	0.450
South_Nash_Concord	2001	07	11	0.070
South_Nash_Concord	2001	07	12	0.110
South_Nash_Concord	2001	07	14	0.040
South_Nash_Concord	2001	07	17	0.400
South_Nash_Concord	2001	07	26	1.030
South_Nash_Concord	2001	08	03	0.150
South_Nash_Concord	2001	08	12	0.230
South_Nash_Concord	2001	08	17	0.200
South_Nash_Concord	2001	08	20	0.050
South_Nash_Concord	2001	08	21	0.020
South_Nash_Concord	2001	08	24	0.030
South_Nash_Concord	2001	09	01	0.460
South_Nash_Concord	2001	09	04	0.160
South_Nash_Concord	2001	09	10	0.250
South_Nash_Concord	2001	09	14	0.280
South_Nash_Concord	2001	09	20	0.120
South_Nash_Concord	2001	09	21	0.620
South_Nash_Concord	2001	09	25	1.550
South_Nash_Concord	2001	09	28	0.070
South_Nash_Concord	2001	10	06	0.040
South_Nash_Concord	2001	10	14	0.050
South_Nash_Concord	2001	10	15	0.340
South_Nash_Concord	2001	10	16	0.190
South_Nash_Concord	2001	10	17	0.030
South_Nash_Concord	2001	10	24	0.100
South_Nash_Concord	2001	10	31	0.230
South_Nash_Concord	2001	11	01	0.050
South_Nash_Concord	2001	11	03	0.050
South_Nash_Concord	2001	11	05	0.150
South_Nash_Concord	2001	11	09	0.040
South_Nash_Concord	2001	11	14	0.010
South_Nash_Concord	2001	11	20	0.060

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2001	11	24	0.010
South_Nash_Concord	2001	11	25	0.160
South_Nash_Concord	2001	11	26	0.010
South_Nash_Concord	2001	11	28	0.010
South_Nash_Concord	2001	11	29	0.350
South_Nash_Concord	2001	11	30	0.200
South_Nash_Concord	2001	12	01	0.150
South_Nash_Concord	2001	12	05	0.020
South_Nash_Concord	2001	12	09	0.300
South_Nash_Concord	2001	12	13	0.070
South_Nash_Concord	2001	12	14	0.520
South_Nash_Concord	2001	12	15	0.100
South_Nash_Concord	2001	12	17	0.500
South_Nash_Concord	2001	12	18	0.180
South_Nash_Concord	2001	12	24	0.340
South_Nash_Concord	2002	01	06	0.020
South_Nash_Concord	2002	01	07	0.220
South_Nash_Concord	2002	01	11	0.050
South_Nash_Concord	2002	01	13	0.540
South_Nash_Concord	2002	01	15	0.020
South_Nash_Concord	2002	01	17	0.040
South_Nash_Concord	2002	01	19	0.080
South_Nash_Concord	2002	01	20	0.010
South_Nash_Concord	2002	01	21	0.120
South_Nash_Concord	2002	01	24	0.120
South_Nash_Concord	2002	01	29	0.030
South_Nash_Concord	2002	01	30	0.210
South_Nash_Concord	2002	01	31	0.380
South_Nash_Concord	2002	02	01	0.350
South_Nash_Concord	2002	02	10	0.380
South_Nash_Concord	2002	02	11	0.270
South_Nash_Concord	2002	02	17	0.100
South_Nash_Concord	2002	02	20	0.040
South_Nash_Concord	2002	02	21	0.320
South_Nash_Concord	2002	02	27	0.410
South_Nash_Concord	2002	03	02	0.010
South_Nash_Concord	2002	03	03	0.590
South_Nash_Concord	2002	03	10	0.370
South_Nash_Concord	2002	03	13	0.010
South_Nash_Concord	2002	03	16	0.040
South_Nash_Concord	2002	03	18	0.140
South_Nash_Concord	2002	03	19	0.040
South_Nash_Concord	2002	03	20	0.690
South_Nash_Concord	2002	03	24	0.050
South_Nash_Concord	2002	03	25	0.030
South_Nash_Concord	2002	03	26	0.750
South_Nash_Concord	2002	03	27	0.450
South_Nash_Concord	2002	03	30	0.130
South_Nash_Concord	2002	04	01	0.590
South_Nash_Concord	2002	04	03	0.170
South_Nash_Concord	2002	04	10	0.040
South_Nash_Concord	2002	04	13	0.120
South_Nash_Concord	2002	04	14	0.080
South_Nash_Concord	2002	04	15	0.470
South_Nash_Concord	2002	04	18	0.020

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2002	04	19	0.010
South_Nash_Concord	2002	04	20	0.030
South_Nash_Concord	2002	04	22	0.100
South_Nash_Concord	2002	04	23	0.010
South_Nash_Concord	2002	04	25	0.580
South_Nash_Concord	2002	04	28	0.390
South_Nash_Concord	2002	04	29	0.340
South_Nash_Concord	2002	04	30	0.020
South_Nash_Concord	2002	05	02	0.800
South_Nash_Concord	2002	05	03	0.010
South_Nash_Concord	2002	05	09	0.100
South_Nash_Concord	2002	05	12	0.420
South_Nash_Concord	2002	05	13	1.440
South_Nash_Concord	2002	05	14	0.260
South_Nash_Concord	2002	05	15	0.010
South_Nash_Concord	2002	05	17	0.010
South_Nash_Concord	2002	05	18	0.690
South_Nash_Concord	2002	05	21	0.010
South_Nash_Concord	2002	05	26	0.010
South_Nash_Concord	2002	05	27	0.030
South_Nash_Concord	2002	05	28	0.030
South_Nash_Concord	2002	05	30	0.010
South_Nash_Concord	2002	05	31	0.550
South_Nash_Concord	2002	06	02	0.100
South_Nash_Concord	2002	06	05	0.660
South_Nash_Concord	2002	06	06	0.600
South_Nash_Concord	2002	06	07	0.290
South_Nash_Concord	2002	06	09	0.020
South_Nash_Concord	2002	06	11	0.440
South_Nash_Concord	2002	06	12	0.650
South_Nash_Concord	2002	06	15	0.430
South_Nash_Concord	2002	06	16	0.050
South_Nash_Concord	2002	06	17	0.160
South_Nash_Concord	2002	06	22	0.850
South_Nash_Concord	2002	06	23	0.170
South_Nash_Concord	2002	06	27	0.550
South_Nash_Concord	2002	06	28	0.360
South_Nash_Concord	2002	07	09	0.080
South_Nash_Concord	2002	07	15	0.120
South_Nash_Concord	2002	07	19	0.490
South_Nash_Concord	2002	07	23	1.450
South_Nash_Concord	2002	07	27	0.020
South_Nash_Concord	2002	08	01	0.060
South_Nash_Concord	2002	08	02	0.010
South_Nash_Concord	2002	08	05	0.010
South_Nash_Concord	2002	08	16	0.060
South_Nash_Concord	2002	08	20	0.070
South_Nash_Concord	2002	08	22	0.340
South_Nash_Concord	2002	08	24	0.210
South_Nash_Concord	2002	08	29	1.100
South_Nash_Concord	2002	08	30	0.100
South_Nash_Concord	2002	09	02	0.040
South_Nash_Concord	2002	09	03	0.010
South_Nash_Concord	2002	09	04	0.210
South_Nash_Concord	2002	09	11	0.010

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2002	09	15	0.150
South_Nash_Concord	2002	09	16	1.870
South_Nash_Concord	2002	09	22	0.040
South_Nash_Concord	2002	09	23	0.340
South_Nash_Concord	2002	09	26	0.080
South_Nash_Concord	2002	09	27	0.800
South_Nash_Concord	2002	09	28	0.070
South_Nash_Concord	2002	09	30	0.010
South_Nash_Concord	2002	10	03	0.010
South_Nash_Concord	2002	10	04	0.160
South_Nash_Concord	2002	10	05	0.050
South_Nash_Concord	2002	10	07	0.020
South_Nash_Concord	2002	10	11	0.120
South_Nash_Concord	2002	10	12	0.320
South_Nash_Concord	2002	10	13	0.440
South_Nash_Concord	2002	10	16	0.670
South_Nash_Concord	2002	10	17	0.050
South_Nash_Concord	2002	10	18	0.020
South_Nash_Concord	2002	10	23	0.160
South_Nash_Concord	2002	10	26	1.070
South_Nash_Concord	2002	11	04	0.160
South_Nash_Concord	2002	11	06	0.880
South_Nash_Concord	2002	11	11	0.070
South_Nash_Concord	2002	11	12	0.820
South_Nash_Concord	2002	11	13	0.230
South_Nash_Concord	2002	11	16	0.010
South_Nash_Concord	2002	11	17	0.560
South_Nash_Concord	2002	11	18	1.000
South_Nash_Concord	2002	11	19	0.120
South_Nash_Concord	2002	11	21	0.050
South_Nash_Concord	2002	11	22	0.590
South_Nash_Concord	2002	11	23	0.010
South_Nash_Concord	2002	11	25	0.060
South_Nash_Concord	2002	11	27	0.060
South_Nash_Concord	2002	11	29	0.010
South_Nash_Concord	2002	11	30	0.030
South_Nash_Concord	2002	12	06	0.170
South_Nash_Concord	2002	12	12	0.560
South_Nash_Concord	2002	12	13	0.040
South_Nash_Concord	2002	12	14	0.790
South_Nash_Concord	2002	12	16	0.070
South_Nash_Concord	2002	12	20	0.520
South_Nash_Concord	2002	12	31	0.070
South_Nash_Concord	2003	01	01	0.250
South_Nash_Concord	2003	01	02	0.030
South_Nash_Concord	2003	01	05	0.140
South_Nash_Concord	2003	01	06	0.040
South_Nash_Concord	2003	01	08	0.160
South_Nash_Concord	2003	01	09	0.220
South_Nash_Concord	2003	01	10	0.030
South_Nash_Concord	2003	02	01	0.080
South_Nash_Concord	2003	02	02	0.660
South_Nash_Concord	2003	02	04	0.410
South_Nash_Concord	2003	02	12	0.010
South_Nash_Concord	2003	02	13	0.030

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2003	02	17	0.340
South_Nash_Concord	2003	02	18	0.240
South_Nash_Concord	2003	02	22	0.640
South_Nash_Concord	2003	02	23	0.530
South_Nash_Concord	2003	03	02	0.710
South_Nash_Concord	2003	03	05	0.130
South_Nash_Concord	2003	03	06	0.030
South_Nash_Concord	2003	03	13	0.080
South_Nash_Concord	2003	03	15	0.010
South_Nash_Concord	2003	03	20	0.390
South_Nash_Concord	2003	03	21	0.520
South_Nash_Concord	2003	03	23	0.010
South_Nash_Concord	2003	03	26	0.460
South_Nash_Concord	2003	03	29	0.390
South_Nash_Concord	2003	03	30	0.420
South_Nash_Concord	2003	04	02	0.210
South_Nash_Concord	2003	04	03	0.120
South_Nash_Concord	2003	04	04	0.730
South_Nash_Concord	2003	04	05	0.250
South_Nash_Concord	2003	04	07	0.060
South_Nash_Concord	2003	04	08	0.050
South_Nash_Concord	2003	04	11	0.470
South_Nash_Concord	2003	04	12	0.020
South_Nash_Concord	2003	04	22	1.080
South_Nash_Concord	2003	04	23	0.100
South_Nash_Concord	2003	04	24	0.030
South_Nash_Concord	2003	04	26	0.750
South_Nash_Concord	2003	05	01	0.050
South_Nash_Concord	2003	05	02	0.700
South_Nash_Concord	2003	05	08	0.280
South_Nash_Concord	2003	05	09	0.200
South_Nash_Concord	2003	05	11	0.370
South_Nash_Concord	2003	05	12	0.420
South_Nash_Concord	2003	05	13	0.100
South_Nash_Concord	2003	05	14	0.130
South_Nash_Concord	2003	05	21	0.230
South_Nash_Concord	2003	05	23	0.090
South_Nash_Concord	2003	05	24	0.240
South_Nash_Concord	2003	05	25	0.250
South_Nash_Concord	2003	05	26	1.210
South_Nash_Concord	2003	05	27	0.020
South_Nash_Concord	2003	05	28	0.160
South_Nash_Concord	2003	05	29	0.020
South_Nash_Concord	2003	05	31	0.240
South_Nash_Concord	2003	06	01	0.170
South_Nash_Concord	2003	06	05	0.230
South_Nash_Concord	2003	06	07	0.250
South_Nash_Concord	2003	06	09	0.020
South_Nash_Concord	2003	06	11	0.100
South_Nash_Concord	2003	06	13	0.320
South_Nash_Concord	2003	06	14	0.200
South_Nash_Concord	2003	06	18	0.040
South_Nash_Concord	2003	06	19	0.030
South_Nash_Concord	2003	06	20	0.010
South_Nash_Concord	2003	06	21	0.020

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2003	06	22	0.090
South_Nash_Concord	2003	06	23	0.070
South_Nash_Concord	2003	06	30	0.050
South_Nash_Concord	2003	07	09	0.080
South_Nash_Concord	2003	07	11	0.420
South_Nash_Concord	2003	07	16	1.160
South_Nash_Concord	2003	07	18	0.080
South_Nash_Concord	2003	07	19	0.050
South_Nash_Concord	2003	07	22	0.120
South_Nash_Concord	2003	08	01	1.810
South_Nash_Concord	2003	08	02	0.200
South_Nash_Concord	2003	08	03	0.240
South_Nash_Concord	2003	08	04	0.120
South_Nash_Concord	2003	08	05	1.690
South_Nash_Concord	2003	08	06	0.380
South_Nash_Concord	2003	08	07	0.030
South_Nash_Concord	2003	08	08	0.100
South_Nash_Concord	2003	08	09	0.490
South_Nash_Concord	2003	08	10	0.840
South_Nash_Concord	2003	08	11	0.030
South_Nash_Concord	2003	08	12	0.080
South_Nash_Concord	2003	08	13	0.100
South_Nash_Concord	2003	08	16	0.540
South_Nash_Concord	2003	08	18	0.130
South_Nash_Concord	2003	09	01	0.090
South_Nash_Concord	2003	09	02	0.380
South_Nash_Concord	2003	09	03	0.080
South_Nash_Concord	2003	09	04	0.530
South_Nash_Concord	2003	09	14	0.010
South_Nash_Concord	2003	09	16	1.040
South_Nash_Concord	2003	09	19	0.360
South_Nash_Concord	2003	09	20	0.010
South_Nash_Concord	2003	09	23	1.570
South_Nash_Concord	2003	09	25	0.050
South_Nash_Concord	2003	09	26	0.320
South_Nash_Concord	2003	09	27	0.020
South_Nash_Concord	2003	09	28	0.520
South_Nash_Concord	2003	09	29	0.010
South_Nash_Concord	2003	10	01	0.030
South_Nash_Concord	2003	10	02	0.040
South_Nash_Concord	2003	10	04	0.120
South_Nash_Concord	2003	10	12	0.240
South_Nash_Concord	2003	10	15	1.310
South_Nash_Concord	2003	10	21	0.120
South_Nash_Concord	2003	10	22	0.100
South_Nash_Concord	2003	10	23	0.130
South_Nash_Concord	2003	10	27	0.690
South_Nash_Concord	2003	10	28	0.010
South_Nash_Concord	2003	10	29	1.440
South_Nash_Concord	2003	11	02	0.100
South_Nash_Concord	2003	11	03	0.150
South_Nash_Concord	2003	11	04	0.230
South_Nash_Concord	2003	11	05	0.330
South_Nash_Concord	2003	11	11	0.070
South_Nash_Concord	2003	11	20	0.520

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2003	11	21	0.010
South_Nash_Concord	2003	11	25	0.060
South_Nash_Concord	2003	11	28	0.440
South_Nash_Concord	2003	11	29	0.160
South_Nash_Concord	2003	12	02	0.070
South_Nash_Concord	2003	12	06	0.460
South_Nash_Concord	2003	12	07	0.110
South_Nash_Concord	2003	12	11	0.730
South_Nash_Concord	2003	12	14	0.440
South_Nash_Concord	2003	12	15	0.370
South_Nash_Concord	2003	12	17	1.570
South_Nash_Concord	2003	12	18	0.030
South_Nash_Concord	2003	12	24	0.300
South_Nash_Concord	2003	12	25	0.050
South_Nash_Concord	2004	01	02	0.060
South_Nash_Concord	2004	01	03	0.160
South_Nash_Concord	2004	01	05	0.250
South_Nash_Concord	2004	01	12	0.130
South_Nash_Concord	2004	01	13	0.010
South_Nash_Concord	2004	01	18	0.010
South_Nash_Concord	2004	01	28	0.050
South_Nash_Concord	2004	02	03	0.370
South_Nash_Concord	2004	02	04	0.100
South_Nash_Concord	2004	02	06	0.340
South_Nash_Concord	2004	02	07	0.120
South_Nash_Concord	2004	02	21	0.110
South_Nash_Concord	2004	03	02	0.020
South_Nash_Concord	2004	03	05	0.090
South_Nash_Concord	2004	03	06	0.050
South_Nash_Concord	2004	03	08	0.090
South_Nash_Concord	2004	03	09	0.010
South_Nash_Concord	2004	03	14	0.010
South_Nash_Concord	2004	03	15	0.020
South_Nash_Concord	2004	03	16	0.210
South_Nash_Concord	2004	03	17	0.050
South_Nash_Concord	2004	03	19	0.020
South_Nash_Concord	2004	03	20	0.120
South_Nash_Concord	2004	03	21	0.130
South_Nash_Concord	2004	03	23	0.010
South_Nash_Concord	2004	03	25	0.250
South_Nash_Concord	2004	03	26	0.090
South_Nash_Concord	2004	03	27	0.300
South_Nash_Concord	2004	03	31	1.170
South_Nash_Concord	2004	04	01	1.640
South_Nash_Concord	2004	04	02	0.570
South_Nash_Concord	2004	04	04	0.330
South_Nash_Concord	2004	04	12	0.040
South_Nash_Concord	2004	04	13	1.970
South_Nash_Concord	2004	04	14	0.120
South_Nash_Concord	2004	04	15	0.150
South_Nash_Concord	2004	04	19	0.020
South_Nash_Concord	2004	04	23	0.420
South_Nash_Concord	2004	04	24	0.040
South_Nash_Concord	2004	04	25	0.250
South_Nash_Concord	2004	04	26	0.800

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2004	04	27	0.230
South_Nash_Concord	2004	05	02	0.010
South_Nash_Concord	2004	05	03	0.440
South_Nash_Concord	2004	05	04	0.600
South_Nash_Concord	2004	05	11	0.030
South_Nash_Concord	2004	05	15	0.210
South_Nash_Concord	2004	05	18	0.310
South_Nash_Concord	2004	05	20	0.070
South_Nash_Concord	2004	05	21	0.020
South_Nash_Concord	2004	05	22	0.180
South_Nash_Concord	2004	05	23	0.870
South_Nash_Concord	2004	05	26	0.110
South_Nash_Concord	2004	05	27	0.180
South_Nash_Concord	2004	05	28	0.870
South_Nash_Concord	2004	06	01	0.230
South_Nash_Concord	2004	06	02	0.020
South_Nash_Concord	2004	06	03	0.290
South_Nash_Concord	2004	06	06	0.010
South_Nash_Concord	2004	06	09	0.660
South_Nash_Concord	2004	06	10	0.060
South_Nash_Concord	2004	06	14	0.040
South_Nash_Concord	2004	06	17	0.010
South_Nash_Concord	2004	06	19	0.010
South_Nash_Concord	2004	06	22	0.020
South_Nash_Concord	2004	06	25	0.350
South_Nash_Concord	2004	06	26	0.230
South_Nash_Concord	2004	06	29	0.370
South_Nash_Concord	2004	07	02	0.040
South_Nash_Concord	2004	07	08	1.160
South_Nash_Concord	2004	07	09	0.020
South_Nash_Concord	2004	07	13	0.160
South_Nash_Concord	2004	07	14	0.040
South_Nash_Concord	2004	07	15	0.150
South_Nash_Concord	2004	07	18	0.120
South_Nash_Concord	2004	07	19	0.740
South_Nash_Concord	2004	07	20	0.060
South_Nash_Concord	2004	07	23	0.010
South_Nash_Concord	2004	07	24	0.020
South_Nash_Concord	2004	07	27	0.640
South_Nash_Concord	2004	07	28	0.550
South_Nash_Concord	2004	08	01	0.170
South_Nash_Concord	2004	08	05	0.080
South_Nash_Concord	2004	08	11	0.170
South_Nash_Concord	2004	08	12	0.340
South_Nash_Concord	2004	08	13	0.580
South_Nash_Concord	2004	08	15	0.530
South_Nash_Concord	2004	08	16	0.550
South_Nash_Concord	2004	08	20	0.130
South_Nash_Concord	2004	08	21	1.350
South_Nash_Concord	2004	08	29	0.620
South_Nash_Concord	2004	08	30	0.100
South_Nash_Concord	2004	09	08	0.990
South_Nash_Concord	2004	09	09	0.970
South_Nash_Concord	2004	09	10	0.010
South_Nash_Concord	2004	09	16	0.010

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2004	09	17	1.100
South_Nash_Concord	2004	09	18	2.420
South_Nash_Concord	2004	09	28	0.420
South_Nash_Concord	2004	09	30	0.190
South_Nash_Concord	2004	10	02	0.050
South_Nash_Concord	2004	10	14	0.050
South_Nash_Concord	2004	10	15	0.810
South_Nash_Concord	2004	10	16	0.400
South_Nash_Concord	2004	10	30	0.290
South_Nash_Concord	2004	10	31	0.010
South_Nash_Concord	2004	11	02	0.140
South_Nash_Concord	2004	11	03	0.170
South_Nash_Concord	2004	11	04	0.610
South_Nash_Concord	2004	11	05	0.060
South_Nash_Concord	2004	11	08	0.010
South_Nash_Concord	2004	11	12	0.010
South_Nash_Concord	2004	11	20	0.050
South_Nash_Concord	2004	11	21	0.100
South_Nash_Concord	2004	11	24	0.510
South_Nash_Concord	2004	11	25	0.280
South_Nash_Concord	2004	11	28	1.280
South_Nash_Concord	2004	12	01	1.000
South_Nash_Concord	2004	12	06	0.030
South_Nash_Concord	2004	12	07	0.630
South_Nash_Concord	2004	12	08	0.020
South_Nash_Concord	2004	12	10	0.470
South_Nash_Concord	2004	12	11	0.270
South_Nash_Concord	2004	12	19	0.070
South_Nash_Concord	2004	12	20	0.060
South_Nash_Concord	2004	12	23	1.090
South_Nash_Concord	2004	12	26	0.050
South_Nash_Concord	2004	12	27	0.060
South_Nash_Concord	2005	01	02	0.030
South_Nash_Concord	2005	01	03	0.050
South_Nash_Concord	2005	01	04	0.250
South_Nash_Concord	2005	01	06	0.500
South_Nash_Concord	2005	01	08	0.350
South_Nash_Concord	2005	01	12	0.350
South_Nash_Concord	2005	01	14	0.810
South_Nash_Concord	2005	01	16	0.040
South_Nash_Concord	2005	01	17	0.010
South_Nash_Concord	2005	01	19	0.080
South_Nash_Concord	2005	01	20	0.010
South_Nash_Concord	2005	01	22	0.150
South_Nash_Concord	2005	01	23	0.130
South_Nash_Concord	2005	01	26	0.170
South_Nash_Concord	2005	01	27	0.010
South_Nash_Concord	2005	02	03	0.080
South_Nash_Concord	2005	02	04	0.230
South_Nash_Concord	2005	02	08	0.020
South_Nash_Concord	2005	02	09	0.020
South_Nash_Concord	2005	02	10	1.000
South_Nash_Concord	2005	02	11	0.010
South_Nash_Concord	2005	02	13	0.110
South_Nash_Concord	2005	02	14	0.170

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	02	15	0.340
South_Nash_Concord	2005	02	16	0.260
South_Nash_Concord	2005	02	21	0.170
South_Nash_Concord	2005	02	22	0.020
South_Nash_Concord	2005	02	23	0.040
South_Nash_Concord	2005	02	24	0.020
South_Nash_Concord	2005	02	25	0.040
South_Nash_Concord	2005	03	01	0.410
South_Nash_Concord	2005	03	08	0.450
South_Nash_Concord	2005	03	11	0.090
South_Nash_Concord	2005	03	12	0.340
South_Nash_Concord	2005	03	13	0.010
South_Nash_Concord	2005	03	24	0.130
South_Nash_Concord	2005	03	28	1.540
South_Nash_Concord	2005	03	29	0.390
South_Nash_Concord	2005	04	01	0.020
South_Nash_Concord	2005	04	02	0.740
South_Nash_Concord	2005	04	03	0.890
South_Nash_Concord	2005	04	07	0.130
South_Nash_Concord	2005	04	08	0.010
South_Nash_Concord	2005	04	20	0.450
South_Nash_Concord	2005	04	21	0.390
South_Nash_Concord	2005	04	22	0.010
South_Nash_Concord	2005	04	23	1.220
South_Nash_Concord	2005	04	24	0.480
South_Nash_Concord	2005	04	25	0.210
South_Nash_Concord	2005	04	27	0.490
South_Nash_Concord	2005	04	28	0.230
South_Nash_Concord	2005	04	30	0.490
South_Nash_Concord	2005	05	01	0.020
South_Nash_Concord	2005	05	02	0.130
South_Nash_Concord	2005	05	07	0.400
South_Nash_Concord	2005	05	08	0.010
South_Nash_Concord	2005	05	15	0.170
South_Nash_Concord	2005	05	16	0.080
South_Nash_Concord	2005	05	18	0.030
South_Nash_Concord	2005	05	21	0.350
South_Nash_Concord	2005	05	22	0.470
South_Nash_Concord	2005	05	23	0.550
South_Nash_Concord	2005	05	24	0.520
South_Nash_Concord	2005	05	25	0.470
South_Nash_Concord	2005	05	26	0.300
South_Nash_Concord	2005	05	27	0.030
South_Nash_Concord	2005	05	29	0.330
South_Nash_Concord	2005	05	30	0.050
South_Nash_Concord	2005	07	01	0.230
South_Nash_Concord	2005	07	06	0.440
South_Nash_Concord	2005	07	07	0.020
South_Nash_Concord	2005	07	08	0.590
South_Nash_Concord	2005	07	09	0.450
South_Nash_Concord	2005	07	14	0.370
South_Nash_Concord	2005	07	17	0.010
South_Nash_Concord	2005	07	22	0.240
South_Nash_Concord	2005	07	27	0.280
South_Nash_Concord	2005	07	31	0.060

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	08	01	0.140
South_Nash_Concord	2005	08	09	0.010
South_Nash_Concord	2005	08	12	0.840
South_Nash_Concord	2005	08	13	0.290
South_Nash_Concord	2005	08	14	0.200
South_Nash_Concord	2005	08	15	0.250
South_Nash_Concord	2005	08	20	0.010
South_Nash_Concord	2005	08	21	0.080
South_Nash_Concord	2005	08	24	0.180
South_Nash_Concord	2005	08	28	0.170
South_Nash_Concord	2005	08	29	0.730
South_Nash_Concord	2005	08	30	0.020
South_Nash_Concord	2005	08	31	0.260
South_Nash_Concord	2005	09	15	0.290
South_Nash_Concord	2005	09	16	0.470
South_Nash_Concord	2005	09	17	0.060
South_Nash_Concord	2005	09	20	0.170
South_Nash_Concord	2005	09	26	0.870
South_Nash_Concord	2005	09	29	0.530
South_Nash_Concord	2005	10	07	0.008
South_Nash_Concord	2005	10	07	0.003
South_Nash_Concord	2005	10	07	0.015
South_Nash_Concord	2005	10	08	0.088
South_Nash_Concord	2005	10	08	0.125
South_Nash_Concord	2005	10	08	0.083
South_Nash_Concord	2005	10	08	0.036
South_Nash_Concord	2005	10	08	0.019
South_Nash_Concord	2005	10	08	0.062
South_Nash_Concord	2005	10	08	0.107
South_Nash_Concord	2005	10	08	0.144
South_Nash_Concord	2005	10	08	0.313
South_Nash_Concord	2005	10	08	0.121
South_Nash_Concord	2005	10	08	0.099
South_Nash_Concord	2005	10	08	0.309
South_Nash_Concord	2005	10	08	0.299
South_Nash_Concord	2005	10	08	0.111
South_Nash_Concord	2005	10	08	0.121
South_Nash_Concord	2005	10	08	0.338
South_Nash_Concord	2005	10	08	0.169
South_Nash_Concord	2005	10	08	0.222
South_Nash_Concord	2005	10	08	0.402
South_Nash_Concord	2005	10	08	0.573
South_Nash_Concord	2005	10	08	0.413
South_Nash_Concord	2005	10	08	0.234
South_Nash_Concord	2005	10	08	0.164
South_Nash_Concord	2005	10	08	0.062
South_Nash_Concord	2005	10	09	0.073
South_Nash_Concord	2005	10	09	0.160
South_Nash_Concord	2005	10	09	0.192
South_Nash_Concord	2005	10	09	0.258
South_Nash_Concord	2005	10	09	0.117
South_Nash_Concord	2005	10	09	0.043
South_Nash_Concord	2005	10	09	0.028
South_Nash_Concord	2005	10	09	0.002
South_Nash_Concord	2005	10	09	0.008

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	10	09	0.003
South_Nash_Concord	2005	10	09	0.001
South_Nash_Concord	2005	10	10	0.009
South_Nash_Concord	2005	10	10	0.005
South_Nash_Concord	2005	10	10	0.005
South_Nash_Concord	2005	10	10	0.008
South_Nash_Concord	2005	10	10	0.002
South_Nash_Concord	2005	10	10	0.007
South_Nash_Concord	2005	10	10	0.023
South_Nash_Concord	2005	10	10	0.011
South_Nash_Concord	2005	10	10	0.033
South_Nash_Concord	2005	10	10	0.008
South_Nash_Concord	2005	10	10	0.008
South_Nash_Concord	2005	10	10	0.015
South_Nash_Concord	2005	10	10	0.240
South_Nash_Concord	2005	10	10	0.256
South_Nash_Concord	2005	10	10	0.123
South_Nash_Concord	2005	10	10	0.048
South_Nash_Concord	2005	10	10	0.119
South_Nash_Concord	2005	10	10	0.042
South_Nash_Concord	2005	10	11	0.018
South_Nash_Concord	2005	10	11	0.067
South_Nash_Concord	2005	10	11	0.128
South_Nash_Concord	2005	10	11	0.005
South_Nash_Concord	2005	10	11	0.007
South_Nash_Concord	2005	10	11	0.003
South_Nash_Concord	2005	10	11	0.008
South_Nash_Concord	2005	10	11	0.002
South_Nash_Concord	2005	10	11	0.008
South_Nash_Concord	2005	10	11	0.013
South_Nash_Concord	2005	10	11	0.003
South_Nash_Concord	2005	10	11	0.007
South_Nash_Concord	2005	10	11	0.017
South_Nash_Concord	2005	10	11	0.023
South_Nash_Concord	2005	10	12	0.008
South_Nash_Concord	2005	10	12	0.123
South_Nash_Concord	2005	10	12	0.058
South_Nash_Concord	2005	10	12	0.065
South_Nash_Concord	2005	10	12	0.054
South_Nash_Concord	2005	10	12	0.032
South_Nash_Concord	2005	10	12	0.005
South_Nash_Concord	2005	10	12	0.005
South_Nash_Concord	2005	10	14	0.003
South_Nash_Concord	2005	10	14	0.007
South_Nash_Concord	2005	10	14	0.026
South_Nash_Concord	2005	10	14	0.040
South_Nash_Concord	2005	10	14	0.028
South_Nash_Concord	2005	10	14	0.006
South_Nash_Concord	2005	10	14	0.004
South_Nash_Concord	2005	10	14	0.006
South_Nash_Concord	2005	10	14	0.002
South_Nash_Concord	2005	10	14	0.011
South_Nash_Concord	2005	10	14	0.023
South_Nash_Concord	2005	10	14	0.023
South_Nash_Concord	2005	10	14	0.010

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	10	14	0.012
South_Nash_Concord	2005	10	14	0.045
South_Nash_Concord	2005	10	14	0.101
South_Nash_Concord	2005	10	14	0.166
South_Nash_Concord	2005	10	14	0.176
South_Nash_Concord	2005	10	14	0.133
South_Nash_Concord	2005	10	14	0.127
South_Nash_Concord	2005	10	14	0.097
South_Nash_Concord	2005	10	14	0.088
South_Nash_Concord	2005	10	14	0.233
South_Nash_Concord	2005	10	15	0.276
South_Nash_Concord	2005	10	15	0.210
South_Nash_Concord	2005	10	15	0.191
South_Nash_Concord	2005	10	15	0.273
South_Nash_Concord	2005	10	15	0.242
South_Nash_Concord	2005	10	15	0.133
South_Nash_Concord	2005	10	15	0.032
South_Nash_Concord	2005	10	15	0.014
South_Nash_Concord	2005	10	15	0.008
South_Nash_Concord	2005	10	15	0.027
South_Nash_Concord	2005	10	15	0.059
South_Nash_Concord	2005	10	15	0.182
South_Nash_Concord	2005	10	15	0.235
South_Nash_Concord	2005	10	15	0.247
South_Nash_Concord	2005	10	15	0.110
South_Nash_Concord	2005	10	15	0.043
South_Nash_Concord	2005	10	15	0.024
South_Nash_Concord	2005	10	15	0.024
South_Nash_Concord	2005	10	15	0.034
South_Nash_Concord	2005	10	15	0.003
South_Nash_Concord	2005	10	18	0.018
South_Nash_Concord	2005	10	18	0.016
South_Nash_Concord	2005	10	18	0.007
South_Nash_Concord	2005	10	22	0.002
South_Nash_Concord	2005	10	22	0.028
South_Nash_Concord	2005	10	22	0.084
South_Nash_Concord	2005	10	22	0.044
South_Nash_Concord	2005	10	22	0.030
South_Nash_Concord	2005	10	23	0.076
South_Nash_Concord	2005	10	23	0.173
South_Nash_Concord	2005	10	23	0.067
South_Nash_Concord	2005	10	23	0.049
South_Nash_Concord	2005	10	23	0.057
South_Nash_Concord	2005	10	23	0.002
South_Nash_Concord	2005	10	23	0.039
South_Nash_Concord	2005	10	23	0.068
South_Nash_Concord	2005	10	23	0.026
South_Nash_Concord	2005	10	23	0.006
South_Nash_Concord	2005	10	23	0.002
South_Nash_Concord	2005	10	23	0.015
South_Nash_Concord	2005	10	23	0.003
South_Nash_Concord	2005	10	24	0.008
South_Nash_Concord	2005	10	24	0.003
South_Nash_Concord	2005	10	24	0.002
South_Nash_Concord	2005	10	24	0.033

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	10	24	0.023
South_Nash_Concord	2005	10	25	0.041
South_Nash_Concord	2005	10	25	0.023
South_Nash_Concord	2005	10	25	0.026
South_Nash_Concord	2005	10	25	0.018
South_Nash_Concord	2005	10	25	0.033
South_Nash_Concord	2005	10	25	0.009
South_Nash_Concord	2005	10	25	0.071
South_Nash_Concord	2005	10	25	0.071
South_Nash_Concord	2005	10	25	0.054
South_Nash_Concord	2005	10	25	0.057
South_Nash_Concord	2005	10	25	0.108
South_Nash_Concord	2005	10	25	0.048
South_Nash_Concord	2005	10	25	0.087
South_Nash_Concord	2005	10	25	0.117
South_Nash_Concord	2005	10	25	0.089
South_Nash_Concord	2005	10	25	0.113
South_Nash_Concord	2005	10	25	0.041
South_Nash_Concord	2005	10	25	0.002
South_Nash_Concord	2005	10	25	0.033
South_Nash_Concord	2005	10	25	0.031
South_Nash_Concord	2005	10	25	0.004
South_Nash_Concord	2005	11	02	0.002
South_Nash_Concord	2005	11	02	0.008
South_Nash_Concord	2005	11	06	0.001
South_Nash_Concord	2005	11	06	0.009
South_Nash_Concord	2005	11	06	0.020
South_Nash_Concord	2005	11	06	0.072
South_Nash_Concord	2005	11	06	0.008
South_Nash_Concord	2005	11	09	0.012
South_Nash_Concord	2005	11	09	0.028
South_Nash_Concord	2005	11	09	0.010
South_Nash_Concord	2005	11	09	0.029
South_Nash_Concord	2005	11	09	0.020
South_Nash_Concord	2005	11	09	0.009
South_Nash_Concord	2005	11	09	0.036
South_Nash_Concord	2005	11	09	0.177
South_Nash_Concord	2005	11	10	0.071
South_Nash_Concord	2005	11	10	0.052
South_Nash_Concord	2005	11	10	0.043
South_Nash_Concord	2005	11	10	0.024
South_Nash_Concord	2005	11	15	0.023
South_Nash_Concord	2005	11	15	0.039
South_Nash_Concord	2005	11	15	0.041
South_Nash_Concord	2005	11	15	0.034
South_Nash_Concord	2005	11	15	0.008
South_Nash_Concord	2005	11	15	0.014
South_Nash_Concord	2005	11	15	0.002
South_Nash_Concord	2005	11	15	0.005
South_Nash_Concord	2005	11	15	0.009
South_Nash_Concord	2005	11	15	0.006
South_Nash_Concord	2005	11	15	0.003
South_Nash_Concord	2005	11	15	0.058
South_Nash_Concord	2005	11	15	0.036
South_Nash_Concord	2005	11	15	0.029

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	11	16	0.006
South_Nash_Concord	2005	11	16	0.008
South_Nash_Concord	2005	11	16	0.007
South_Nash_Concord	2005	11	16	0.003
South_Nash_Concord	2005	11	16	0.009
South_Nash_Concord	2005	11	16	0.001
South_Nash_Concord	2005	11	16	0.006
South_Nash_Concord	2005	11	16	0.004
South_Nash_Concord	2005	11	16	0.065
South_Nash_Concord	2005	11	16	0.093
South_Nash_Concord	2005	11	16	0.112
South_Nash_Concord	2005	11	16	0.193
South_Nash_Concord	2005	11	16	0.113
South_Nash_Concord	2005	11	17	0.123
South_Nash_Concord	2005	11	17	0.136
South_Nash_Concord	2005	11	17	0.065
South_Nash_Concord	2005	11	17	0.002
South_Nash_Concord	2005	11	21	0.023
South_Nash_Concord	2005	11	22	0.068
South_Nash_Concord	2005	11	22	0.077
South_Nash_Concord	2005	11	22	0.060
South_Nash_Concord	2005	11	22	0.028
South_Nash_Concord	2005	11	22	0.046
South_Nash_Concord	2005	11	22	0.073
South_Nash_Concord	2005	11	22	0.059
South_Nash_Concord	2005	11	22	0.035
South_Nash_Concord	2005	11	22	0.026
South_Nash_Concord	2005	11	22	0.016
South_Nash_Concord	2005	11	22	0.075
South_Nash_Concord	2005	11	22	0.105
South_Nash_Concord	2005	11	22	0.052
South_Nash_Concord	2005	11	22	0.114
South_Nash_Concord	2005	11	22	0.171
South_Nash_Concord	2005	11	22	0.043
South_Nash_Concord	2005	11	22	0.008
South_Nash_Concord	2005	11	22	0.011
South_Nash_Concord	2005	11	22	0.005
South_Nash_Concord	2005	11	22	0.006
South_Nash_Concord	2005	11	24	0.009
South_Nash_Concord	2005	11	24	0.017
South_Nash_Concord	2005	11	24	0.019
South_Nash_Concord	2005	11	24	0.011
South_Nash_Concord	2005	11	24	0.003
South_Nash_Concord	2005	11	24	0.001
South_Nash_Concord	2005	11	25	0.003
South_Nash_Concord	2005	11	25	0.004
South_Nash_Concord	2005	11	25	0.009
South_Nash_Concord	2005	11	25	0.011
South_Nash_Concord	2005	11	25	0.011
South_Nash_Concord	2005	11	25	0.002
South_Nash_Concord	2005	11	27	0.001
South_Nash_Concord	2005	11	27	0.003
South_Nash_Concord	2005	11	27	0.005
South_Nash_Concord	2005	11	27	0.005
South_Nash_Concord	2005	11	27	0.002

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	11	27	0.001
South_Nash_Concord	2005	11	27	0.003
South_Nash_Concord	2005	11	27	0.003
South_Nash_Concord	2005	11	27	0.003
South_Nash_Concord	2005	11	28	0.001
South_Nash_Concord	2005	11	28	0.003
South_Nash_Concord	2005	11	28	0.004
South_Nash_Concord	2005	11	28	0.006
South_Nash_Concord	2005	11	28	0.003
South_Nash_Concord	2005	11	28	0.003
South_Nash_Concord	2005	11	28	0.005
South_Nash_Concord	2005	11	28	0.009
South_Nash_Concord	2005	11	28	0.013
South_Nash_Concord	2005	11	28	0.014
South_Nash_Concord	2005	11	28	0.013
South_Nash_Concord	2005	11	28	0.013
South_Nash_Concord	2005	11	28	0.009
South_Nash_Concord	2005	11	28	0.015
South_Nash_Concord	2005	11	28	0.017
South_Nash_Concord	2005	11	28	0.015
South_Nash_Concord	2005	11	28	0.006
South_Nash_Concord	2005	11	28	0.003
South_Nash_Concord	2005	11	28	0.003
South_Nash_Concord	2005	11	28	0.003
South_Nash_Concord	2005	11	29	0.003
South_Nash_Concord	2005	11	29	0.003
South_Nash_Concord	2005	11	29	0.003
South_Nash_Concord	2005	11	29	0.002
South_Nash_Concord	2005	11	29	0.003
South_Nash_Concord	2005	11	29	0.003
South_Nash_Concord	2005	11	29	0.002
South_Nash_Concord	2005	11	30	0.029
South_Nash_Concord	2005	11	30	0.204
South_Nash_Concord	2005	11	30	0.167
South_Nash_Concord	2005	11	30	0.023
South_Nash_Concord	2005	11	30	0.017
South_Nash_Concord	2005	11	30	0.005
South_Nash_Concord	2005	11	30	0.021
South_Nash_Concord	2005	11	30	0.016
South_Nash_Concord	2005	11	30	0.014
South_Nash_Concord	2005	11	30	0.067
South_Nash_Concord	2005	11	30	0.083
South_Nash_Concord	2005	11	30	0.090
South_Nash_Concord	2005	11	30	0.076
South_Nash_Concord	2005	11	30	0.066
South_Nash_Concord	2005	11	30	0.003
South_Nash_Concord	2005	12	02	0.010
South_Nash_Concord	2005	12	02	0.010
South_Nash_Concord	2005	12	02	0.009
South_Nash_Concord	2005	12	02	0.001
South_Nash_Concord	2005	12	05	0.003
South_Nash_Concord	2005	12	05	0.017
South_Nash_Concord	2005	12	05	0.018
South_Nash_Concord	2005	12	05	0.004
South_Nash_Concord	2005	12	05	0.008

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	12	06	0.007
South_Nash_Concord	2005	12	06	0.003
South_Nash_Concord	2005	12	10	0.025
South_Nash_Concord	2005	12	10	0.066
South_Nash_Concord	2005	12	10	0.068
South_Nash_Concord	2005	12	10	0.051
South_Nash_Concord	2005	12	10	0.019
South_Nash_Concord	2005	12	10	0.011
South_Nash_Concord	2005	12	11	0.008
South_Nash_Concord	2005	12	11	0.016
South_Nash_Concord	2005	12	11	0.014
South_Nash_Concord	2005	12	11	0.003
South_Nash_Concord	2005	12	11	0.005
South_Nash_Concord	2005	12	11	0.005
South_Nash_Concord	2005	12	16	0.036
South_Nash_Concord	2005	12	16	0.156
South_Nash_Concord	2005	12	16	0.228
South_Nash_Concord	2005	12	16	0.393
South_Nash_Concord	2005	12	16	0.273
South_Nash_Concord	2005	12	16	0.082
South_Nash_Concord	2005	12	16	0.039
South_Nash_Concord	2005	12	16	0.013
South_Nash_Concord	2005	12	17	0.009
South_Nash_Concord	2005	12	17	0.001
South_Nash_Concord	2005	12	23	0.009
South_Nash_Concord	2005	12	23	0.001
South_Nash_Concord	2005	12	23	0.019
South_Nash_Concord	2005	12	23	0.011
South_Nash_Concord	2005	12	25	0.006
South_Nash_Concord	2005	12	25	0.054
South_Nash_Concord	2005	12	25	0.040
South_Nash_Concord	2005	12	25	0.001
South_Nash_Concord	2005	12	25	0.049
South_Nash_Concord	2005	12	25	0.087
South_Nash_Concord	2005	12	25	0.110
South_Nash_Concord	2005	12	26	0.183
South_Nash_Concord	2005	12	26	0.148
South_Nash_Concord	2005	12	26	0.043
South_Nash_Concord	2005	12	26	0.028
South_Nash_Concord	2005	12	26	0.017
South_Nash_Concord	2005	12	26	0.030
South_Nash_Concord	2005	12	26	0.006
South_Nash_Concord	2005	12	26	0.003
South_Nash_Concord	2005	12	26	0.007
South_Nash_Concord	2005	12	26	0.003
South_Nash_Concord	2005	12	26	0.007
South_Nash_Concord	2005	12	26	0.019
South_Nash_Concord	2005	12	26	0.208
South_Nash_Concord	2005	12	26	0.108
South_Nash_Concord	2005	12	26	0.320
South_Nash_Concord	2005	12	26	0.271
South_Nash_Concord	2005	12	26	0.118
South_Nash_Concord	2005	12	26	0.018
South_Nash_Concord	2005	12	26	0.010
South_Nash_Concord	2005	12	26	0.031

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	12	26	0.033
South_Nash_Concord	2005	12	26	0.018
South_Nash_Concord	2005	12	26	0.008
South_Nash_Concord	2005	12	27	0.003
South_Nash_Concord	2005	12	27	0.008
South_Nash_Concord	2005	12	29	0.013
South_Nash_Concord	2005	12	29	0.032
South_Nash_Concord	2005	12	29	0.011
South_Nash_Concord	2005	12	29	0.013
South_Nash_Concord	2005	12	29	0.024
South_Nash_Concord	2005	12	29	0.063
South_Nash_Concord	2005	12	29	0.032
South_Nash_Concord	2005	12	29	0.011
South_Nash_Concord	2005	12	29	0.013
South_Nash_Concord	2005	12	29	0.004
South_Nash_Concord	2005	12	29	0.006
South_Nash_Concord	2005	12	29	0.010
South_Nash_Concord	2005	12	30	0.006
South_Nash_Concord	2005	12	30	0.004
South_Nash_Concord	2006	01	02	0.031
South_Nash_Concord	2006	01	02	0.038
South_Nash_Concord	2006	01	02	0.042
South_Nash_Concord	2006	01	02	0.019
South_Nash_Concord	2006	01	02	0.001
South_Nash_Concord	2006	01	02	0.001
South_Nash_Concord	2006	01	02	0.009
South_Nash_Concord	2006	01	03	0.010
South_Nash_Concord	2006	01	04	0.008
South_Nash_Concord	2006	01	04	0.002
South_Nash_Concord	2006	01	07	0.009
South_Nash_Concord	2006	01	07	0.001
South_Nash_Concord	2006	01	10	0.007
South_Nash_Concord	2006	01	10	0.033
South_Nash_Concord	2006	01	10	0.029
South_Nash_Concord	2006	01	10	0.020
South_Nash_Concord	2006	01	10	0.011
South_Nash_Concord	2006	01	11	0.032
South_Nash_Concord	2006	01	11	0.068
South_Nash_Concord	2006	01	11	0.129
South_Nash_Concord	2006	01	11	0.026
South_Nash_Concord	2006	01	11	0.166
South_Nash_Concord	2006	01	12	0.076
South_Nash_Concord	2006	01	12	0.010
South_Nash_Concord	2006	01	12	0.004
South_Nash_Concord	2006	01	14	0.002
South_Nash_Concord	2006	01	14	0.008
South_Nash_Concord	2006	01	14	0.005
South_Nash_Concord	2006	01	14	0.005
South_Nash_Concord	2006	01	14	0.011
South_Nash_Concord	2006	01	14	0.048
South_Nash_Concord	2006	01	14	0.026
South_Nash_Concord	2006	01	14	0.047
South_Nash_Concord	2006	01	14	0.060
South_Nash_Concord	2006	01	14	0.009
South_Nash_Concord	2006	01	14	0.004

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	01	14	0.006
South_Nash_Concord	2006	01	14	0.001
South_Nash_Concord	2006	01	14	0.048
South_Nash_Concord	2006	01	14	0.118
South_Nash_Concord	2006	01	15	0.037
South_Nash_Concord	2006	01	15	0.025
South_Nash_Concord	2006	01	15	0.002
South_Nash_Concord	2006	01	17	0.015
South_Nash_Concord	2006	01	17	0.032
South_Nash_Concord	2006	01	17	0.021
South_Nash_Concord	2006	01	17	0.011
South_Nash_Concord	2006	01	17	0.005
South_Nash_Concord	2006	01	17	0.007
South_Nash_Concord	2006	01	18	0.003
South_Nash_Concord	2006	01	18	0.041
South_Nash_Concord	2006	01	18	0.060
South_Nash_Concord	2006	01	18	0.053
South_Nash_Concord	2006	01	18	0.057
South_Nash_Concord	2006	01	18	0.034
South_Nash_Concord	2006	01	18	0.029
South_Nash_Concord	2006	01	18	0.038
South_Nash_Concord	2006	01	18	0.050
South_Nash_Concord	2006	01	18	0.018
South_Nash_Concord	2006	01	18	0.103
South_Nash_Concord	2006	01	18	0.210
South_Nash_Concord	2006	01	18	0.168
South_Nash_Concord	2006	01	18	0.138
South_Nash_Concord	2006	01	18	0.020
South_Nash_Concord	2006	01	18	0.019
South_Nash_Concord	2006	01	18	0.009
South_Nash_Concord	2006	01	24	0.005
South_Nash_Concord	2006	01	24	0.102
South_Nash_Concord	2006	01	24	0.142
South_Nash_Concord	2006	01	24	0.131
South_Nash_Concord	2006	01	24	0.091
South_Nash_Concord	2006	01	24	0.055
South_Nash_Concord	2006	01	24	0.015
South_Nash_Concord	2006	01	25	0.010
South_Nash_Concord	2006	01	25	0.050
South_Nash_Concord	2006	01	25	0.049
South_Nash_Concord	2006	01	25	0.035
South_Nash_Concord	2006	01	25	0.027
South_Nash_Concord	2006	01	25	0.014
South_Nash_Concord	2006	01	25	0.005
South_Nash_Concord	2006	01	26	0.009
South_Nash_Concord	2006	01	26	0.001
South_Nash_Concord	2006	01	29	0.003
South_Nash_Concord	2006	01	29	0.054
South_Nash_Concord	2006	01	29	0.072
South_Nash_Concord	2006	01	29	0.093
South_Nash_Concord	2006	01	29	0.128
South_Nash_Concord	2006	01	29	0.030
South_Nash_Concord	2006	01	30	0.003
South_Nash_Concord	2006	01	30	0.008
South_Nash_Concord	2006	02	01	0.032

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	02	01	0.043
South_Nash_Concord	2006	02	01	0.018
South_Nash_Concord	2006	02	01	0.012
South_Nash_Concord	2006	02	01	0.006
South_Nash_Concord	2006	02	03	0.001
South_Nash_Concord	2006	02	03	0.068
South_Nash_Concord	2006	02	03	0.168
South_Nash_Concord	2006	02	03	0.121
South_Nash_Concord	2006	02	03	0.039
South_Nash_Concord	2006	02	03	0.120
South_Nash_Concord	2006	02	03	0.147
South_Nash_Concord	2006	02	03	0.049
South_Nash_Concord	2006	02	03	0.008
South_Nash_Concord	2006	02	04	0.005
South_Nash_Concord	2006	02	04	0.054
South_Nash_Concord	2006	02	04	0.042
South_Nash_Concord	2006	02	04	0.027
South_Nash_Concord	2006	02	04	0.053
South_Nash_Concord	2006	02	04	0.097
South_Nash_Concord	2006	02	05	0.149
South_Nash_Concord	2006	02	05	0.168
South_Nash_Concord	2006	02	05	0.051
South_Nash_Concord	2006	02	05	0.108
South_Nash_Concord	2006	02	05	0.018
South_Nash_Concord	2006	02	05	0.003
South_Nash_Concord	2006	02	05	0.023
South_Nash_Concord	2006	02	05	0.235
South_Nash_Concord	2006	02	05	0.098
South_Nash_Concord	2006	02	05	0.022
South_Nash_Concord	2006	02	05	0.007
South_Nash_Concord	2006	02	05	0.003
South_Nash_Concord	2006	02	13	0.013
South_Nash_Concord	2006	02	13	0.012
South_Nash_Concord	2006	02	13	0.026
South_Nash_Concord	2006	02	13	0.038
South_Nash_Concord	2006	02	13	0.012
South_Nash_Concord	2006	02	14	0.005
South_Nash_Concord	2006	02	14	0.005
South_Nash_Concord	2006	02	14	0.007
South_Nash_Concord	2006	02	14	0.009
South_Nash_Concord	2006	02	14	0.004
South_Nash_Concord	2006	02	14	0.009
South_Nash_Concord	2006	02	14	0.001
South_Nash_Concord	2006	02	17	0.029
South_Nash_Concord	2006	02	17	0.041
South_Nash_Concord	2006	02	17	0.028
South_Nash_Concord	2006	02	17	0.023
South_Nash_Concord	2006	02	17	0.009
South_Nash_Concord	2006	02	23	0.012
South_Nash_Concord	2006	02	23	0.008
South_Nash_Concord	2006	03	09	0.003
South_Nash_Concord	2006	03	09	0.008
South_Nash_Concord	2006	03	10	0.007
South_Nash_Concord	2006	03	10	0.003
South_Nash_Concord	2006	03	10	0.018

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	03	10	0.003
South_Nash_Concord	2006	03	13	0.003
South_Nash_Concord	2006	03	13	0.018
South_Nash_Concord	2006	03	13	0.016
South_Nash_Concord	2006	03	13	0.042
South_Nash_Concord	2006	03	13	0.040
South_Nash_Concord	2006	03	13	0.011
South_Nash_Concord	2006	03	13	0.017
South_Nash_Concord	2006	03	13	0.251
South_Nash_Concord	2006	03	14	0.131
South_Nash_Concord	2006	03	14	0.002
South_Nash_Concord	2006	03	14	0.016
South_Nash_Concord	2006	03	14	0.023
South_Nash_Concord	2006	03	14	0.002
South_Nash_Concord	2006	03	14	0.026
South_Nash_Concord	2006	03	14	0.008
South_Nash_Concord	2006	03	14	0.006
South_Nash_Concord	2006	04	01	0.002
South_Nash_Concord	2006	04	01	0.008
South_Nash_Concord	2006	04	01	0.014
South_Nash_Concord	2006	04	01	0.024
South_Nash_Concord	2006	04	01	0.012
South_Nash_Concord	2006	04	03	0.003
South_Nash_Concord	2006	04	03	0.017
South_Nash_Concord	2006	04	04	0.042
South_Nash_Concord	2006	04	04	0.073
South_Nash_Concord	2006	04	04	0.103
South_Nash_Concord	2006	04	04	0.052
South_Nash_Concord	2006	04	04	0.009
South_Nash_Concord	2006	04	04	0.018
South_Nash_Concord	2006	04	04	0.139
South_Nash_Concord	2006	04	04	0.362
South_Nash_Concord	2006	04	04	0.268
South_Nash_Concord	2006	04	04	0.175
South_Nash_Concord	2006	04	04	0.051
South_Nash_Concord	2006	04	04	0.076
South_Nash_Concord	2006	04	04	0.035
South_Nash_Concord	2006	04	04	0.012
South_Nash_Concord	2006	04	04	0.008
South_Nash_Concord	2006	04	05	0.007
South_Nash_Concord	2006	04	05	0.016
South_Nash_Concord	2006	04	05	0.023
South_Nash_Concord	2006	04	05	0.018
South_Nash_Concord	2006	04	05	0.034
South_Nash_Concord	2006	04	05	0.050
South_Nash_Concord	2006	04	05	0.030
South_Nash_Concord	2006	04	05	0.003
South_Nash_Concord	2006	04	06	0.010
South_Nash_Concord	2006	04	07	0.035
South_Nash_Concord	2006	04	07	0.034
South_Nash_Concord	2006	04	07	0.020
South_Nash_Concord	2006	04	07	0.017
South_Nash_Concord	2006	04	07	0.004
South_Nash_Concord	2006	04	08	0.002
South_Nash_Concord	2006	04	08	0.008

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	04	14	0.004
South_Nash_Concord	2006	04	15	0.006
South_Nash_Concord	2006	04	18	0.007
South_Nash_Concord	2006	04	18	0.003
South_Nash_Concord	2006	04	22	0.001
South_Nash_Concord	2006	04	22	0.044
South_Nash_Concord	2006	04	22	0.065
South_Nash_Concord	2006	04	22	0.049
South_Nash_Concord	2006	04	22	0.020
South_Nash_Concord	2006	04	23	0.005
South_Nash_Concord	2006	04	23	0.007
South_Nash_Concord	2006	04	23	0.022
South_Nash_Concord	2006	04	23	0.023
South_Nash_Concord	2006	04	23	0.025
South_Nash_Concord	2006	04	23	0.058
South_Nash_Concord	2006	04	23	0.022
South_Nash_Concord	2006	04	23	0.006
South_Nash_Concord	2006	04	23	0.004
South_Nash_Concord	2006	04	23	0.056
South_Nash_Concord	2006	04	23	0.055
South_Nash_Concord	2006	04	23	0.045
South_Nash_Concord	2006	04	23	0.052
South_Nash_Concord	2006	04	23	0.085
South_Nash_Concord	2006	04	23	0.081
South_Nash_Concord	2006	04	23	0.128
South_Nash_Concord	2006	04	23	0.017
South_Nash_Concord	2006	04	23	0.066
South_Nash_Concord	2006	04	24	0.118
South_Nash_Concord	2006	04	24	0.134
South_Nash_Concord	2006	04	24	0.044
South_Nash_Concord	2006	04	24	0.034
South_Nash_Concord	2006	04	24	0.006
South_Nash_Concord	2006	04	24	0.001
South_Nash_Concord	2006	04	24	0.013
South_Nash_Concord	2006	04	24	0.006
South_Nash_Concord	2006	04	24	0.012
South_Nash_Concord	2006	04	24	0.018
South_Nash_Concord	2006	04	24	0.007
South_Nash_Concord	2006	04	24	0.013
South_Nash_Concord	2006	04	25	0.008
South_Nash_Concord	2006	04	25	0.002
South_Nash_Concord	2006	05	02	0.003
South_Nash_Concord	2006	05	02	0.033
South_Nash_Concord	2006	05	02	0.043
South_Nash_Concord	2006	05	02	0.015
South_Nash_Concord	2006	05	02	0.090
South_Nash_Concord	2006	05	02	0.068
South_Nash_Concord	2006	05	02	0.110
South_Nash_Concord	2006	05	02	0.038
South_Nash_Concord	2006	05	02	0.020
South_Nash_Concord	2006	05	02	0.028
South_Nash_Concord	2006	05	02	0.015
South_Nash_Concord	2006	05	02	0.018
South_Nash_Concord	2006	05	02	0.028
South_Nash_Concord	2006	05	02	0.013

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	05	02	0.008
South_Nash_Concord	2006	05	02	0.005
South_Nash_Concord	2006	05	02	0.005
South_Nash_Concord	2006	05	02	0.028
South_Nash_Concord	2006	05	03	0.048
South_Nash_Concord	2006	05	03	0.113
South_Nash_Concord	2006	05	03	0.045
South_Nash_Concord	2006	05	03	0.013
South_Nash_Concord	2006	05	03	0.010
South_Nash_Concord	2006	05	03	0.013
South_Nash_Concord	2006	05	03	0.010
South_Nash_Concord	2006	05	03	0.115
South_Nash_Concord	2006	05	03	0.019
South_Nash_Concord	2006	05	03	0.014
South_Nash_Concord	2006	05	03	0.012
South_Nash_Concord	2006	05	03	0.024
South_Nash_Concord	2006	05	03	0.024
South_Nash_Concord	2006	05	03	0.011
South_Nash_Concord	2006	05	03	0.008
South_Nash_Concord	2006	05	03	0.008
South_Nash_Concord	2006	05	03	0.008
South_Nash_Concord	2006	05	03	0.005
South_Nash_Concord	2006	05	09	0.013
South_Nash_Concord	2006	05	09	0.028
South_Nash_Concord	2006	05	09	0.058
South_Nash_Concord	2006	05	09	0.058
South_Nash_Concord	2006	05	09	0.025
South_Nash_Concord	2006	05	09	0.025
South_Nash_Concord	2006	05	09	0.050
South_Nash_Concord	2006	05	09	0.040
South_Nash_Concord	2006	05	09	0.018
South_Nash_Concord	2006	05	10	0.005
South_Nash_Concord	2006	05	10	0.012
South_Nash_Concord	2006	05	10	0.003
South_Nash_Concord	2006	05	10	0.008
South_Nash_Concord	2006	05	10	0.035
South_Nash_Concord	2006	05	10	0.045
South_Nash_Concord	2006	05	10	0.027
South_Nash_Concord	2006	05	10	0.087
South_Nash_Concord	2006	05	10	0.120
South_Nash_Concord	2006	05	10	0.048
South_Nash_Concord	2006	05	10	0.025
South_Nash_Concord	2006	05	10	0.057
South_Nash_Concord	2006	05	10	0.012
South_Nash_Concord	2006	05	10	0.005
South_Nash_Concord	2006	05	11	0.002
South_Nash_Concord	2006	05	11	0.007
South_Nash_Concord	2006	05	11	0.022
South_Nash_Concord	2006	05	11	0.018
South_Nash_Concord	2006	05	11	0.007
South_Nash_Concord	2006	05	11	0.002
South_Nash_Concord	2006	05	11	0.007
South_Nash_Concord	2006	05	11	0.010
South_Nash_Concord	2006	05	11	0.002
South_Nash_Concord	2006	05	12	0.007

Composite Precipitation File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	05	12	0.002
South_Nash_Concord	2006	05	12	0.020
South_Nash_Concord	2006	05	12	0.050
South_Nash_Concord	2006	05	12	0.012
South_Nash_Concord	2006	05	13	0.055
South_Nash_Concord	2006	05	13	0.080
South_Nash_Concord	2006	05	13	0.017
South_Nash_Concord	2006	05	13	0.252
South_Nash_Concord	2006	05	13	0.215
South_Nash_Concord	2006	05	13	0.037
South_Nash_Concord	2006	05	13	0.005
South_Nash_Concord	2006	05	13	0.065
South_Nash_Concord	2006	05	13	0.150
South_Nash_Concord	2006	05	13	0.223
South_Nash_Concord	2006	05	13	0.175
South_Nash_Concord	2006	05	13	0.173
South_Nash_Concord	2006	05	13	0.095
South_Nash_Concord	2006	05	13	0.110
South_Nash_Concord	2006	05	13	0.219
South_Nash_Concord	2006	05	13	0.228
South_Nash_Concord	2006	05	13	0.256
South_Nash_Concord	2006	05	13	0.396
South_Nash_Concord	2006	05	13	0.263
South_Nash_Concord	2006	05	13	0.160
South_Nash_Concord	2006	05	13	0.108
South_Nash_Concord	2006	05	13	0.085
South_Nash_Concord	2006	05	13	0.057
South_Nash_Concord	2006	05	13	0.027
South_Nash_Concord	2006	05	14	0.070
South_Nash_Concord	2006	05	14	0.172
South_Nash_Concord	2006	05	14	0.193
South_Nash_Concord	2006	05	14	0.105
South_Nash_Concord	2006	05	14	0.063
South_Nash_Concord	2006	05	14	0.042
South_Nash_Concord	2006	05	14	0.130
South_Nash_Concord	2006	05	14	0.280
South_Nash_Concord	2006	05	14	0.273
South_Nash_Concord	2006	05	14	0.138
South_Nash_Concord	2006	05	14	0.302
South_Nash_Concord	2006	05	14	0.190
South_Nash_Concord	2006	05	14	0.047
South_Nash_Concord	2006	05	14	0.028
South_Nash_Concord	2006	05	14	0.015
South_Nash_Concord	2006	05	14	0.227
South_Nash_Concord	2006	05	14	0.243
South_Nash_Concord	2006	05	14	0.102
South_Nash_Concord	2006	05	14	0.102
South_Nash_Concord	2006	05	14	0.060
South_Nash_Concord	2006	05	14	0.080
South_Nash_Concord	2006	05	14	0.055
South_Nash_Concord	2006	05	14	0.008
South_Nash_Concord	2006	05	14	0.020
South_Nash_Concord	2006	05	15	0.015
South_Nash_Concord	2006	05	15	0.010
South_Nash_Concord	2006	05	15	0.005

Composite Precipitation File

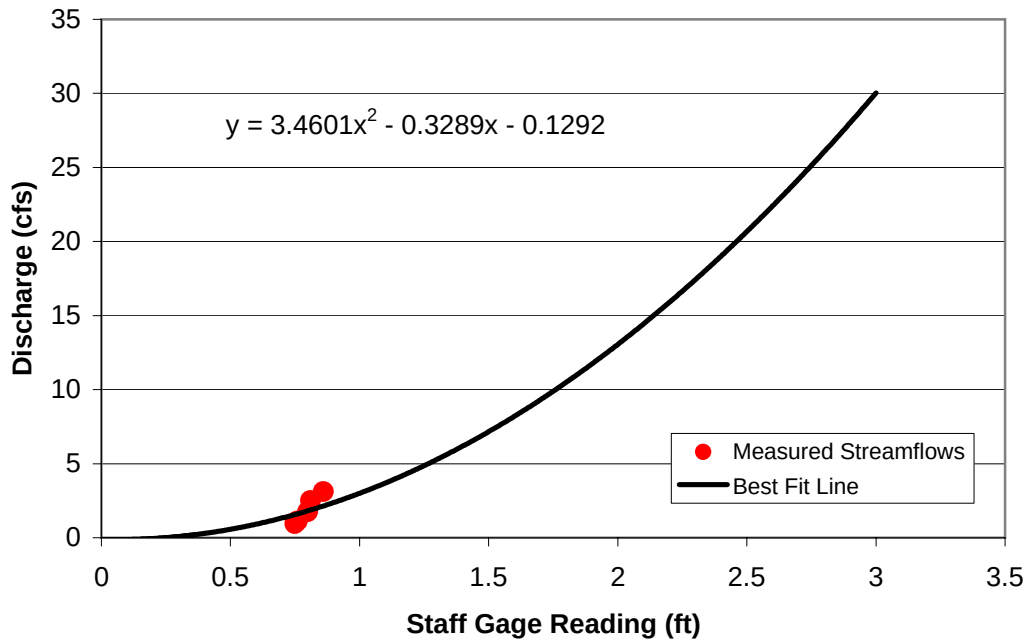
Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	05	15	0.005
South_Nash_Concord	2006	05	15	0.015
South_Nash_Concord	2006	05	15	0.008
South_Nash_Concord	2006	05	15	0.005
South_Nash_Concord	2006	05	15	0.050
South_Nash_Concord	2006	05	15	0.060
South_Nash_Concord	2006	05	15	0.008
South_Nash_Concord	2006	05	15	0.002
South_Nash_Concord	2006	05	15	0.008
South_Nash_Concord	2006	05	15	0.008
South_Nash_Concord	2006	05	15	0.012
South_Nash_Concord	2006	05	15	0.005
South_Nash_Concord	2006	05	16	0.005
South_Nash_Concord	2006	05	16	0.015
South_Nash_Concord	2006	05	16	0.080
South_Nash_Concord	2006	05	16	0.055
South_Nash_Concord	2006	05	16	0.023
South_Nash_Concord	2006	05	16	0.007
South_Nash_Concord	2006	05	16	0.015
South_Nash_Concord	2006	05	16	0.055
South_Nash_Concord	2006	05	16	0.058
South_Nash_Concord	2006	05	16	0.095
South_Nash_Concord	2006	05	16	0.075
South_Nash_Concord	2006	05	16	0.013
South_Nash_Concord	2006	05	16	0.027
South_Nash_Concord	2006	05	16	0.013
South_Nash_Concord	2006	05	17	0.045
South_Nash_Concord	2006	05	17	0.015
South_Nash_Concord	2006	05	19	0.002
South_Nash_Concord	2006	05	19	0.110
South_Nash_Concord	2006	05	19	0.088
South_Nash_Concord	2006	05	19	0.082
South_Nash_Concord	2006	05	19	0.265
South_Nash_Concord	2006	05	19	0.100
South_Nash_Concord	2006	05	19	0.030
South_Nash_Concord	2006	05	19	0.070
South_Nash_Concord	2006	05	21	0.020
South_Nash_Concord	2006	05	21	0.175
South_Nash_Concord	2006	05	21	0.025
South_Nash_Concord	2006	05	21	0.075
South_Nash_Concord	2006	05	21	0.145
South_Nash_Concord	2006	05	26	0.177
South_Nash_Concord	2006	05	26	0.050
South_Nash_Concord	2006	05	26	0.023
South_Nash_Concord	2006	06	01	0.063
South_Nash_Concord	2006	06	01	0.202
South_Nash_Concord	2006	06	01	0.153
South_Nash_Concord	2006	06	02	0.088
South_Nash_Concord	2006	06	02	0.075
South_Nash_Concord	2006	06	02	0.080
South_Nash_Concord	2006	06	02	0.008
South_Nash_Concord	2006	06	02	0.007
South_Nash_Concord	2006	06	02	0.012
South_Nash_Concord	2006	06	02	0.015
South_Nash_Concord	2006	06	02	0.007

Composite Precipitation File

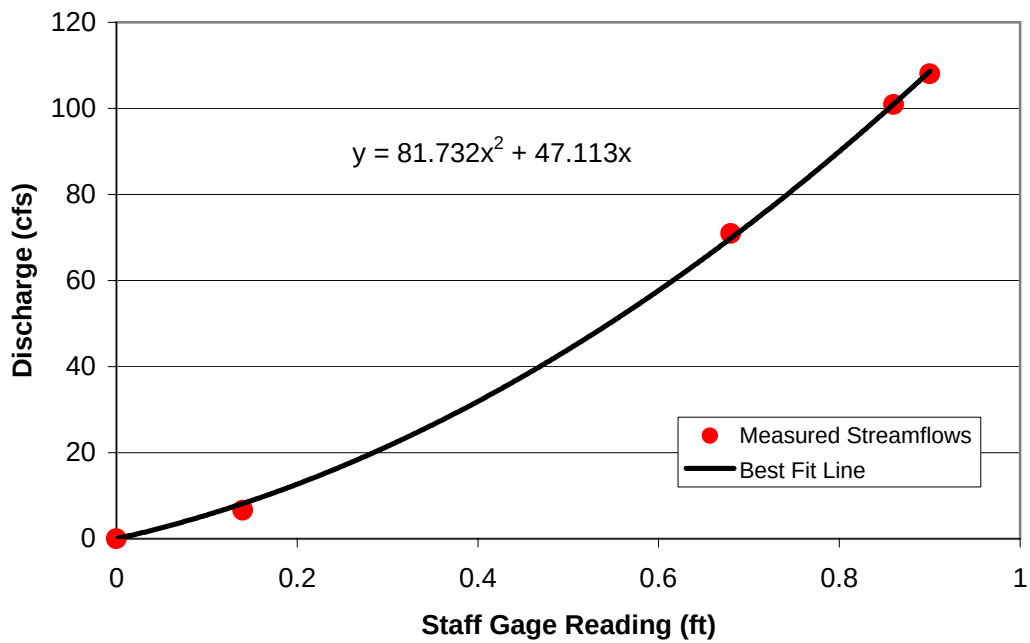
Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	06	02	0.002
South_Nash_Concord	2006	06	02	0.008
South_Nash_Concord	2006	06	02	0.005
South_Nash_Concord	2006	06	02	0.010
South_Nash_Concord	2006	06	02	0.043
South_Nash_Concord	2006	06	02	0.020
South_Nash_Concord	2006	06	02	0.040
South_Nash_Concord	2006	06	03	0.008
South_Nash_Concord	2006	06	03	0.002
South_Nash_Concord	2006	06	03	0.018
South_Nash_Concord	2006	06	03	0.015
South_Nash_Concord	2006	06	03	0.057
South_Nash_Concord	2006	06	03	0.087
South_Nash_Concord	2006	06	03	0.139
South_Nash_Concord	2006	06	03	0.058
South_Nash_Concord	2006	06	03	0.084
South_Nash_Concord	2006	06	03	0.030
South_Nash_Concord	2006	06	03	0.015
South_Nash_Concord	2006	06	03	0.010
South_Nash_Concord	2006	06	03	0.030
South_Nash_Concord	2006	06	03	0.022
South_Nash_Concord	2006	06	03	0.025
South_Nash_Concord	2006	06	03	0.023
South_Nash_Concord	2006	06	03	0.040
South_Nash_Concord	2006	06	03	0.175
South_Nash_Concord	2006	06	03	0.202
South_Nash_Concord	2006	06	03	0.078
South_Nash_Concord	2006	06	03	0.068
South_Nash_Concord	2006	06	03	0.075
South_Nash_Concord	2006	06	03	0.095
South_Nash_Concord	2006	06	03	0.092
South_Nash_Concord	2006	06	04	0.138
South_Nash_Concord	2006	06	04	0.110
South_Nash_Concord	2006	06	04	0.015
South_Nash_Concord	2006	06	04	0.028
South_Nash_Concord	2006	06	04	0.008
South_Nash_Concord	2006	06	04	0.010
South_Nash_Concord	2006	06	04	0.008
South_Nash_Concord	2006	06	04	0.002

Appendix B Stage Discharge Curves

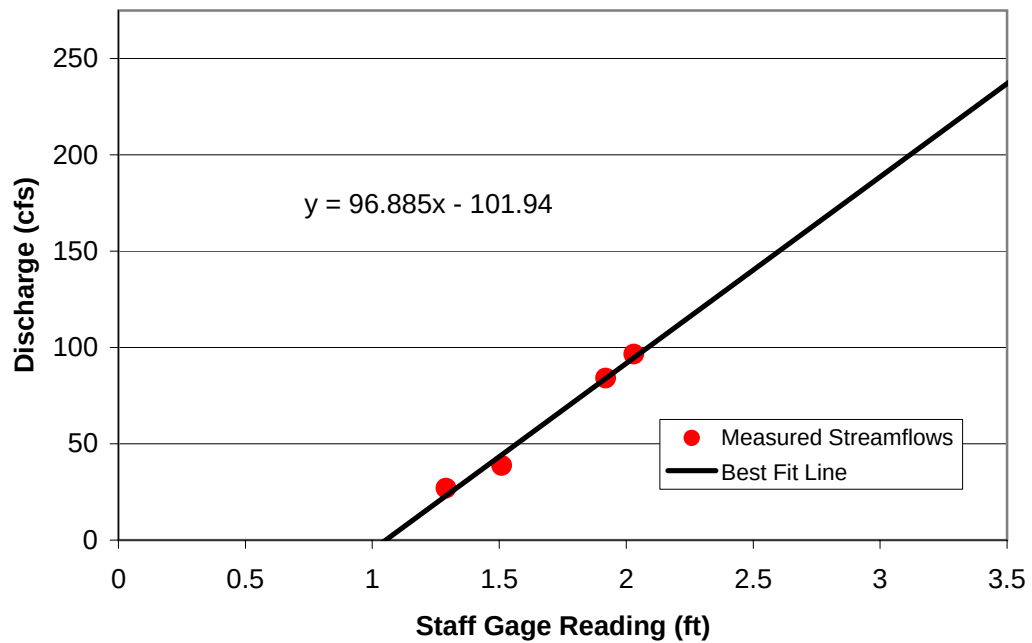
T-1 (01-BFB) Stage Discharge Curve



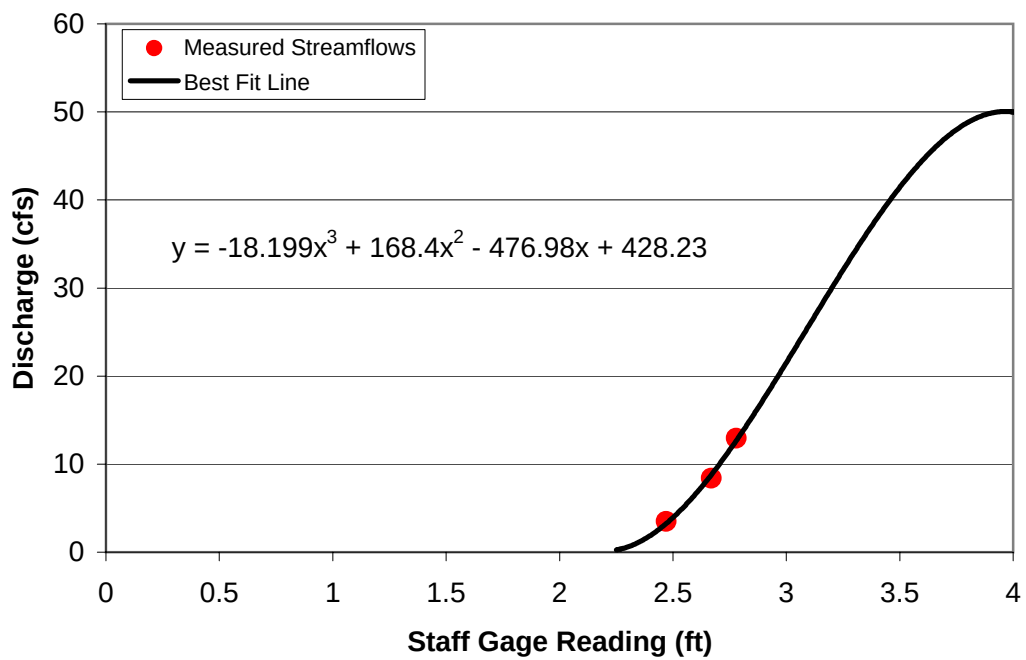
T-2 (09-PEN) Stage Discharge Curve



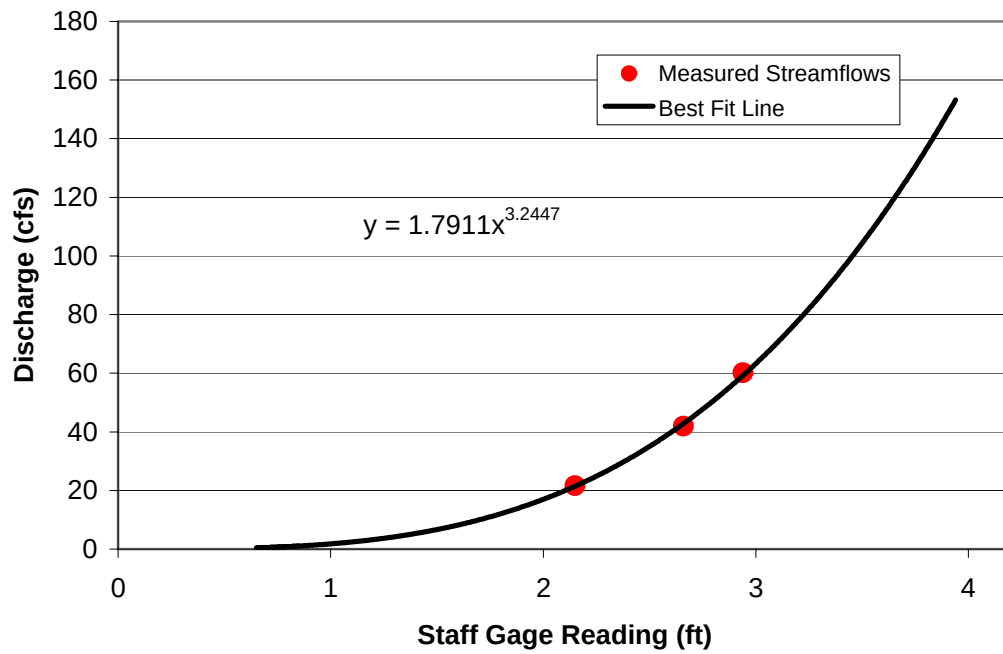
T-3 (09T-PEN) Stage Discharge Curve



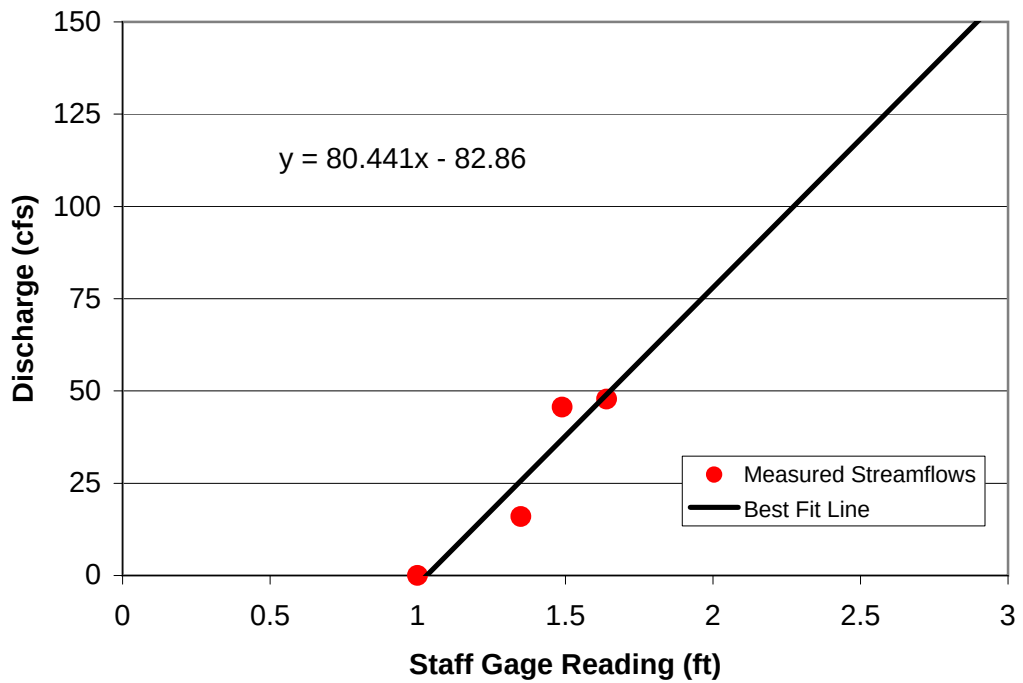
T-4 (09-XPB) Stage Discharge Curve



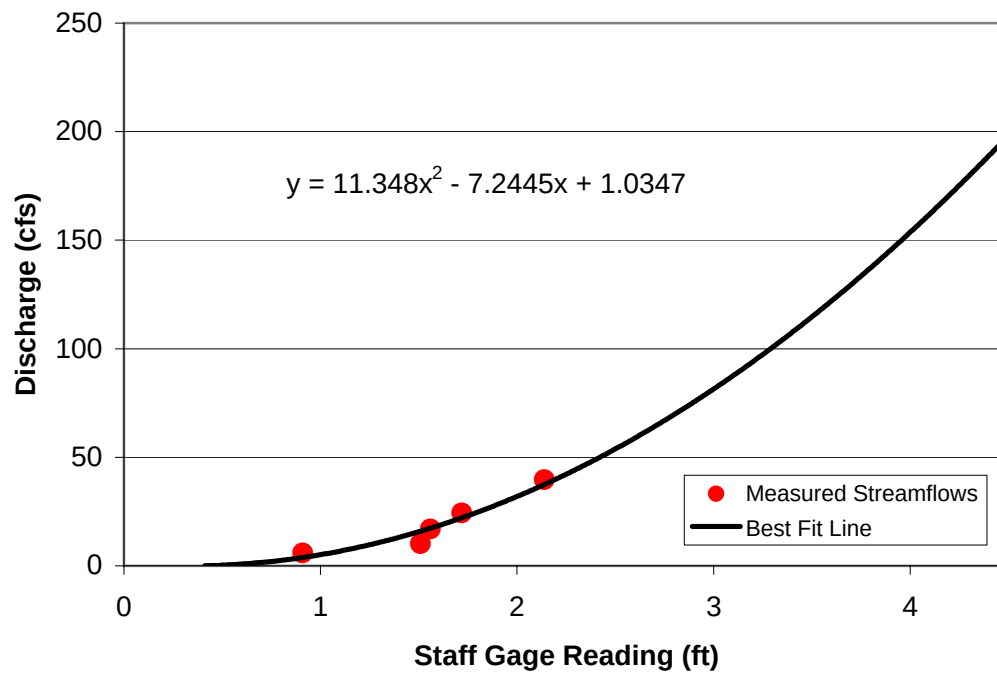
T-5 (01-WCH) Stage Discharge Curve



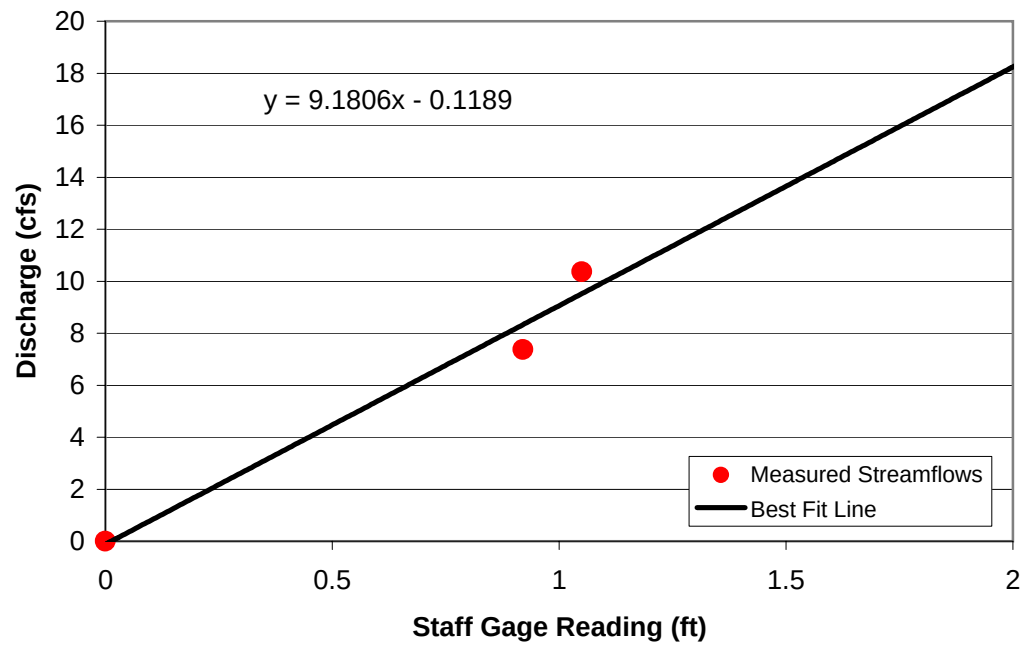
T-6 (01-XWB) Stage Discharge Curve



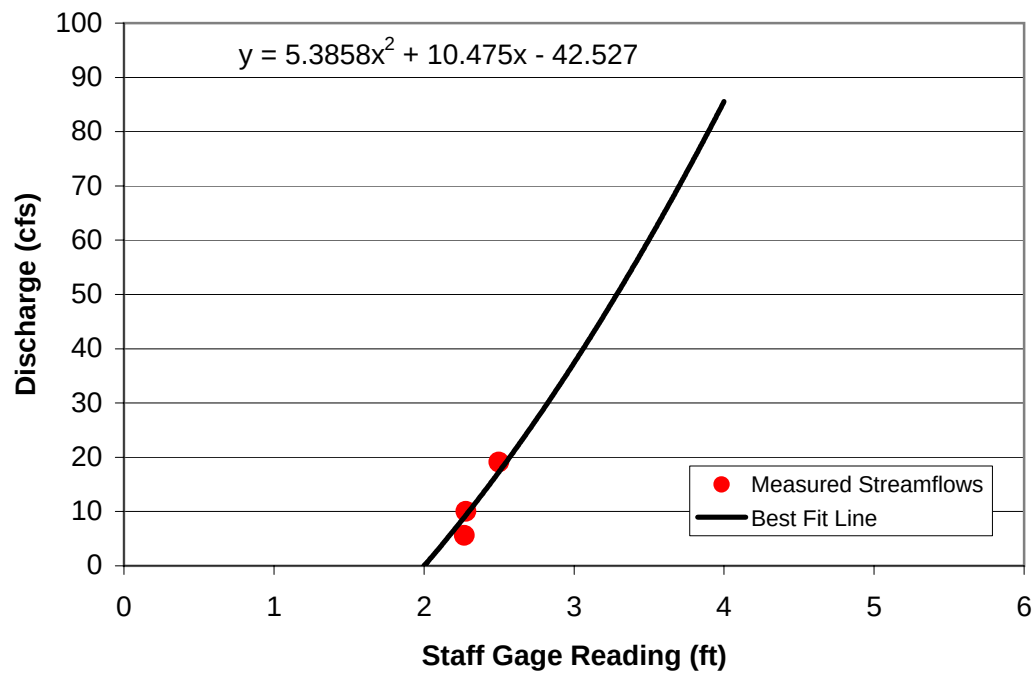
T-7 (02-WCH) Stage Discharge Curve



T-8 (12-PEN) Stage Discharge Curve



T-9 (01-MUD) Stage Discharge Curve



T-1 Streamflow Calculations Page 1										
			06/12/05 Staff Gage Reading			0.76	06/22/05 Staff Gage Reading			0.75
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow
14.5										
15	4.72	0.13	0.63	0.32	0.28	0.09	0.62	0.31	0.22	0.07
15.5	4.62	0.23	0.53	0.27	0.55	0.15	0.52	0.26	0.43	0.11
16	5.07	-0.22	0.98	0.49	0.42	0.21	0.97	0.49	0.47	0.23
16.5	5.1	-0.25	1.01	0.51	0.45	0.23	1.00	0.50	0.45	0.23
17	5.02	-0.17	0.93	0.47	0.31	0.14	0.92	0.46	0.34	0.16
17.5	5.08	-0.23	0.99	0.50	0.27	0.13	0.98	0.49	0.23	0.11
18	5.1	-0.25	1.01	0.51	0.15	0.08	1.00	0.50	0.08	0.04
18.5	4.99	-0.14	0.9	0.45	0.12	0.05	0.89	0.45	0.03	0.01
19	4.93	-0.08	0.84	0.42	0.06	0.03	0.83	0.42	0.00	0.00
19.5	4.81	0.04	0.72	0.36	0.04	0.01	0.71	0.36	0.06	0.02
20	4.66	0.19	0.57	0.29	0.02	0.01	0.56	0.28	-0.05	-0.01
20.5	4.52	0.33	0.43	0.22	0.01	0.00	0.42	0.21	-0.07	-0.01
21	4.37	0.48	0.28	0.14	0	0.00	0.27	0.14	0.00	0.00
21.5	4.3	0.55	0.21	0.11	0	0.00	0.20	0.10	0.00	0.00
22	4.2	0.65	0.11	0.06	0	0.00	0.10	0.05	0.00	0.00
22.5	4.1	0.75	0.01	0.01	0	0.00	0.00	0.00	0.00	0.00
23	3.96	0.89	0	0.00	0	0.00	0.00	0.00	0.00	0.00
23.5	3.8	1.05	0	0.00	0	0.00	0.00	0.00	0.00	0.00
24	3.5	1.35	0	0.00	0	0.00	0.00	0.00	0.00	0.00
24.5	3.72	1.13	0	0.00	0	0.00	0.00	0.00	0.00	0.00
25	2.58	2.27	0	0.00	0	0.00	0.00	0.00	0.00	0.00
25.5				5.08	Flow	1.12	cfs	5.00	Flow	0.948

Site Survey Information			
		Staff Guage Shot	4.85
		Staff Guage Reading	0.76
		Benchmark (Invert of Middle Culvert)	3.56

T-1 Streamflow Calculations Page 2											
11/16/05 Staff Gage Reading			0.80	12/1/05 Staff Gage Reading			0.86	1/13/06 Staff Gage Reading			0.81
Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow
0.67	0.67	0.13	0.09	0.73	0.73	0.53	0.39	0.68	0.68	0.44	0.30
0.57			0.00	0.63			0.00				0.00
1.02	1.02	0.53	0.54	1.08	1.08	0.88	0.95	1.03	1.03	0.78	0.80
1.05			0.00	1.11			0.00				0.00
0.97	0.97	0.51	0.49	1.03	1.03	0.64	0.66	0.98	0.98	0.51	0.50
1.03			0.00	1.09			0.00				0.00
1.05	1.05	0.37	0.39	1.11	1.11	0.46	0.51	1.06	1.06	0.49	0.52
0.94			0.00	1.00			0.00				0.00
0.88	0.88	0.22	0.19	0.94	0.94	0.45	0.42	0.89	0.89	0.28	0.25
0.76			0.00	0.82			0.00				0.00
0.61	0.61	0.09	0.05	0.67	0.67	0.22	0.15	0.62	0.62	0.18	0.11
0.47			0.00	0.53			0.00				0.00
0.32	0.32	0.00	0.00	0.38	0.38	0.09	0.03	0.33	0.33	0.06	0.02
0.25			0.00	0.31			0.00				0.00
0.15	0.15		0.00	0.21	0.21	0.02	0.00	0.16	0.16	0.01	0.00
0.05	0.05		0.00				0.00				0.00
0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00
0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00
0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00
0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00
0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00
cfs	5.72	Flow	1.76	cfs	6.15	Flow	3.12	cfs	5.75	Flow	2.50

T-2 Streamflow Calculations					
Location	D.L. Reading *	S.G. Reading**	Depth	Width	Flow
9/29/2005	1.73	0.14	0.14	38.00	6.63
11/17/2005	2.27	0.68	0.68	38.00	70.96
12/1/2005	2.49	0.90	0.9	38.00	108.04
1/13/2006	2.45	0.86	0.86	38.00	100.92

*D.L. = Datalogger Reading

**S.G. = Staff Gage Readings

T-3 Streamflow Calculations Page 1											
Site Information			06/12/05 Staff Gage Reading			1.51	06/22/05 Staff Gage Reading			1.29	
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	
55.9	start										
56	11.57	1.02	0.49	0.27	0.38	0.10	0.27	0.15	0.04	0.01	
57	11.57	1.02	0.49	0.49	0.38	0.19	0.27	0.27	0.04	0.01	
58	14.53	-1.94	3.45	3.45	0.62	2.14	3.23	3.23	0.48	1.55	
59	14.51	-1.92	3.43	3.43	0.54	1.85	3.21	3.21	0.64	2.05	
60	15.04	-2.45	3.96	3.96	1.03	4.08	3.74	3.74	0.64	2.39	
61	15.31	-2.72	4.23	4.23	1.03	4.36	4.01	4.01	0.74	2.97	
62	15.72	-3.13	4.64	4.64	1.03	4.78	4.42	4.42	0.78	3.45	
63	14.9	-2.31	3.82	3.82	1.01	3.86	3.60	3.60	0.81	2.92	
64	15.61	-3.02	4.53	4.53	0.98	4.44	4.31	4.31	0.75	3.23	
65	15.51	-2.92	4.43	4.43	0.94	4.16	4.21	4.21	0.73	3.07	
66	15.75	-3.16	4.67	4.67	1.15	5.37	4.45	4.45	0.74	3.29	
67	15.56	-2.97	4.48	3.36	1.02	3.43	4.26	3.20	0.64	2.04	
67.5	end			41.28	Flow	38.75 cfs		38.79	Flow	26.99 cfs	

Site Survey Information	
Staff Guage Shot	12.59
Staff Guage Reading	1.51
BM top of steel 2.92	

T-3 Streamflow Calculations Page 2											
		1/13/06 Staff Gage Reading			2.03		2/01/06 Staff Gage Reading			1.92	
	EL	Depth	Area	Velocity	Flow		Depth	Area	Velocity	Flow	
86.5											
87.50	1.02	1.01	0.505	2.43	1.23		0.9	0.45	2.29	1.03	
88.50	1.02	1.01	1.01	2.53	2.56		0.9	0.90	1.93	1.74	
89.50	-1.94	3.97	3.97	2.34	9.29		3.86	3.86	2.02	7.80	
90.50	-1.92	3.95	3.95	2.37	9.36		3.84	3.84	1.93	7.41	
91.50	-2.45	4.48	4.48	2.35	10.53		4.37	4.37	2.03	8.87	
92.50	-2.72	4.75	4.75	2.17	10.31		4.64	4.64	2.04	9.47	
93.50	-3.13	5.16	5.16	2.27	11.71		5.05	5.05	1.97	9.95	
94.50	-2.31	4.34	4.34	2.19	9.50		4.23	4.23	1.93	8.16	
95.50	-3.02	5.05	5.05	1.77	8.94		4.94	4.94	1.79	8.84	
96.50	-2.92	4.95	4.95	1.79	8.86		4.84	4.84	1.78	8.62	
97.50	-3.16	5.19	5.19	1.88	9.76		5.08	5.08	1.63	8.28	
98.50	-2.97	5.00	2.50	1.77	4.43		4.89	2.45	1.57	3.84	
			45.855	Flow	96.47	cfs		44.645	Flow	84.00	cfs

T-4 Streamflow Calculations											
			11/16/05 Staff Gage Reading			2.47	11/16/05 Staff Gage Reading			2.78	
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	
Culvert	3.7	-1.23	3.7	11.26	0.31	3.49	4.01	11.34	1.14	12.93	
						Flow	3.49	cfs		Flow	12.93 cfs

Site Survey Information	
Staff Guage Reading	2.47

1/13/06 Staff Gage Reading				2.67	
Depth	Area	Velocity	Flow		
3.9	11.34	0.74	8.39		
				Flow	8.39 cfs

T-5 Streamflow Calculations Page 1											
			11/16/05 Staff Gage Reading			2.15	12/1/05 Staff Gage Reading			2.94	
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	
Culv A	0.78	1.37	0.78	1.64	0.15	0.25	1.57	3.30	1.5	4.95	
Culv C	0.85	1.3	0.85	1.87	0.39	0.73	1.64	3.61	1.59	5.74	
36											
37	3.66	-1.51	3.66	3.66	1.08	3.95	4.45	4.45	1.58	7.03	
38	3.45	-1.3	3.45	3.45	0.9	3.11	4.24	4.24	2.25	9.54	
39	3.45	-1.3	3.45	3.45	0.95	3.28	4.24	4.24	2.1	8.90	
40	3.38	-1.23	3.38	3.38	1.11	3.75	4.17	4.17	2.3	9.59	
41	3.68	-1.53	3.68	3.68	1.31	4.82	4.47	4.47	2.44	10.91	
42	3.65	-1.5	3.65	3.65	0.55	2.01	4.44	4.44	1.24	5.51	
43	3.36	-1.21	3.36	3.36	-0.08	-0.27	4.15	4.15	-0.48	-1.99	
44	End										
					Flow	21.62	cfs				
								Flow	60.17	cfs	

Site Survey Information	
Staff Guage Reading	2.15

T-5 Streamflow Calculations Page 2			
1/13/06 Staff Gage Reading			2.66
Depth	Area	Velocity	Flow
1.29	2.71	1.02	2.76
1.36	2.99	1.05	3.14
4.17	4.17	1.32	5.50
3.96	3.96	1.47	5.82
3.96	3.96	1.72	6.81
3.89	3.89	1.78	6.92
4.19	4.19	1.98	8.30
4.16	4.16	0.89	3.70
3.87	3.87	-0.28	-1.08
		Flow	41.88

T-6 Streamflow Calculations Page 1							
			11/16/05 Staff Gage Reading			1.35	
Location	Reading	Elevation	Depth	Area	Velocity	Flow	
3		1.35	0	0.00	0	0.00	
4	0.45	0.9	0.45	0.45	0	0.00	
5	0.82	0.53	0.82	0.82	0	0.00	
6	1	0.35	1	1.00	0.01	0.01	
7	1.18	0.17	1.18	1.18	0.02	0.02	
8	1.39	-0.04	1.39	1.39	0.04	0.06	
9	1.55	-0.2	1.55	1.55	0.03	0.05	
10	1.49	-0.14	1.49	1.49	-0.01	-0.01	
11	1.71	-0.36	1.71	1.71	0.08	0.14	
12	1.96	-0.61	1.96	1.96	0.09	0.18	
13	2.25	-0.9	2.25	2.25	0.11	0.25	
14	2.57	-1.22	2.57	2.57	0.23	0.59	
15	2.77	-1.42	2.77	2.77	0.34	0.94	
16	2.88	-1.53	2.88	2.88	0.43	1.24	
17	2.88	-1.53	2.88	2.88	0.44	1.27	
18	2.73	-1.38	2.73	2.73	0.4	1.09	
19	2.66	-1.31	2.66	2.66	0.32	0.85	
20	2.54	-1.19	2.54	2.54	0.25	0.64	
21	2.71	-1.36	2.71	2.71	0.25	0.68	
22	2.57	-1.22	2.57	2.57	0.22	0.57	
23	3.31	-1.96	3.31	3.31	0.22	0.73	
24	3.33	-1.98	3.33	3.33	0.24	0.80	
25	2.99	-1.64	2.99	2.99	0.12	0.36	
26	3.8	-2.45	3.8	3.80	0.22	0.84	
27	3.93	-2.58	3.93	3.93	0.24	0.94	
28	4.22	-2.87	4.22	4.22	0.22	0.93	
29	4.06	-2.71	4.06	4.06	0.3	1.22	
30	3.71	-2.36	3.71	3.71	0.17	0.63	
31	3.23	-1.88	3.23	3.23	0.16	0.52	
32	2.46	-1.11	2.46	2.46	0.1	0.25	
33	1.86	-0.51	1.86	1.86	0.1	0.19	
					Flow	15.93	cfs

Site Survey Information	
Staff Guage Reading	1.35

T-6 Streamflow Calculations Page 2								
12/1/05 Staff Gage Reading			1.64	12/1/05 Staff Gage Reading			1.49	
Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	
0.29	0.29	0	0.00	0.14	0.14	0	0.00	
0.74	0.74	0	0.00	0.59	0.59	0	0.00	
1.11	1.11	0	0.00	0.96	0.96	0	0.00	
1.29	1.29	0	0.00	1.14	1.14	-0.2	-0.23	
1.47	1.47	0	0.00	1.32	1.32	0	0.00	
1.68	1.68	-0.05	-0.08	1.53	1.53	0.04	0.06	
1.84	1.84	0	0.00	1.69	1.69	0.04	0.07	
1.78	1.78	0	0.00	1.63	1.63	0.06	0.10	
2	2.00	0.12	0.24	1.85	1.85	0.06	0.11	
2.25	2.25	0.36	0.81	2.1	2.10	0.09	0.19	
2.54	2.54	0.28	0.71	2.39	2.39	0.14	0.33	
2.86	2.86	0.26	0.74	2.71	2.71	0.19	0.51	
3.06	3.06	0.39	1.19	2.91	2.91	0.23	0.67	
3.17	3.17	0.75	2.38	3.02	3.02	0.65	1.96	
3.17	3.17	0.75	2.38	3.02	3.02	0.67	2.02	
3.02	3.02	0.85	2.57	2.87	2.87	0.81	2.32	
2.95	2.95	0.95	2.80	2.8	2.80	0.83	2.32	
2.83	2.83	0.96	2.72	2.68	2.68	0.79	2.12	
3	3.00	0.83	2.49	2.85	2.85	0.8	2.28	
2.86	2.86	0.88	2.52	2.71	2.71	0.8	2.17	
3.6	3.60	0.82	2.95	3.45	3.45	0.82	2.83	
3.62	3.62	0.79	2.86	3.47	3.47	0.95	3.30	
3.28	3.28	0.68	2.23	3.13	3.13	0.9	2.82	
4.09	4.09	0.68	2.78	3.94	3.94	0.95	3.74	
4.22	4.22	0.68	2.87	4.07	4.07	0.91	3.70	
4.51	4.51	0.95	4.28	4.36	4.36	0.93	4.05	
4.35	4.35	0.53	2.31	4.2	4.20	1.02	4.28	
4	4.00	0.64	2.56	3.85	3.85	0.54	2.08	
3.52	3.52	0.58	2.04	3.37	3.37	0.42	1.42	
2.75	2.75	0.3	0.83	2.6	2.60	0.11	0.29	
2.15	2.15	0.3	0.65	2	2.00	0.05	0.10	
		Flow	47.82	cfs		Flow	45.63	cfs

T-7 Streamflow Calculations Page 1											
			06/12/05 Staff Gage Reading			1.51	06/22/05 Staff Gage Reading			0.91	
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	
71.2	start										
72	4.23	-0.62	2.13	1.38	0.68	0.94	1.53	0.99	0.22	0.22	
72.5	4.26	-0.65	2.16	1.08	0.74	0.80	1.56	0.78	0.26	0.20	
73	4.37	-0.76	2.27	1.14	0.98	1.11	1.67	0.84	0.70	0.58	
73.5	4.25	-0.64	2.15	1.08	0.9	0.97	1.55	0.78	0.75	0.58	
74	4.32	-0.71	2.22	1.11	0.7	0.78	1.62	0.81	0.72	0.58	
74.5	4.31	-0.7	2.21	1.11	0.8	0.88	1.61	0.81	0.70	0.56	
75	4.39	-0.78	2.29	1.15	0.69	0.79	1.69	0.85	0.51	0.43	
75.5	4.24	-0.63	2.14	1.07	0.51	0.55	1.54	0.77	0.51	0.39	
76	4.27	-0.66	2.17	1.09	0.45	0.49	1.57	0.79	0.35	0.27	
76.5	4.82	-1.21	2.72	1.36	0.38	0.52	2.12	1.06	0.44	0.47	
77	4.94	-1.33	2.84	1.42	0.37	0.53	2.24	1.12	0.44	0.49	
77.5	4	-0.39	1.9	0.95	0.44	0.42	1.30	0.65	0.32	0.21	
78	3.92	-0.31	1.82	0.91	0.39	0.35	1.22	0.61	0.34	0.21	
78.5	3.9	-0.29	1.8	0.90	0.28	0.25	1.20	0.60	0.30	0.18	
79	3.85	-0.24	1.75	0.88	0.22	0.19	1.15	0.58	0.14	0.08	
79.5	3.87	-0.26	1.77	0.89	0.12	0.11	1.17	0.59	0.14	0.08	
80	3.9	-0.29	1.8	0.90	0.13	0.12	1.20	0.60	0.09	0.05	
80.5	3.9	-0.29	1.8	0.90	0.14	0.13	1.20	0.60	0.12	0.07	
81	3.87	-0.26	1.77	0.89	0.15	0.13	1.17	0.59	0.16	0.09	
81.5	3.85	-0.24	1.75	0.88	0.15	0.13	1.15	0.58	0.10	0.06	
82	3.4	0.21	1.3	0.65	0.04	0.03	0.70	0.35	0.00	0.00	
82.5	3.2	0.41	1.1	0.55	0.02	0.01	0.50	0.25	0.00	0.00	
83	3.16	0.45	1.06	0.42	0	0.00	0.46	0.18	0.00	0.00	
83.3	end				Flow	10.22	cfs		Flow	5.83	cfs

Site Survey Information			
		Staff Guage Shot	3.61
		Staff Guage Reading	1.03
Benchmark bottom of concrete above staff guage -2.33			

T-7 Streamflow Calculations Page 2				
06/22/05 Staff Gage Reading			1.56	
Depth	Area	Velocity	Flow	
		0		
2.18	1.42	1.47	2.08	
2.21	1.11	1.28	1.41	
2.32	1.16	1.1	1.28	
2.20	1.10	1.06	1.17	
2.27	1.14	1.06	1.20	
2.26	1.13	0.99	1.12	
2.34	1.17	0.89	1.04	
2.19	1.10	0.89	0.97	
2.22	1.11	0.87	0.97	
2.77	1.39	0.85	1.18	
2.89	1.45	0.88	1.27	
1.95	0.98	0.81	0.79	
1.87	0.94	0.81	0.76	
1.85	0.93	0.65	0.60	
1.80	0.90	0.49	0.44	
1.82	0.91	0.22	0.20	
1.85	0.93	0.25	0.23	
1.85	0.93	0.23	0.21	
1.82	0.91	0.08	0.07	
1.80	0.90	0	0.00	
1.35	0.68	0	0.00	
1.15	0.58	0	0.00	
1.11	0.44	0	0.00	
		Flow	17.00	cfs

T-7 Streamflow Calculations Page 3										
			06/12/05 Staff Gage Reading			2.14	1/13/06 Staff Gage Reading			1.72
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow
71.2	start									
72	2.55	-0.41	2.55	1.66	2.6	4.31	2.13	1.38	2.22	3.07
72.5	2.98	-0.84	2.98	1.49	2.69	4.01	2.56	1.28	2.02	2.59
73	2.86	-0.72	2.86	1.43	2.54	3.63	2.44	1.22	1.7	2.07
73.5	2.97	-0.83	2.97	1.49	2.28	3.39	2.55	1.28	1.46	1.86
74	2.95	-0.81	2.95	1.48	2.07	3.05	2.53	1.27	1.3	1.64
74.5	3.05	-0.91	3.05	1.53	2.08	3.17	2.63	1.32	1.34	1.76
75	3	-0.86	3	1.50	1.84	2.76	2.58	1.29	1.25	1.61
75.5	2.84	-0.7	2.84	1.42	1.52	2.16	2.42	1.21	1.21	1.46
76	2.77	-0.63	2.77	1.39	1.45	2.01	2.35	1.18	1.22	1.43
76.5	2.73	-0.59	2.73	1.37	1.36	1.86	2.31	1.16	1.09	1.26
77	2.54	-0.4	2.54	1.27	1.18	1.50	2.12	1.06	1.02	1.08
77.5	2.78	-0.64	2.78	1.39	0.9	1.25	2.36	1.18	0.82	0.97
78	2.58	-0.44	2.58	1.29	0.95	1.23	2.16	1.08	0.75	0.81
78.5	2.55	-0.41	2.55	1.28	0.9	1.15	2.13	1.07	0.75	0.80
79	2.47	-0.33	2.47	1.24	0.68	0.84	2.05	1.03	0.57	0.58
79.5	2.4	-0.26	2.4	1.20	0.81	0.97	1.98	0.99	0.46	0.46
80	2.27	-0.13	2.27	1.14	0.78	0.89	1.85	0.93	0.32	0.30
80.5	2.28	-0.14	2.28	1.14	0.57	0.65	1.86	0.93	0.33	0.31
81	2.19	-0.05	2.19	1.10	0.48	0.53	1.77	0.89	0.15	0.13
81.5	2.08	0.06	2.08	1.04	0.33	0.34	1.66	0.83	0.09	0.07
82	1.94	0.2	1.94	0.97	0.02	0.02	1.52	0.76	0.07	0.05
82.5	1.86	0.28	1.86	0.93	-0.01	-0.01	1.44	0.72	0	0.00
83	1.64	0.5	1.64	0.66	-0.05	-0.03	1.22	0.49	0	0.00
	end				Flow	39.66			Flow	24.33

Site Survey Information	
Staff Guage Reading	2.14

T-8 Streamflow Calculations											
			11/16/05 Staff Gage Reading			1.1	12/1/05 Staff Gage Reading			1.05	
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	
85											
86	0.77	0.33	0.77	0.77	0.88	0.68	0.72	0.72	1.73	1.25	
87	1.09	0.01	1.09	1.09	0.55	0.60	1.04	1.04	1.88	1.96	
88	1.25	-0.15	1.25	1.25	0.61	0.76	1.2	1.20	1.93	2.32	
89	1.25	-0.15	1.25	1.25	0.87	1.09	1.2	1.20	2.1	2.52	
90	1.19	-0.09	1.19	1.19	0.8	0.95	1.14	1.14	2.04	2.33	
91	End			5.55				5.30			
					Flow	4.08	cfs		Flow	10.36	cfs

*Downed tree may have altered 11/16 readings

Site Survey Information	
Staff Gauge Reading	1.1

1/13/06 Staff Gage Reading			0.92	
Depth	Area	Velocity	Flow	
0.59	0.59	1.52	0.90	
0.91	0.91	1.69	1.54	
1.07	1.07	1.6	1.71	
1.07	1.07	1.65	1.77	
1.01	1.01	1.44	1.45	
	4.65			
		Flow	7.37	cfs

T-9 Streamflow Calculations											
			11/16/05 Staff Gage Reading			2.27	11/16/05 Staff Gage Reading			2.5	
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	
Culvert 1	2.16	0.11	2.16	6.92	0.45	3.11	2.39	7.83	1.19	9.32	
Culvert 2	2.16	0.11	2.16	6.92	0.36	2.49	2.39	7.83	1.25	9.79	
	End										
					Flow	5.61	cfs		Flow	19.11	cfs

*(2) 4' dia culverts at same elevation, velocities vary based on stream orientation.

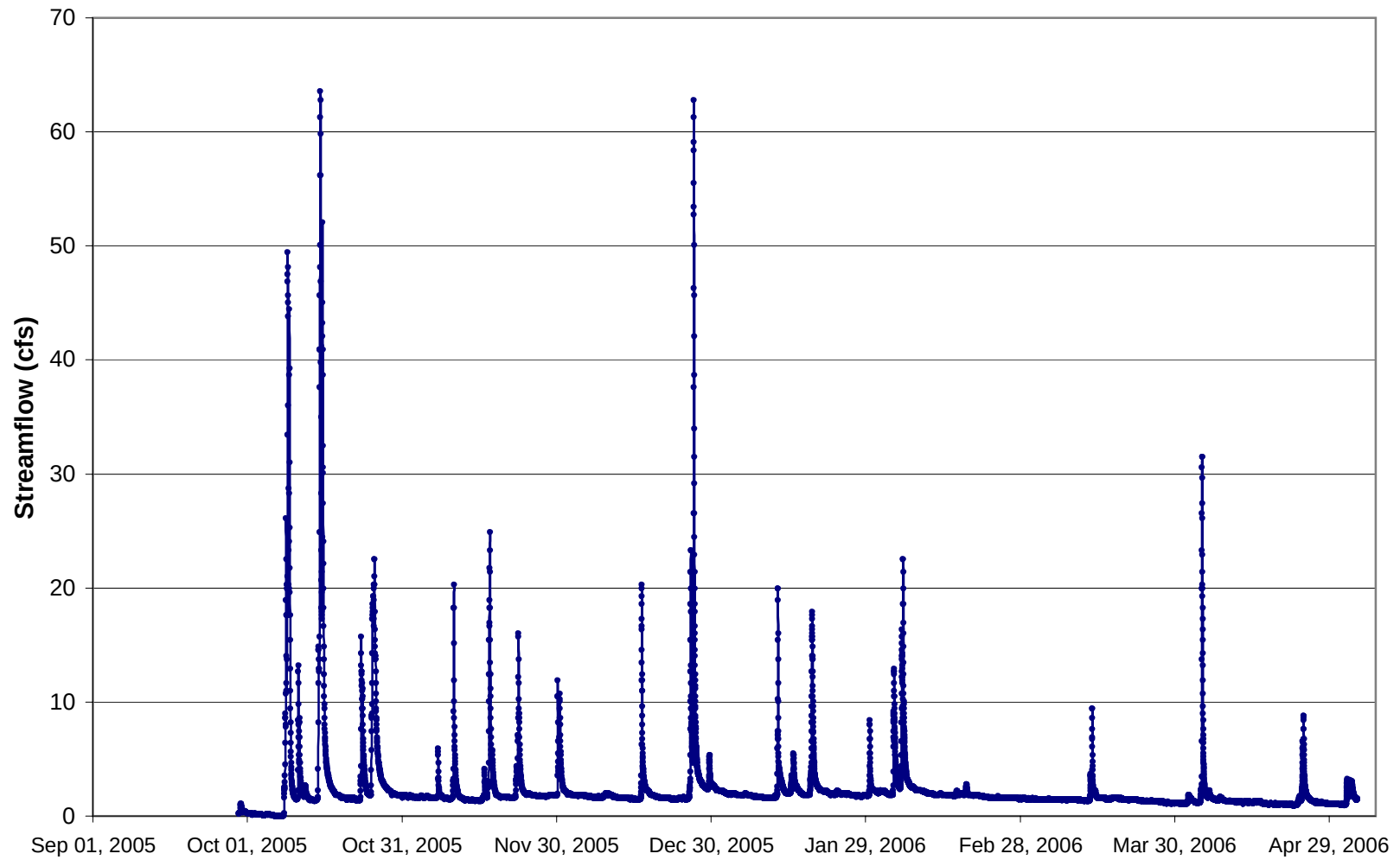
Site Survey Information	
Staff Guage Reading	2.27

1/13/06 Staff Gage Reading			2.28	
Depth	Area	Velocity	Flow	
2.17	6.93	0.76	5.27	
2.17	6.93	0.69	4.78	
cfs		Flow	10.05	cfs

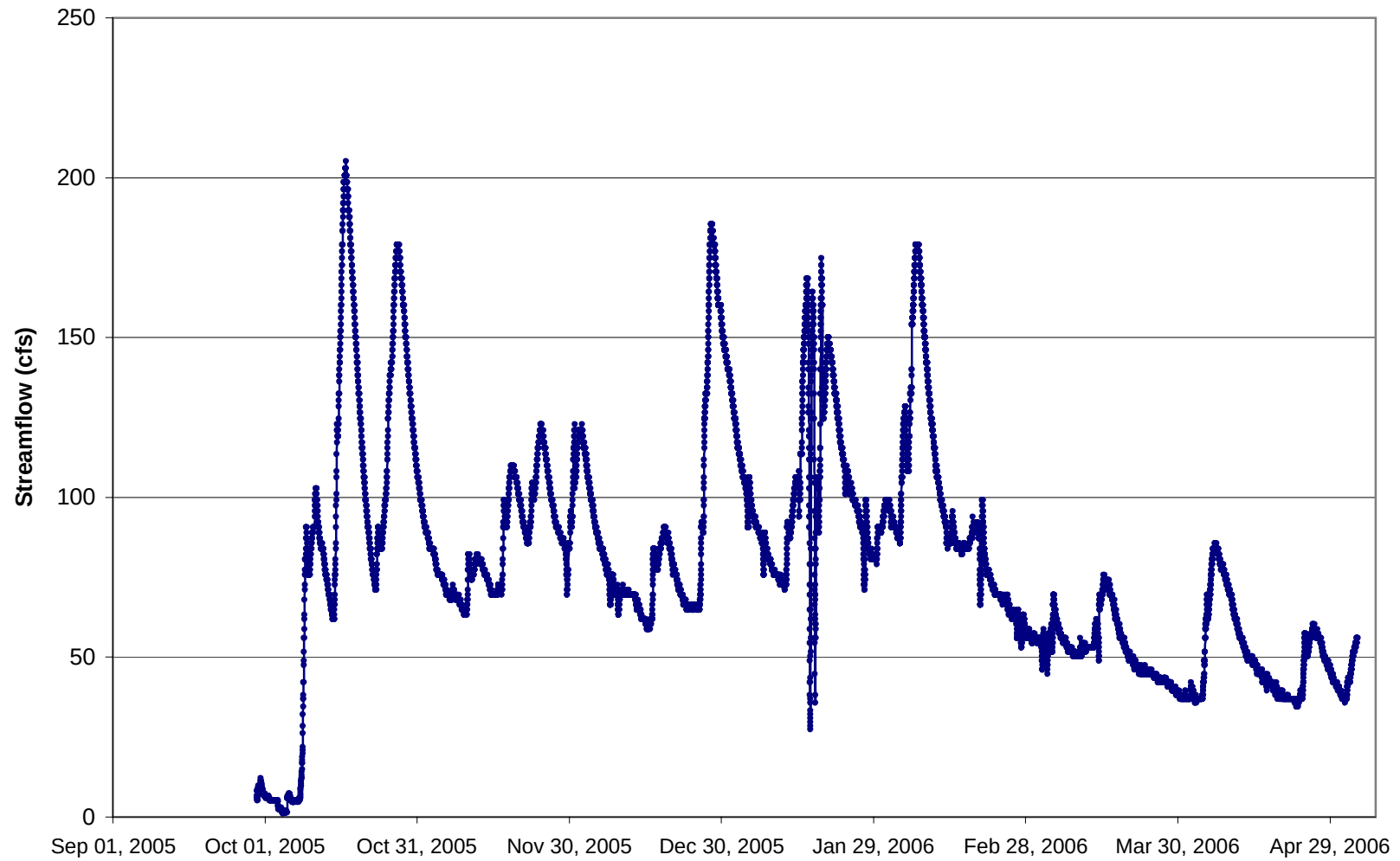
Appendix C

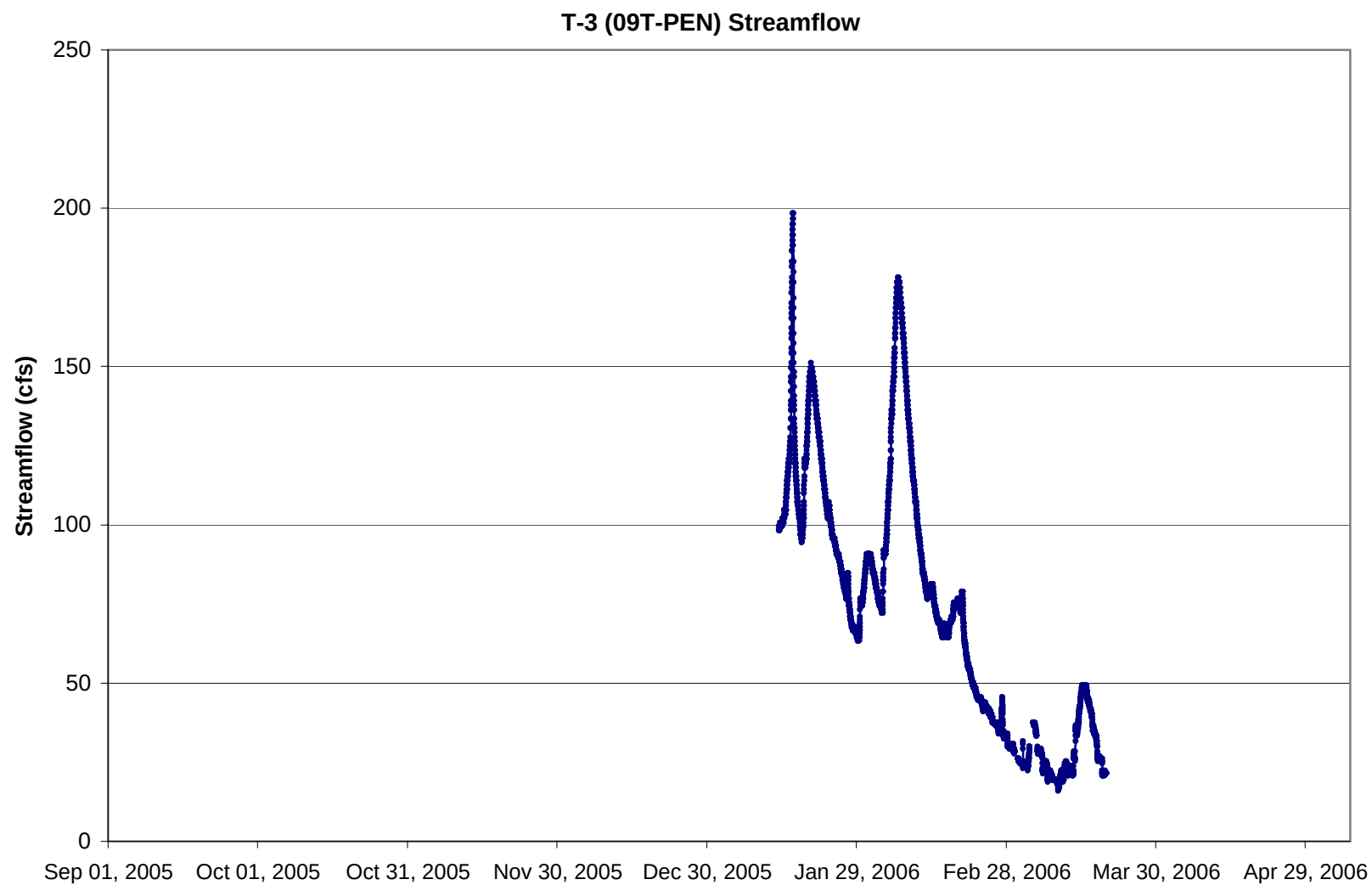
Measured Streamflows

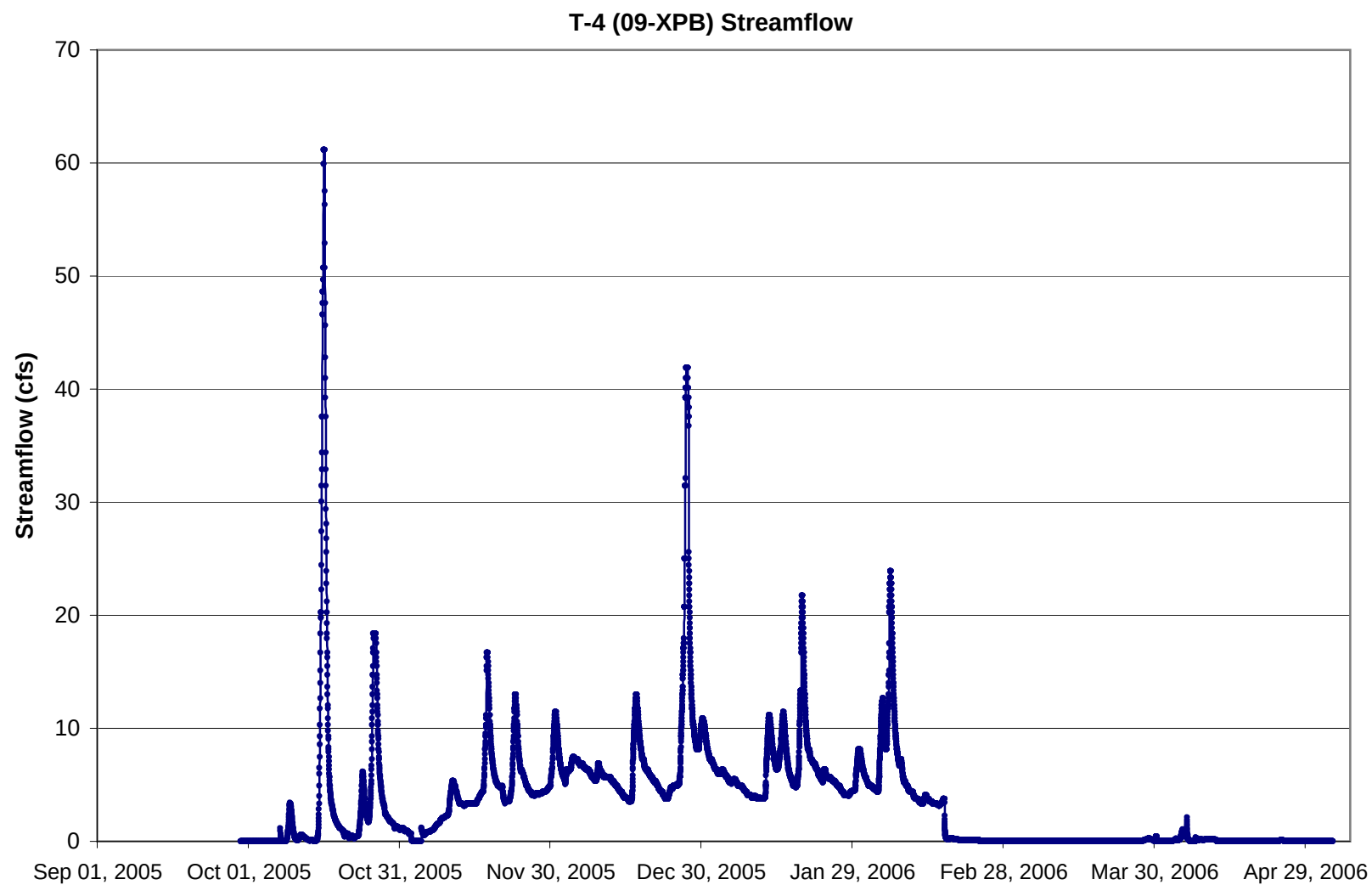
T-1 (01-BFB) Streamflow



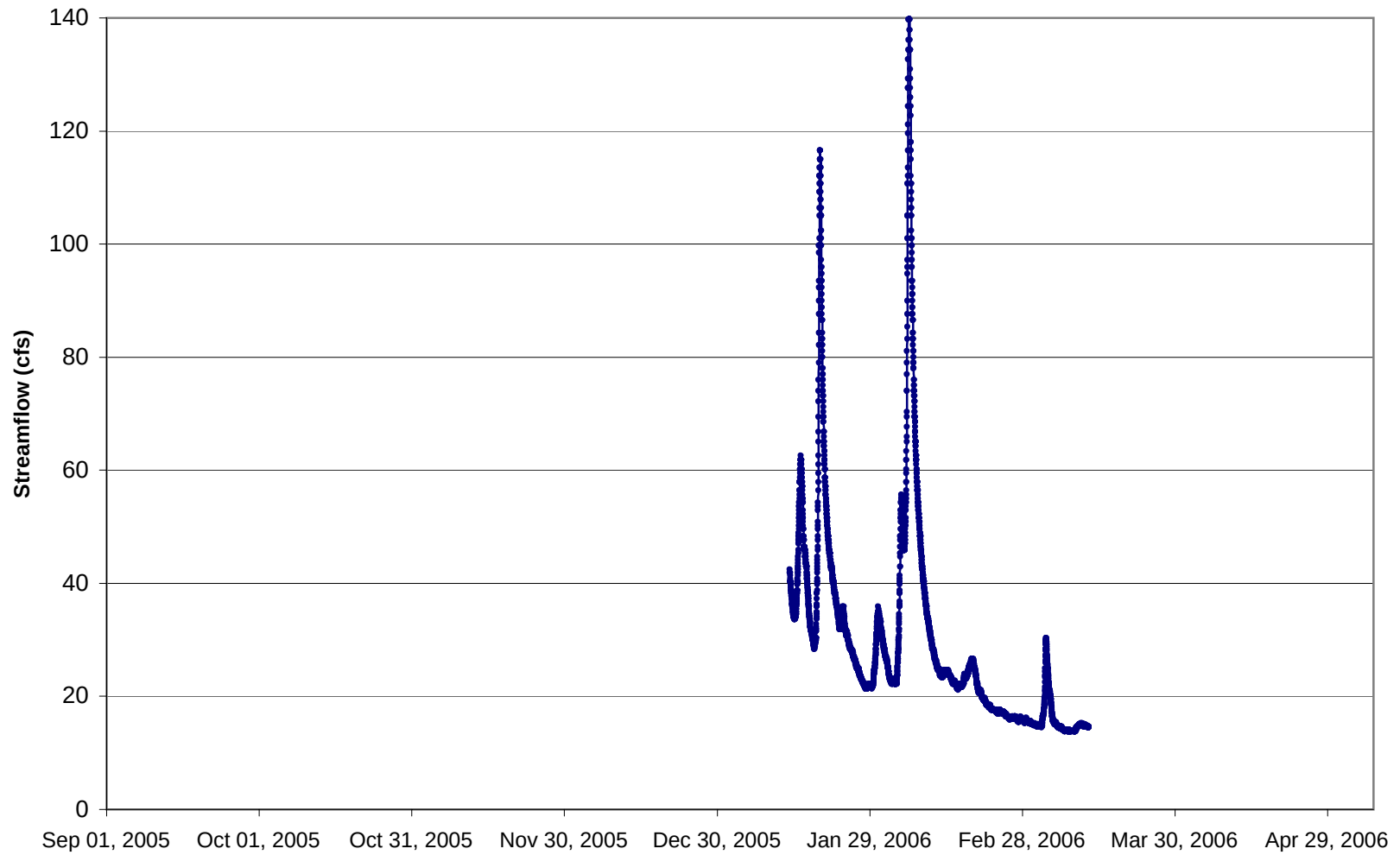
T-2 (09-PEN) Streamflow



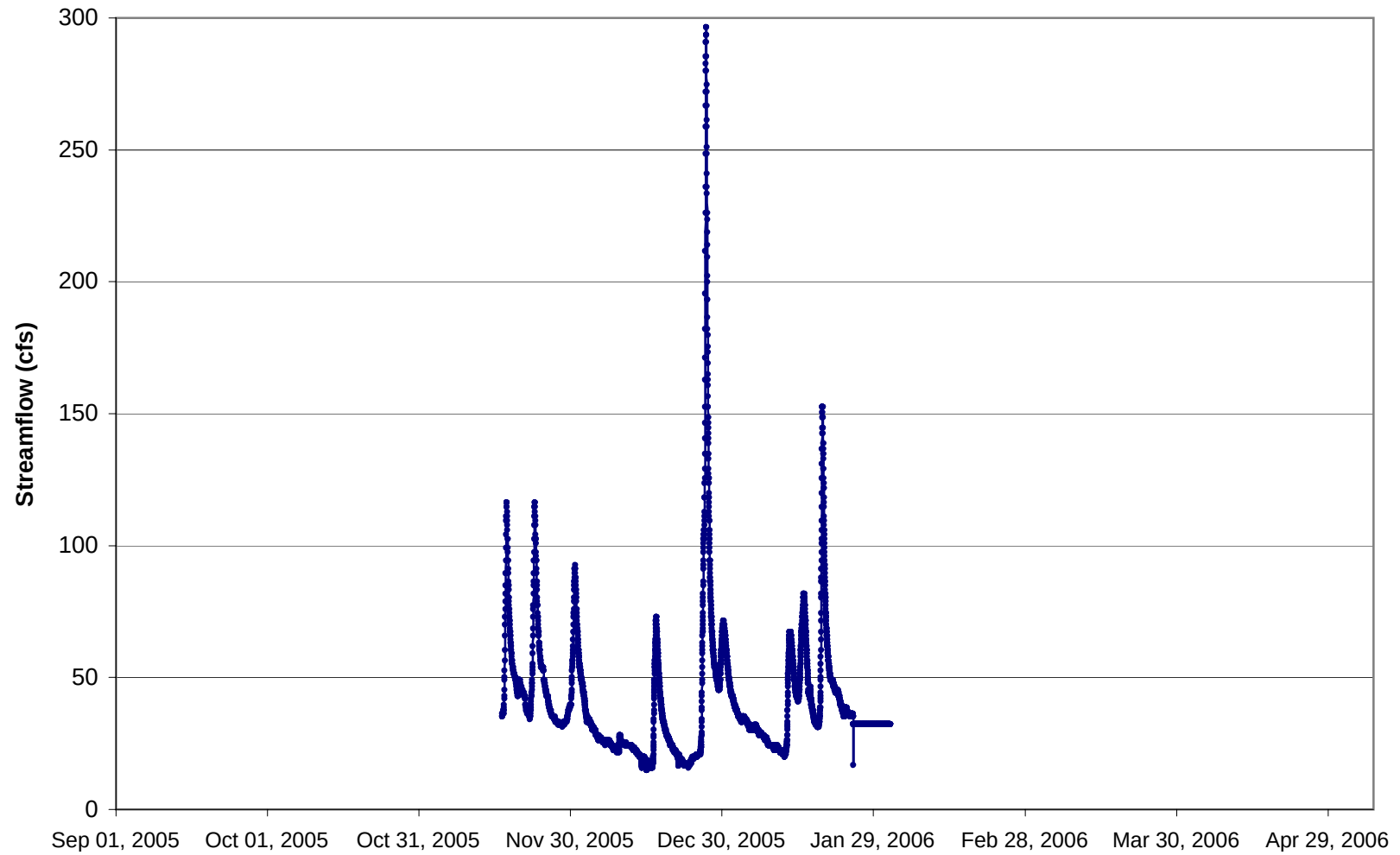




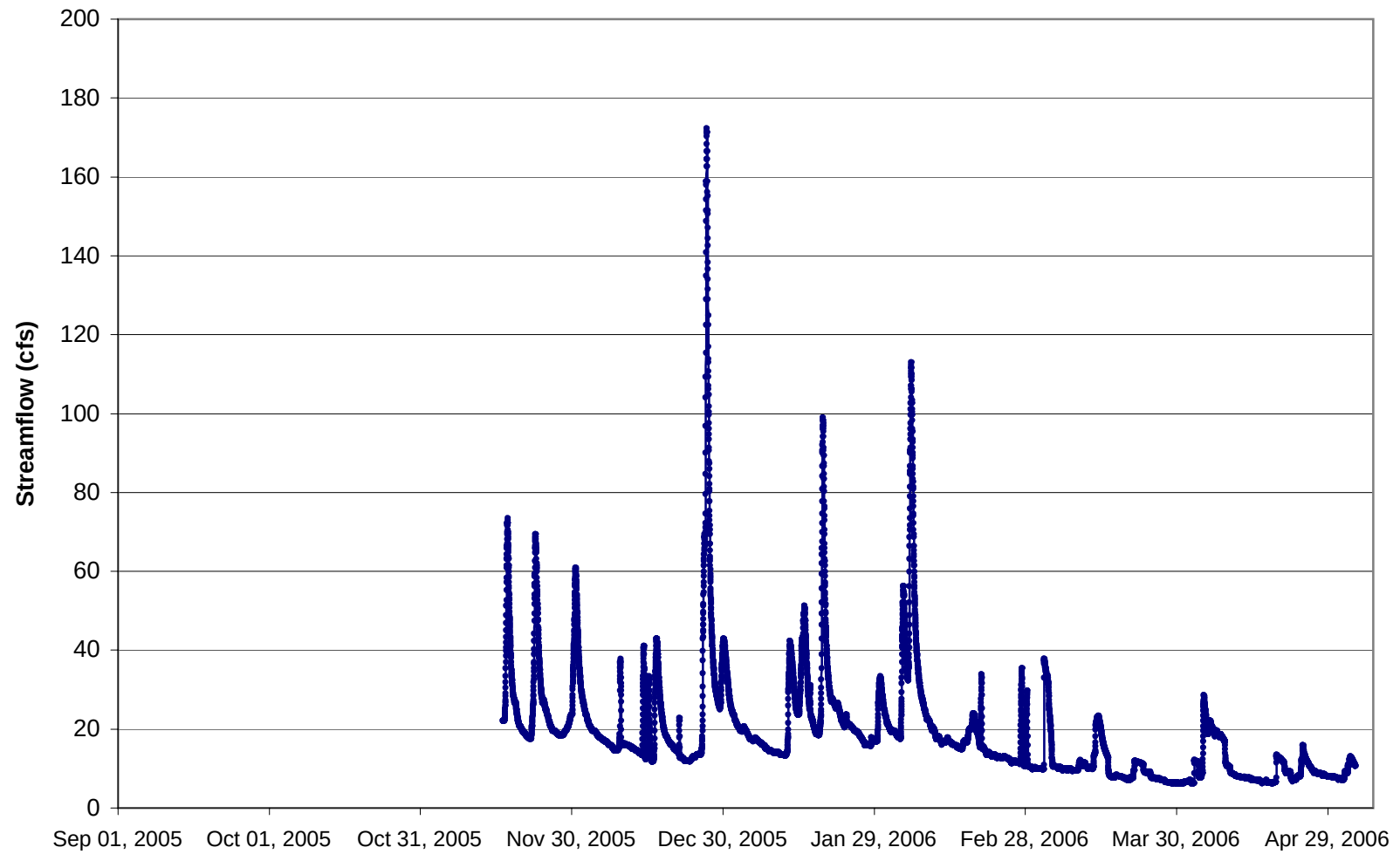
T-5 (01-WCH) Streamflow



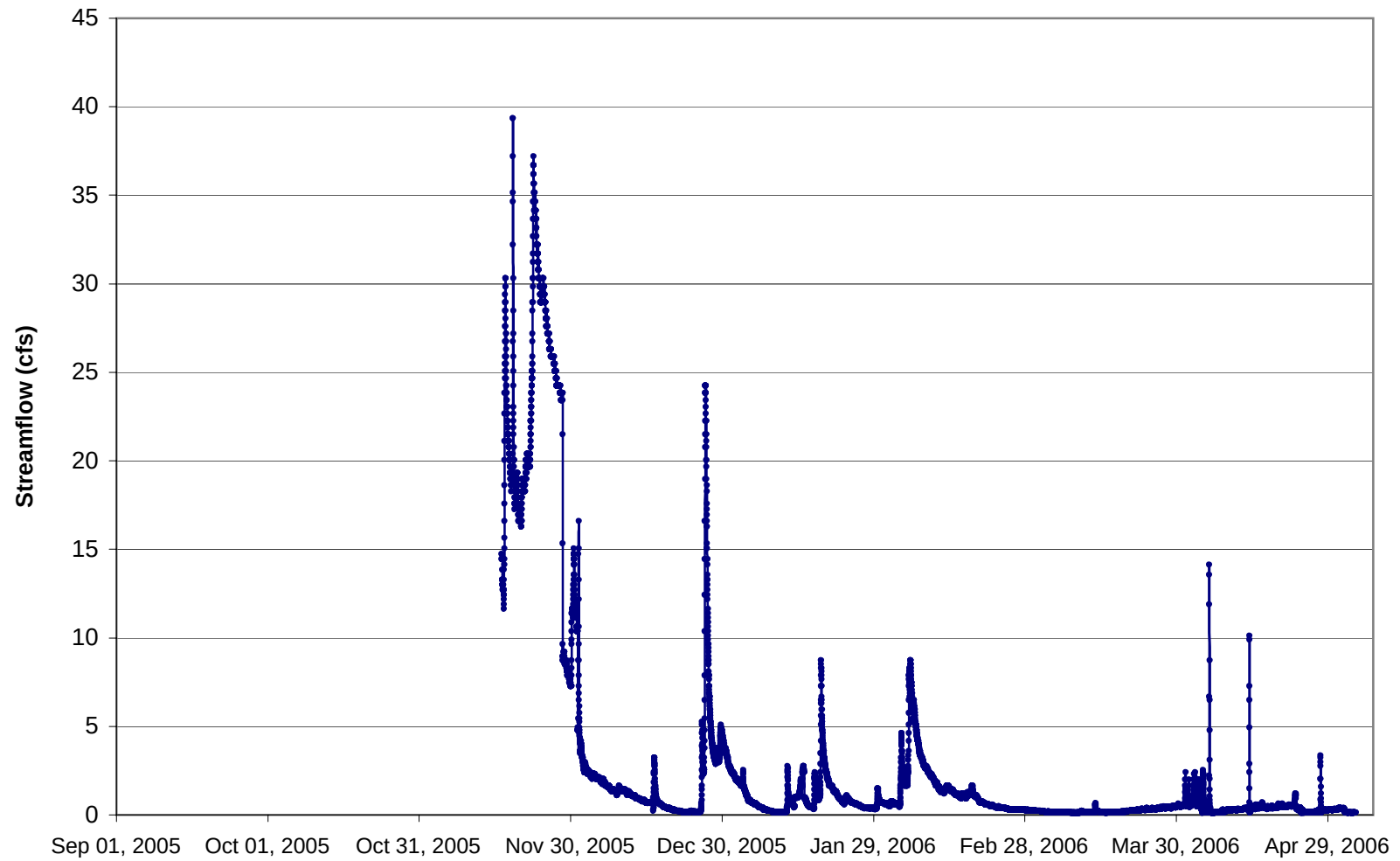
T-6 (01-XWB) Streamflow



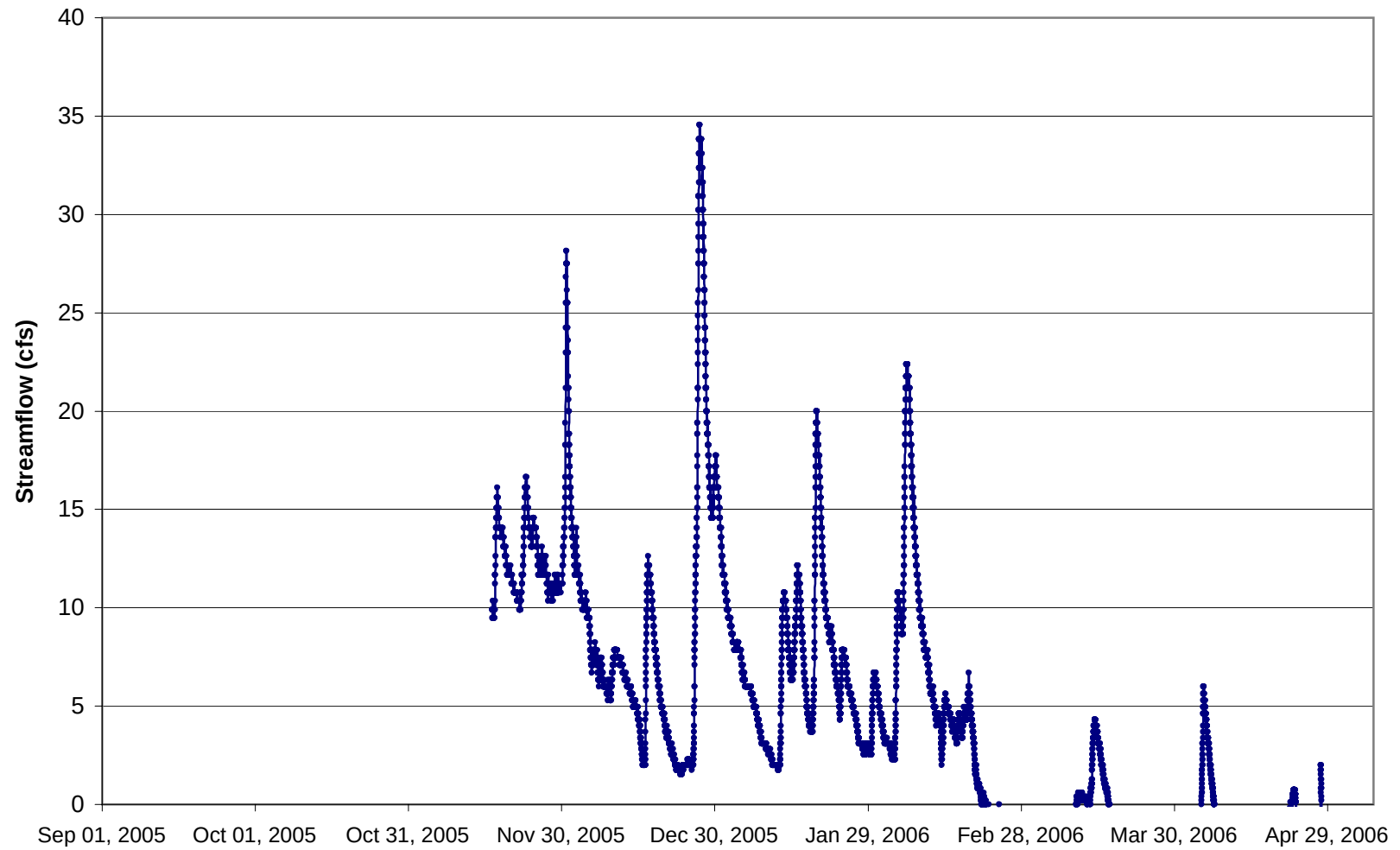
T-7 (02-WCH) Streamflows



T-8 (12-PEN) Streamflow



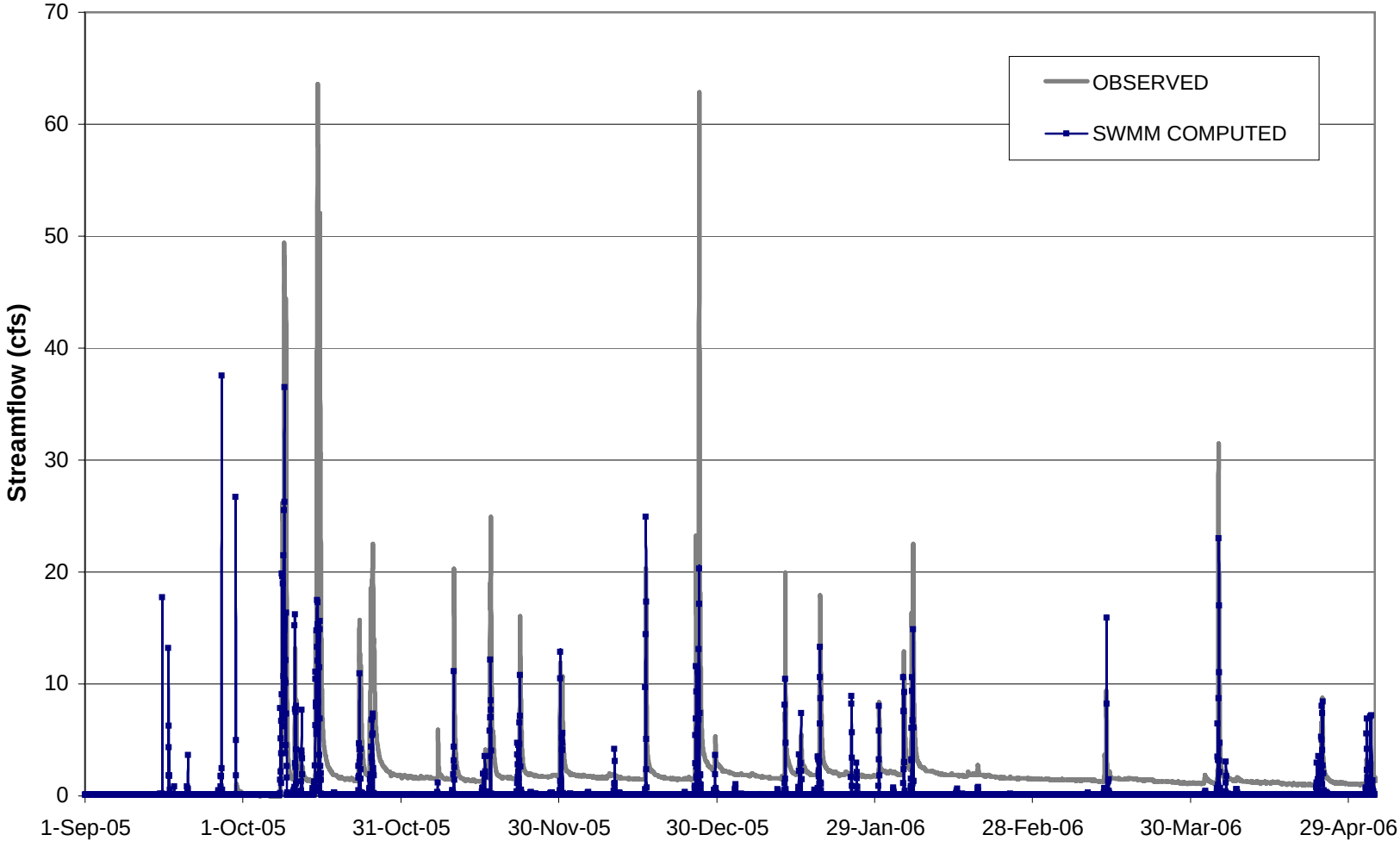
T-9 (01-MUD) Streamflow



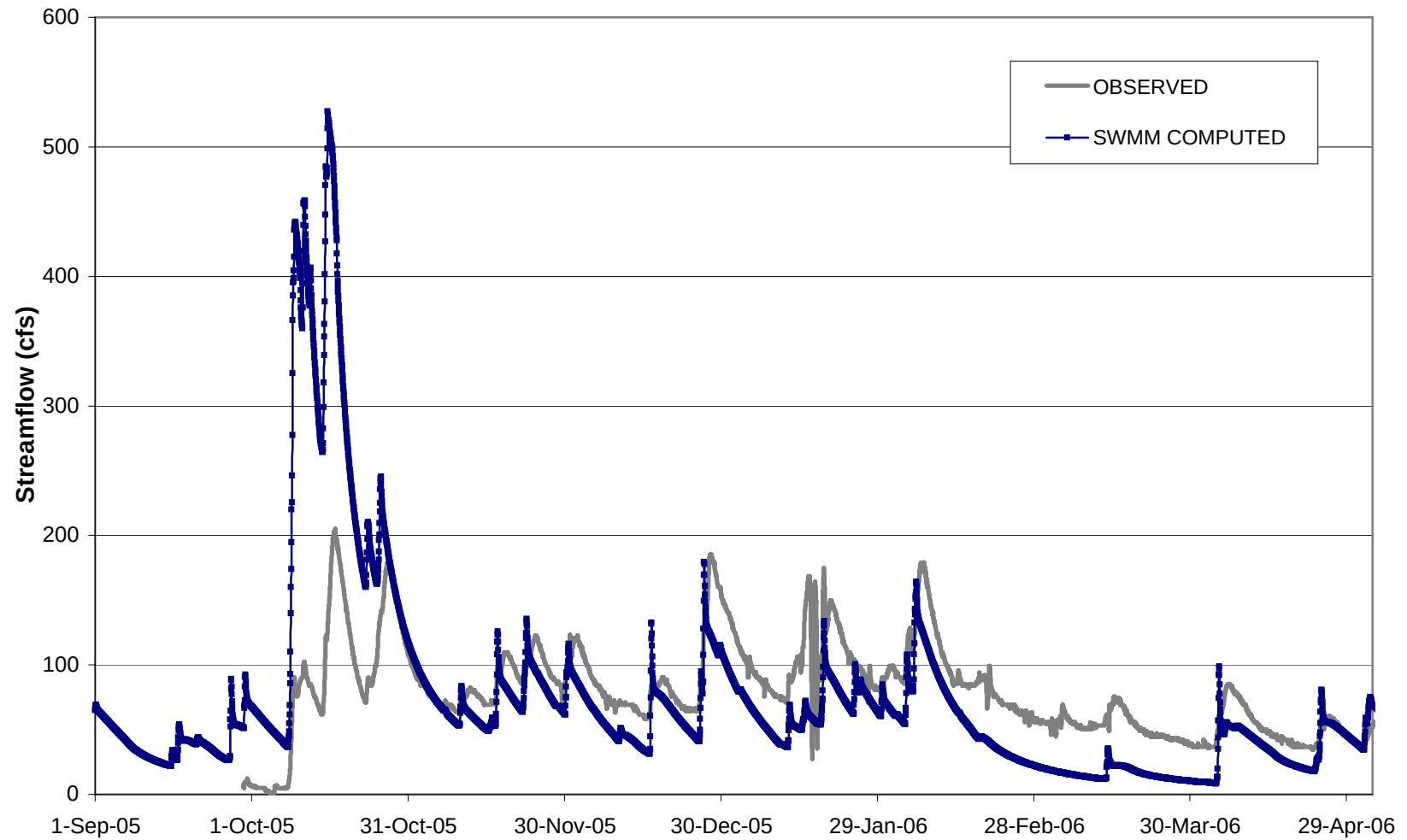
Appendix D

Streamflow Calibration Curves

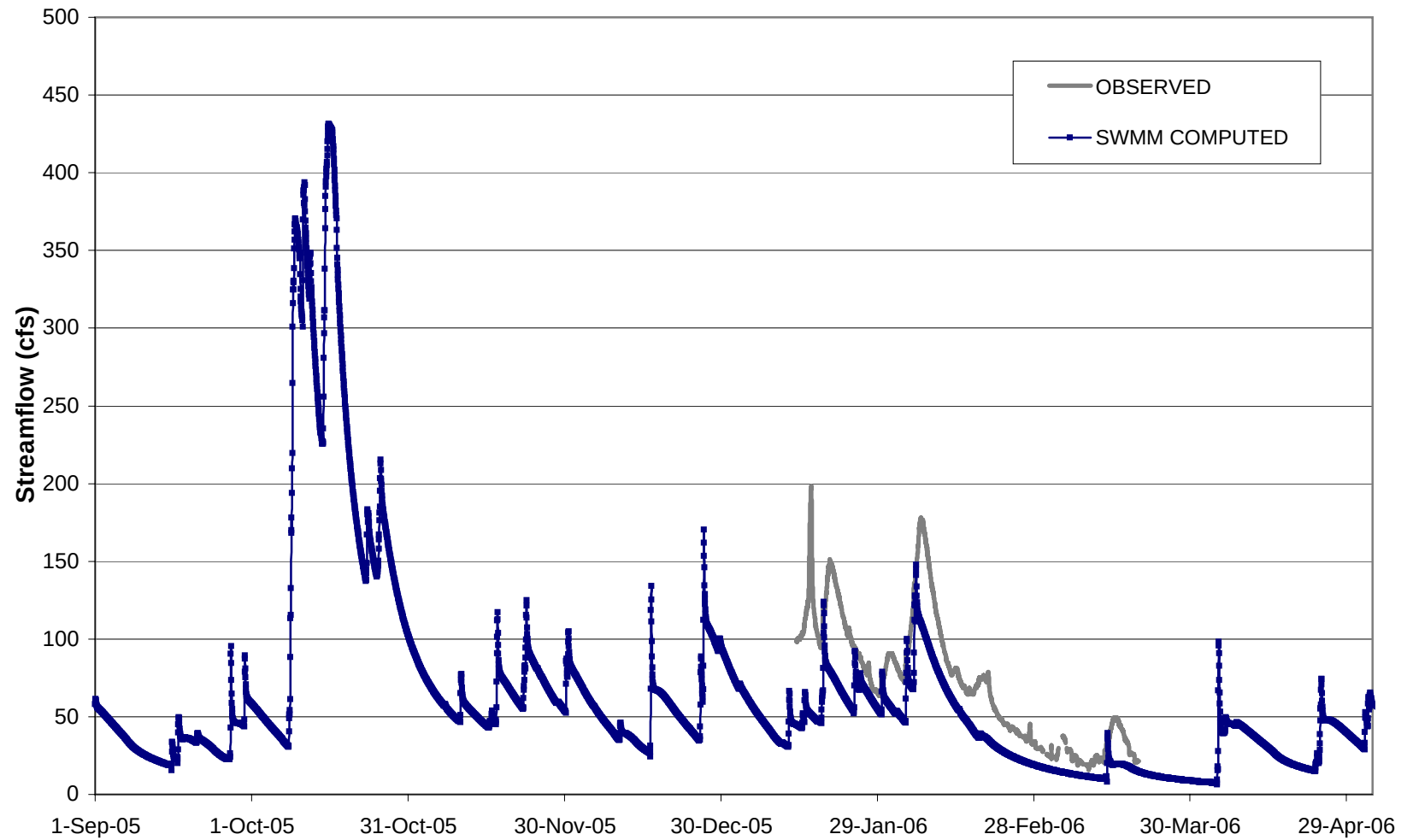
T-1 (01-BFB) Streamflow Calibration Curve



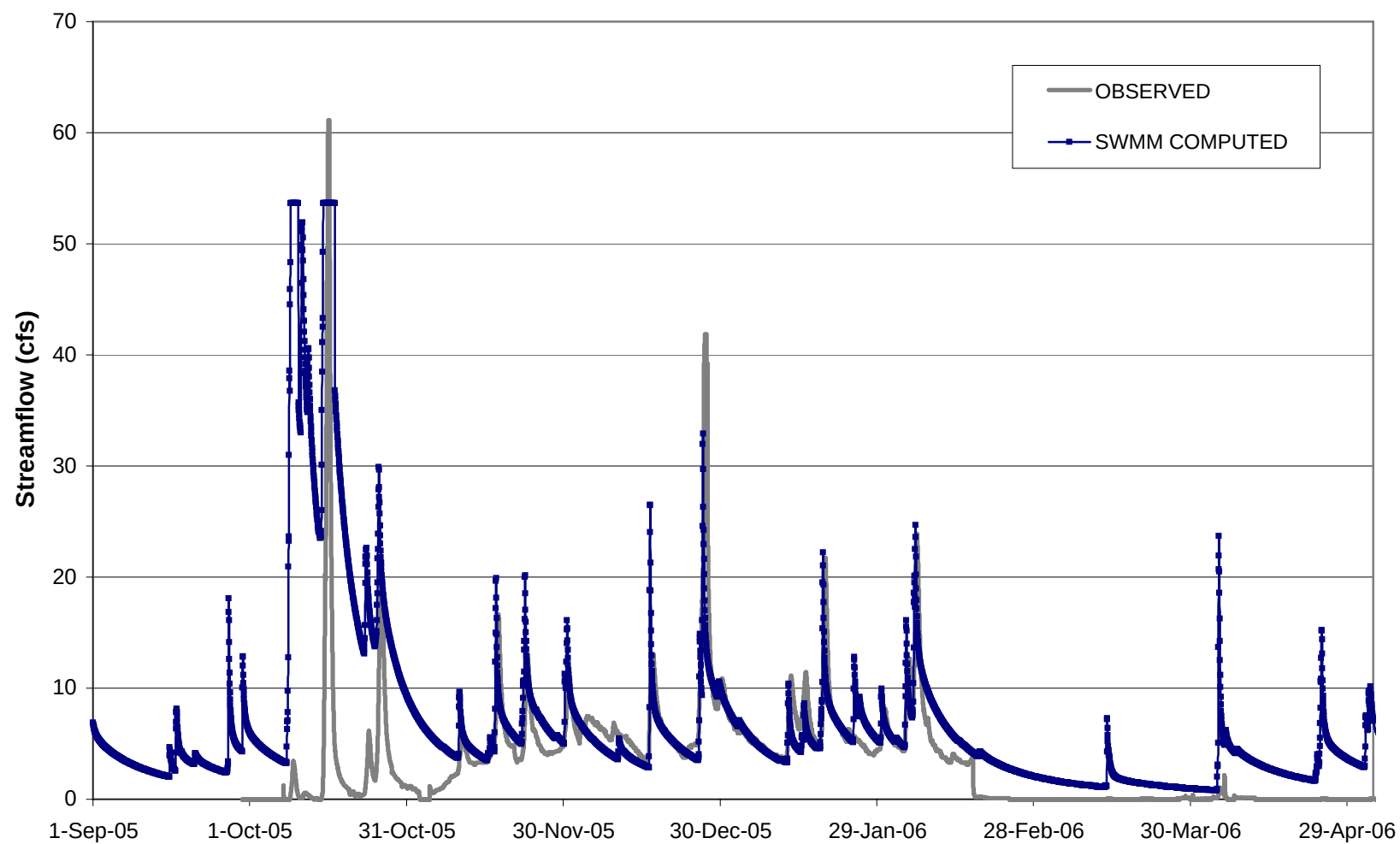
T-2 (09-PEN) Streamflow Calibration Curve



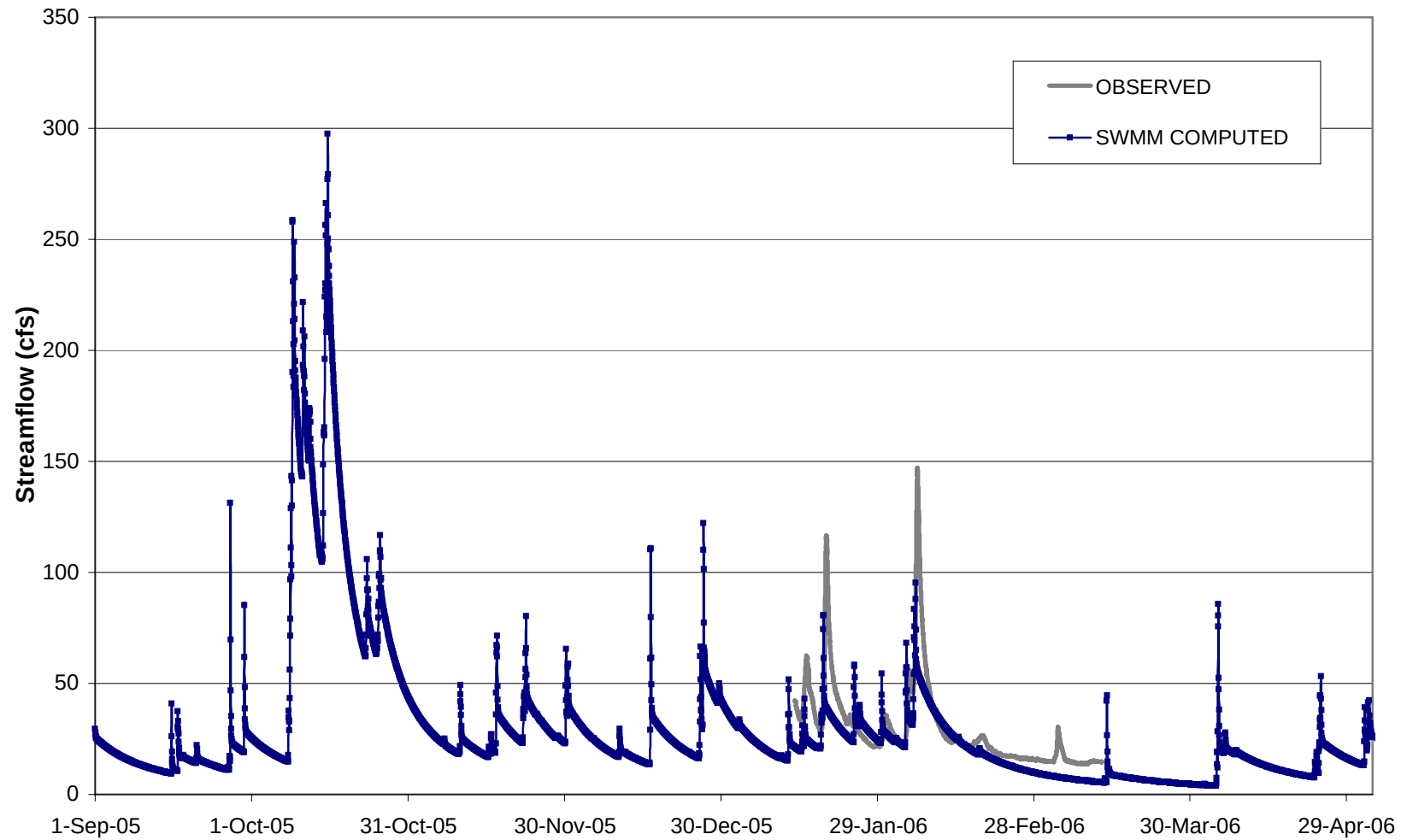
T-3 (09T-PEN) Streamflow Calibration Curve



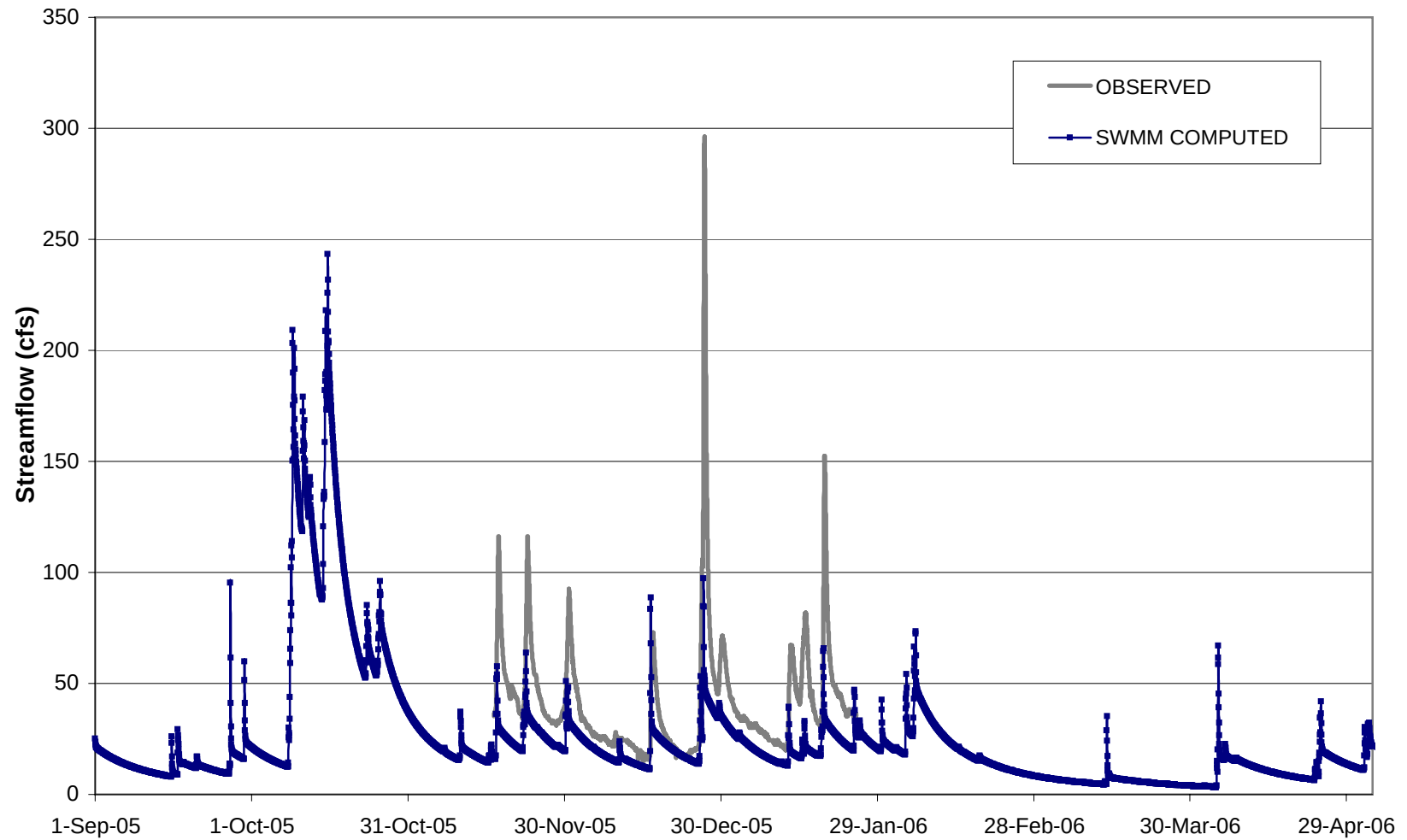
T-4 (09-XPB) Streamflow Calibration Curve



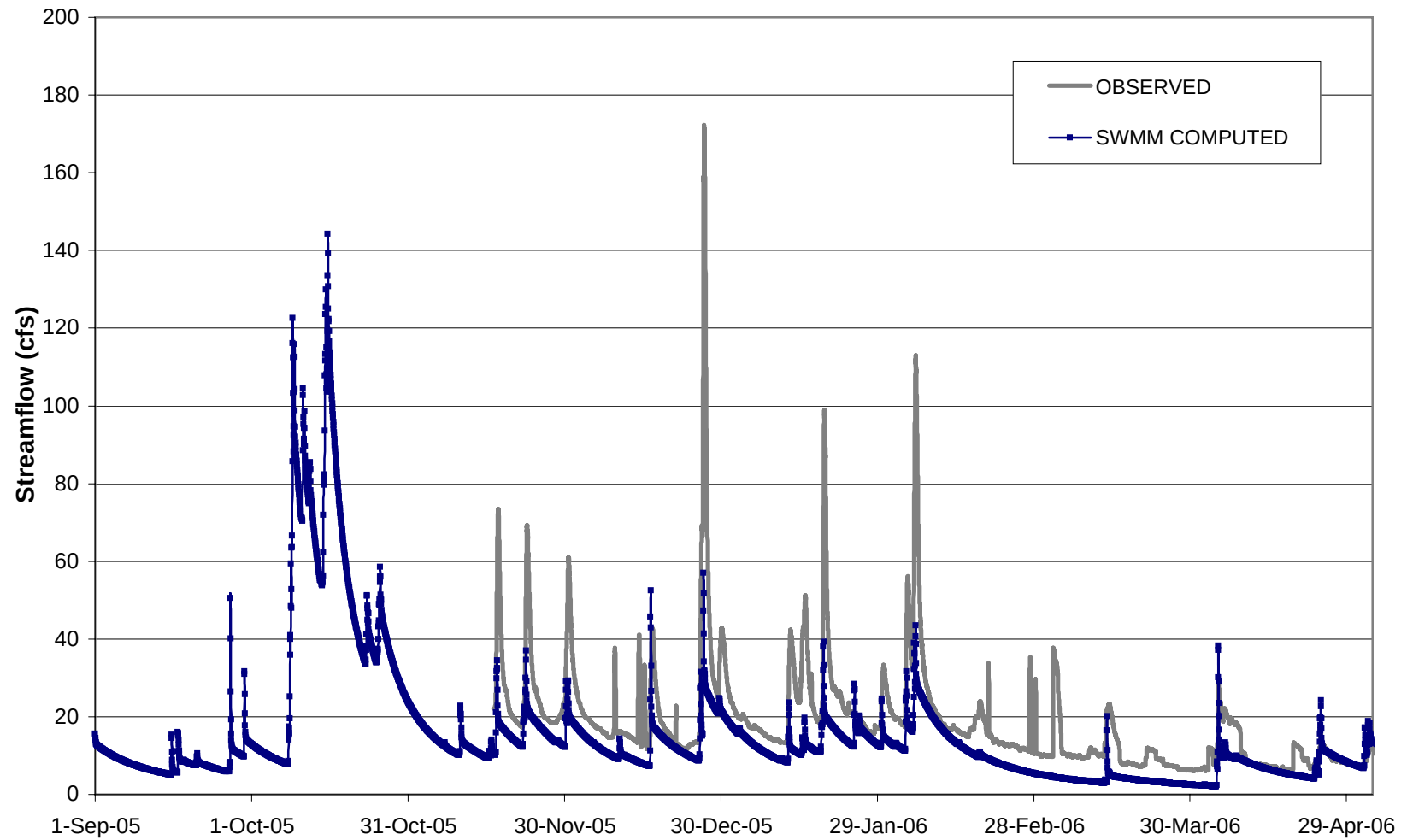
T-5 (01-WCH) Streamflow Calibration Curve



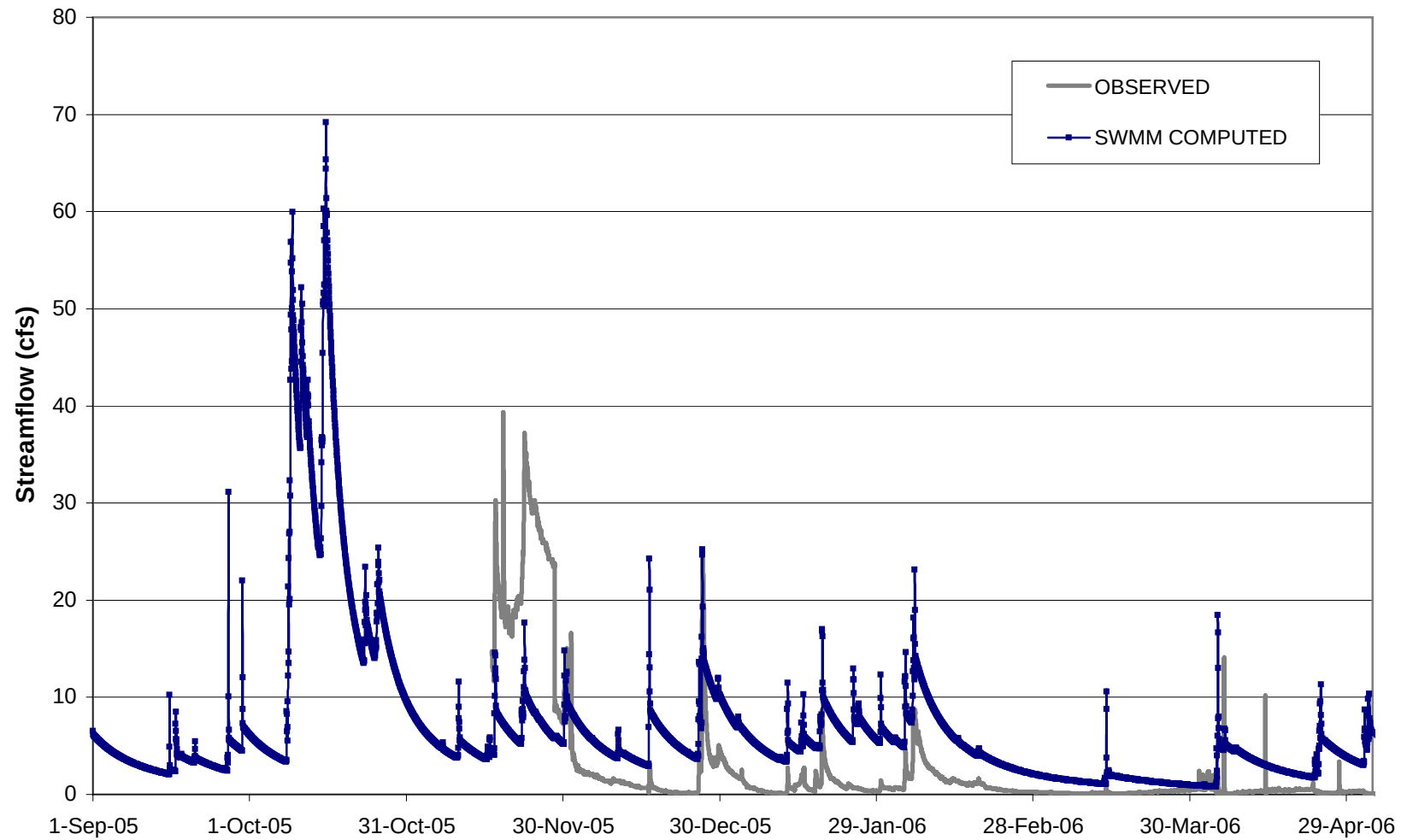
T-6 (01-XWB) Streamflow Calibration Curve



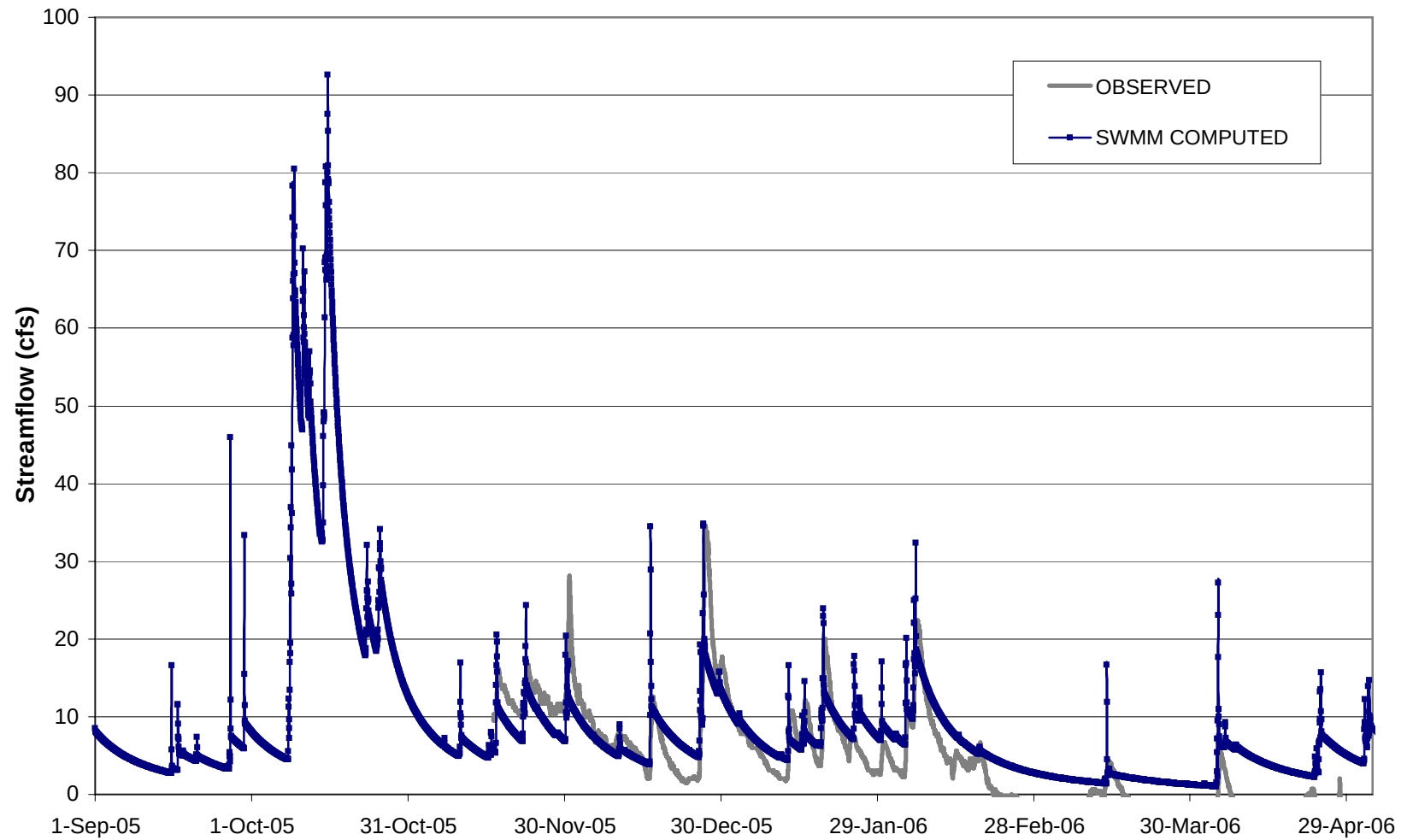
T-7 (02-WCH) Streamflow Calibration Curve



T-8 (12-PEN) Streamflow Calibration Curve



T-9 (01-MUD) Streamflow Calibration Curve



Appendix E

BMP Sampling Results

2006 Pennichuck Brook BMP Sampling Results

SW-1 Conway Office Swale				
Date	Rainfall (in.)	Location	TSS (mg/L)	Phosphorous (mg/L)
8/15/2006	0.25	Inlet	<5	0.16
		Outlet	None	None
8/21/2006	1.65	Inlet	<5	<0.05
		Outlet	<5	0.06
9/5/2006	1.20	Inlet	<5	<0.05
		Outlet	<5	0.06

SW-4 Celina Avenue Forebay/Sediment Trap				
Date	Rainfall (in.)	Location	TSS (mg/L)	Phosphorous (mg/L)
5/27/2006	0.25	Inlet	8	0.12
		Outlet	<5	0.12
6/2/2006	2.90	Inlet	<5	0.08
		Outlet	<5	0.11
6/15/2006	0.40	Inlet	<5	0.06
		Outlet	<5	0.05
7/13/2006	1.95	Inlet	<5	0.20
		Outlet	<5	0.21

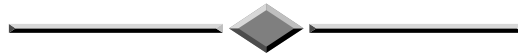
SW-2 Home Depot Detention Basin With Grass				
Date	Rainfall (in.)	Location	TSS (mg/L)	Phosphorous (mg/L)
9/5/2006	1.2	Inlet	<5	<0.05
		Outlet	<5	0.07
9/15/2006	0.35	Inlet	<5	0.07
		Outlet	<5	<0.05
10/2/2006	1.10	Inlet	<5	<0.05
		Outlet	<5	0.056

SW-5 White Oak Drive Detention Basin With Wetland Plants				
Date	Rainfall (in.)	Location	TSS (mg/L)	Phosphorous (mg/L)
5/27/2006	0.25	Inlet	18	0.37
		Outlet	None	None
6/2/2006	2.90	Inlet	<5	0.13
		Outlet	<5	0.14
7/13/2006	1.95	Inlet	90	0.18
		Outlet	70	0.12

SW-3 Pennichuck Square Infiltration - LID				
Date	Rainfall (in.)	Location	TSS (mg/L)	Phosphorous (mg/L)
8/15/2006	0.25	Inlet	<5	<0.05
		Outlet	None	None
8/21/2006	1.65	Inlet	<5	<0.05
		Outlet	<5	<0.05
9/5/2006	1.20	Inlet	<5	0.06
		Outlet	<5	0.06

SW-6 White Oak Drive Naturalizing Detention Basin				
Date	Rainfall (in.)	Location	TSS (mg/L)	Phosphorous (mg/L)
5/27/2006	0.25	Inlet	27	0.28
		Outlet	None	None
6/2/2006	2.90	Inlet	<5	0.15
		Outlet	<5	0.11
7/13/2006	1.95	Inlet	<5	0.10
		Outlet	<5	0.14

Appendix E:
2000 New Hampshire Technical
Community College BMP Sampling



Pennichuck Brook Urban Runoff Project

April 2000

**Prepared by the
Nashua Regional Planning Commission**

**This project was funded in part by a New Hampshire Department of Environmental Services
Nonpoint Source Program Local Initiative Grant
with matching funds provided by Pennichuck Water Works.**





Project Summary and Goals

The goal of the *Pennichuck Brook Urban Stormwater Project* is to decrease the impacts of urban runoff on the Holt Brook tributary and the Pennichuck Brook watershed. Accomplishing this goal involved:

- Diverting the untreated discharge through a multi-cell stormwater treatment system
- Educating the businesses in the drainage area on the negative impacts of NPS and accidental spills on the city's public water supply
- Increasing public awareness of the link between the stormwater drainage system and the public drinking water supply through a storm drain stenciling program
- Demonstrating the effectiveness of low technology urban runoff management practices on water resources
- Encouraging local planning boards to incorporate urban runoff best management practices in the designs of future development in the communities

Introduction

Through regulation and education, the impact of point sources of pollution have been reduced and the focus has shifted to nonpoint sources of pollution. The *New Hampshire Nonpoint Source Pollution Management Plan*, published in 1999 by the NH Department of Environmental Services, identifies urban runoff as the primary area of concern for impacts to water quality in the State. The Pennichuck Brook system is the major water supply source for the Nashua region and serves as Pennichuck Water Works primary source of water (approximately 75 percent). Portions of the Pennichuck Brook watershed are impacted by urban runoff from industrial, commercial and high density residential uses as well as the region's major transportation networks, the FE Everett Turnpike and NH Route 101A. This project deals with the impacts of urban runoff on the Pennichuck Brook system and includes both the construction of structural measures and educational efforts to reduce the impacts of nonpoint source pollution on the region's most important public water supply source.

The *Pennichuck Brook Urban Runoff Project* focuses on treating the discharge from the stormwater outfall with the greatest impact on water quality in the Pennichuck Brook. The outfall is located along a highly urbanized section of the NH Route 101A corridor in Nashua, more specifically on a NH Department of Transportation (DOT) easement on the NH Technical College property. The drainage area of the outfall is approximately 79 acres with an estimated impervious coverage of 60 percent. Fifty-two catch basins collect stormwater runoff from the streets, residential neighborhoods and parking lots of the roughly 60 businesses in the drainage area. See Sheet 1 of 2 in Appendix A.

The drainage area contains such varied uses as car washes, gas stations, automobile oil and lubrication services, automobile muffler and brake services, dry cleaners, restaurants and retail establishments. The threat of an accidental spill contaminating the Pennichuck Brook system is very real. In December of 1994, an accidental oil spill at the Greased Lightning facility leaked into a floor drain, which was connected to a storm drain, and was discharged to the Holt Pond tributary at the outfall behind the NH Technical College. Given the types of businesses within the drainage area and within the greater watershed, increasing awareness of the potential negative impact of business or individual actions on the public drinking water supply is an important aspect of the project. Information and educational tools developed for this project can be utilized throughout the Pennichuck Brook watershed and can also be transferred to other communities.

Development within the Pennichuck Brook watershed continues and local planning boards need to become better informed about the negative impacts of stormwater runoff on water quality. The project will provide the boards with hard evidence on the effectiveness of this particular stormwater treatment



measure. The results of the water quality monitoring will be forwarded to the Planning Boards and Health Officials when they become available. The Planning Board education component of the project aims to provide boards with better information on which to make stormwater management decisions. Nineteen people throughout the region participated in the Stormwater Management Workshop held on December 9, 1999. Subsequent workshops have been held comparing the different types and effectiveness of stormwater treatment systems. The NRPC will continue to keep municipalities apprised of new technologies through the REPP III Quarterly Water Resources meetings. The towns are also submitting projects to the NHDES Year 2000 Biomonitoring Program through the Watershed Bureau's Biology Division.

Project Tasks

Task 1. Engineering Design and Specifications: The site was surveyed by a licensed land surveyor and the treatment system was designed in conjunction with the NH DES. The treatment system is a sequence of multiple treatment cells, each with a particular treatment function. The system will treat up to a 10-year storm (40-CFS) and encompasses about .75% of the total watershed area. The system will remove pollutants via sedimentation, filtration, biological uptake and chemical reduction. See Appendix A for the location of the treatment cells and their functions.

Task 2. Construction and Inspection: West Environmental, Inc monitored the entire construction of the stormwater treatment wetland. The excavation was performed by Audrey Construction in the summer of 1998. Park Construction graded the site in September. Extensive dewatering was necessary for construction equipment in the basin areas. Twelve inches of topsoil was spread over the medium to fine subsoil to provide a good planting medium. A.J. Cameron Sod Farms, Inc. performed the landscaping at the site and plant materials were purchased from New England Wetland Plants. Planting was completed in mid-October. See Appendix B for the plant material invoice, a photo log of construction, and follow up inspection report.

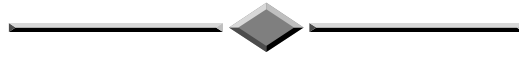
Task 3. Water Quality Monitoring: Monitoring was postponed for a year to allow the wetland vegetation to take hold and give a better indication of the materials that are trapped and settled out in the system. Despite a very dry season, 80% of the vegetation planted survived. Wet weather water quality monitoring will be conducted at four sites within the treatment system. Samples will be analyzed for E-coli, dissolved oxygen, nitrates, ammonia, petroleum hydrocarbons, TKN, total suspended solids, phosphorous and drinking water detection limits for RCRA regulated metals. Pennichuck Water Works has contracted the analyses of all parameters to a certified laboratory. Ten sampling runs will be conducted by Pennichuck staff. A Quality Assurance Project Plan (QAPP), describing the monitoring plan and quality assurance/quality control measures has been submitted to the US EPA. See Appendix C. The results of the water quality monitoring will be forwarded as a supplemental report upon approval of the QAPP and completion of sampling.

Task 4. Education Program: The education component of the project consisted of creating a pamphlet and compiling a packet of information on non-point sources (NPS) of pollution and Best Management Practices (BMPs) developed by New Hampshire Department of Environmental Services (NH DES). The larger businesses in the stormwater drainage area were visited and presented an overview of the project and supplied with the educational packets. The majority of the 21 businesses were interested in the project and willing to read through the material provided. See Appendix D for the educational materials. The 52 public storm drain inlets in the area were stenciled "Dump No Waste/Protect Your Water" to alert the public of the fate of runoff water and materials carried with it from streets, parking areas, and landscaped areas. To increase employee awareness, NRPC will stencil drains on private property with the permission of the owner.



Task 5. Planning Board Education Program: A training workshop on NPS, BMPs, alternative technologies, and effective buffers was held on December 9, 1999 for planning boards, municipal planners, conservation commissions and enforcement officials in the Pennichuck Brook watershed. See Appendix E.

Task 6. Supplemental Final Report: A discussion of the results of the ten wet weather water quality monitoring results will be supplied upon their completion.



Appendix A

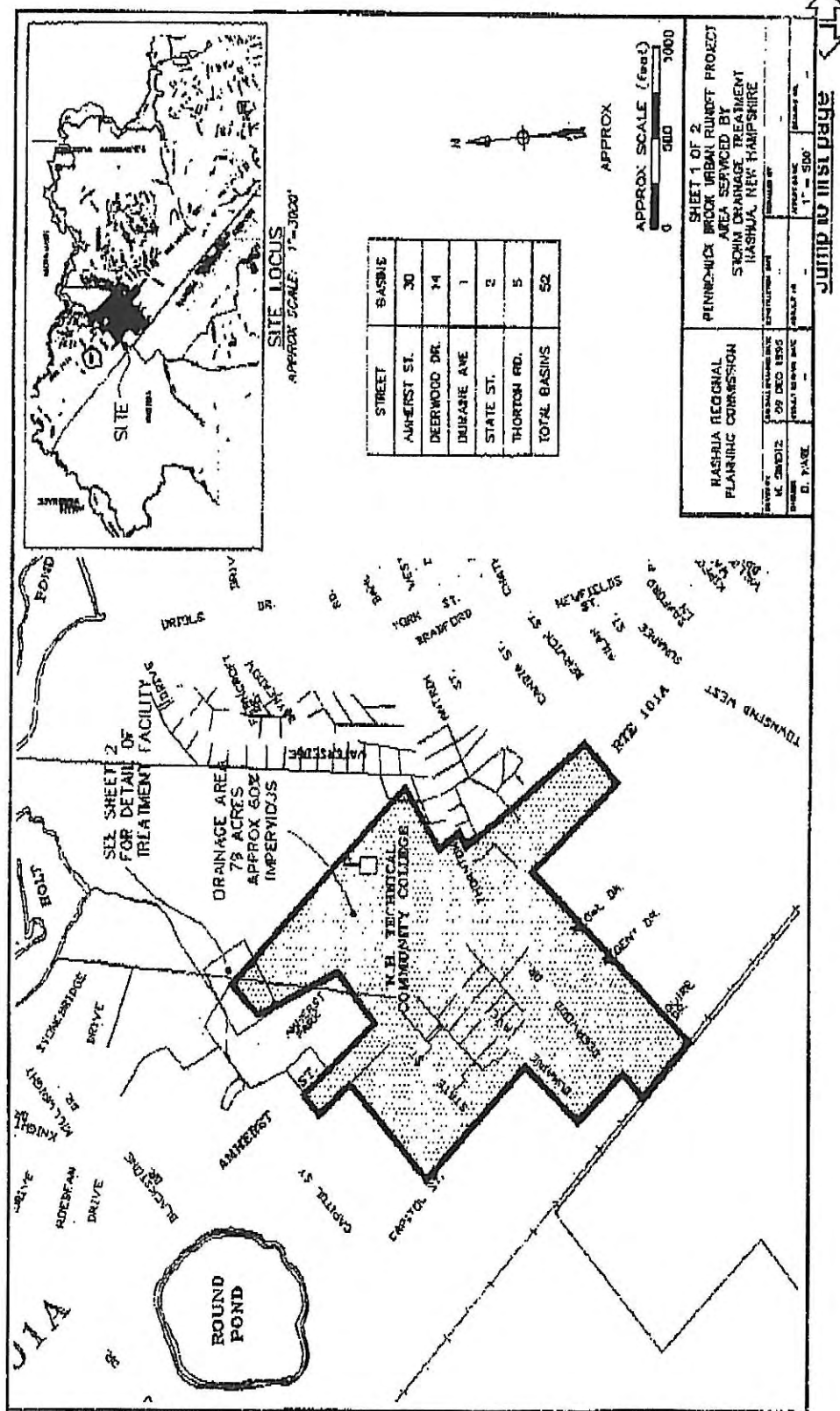
Treatment Cell Locations and Their Functions



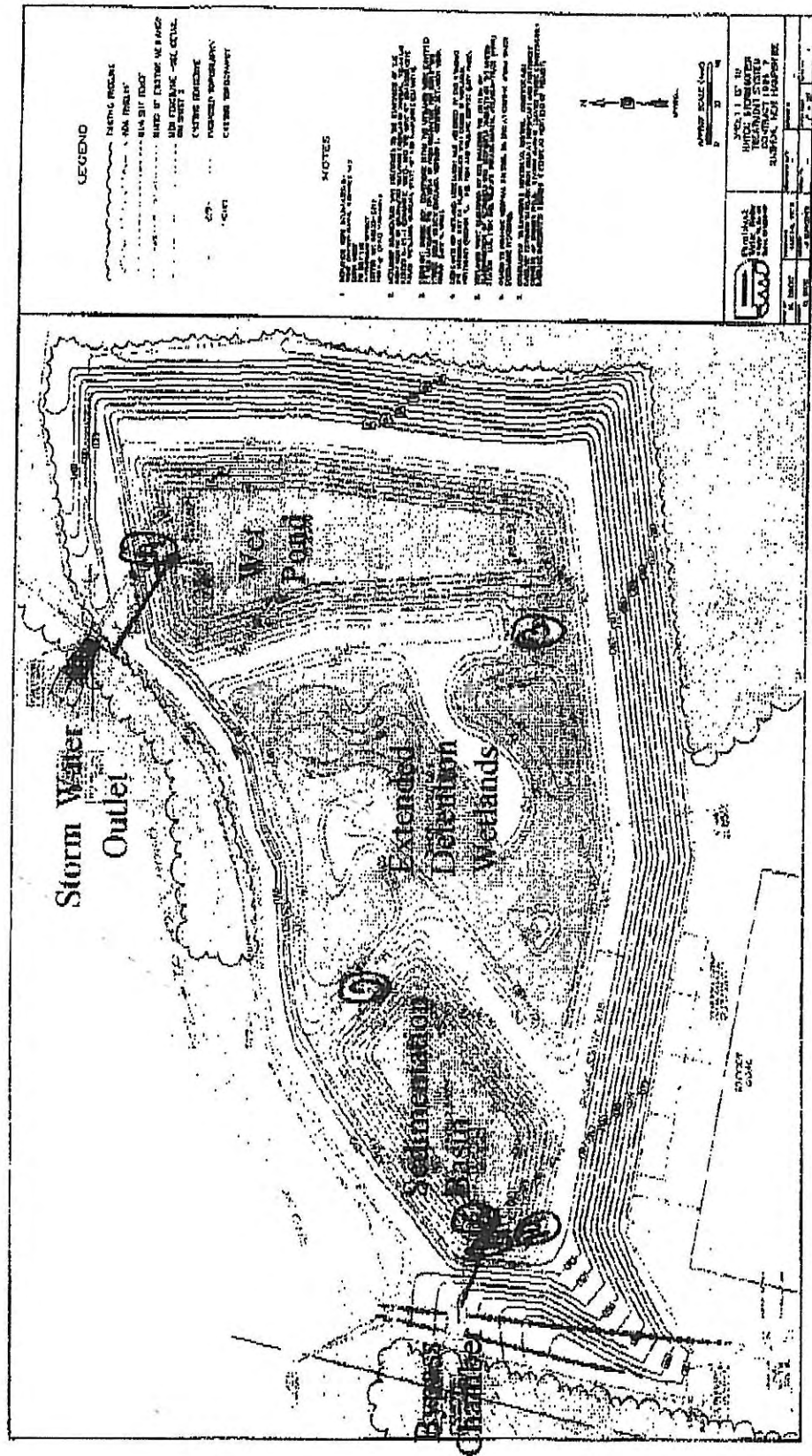
The Treatment Cell Functions

1. ***Sediment Forebay*** - This bay of the sedimentation basin is small and readily accessible for cleaning by heavy equipment without having to enter it. This bay will capture most of the heavy grits and sands being discharged into the treatment system from the storm drainage. The presence of this forebay will extend the life of the sedimentation basin between cleanings.
2. ***Sediment Bay*** - This larger sedimentation follows the sediment forebay and will remove smaller particulate matter. Its detention time and depth are such that cleaning will require equipment to enter into basin. The basin is equipped with an oil water separator at its outlet, which allows the basin to drain slowly between storms.
3. ***Oil/Water Separator*** - This will capture the floating oils that are present in stormwater stream that are not in solution. Vac trucks can access this separator to remove the collected oils.
4. ***Marsh Channel*** - This part of the treatment process is a vegetated wetland and will reduce nutrient loadings through biological uptake.
5. ***Wet Pond*** - The wet pond provides for additional nutrient uptake, final sedimentation, groundwater infiltration, and wildlife habitat.
6. ***Rip Rap Check Dams*** - These dams serve as filters as low flows can flow through them, allowing for fines to be captured in the gravel face of each check dam.

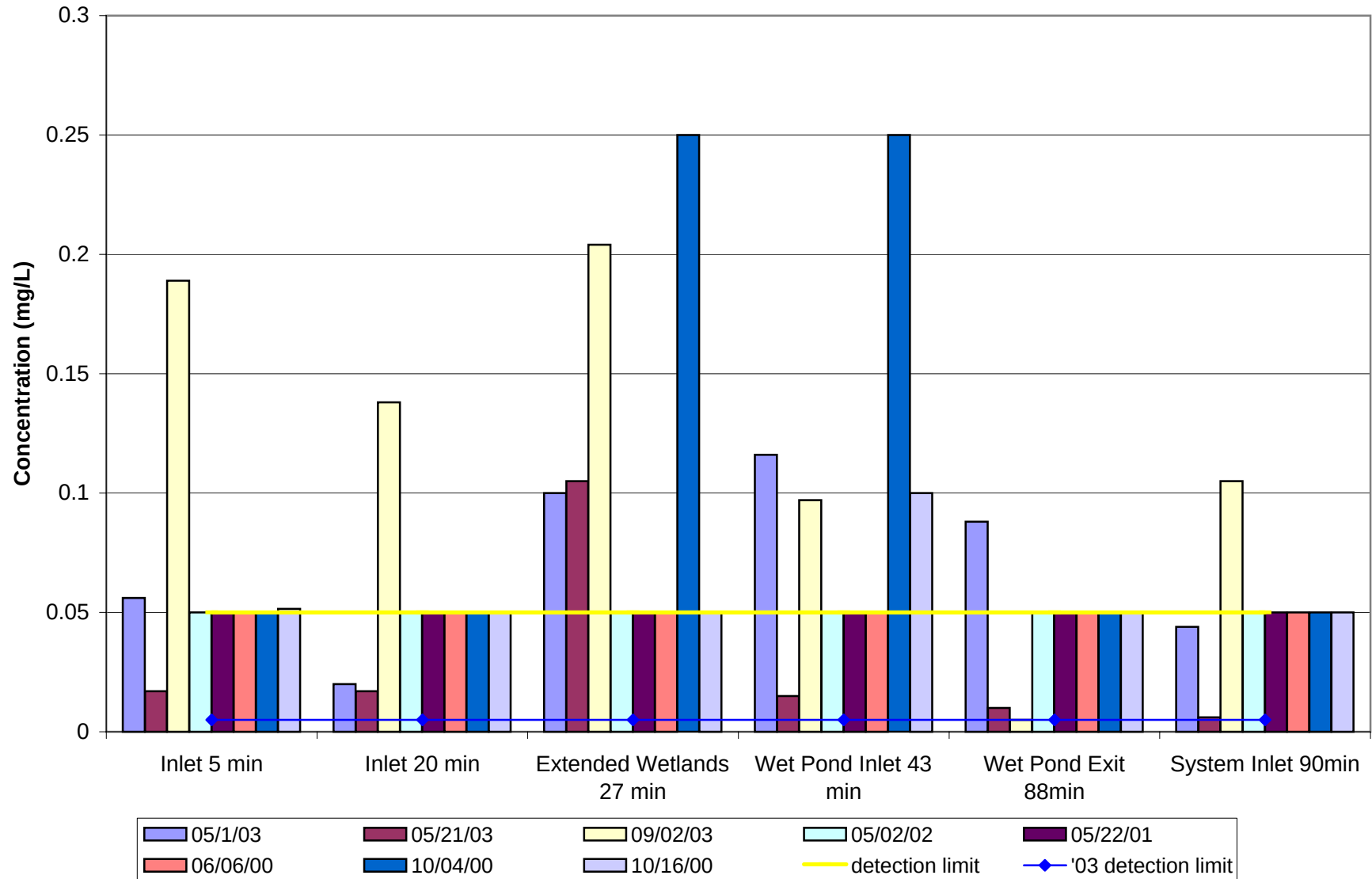
Overview of Area Treated



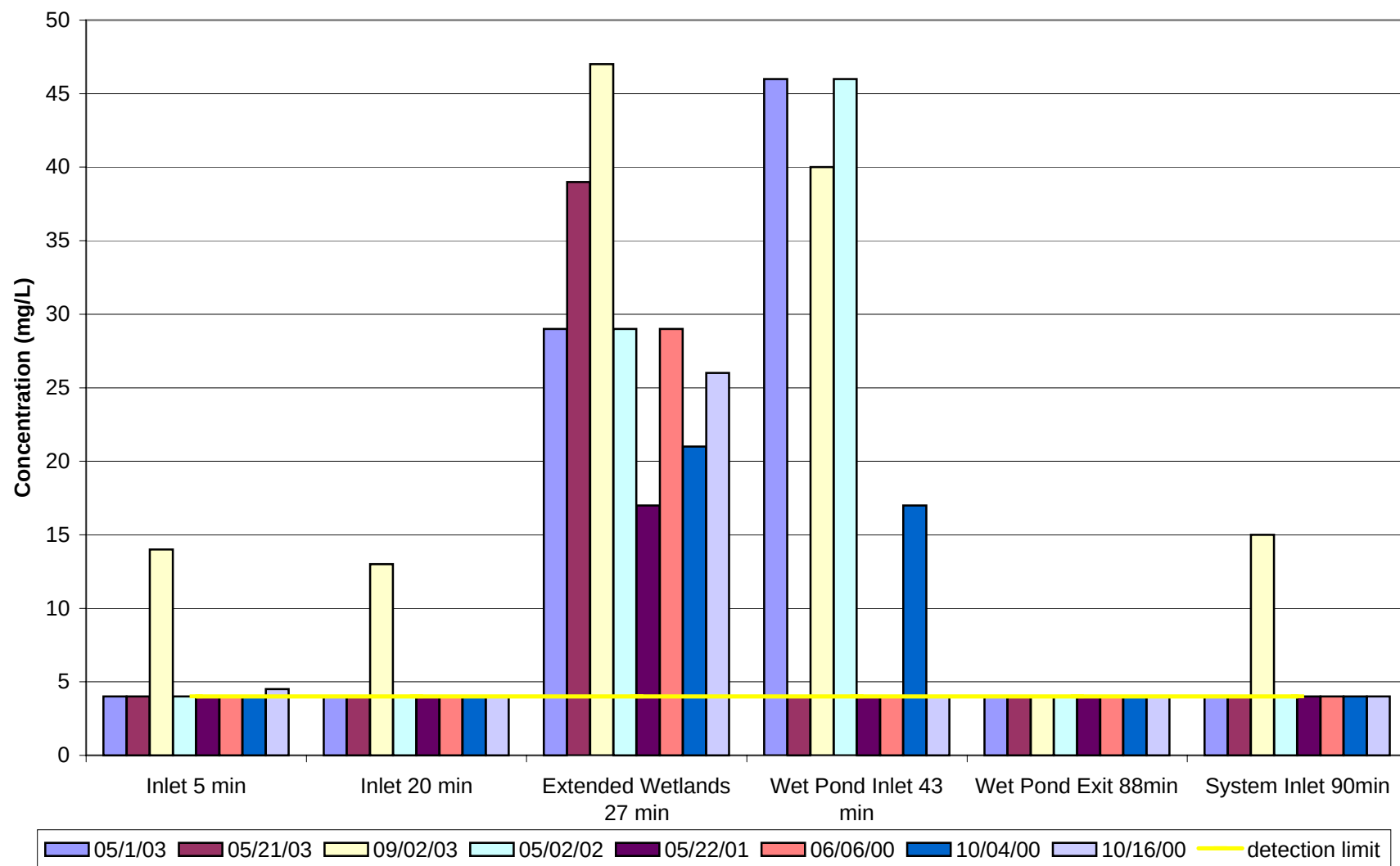
Treatment System Overview



URP Phosphorous Sampling Results



URP Total Suspended Solids



Sampling Results

05/1/03						
	Extended Wetlands Wet Pond Wet Pond System Inlet 5 min Inlet 20 min 27 min Inlet 43 min Exit 88min Inlet 90min					
Total suspended Solids	4	4	29	46	4	4
Nitrate	1.83	1.84	1.61	1.24	1.46	1.99
Ammonia	0.102	0.1	0.1	0.125	0.1	0.1
TKN	0.603	0.855	0.641	0.716	0.59	0.427
Phosphorous	0.056	0.02	0.1	0.116	0.088	0.044
Fecal Coliform	0	0	0	8	0	0
Arsenic	0.05	0.05	0.05	0.05	0.05	0.05
Barium	0.088	0.086	0.099	0.088	0.071	0.098
Cadmium	0.005	0.005	0.005	0.005	0.005	0.005
Chromium	0.013	0.012	0.01	0.015	0.01	0.01
Lead	0.03	0.03	0.03	0.03	0.03	0.03
Selenium	0.05	0.05	0.05	0.05	0.05	0.05
Silver	0.007	0.007	0.007	0.007	0.007	0.007
Mercury	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
05/21/03						
	Extended Wetlands Wet Pond Wet Pond System Inlet 5 min Inlet 20 min 27 min Inlet 43 min Exit 88min Inlet 90min					
Total suspended Solids	4	4	39	4	4	4
Nitrate	1.97	1.74	1.63	1.26	1.03	1.89
Ammonia	0.252	0.1	0.106	0.198	0.1	0.1
TKN	0.395	0.484	0.614	0.785	0.34	0.66
Phosphorous	0.017	0.017	0.105	0.015	0.01	0.006
Fecal Coliform	0	0	9	13	0	0
Arsenic	0.05	0.05	0.05	0.05	0.05	0.05
Barium	0.083	0.088	0.094	0.069	0.075	0.084
Cadmium	0.005	0.005	0.005	0.005	0.005	0.005
Chromium	0.012	0.012	0.01	0.01	0.01	0.01
Lead	0.03	0.03	0.03	0.03	0.03	0.03
Selenium	0.05	0.05	0.05	0.05	0.05	0.05
Silver	0.007	0.007	0.007	0.007	0.007	0.007
Mercury	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
09/02/03						
	Extended Wetlands Wet Pond Wet Pond System Inlet 5 min Inlet 20 min 27 min Inlet 43 min Exit 88min Inlet 90min					
Total suspended Solids	14	13	47	40	4	15
Nitrate	1	1	1	1	1	1
Ammonia	0.801	0.778	0.228	0.251	0.136	0.732
TKN	1.75	1.45	0.856	0.7	0.304	1.2
Phosphorous	0.189	0.138	0.204	0.097	0.005	0.105
Fecal Coliform	14000	13000	1490	28	91	20000
Arsenic	0.05	0.05	0.05	0.05	0.05	0.05
Barium	0.041	0.043	0.073	0.059	0.06	0.038
Cadmium	0.005	0.005	0.005	0.005	0.005	0.005
Chromium	0.012	0.012	0.01	0.01	0.01	0.01
Lead	0.03	0.03	0.03	0.03	0.03	0.03
Selenium	0.05	0.05	0.05	0.05	0.05	0.05
Silver	0.007	0.007	0.007	0.007	0.007	0.007
Mercury	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005

Sampling Results

05/02/02						
	Inlet 5 min	Inlet 20 min	Extended Wetlands 27 min	Wet Pond Inlet 43 min	Wet Pond Exit 88min	System Inlet 90min
Total suspended Solids	4	4	29	46	4	4
Nitrate	1.71	2.00	1	1	1	2
Ammonia	0.25	0.25	0.25	0.25	0.25	0.25
TKN	0.523	0.826	0.359	0.561	0.434	0.573
Phosphorous	0.05	0.05	0.05	0.05	0.05	0.05
Fecal Coliform	0	0	1	3	0	0
Arsenic	0.1	0.1	0.1	0.1	0.1	0.1
Barium	0.072	0.057	0.044	0.034	0.062	0.061
Cadmium	0.01	0.01	0.01	0.01	0.01	0.01
Chromium	0.01	0.01	0.01	0.01	0.01	0.01
Lead	0.05	0.05	0.05	0.05	0.05	0.05
Selenium	0.1	0.1	0.1	0.1	0.1	0.1
Silver	0.01	0.01	0.01	0.01	0.01	0.01
Mercury	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006

Sampling Results

05/22/01						
	Inlet 5 min	Inlet 20 min	Extended Wetlands 27 min	Wet Pond Inlet 43 min	Wet Pond Exit 88min	System Inlet 90min
Total suspended	4	4	17	4	4	4
Nitrate	1.68	1.62	1.58	1.19	1	1.56
Ammonia	0.172	0.1	0.137	0.1	0.122	0.1
TKN	0.338	0.826	0.471	0.317	0.387	0.415
Phosphorus	0.05	0.05	0.05	0.05	0.05	0.05
Fecal Coliform	0	0	29	121	0	1
Arsenic	0.1	0.1	0.1	0.1	0.1	0.1
Barium	0.061	0.059	0.098	0.043	0.062	0.055
Cadmium	0.01	0.01	0.01	0.01	0.01	0.01
Chromium	0.01	0.01	0.01	0.01	0.01	0.01
Lead	0.05	0.05	0.05	0.05	0.05	0.05
Selenium	0.1	0.1	0.1	0.1	0.1	0.1
Silver	0.01	0.01	0.01	0.01	0.01	0.01
Mercury	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005

Sampling Results

06/06/00						
	Inlet 5 min	Inlet 20 min	Extended Wetlands 27 min	Wet Pond Inlet 43 min	Wet Pond Exit 88min	System Inlet 90min
Total suspended Solids	4	4	29	4	4	4
Nitrate	1.87	1.80	1.4	1.07	1.1	1.77
Ammonia	0.23	0.13	0.22	0.25	0.22	0.19
TKN	0.614	0.647	0.78	0.972	0.528	0.282
Phosphorous	0.050	0.05	0.05	0.05	0.05	0.05
Fecal Coliform	20	3	15	220	1	1
Arsenic	0.1	0.1	0.1	0.1	0.1	0.1
Barium	0.052	0.057	0.05	0.051	0.085	0.066
Cadmium	0.01	0.01	0.01	0.01	0.01	0.01
Chromium	0.01	0.01	0.01	0.01	0.01	0.01
Lead	0.05	0.05	0.05	0.05	0.05	0.05
Selenium	0.1	0.1	0.1	0.1	0.1	0.1
Silver	0.01	0.01	0.01	0.01	0.01	0.01
Mercury	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
10/04/00						
	Inlet 5 min	Inlet 20 min	Extended Wetlands 27 min	Wet Pond Inlet 43 min	Wet Pond Exit 88min	System Inlet 90min
Total suspended Solids	4	4	21	17	4	4
Nitrate	1.70	1.82	1	1.13	1	1.72
Ammonia	0.114	0.106	0.1	0.128	0.133	0.139
TKN	0.459	0.653	1.33	0.928	0.199	0.491
Phosphorous	0.050	0.05	0.25	0.25	0.05	0.05
Fecal Coliform	36.5	30	11	1	90	3
Arsenic	0.1	0.1	0.1	0.1	0.1	0.1
Barium	0.052	0.051	0.05	0.058	0.061	0.05
Cadmium	0.01	0.01	0.01	0.01	0.01	0.01
Chromium	0.01	0.01	0.01	0.01	0.01	0.01
Lead	0.05	0.05	0.05	0.05	0.05	0.05
Selenium	0.1	0.1	0.1	0.1	0.1	0.1
Silver	0.01	0.01	0.01	0.01	0.01	0.01
Mercury	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
10/16/00						
	Inlet 5 min	Inlet 20 min	Extended Wetlands 27 min	Wet Pond Inlet 43 min	Wet Pond Exit 88min	System Inlet 90min
Total suspended Solids	4.5	4	26	4	4	4
Nitrate	1.61	1.59	1.17	1	1	1.52
Ammonia	0.1	0.165	0.1	0.132	0.1	0.1
TKN	0.579	0.394	0.582	2.29	0.433	0.549
Phosphorous	0.052	0.05	0.05	0.1	0.05	0.05
Fecal Coliform	35.5	33	26	30	12	32
Arsenic	0.05	0.05	0.05	0.05	0.05	0.05
Barium	0.06	0.058	0.065	0.381	0.082	0.062
Cadmium	0.005	0.005	0.005	0.005	0.005	0.005
Chromium	0.01	0.01	0.01	0.01	0.01	0.01
Lead	0.03	0.03	0.03	0.03	0.03	0.03
Selenium	0.05	0.05	0.05	0.05	0.05	0.05
Silver	0.007	0.007	0.007	0.007	0.007	0.007
Mercury	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005

Appendix E:
2001 Somerset Plaza and NH DOT Park
& Ride Facility BMP Sampling

BOIRE FIELD BROOK SUBWATERSHED PROJECT

***2000 Nonpoint Source Program
Local Initiative Grant***

December 31, 2001



Prepared by the



NASHUA REGIONAL PLANNING COMMISSION

with funding by



This project was funded in part by a New Hampshire Department of Environmental Services
Nonpoint Source Program Local Initiative Grant with in-kind services provided by the
City of Nashua, Pennichuck Water Works, and
NHDES Watershed Bureau.



PROJECT SUMMARY AND GOALS

The goal of the *Boire Field Brook Subwatershed Project* was to assess the impacts of stormwater runoff on a portion of the Boire Field Brook Subwatershed of the Pennichuck Brook Watershed. In addition, the project included a component to educate private landowners that maintenance of stormwater systems is their responsibility and that improperly functioning systems allow non-point source (NPS) pollutants to flow into the public drinking water supply. This study will be used as a case study to develop a citywide stormwater management program for compliance with the EPA Phase II Stormwater Regulations. Steps taken toward accomplishing this goal involved:

- An inventory of existing closed and open drainage systems
- Identifying data needs for planning and best management implementation
- Conducting an initial review of legal issues to enforce current regulations and improve maintenance standards
- Educating the businesses located in the drainage area on the negative impacts of NPS pollution, sedimentation and accidental spills on the City's public water supply
- Increasing public awareness of the link between the stormwater drainage system and the public drinking water supply through a storm drain stenciling program
- Encouraging local businesses to incorporate urban runoff best management practices in the designs of future development in the City
- Assisting private landowners with maintenance plans for systems on their properties

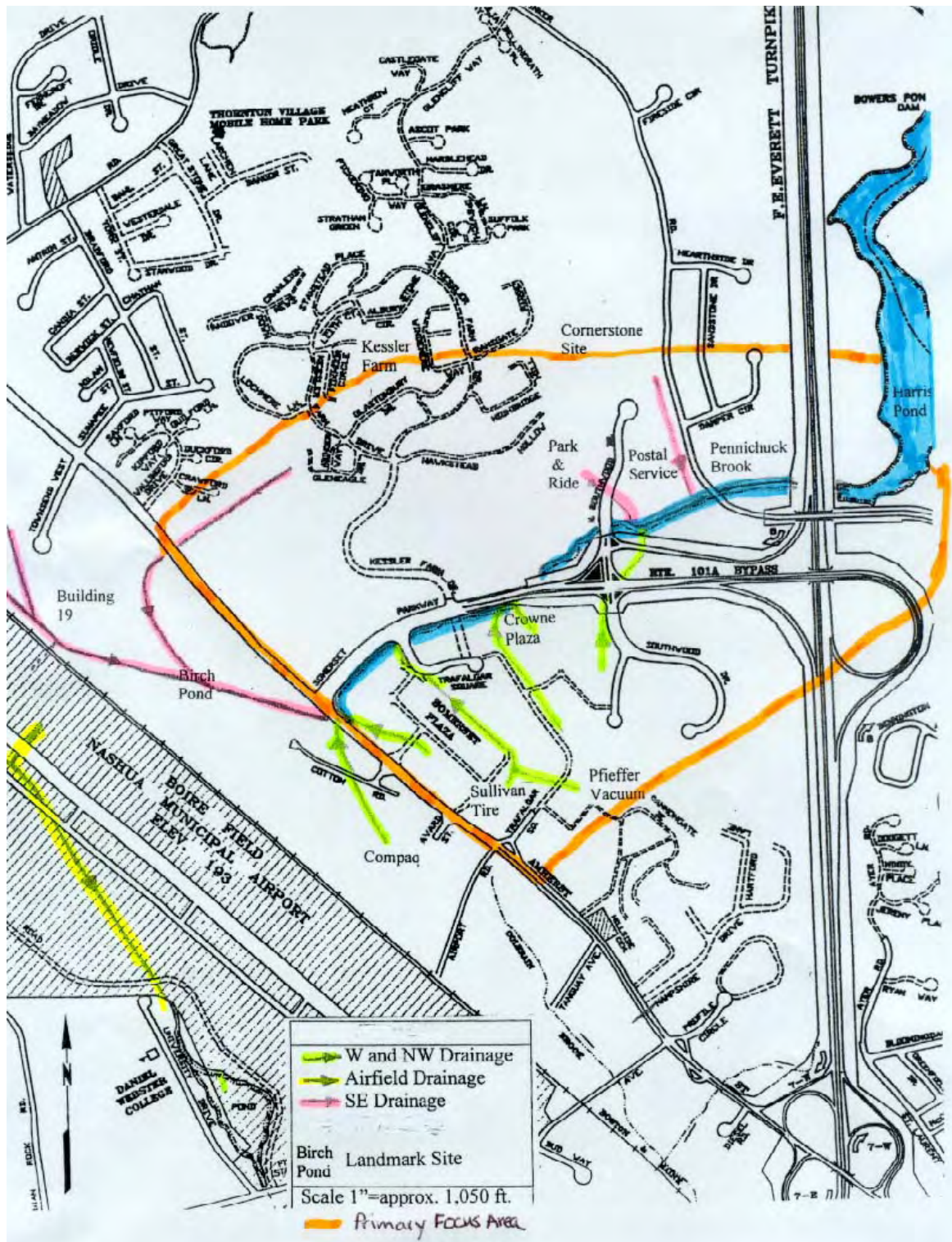
INTRODUCTION

The Pennichuck Brook system is the major water supply source for the Nashua region and serves as the primary source of water (approximately 75%) for the Pennichuck Water Works. The Boire Field Brook flows directly into Harris Pond, which is the closest pond to the Pennichuck Water Works treatment facility. The Boire Field Brook Subwatershed is impacted by urban runoff from industrial, commercial and high-density residential uses as well as the region's major transportation networks, the FE Everett Turnpike and NH Route 101A. The primary focus was along the Boire Field Brook from Amherst Street (Route 101A) along Somerset Parkway to Harris Pond (see Figure 1, Project Area).

In an effort to protect the region's water supply, the *Boire Field Brook Subwatershed Project* focused on inventorying and evaluating existing stormwater drainage systems. In 1999 and 2000, Nashua obtained new Geographic Information System (GIS) data for catch basins and other stormwater information derived from aerial photography. The existing data was field checked to verify accuracy and to account for possible omissions on the mapping. The City needed to evaluate existing data for completeness and determine what type of information will be necessary for a citywide stormwater drainage program for EPA Phase II compliance expected in 2003. The project also involved identifying areas for the construction of a larger treatment system similar to the one constructed behind the Technical College next to Holt Pond. This watershed will be used as a case study by the City of Nashua to prepare an effective citywide drainage plan.



Figure 1. Project Area





PROJECT TASKS

TASK 1 *Research, Inventory and Assessment of Existing Stormwater Drainage Systems in the Subwatershed*



Figure 2.

Sedimentation and Litter in Drainage Swale

NRPC and the City of Nashua Planning staff researched all site plans in the project area. A landowner mailing database was created and a letter was sent to the property owners/managers. The letter and mailing list is in Task 1 of the Appendix. The letter gave an overview of the project and requested permission to access the property to inspect stormwater drainage systems. The City of Nashua Planning, Pennichuck Water Works Engineering Department and NRPC reviewed the plans for potential areas to conduct wet weather water quality monitoring based on the age of the stormwater systems and their accessibility. Pennichuck and NRPC field checked the project area in April 2001. Two sites were chosen for sampling and all problems or deficiencies were noted at this time. Problems on private property were photographed and turned over to the City of Nashua Code Enforcement Department. The majority of the problems were clogged pipes, sedimentation and litter in drainage swales (Figure 2).

TASK 2 *Develop Database*

Assess the quality of existing data and determine what information will be needed for citywide stormwater compliance based on this sub-watershed.

A Geographic Information System (GIS) map was generated to show catch basin, flow direction, and public stormwater systems (pipes, basins and swales). Private stormwater systems were taken from individual site plans and incorporated into the map and database. A grid system was designed for the database but it proved too cumbersome and the scale was not useful. Rather, the database was designed to access property/stormwater drainage systems by the City Tax Assessors number, Sheet/Lot number or the street address. The closest street and directional indicator will identify swales. This will enable all City departments to access the information. Properties or area can be accessed by the Tax Assessors code or by Sheet/Lot number. The complete engineering summary is in Task 2 of the Appendix.

Recommendations

- Upon final approval and/or final inspection of a site plan, the Planning Department should forward the site plan to the Engineering Department for inclusion in the database before filing the plan with the Hillsborough County Registry of Deeds. This will enable the Engineering Department to automatically set a maintenance reporting schedule.
- Maintenance reports should be generated monthly to enable the enforcement entity to schedule visits or notification in the most time efficient manner.



- The City of Nashua should form a committee to discuss the role and personnel involved for enforcement of maintenance or remediation of stormwater drainage systems on private properties.
- A systematic inspection schedule of all citywide stormwater drainage systems should be developed and added to the database.
- When plans are submitted to the Department of Environmental Services (DES) for Site Specific Review, the DES project number should be reported to the Engineering Department for inclusion in the database.

TASK 3 Legal Review

An initial review of the City's rights to improve stormwater management on private property based on current regulations was completed. This includes annual maintenance (vacuuming catch basins), dredging swales or remediation measures based on field observation and water quality data collected during 2001.

This task is a brief review of the City of Nashua's legal rights to enforce existing and improved stormwater maintenance standards on private property. Existing regulatory measures, which could include stormwater maintenance standards, would apply in connection to new applications for land use control permits, such as subdivision and site plan applications. There is no means of imposing stormwater maintenance standards on unimproved land or on improved land whose improvements predate the stormwater maintenance regulations.

With respect to land approved for development since the effective date of the stormwater management regulations, stormwater management can be enforced to the extent that it has been required as a condition of the site plan approval. However, land approved for development by subdivision or site plan approval, but not yet actually improved before the enactment of the stormwater (or any other) regulations, is, to some extent, exempt from such regulations under RSA 676:12 and 674:39. The exception under RSA 674:39 is for "regulations and ordinances which expressly protect public health standards such as water quality and sewerage treatment requirements." This is a question of technical and scientific fact.

In addition to those regulations that are applicable to private development, the City may, of course, enforce stormwater management practices that are reasonably required to protect streets and other public infrastructure, provided that the City has obtained easements for that purpose. Finally, in the event that accumulations of water constitute a public nuisance, the City has the common law power to abate such a nuisance by legal action.

The City's current ordinances have been reviewed. When the City enacted ordinances concerning stormwater in December of 1998, it required stormwater management to be a part of every subdivision and site plan. For subdivisions, the applicant must submit a stormwater management report, signed by a state-registered engineer, detailing the stormwater practices used in the subdivision and their compliance with established stormwater management standards (NRO 16-107 (a)(15)). One of the subdivision approval factors is a review of the areas provided for detention, treatment, infiltration or other handling of stormwater (NRO 16-108 (b)(7)). There are also equivalent provisions for site plans, including the submission of a stormwater management report (NRO 16-122 (f)(13)) and an adequate means of handling stormwater runoff as a factor in approval (NRO 16-123 (b)(8)). Therefore, any subdivisions or site plans approved since December of 1998 should have enforceable stormwater management components in place, although they still may not be to the level or extent that may be desired in the future. The original legal summary is located in Task 3 of the Appendix.



TASK 4 Develop a Quality Assurance Protection Plan (QAPP)

The EPA final approval letter and signature sheet of the QAPP is in Task 4 of the Appendix.

TASK 5 Wet Weather Water Quality Monitoring

Wet weather water quality was measured at two (2) sites in the subwatershed. Water quality at the two sites was tested at the inlet and outfall of a new and an older open drainage system. The original results and receipts are in Task 5 of the Appendix. The new system is located at the Department of Transportation (DOT) Park and Ride Facility off of Somerset Parkway (Exit 8 of the FE Everett Turnpike) on North Southwood Drive. It was designed to be an infiltration system with an overflow pipe at the outlet (east end). Vegetation and sediment were present and therefore some trapping of sediment and nutrient uptake has occurred. The system is wide and deep and has the potential to hold water compared to the older system.



Figure 3. DOT Retention Basin Inlet



Figure 4. DOT Retention Basin Outlet (overflow)

The older system is located along Amherst Street (Route 101A) in the Somerset Plaza. The Plaza was built in the late 1980's. The swale collects water from 14 catch basins located on the main parking lot in front of the complex. The stormwater is hardpiped directly to the swale. The swale is heavily vegetated and filled with coarse-grained sediment. It is shallow, narrow and runs for approximately 100 feet before reaching the confluence of Boire Field Brook. It probably allows a great deal of sediment to flow into the Boire Field Brook due to lack of maintenance.



Figure 5. Somerset Plaza Swale Inlet



Figure 6. Somerset Plaza Swale Outlet (above confluence of Boire Field Brook)

During all sampling events, the older drainage swale at Somerset Plaza was tested first. The water moves through the system at a greater rate. Three of the four sampling runs caught the first flush.

Although petroleum hydrocarbons and metals may be a problem, we elected not to test for them due to the expense and scope of the overall grant. Rather, we wanted to get a very basic assessment of the water quality in the project area. Sampling was conducted for the following: 1) total suspended solids (TSS); 2) total Kjeldahl nitrogen (TKN); 3) total phosphorous (TP); and 4) *E. coli*. The four parameters were chosen for the following reasons:

- TSS - Large volumes of urban runoff flow from parking lots and other impervious areas in the watershed.
- TKN - Commercial fertilizer use and stagnating water is found in the subwatershed.
- TP - Commercial landscaping is prevalent and high numbers of waterfowl are found throughout the subwatershed.
- *E. coli* - The housing developments allow dogs, and waterfowl is attracted to the detention ponds near the Crown Plaza Hotel.

Total Suspended Solids (TSS)

The 1997 Stormwater Characterization study, conducted in Concord by NHDES, found a range of <1 to 146 mg/L with a study mean of 143mg/L for TSS. The samples at both sites ranged from <4 to 17mg/L which is well below the study mean of 143mg/L.

Total Kjeldahl Nitrogen (TKN)

This is a measure of inorganic ammonia nitrogen and total organic nitrogen. High readings indicate nutrient rich waters, generally characterized by high levels of biological production. In general, TKN and relative nitrogen species will be higher than phosphorus levels. Nitrogen is readily soluble and its levels usually increase as flow increases. The 1997 Stormwater Characterization study found a range of 0.53 to 13.7 mg/L with a study mean of 3.394mg/L. The samples at both sites ranged between 0.100 and 1.35mg/L, which is well below the study mean for stormwater.



Phosphorous-P

Phosphorous along with nitrogen is a plant nutrient that determines the amount of an alga growth that can occur. In freshwater in New Hampshire, phosphorus is considered the limiting nutrient. Phosphorus is not readily soluble and is more closely related to erosion. Phosphorus levels were extremely high throughout the season with a range of 0.050 – 0.211 mg/L. The level of concern established by NHDES is 0.02 mg/L. The season average at site 1 was 0.155 mg/L and site 2 was 0.074mg/L. Values >0.04 mg/L is considered excessive. The levels are indicative of the high levels of sediment and dissolved materials flowing through the swale.

E. coli

This bacteria is used as an indicator of human sewage but elevated numbers can occur in the presence of waterfowl or any other warm-blooded animal. The State of New Hampshire sets water quality standards for Class B waters. Designated uses for Class B waters includes fishing, swimming and other recreational purposes. The testing sites are not used for these purposes but are used to illustrate that the water flowing from these stormwater drainage systems enter into Class A waters which are designated drinking water supplies. Drinking water should have no *E. coli* after treatment. The acceptable level of *E. coli* is determined by risk analysis based on statistics to protect human health. *E. coli* levels at designated swimming beaches should not exceed 88 per 100 milliliter (mg/L) in any one sample, or exceed a three-sample average over a 60-day period of 47/100mL. Recreational waters that are not designated beaches should not have more than 406 *E. coli*/100mL in any one sample, or more than 126/100mL in a 60-day, three-sample average. Occasional higher numbers are not unusual, particularly after storm events and where urban or agricultural runoff occurs. These levels are generally not considered unsafe unless investigation indicates the source to be sewage. At both sites all tests exceeded 200mg/L.

September 14, 2001

This was the first rain event in approximately a month and the samples were collected late morning during the first flush. Rainfall readings at Pennichuck Water Works (Pennichuck) in Nashua registered 0.25 inches on the 14th. Due to the failure of ziplock bags during incubation, all bacteria samples for *E. Coli* analysis were lost. A duplicate sample for *E. coli* was taken at the Somerset Inlet but was also lost at the lab.

Analyte and Method	Somerset Inlet Pipe	Somerset Outlet Pipe	Park & Ride Inlet Pipe	Park & Ride Outlet Pipe	Detection Limit PQL
Total Suspended Solids 160.2	6 mg/L	17 mg/L	16 mg/L	9 mg/L	4 mg/L
Kjeldahl-N 351.3	0.486 mg/L	0.341 mg/L	1.23 mg/L	0.136 mg/L	0.100 mg/L
Phosphorous-P 365.2	0.209 mg/L	0.174 mg/L	0.099 mg/L	0.055 mg/L	0.050 mg/L
<i>E. Coli</i> SM 9213D	Lab Failure	Lab Failure	Lab Failure	Lab Failure	NA

September 21, 2001

This was the first rain event since the September 14th sampling. The samples were taken at 9 am approximately 9 hours after it started raining. Rainfall readings at Pennichuck registered 0.74 inches on the 21st. A duplicate sample was taken at the Somerset Outlet for TKN and Phosphorous since they use the same preservative (H₂SO₄). The lab did not process the duplicates even though they were listed on the chain of custody sheet.



**Boire Field Brook Subwatershed Project
2000 Nonpoint Source Program
Local Initiative Grant – December 31, 2001**

Analyte and Method	Somerset Inlet Pipe	Somerset Outlet Pipe	Park & Ride Inlet Pipe	Park & Ride Outlet Pipe	Detection Limit PQL
Total Suspended Solids 160.2	8 mg/L	5 mg/L	5 mg/L	5 mg/L	4 mg/L
Kjeldahl-N 351.3	1.35 mg/L	1.3 mg/L	0.119 mg/L	0.186 mg/L	0.100 mg/L
Phosphorous-P 365.2	0.211 mg/L	0.183 mg/L	<0.050 mg/L	<0.05 mg/L	0.050 mg/L
E. Coli SM 9213D	>200 mg/L	>200 mg/L	>200 mg/L	>200 mg/L	0 Colonies per 100mls

September 25, 2001

This was the first rain event since the September 21st sampling. The samples were taken late morning during the first flush. A duplicate sample was taken at the Park & Ride Outlet for *E.coli*. Rainfall readings at Pennichuck registered a trace on the 25th and .63 inches on the 26th. The readings are generally taken in the morning, which would explain why only a trace was registered on the 25th.

Analyte and Method	Somerset Inlet Pipe	Somerset Outlet Pipe	Park & Ride Inlet Pipe	Park & Ride Outlet Pipe	Detection Limit PQL
Total Suspended Solids 160.2	<4 mg/L	5 mg/L	<4 mg/L	17 mg/L	4 mg/L
Kjeldahl-N 351.3	0.972 mg/L	1.11 mg/L	0.417 mg/L	0.769 mg/L	0.100 mg/L
Phosphorous-P 365.2	0.12 mg/L	0.124 mg/L	0.075 mg/L	0.122 mg/L	0.050 mg/L
E. Coli SM 9213D	>200 mg/L	>200 mg/L	>200 mg/L	>200 mg/L Duplicate >200 mg/L	0 Colonies per 100mls

October 15, 2001

This was the first rain event since September 14th sampling. The samples were taken at approximately 9 am. Rainfall readings at Pennichuck registered 0.21 inches.

Analyte and Method	Somerset Inlet Pipe	Somerset Outlet Pipe	Park & Ride Inlet Pipe	Park & Ride Outlet Pipe	Detection Limit PQL
Total Suspended Solids 160.2	5 mg/L	<4 mg/L	<4 mg/L	<4 mg/L	4 mg/L
Kjeldahl-N 351.3	1.28 mg/L	1.08 mg/L	<0.100 mg/L	0.643 mg/L	0.100 mg/L
Phosphorous-P 365.2	0.124 mg/L	0.091 mg/L	0.066 mg/L	0.073 mg/L	0.050 mg/L
E. Coli SM 9213D	>200 mg/L	>200 mg/L	>200 mg/L	>200 mg/L	0 Colonies per 100mls

TASK 6 Storm Drain Stenciling

The public storm drains in the project area were stenciled to increase awareness of the connection between stormwater runoff and the drinking water supply. This included all of the catch basins on Amherst Street from Sullivan Tire to Building 19. Somerset Parkway was stenciled from Amherst Street to North Southwood Drive. This accounts for 37 drains stenciled in the Project area. We did not receive any response to our offer to stencil the drains on private property. Since landowner permission was required, no drains were stenciled.



TASK 7 Landowner and Business Education Program

A packet was developed using existing information on NPS BMPs for landowners and businesses. Pennichuck Water Works developed flyers specifically for automotive and landscaping businesses. Each of the landowners and business complexes in the drainage area was mailed information on controlling NPS pollution, snow removal/storage and road salt. Specific maintenance programs were developed for the landowners based on field observations and water quality results. The mailing list is in Task 1 of the Appendix and the letter and educational materials are in Task 7 of the Appendix.

TASK 8 Identifying Sites for Future Treatment Measures

Identify sites with high sedimentation, failing systems and poor water quality for future treatment systems based on the field observations and water quality/sedimentation data.

On field visits within the Boire Field Brook Subwatershed there are three observations that relate to water quality. Most stormwater treatment devices appear to be overtaxed by sediment buildup. First, the removal of the sediment will add both longevity and treatment effectiveness (phosphorus adhering to particles) of the existing stormwater systems. There is no means of imposing stormwater maintenance standards on unimproved land or on improved land whose improvements predate the stormwater maintenance regulations of 1998. A systematic inspection schedule of private stormwater drainage systems could be developed using the existing GIS database. It is recommended that the City of Nashua should form a committee to discuss the role and personnel involved in identification of problems and enforcement of maintenance or remediation of stormwater drainage systems using health code or site plan violations.

Second, the chain of detention ponds and swales attract an abundance of waterfowl throughout the watershed. The ponds are a favorite lunch spot and workers enjoy feeding the ducks. Educational materials could be developed that explain that the waterfowl are the source of bacteria and phosphorus. Water quality is not the only issue; feeding bread to ducks is harmful to their health. Waterfowl can develop metabolic bone disease and other nutritional diseases. The City of Nashua should consider adopting an ordinance that prohibits the feeding of wildlife throughout the Pennichuck watershed.

Finally, another prevalent problem in the watershed is the improper storage and disposal of street sand. It is common practice to dump sand in a corner of a parking lot or in the drainage swales. The City of Nashua Public Works Department should undertake an educational mailing directed at contractors in the snow removal trade.

Specific problems noted for future improvements include:

- The swale on the south and east sides of Somerset Plaza needs to have the litter and sediment removed to allow for maximum nutrient uptake and retention of suspended solids in the stormwater. The City of Nashua Code Enforcement has been notified that parking lot sand and ripped fertilizer bags have been dumped into the swale.
- The Park and Ride infiltration basin appears to be leaking water at the base of the outfall pipe. This was observed during the four sampling runs. The water seepage does not allow the basin to fill beyond half a foot for maximum infiltration.
- The Exit 8 detention area is quite large and equipped with a control valve. The gate was in the upright position, which allows the water to flow untreated directly in Boire Field Brook just above the convergence of Pennichuck Brook. This is close to the water supply uptake pond at Pennichuck Water Work's Treatment Plant. The Department of Transportation will be notified.



TASK 9 Final Report

The final report was prepared by the Nashua Regional Planning Commission and reviewed by Pennichuck Water Works and the City of Nashua Engineering, Legal and Planning Departments.

#500P-5

APPENDICES NOT INCLUDED IN DIGITAL VERSION

Appendix F

In-Pond Phosphorus Calculations

Pennichuck Brook Watershed Existing In-pond Concentrations and Parameters						
	Stump Pond	Pennichuck Pond	Holts Pond	Bowers Pond	Harris Pond	Supply Pond
Lake area (km2)	0.08	0.23	0.09	0.37	0.32	0.06
Mean Depth (m)	1.52	1.52	0.62	1.83	4.07	3.05
Watershed area (km2)	5.56	19.06	58.74	65.37	69.99	71.28
Runoff phosphorus loadings (kg/yr)	254	92	967	535	493	133
New Streamflow Phosphorus loadings (kg/yr)	60	180	369	61	23	12
phosphorus loadings (kg/yr)	314	271	1335	597	516	144
Phosphorus loadings from Merrimack River (kg/yr)	0	0	0	131	0	0
Phosphorus loadings from preceding pond(s) (kg/yr)	0	0	401	1693	1862	1859
Total phosphorus loadings (kg/yr)	314	271	1736	2420	2378	2003
Total phosphorus loadings (g/m ² -yr)	4	1	19	7	8	32
Runoff (m/yr)	12	3	44	5	5	6
New Streamflow (m/yr)	36	39	198	8	4	9
Merrimack River Flow (m/yr)				6		
Streamflow from preceding pond(s) (m/yr)			146	97	137	730
Hydraulic Loading (m/yr)	48	42	388	116	146	746
In-pond Phosphorus (mg/l)	0.054	0.019	0.047	0.043	0.040	0.042
Average Observed P (mg/l)			0.051	0.045	0.038	0.041
P leaving pond (kg/yr)	217	184	1693	1862	1859	1976

Groundwater (Baseflow) Concentration	0.020	mg/l
Rainfall	43.58	inches

Pennichuck Brook Watershed Buildout In-pond Concentrations and Parameters						
	Stump Pond	Pennichuck Pond	Holts Pond	Bowers Pond	Harris Pond	Supply Pond
Lake area (km2)	0.08	0.23	0.09	0.37	0.32	0.06
Mean Depth (m)	1.52	1.52	0.62	1.83	4.07	3.05
Watershed area (km2)	5.56	19.06	58.74	65.37	69.99	71.28
Runoff phosphorus loadings (kg/yr)	264	105	1048	580	569	138
New Streamflow Phosphorus loadings (kg/yr)	56	179	377	59	21	11
phosphorus loadings (kg/yr)	320	284	1425	639	590	150
Phosphorus loadings from Merrimack River (kg/yr)	0	0	0	152.3	0	0
Phosphorus loadings from preceding pond(s) (kg/yr)	0	0	415	1795	1994	2023
Total phosphorus loadings (kg/yr)	320	284	1840	2586	2584	2172
Total phosphorus loadings (g/m ² -yr)	4	1	20	7	8	34
Runoff (m/yr)	15	3	45	6	6	7
New Streamflow (m/yr)	33	39	203	8	3	9
Merrimack River Flow (m/yr)				6.6		
Streamflow from preceding pond(s) (m/yr)			149	99	141	750
Hydraulic Loading (m/yr)	49	42	396	119	150	766
In-pond Phosphorus (mg/l)	0.055	0.020	0.049	0.045	0.043	0.044
Average Observed P (mg/l)			0.051	0.045	0.038	0.041
P leaving pond (kg/yr)	223	193	1795	1994	2023	2144

Groundwater (Baseflow) Concentration	0.020	mg/l
Rainfall	43.58	inches

Appendix G

Summary Status of Past Recommendations

Study & Recommendations					Actions Taken	Actions in Progress	Actions Needed/ Remarks
	Completed	In Progress / On-going	Incomplete / On Hold	Deferred / Removed			
	Pennichuck Water Works Watershed Management Plan, August 1998						
1. Work with Towns to Reduce Future Imperviousness through Ordinances		○			Developed street specifications document with Nashua and distributed to other towns.	Refer to Recommendation 4 under 2012 Restoration Plan.	
2. Work with Towns to Require Buffer Zones Around the Water Supply			○		Nashua and Hollis have passed ordinances.		Investigate and update status.
3. Minimize Transportation Impacts							
a. Work with Public Works Departments and DOT to Minimize Discharges		○			Letters and catch basin location maps were sent in 2003. All Towns are regulated by the NPDES Phase II MS4 permit, which requires them to address stormwater runoff from their systems.	Refer to Recommendation 4 under 2012 Restoration Plan.	
b. Work with Fire/Police Departments to Address Spills and Storm Drains	○				As part of the 2003 Storm Drain Mapping and Marking Project, letters and maps (showing catch basin locations) were sent informing officials of outfall locations.		
c. Develop a Demonstration Roadway to Show More Environmentally Friendly Designs				○	Developed street specifications document with Nashua and distributed materials to other towns. Decided to focus on educational route to work with Towns on benefits of stormwater design criteria and LID practices.	Refer to Recommendation 4 under 2012 Restoration Plan.	
4. Education							
a. Send Questionnaire to Residents Regarding Status of Watershed Knowledge		○			Performed this at smaller scale in select areas of watershed. A Community Based Social Marketing (CBSM) education program was completed for the Stump Pond Brook Watershed in 2009, which included a questionnaire survey.	Refer to Recommendation 1 under 2012 Restoration Plan for planned education activities.	Refer to Recommendation 1 under 2012 Restoration Plan for planned education activities.
b. Develop School Education Program		○			Refer to Recommendation 1d under 2012 Restoration Plan.	Refer to Recommendation 1d under 2012 Restoration Plan.	Meet with school district and teachers, develop and implement program.
c. Hold Technical Transfer Workshop	○	○			Two technical transfer workshops were held in April 2002.		
d. Send Follow-up Questionnaire to Gauge Effectiveness of Education Program		○			See 4a. above.	See 4a. above.	See 4a. above.
5. Modify Watershed Regulations		○			Deferred to NPDES Phase II program requirements.	Refer to Recommendation 4 under 2012 Restoration Plan.	
6. Map Sediment Depths in Each Pond & Identify Dredging Options. Perform Periodic Sediment Depth Mapping of Ponds		○			A sediment study was completed in 2000. This was updated in 2010-2012 with sediment depth maps provided.	Refer to Recommendation 6 under 2012 Restoration Plan.	
7. Evaluate Subwatersheds for Potential Application of Best Management Practices Including Infiltration Controls at Specific Sites	○				Studies of subwatersheds completed in 2004 with identification of BMP sites. Top BMP retrofit locations identified in 2012 Watershed Restoration Plan. Refer to Recommendation 3 under 2012 Restoration Plan.	Refer to Recommendation 3 under 2012 Restoration Plan.	
8. Request Status Reports on Hazardous Waste Sites in Watershed and Discuss Annually with NHDES				○	Removed recommendation since NHDES adequately regulates hazardous waste sites.		
9. Develop and Provide Education Materials for "Hot Spots" (e.g., properties with higher potential pollutant load)	○				Educational brochures were created and mailed out to automotive, agricultural, and landscaping businesses in 2000-2001. Follow-up visits were conducted and a report on findings was completed in 2002.		
10. Annually Measure Impervious Area in Watershed and Stream Channel Dimensions at Select Locations		○			None known for measurement of impervious area. Deferred to NPDES Phase II program as this may be future requirement. Pennichuck measures streamflows at nine tributaries to observe impacts of development on flows, in lieu of stream channel dimensions, which also show impact of development.	Continuous streamflow measurements performed under long-term monitoring program.	
11. Monitoring Performance of Stormwater Demonstration Projects		○			Several BMPs were monitored during development of the 2008 Watershed Restoration Plan including demonstration projects (Celina Avenue forebay/sediment trap, Pennichuck Square infiltration and the NH Technical College wetland/retention) and existing, non-demonstration BMPs (the Conway Office swale, Home Depot detention basin, White Oak Drive detention basin).		Ongoing effort. Monitor performance of new stormwater demonstration projects as deemed appropriate.

Study & Recommendations					Actions Taken	Actions in Progress	Actions Needed/ Remarks
	Completed	In Progress / On-going	Incomplete / On Hold	Deferred / Removed			
12. Develop & Implement Long-Term Monitoring Program of Ponds and Tributaries		○			A sampling program was started in 2005, including sampling of the nine tributaries for specific water quality parameters. This was refined in 2007 to include continuous flow monitoring and additional sampling dates. In-pond samples are also collected.	Refer to Recommendation 8 under 2012 Restoration Plan.	
Study of Urban Non-Point Source Pollution – Boire Field Brook Subwatershed, Spring 2000							
1. Stabilize Slope and Install Sediment Forebay at Cornerstone Site	○				Received DES grant. Completed in 2001.		
2. Discourage Waterfowl Population at Crowne Plaza through Public Education, Structural Deterrents, Feeding Deterrents and Ordinances			○		Visit by CEI staff in 2003 discovered two “Please Do Not Feed Waterfowl” signs near one detention pond.		Investigate and update status.
3. Other Recommendations							
a. Use Ordinances to Require Aesthetically Pleasing Detention Pond Designs & O&M Plans		○			The City of Nashua has such provisions.		Investigate and update status.
b. Educate Contractors about Proper Storage and Disposal of Street Sweepings		○				Refer to Recommendation 2 under 2012 Restoration Plan. Will include information on proper disposal.	
c. Eliminate Petroleum in Runoff from Sullivan Tire			○		None known.		Investigate and update status.
d. Use Catch Basin Markers to Educate Public About Connection to Water Supply (prompted by observation of paint dumping in catch basin)	○				A state grant was awarded to PWW in 2002 to map and mark storm drains within the Pennichuck Watershed. Drains were marked in Spring/Summer 2004.		
e. Investigate Black Scum from Outfall Near Bank Boston through Bacteria Testing of Discharge				○	None known. Deferred to Nashua's NPDES Phase II stormwater program.		
Sediment Study of Pennichuck Ponds, July 2000							
1. Review and Update Construction Site Runoff and Erosion Control Measures in Ordinances		○			Deferred to NPDES Phase II program requirements.	Refer to Recommendations 4 under 2012 Restoration Plan.	
2. Evaluate Construction of Sediment Forebays Within Ponds							
a. Evaluate Feasibility of Forebays	○				Evaluation was conducted and funding was applied for this project from the state but was not awarded.		
b. Construction of In-Pond Forebays				○	Construction of in-pond forebays was not received favorably by permitting agencies.		
3. Perform Long-term Sediment Monitoring		○			Refer to Recommendation 6 under 1998 Management Plan.	Refer to Recommendation 8 under 2012 Restoration Plan.	Future evaluation of accumulation data should help define corrective action if warranted.
Study of Urban Non-Point Source Pollution – Pennichuck Brook to Bowers Pond, Spring 2001							
1. Install Baffle Tank at Amherst Park			○		After further review by CEI and PWW, it was decided that a baffle tank was not the best approach to the sedimentation problem. In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list and can be re-evaluated at a future date.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.
2. Remove Sediment in Blackstone Drive Detention Pond			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. The Blackstone Apartment Complex Wet Pond was identified for improvements.	Focusing on working with Towns, public education and street sweeping/catch basin cleaning over the next few years, as these provide greater potential benefit for the dollar.	On-hold while focusing on public education.
3. Remove Sediment Delta Behind Silt Boom at Completion of Upgradient Construction				○	Unknown if sediment delta was removed before the silt boom was removed by the developer.		
4. Investigate Old Dump Site at Millwright Drive for Potential Water Quality Threats			○		None known.		Investigate and update status.
5. Evaluate Retrofits to Detention Pond off Watersedge Drive to Increase Treatment Capacity			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.

Study & Recommendations					Actions Taken	Actions in Progress	Actions Needed/ Remarks
	Completed	In Progress / On-going	Incomplete / On Hold	Deferred / Removed			
6. Investigate Old Construction Storage Area in Thornton Village Mobile Home Park for Potential Water Quality Threats			○		None known.		Investigate and update status.
7. Maintain Existing Drainage System in Thornton Village Mobile Home Park to Remove Sediment Accumulations			○		None known.		Investigate and update status.
8. Confirm UST off Waterview Drive was Removed Using Standard Practices and Underlying Soils were Free of Contamination			○		None known.		Investigate and update status.
9. Inspect Swales at Thornton Road Bridge for Adequate Vegetation Establishment	○				CEI field visits (2003-2004) confirm that vegetation has been established.		
10. Pennichuck to Request Review of Proposed Logging Operations within 200 feet of the Ponds or its Tributaries			○		Unknown if recent logging activities have occurred.		Review logging activities.
Hot Spot Visitations – Pennichuck Watershed, May 2002							
1. Catch Basin Cleaning and Housekeeping Practices	○				A letter was sent to hot spot facilities in 2002.		
2. Storm Drain Markers	○				A state grant was awarded to PWW in 2002 to map and mark storm drains within the Pennichuck Watershed. Drains were marked in Spring/Summer 2004.		
Study of Urban Non-Point Source Pollution – Witches Brook East (WBE) Subwatershed, Summer 2002							
1. Install Infiltration Basin to Treat Runoff from Columbia Drive and Atomic Ski Site Discharge			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.
2. Install Infiltration Strip at Norwich Building Discharges			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.
3. Install Stilling Basin at H&M Metals Discharges as Shown on 1994 Site Plan			○		None known.		Re-evaluate after implementation of top 10 sites has been performed per 2012 Restoration Plan recommendations.
4. Develop More Stringent Steep Slope and Post Development Runoff Control Regulations		○			Deferred to NPDES Phase II program requirements.	Refer to Recommendation 4 under 2012 Restoration Plan.	
5. Sample Discharge (observed to be milky white) from Loading Dock Area Behind the J.R. Poirier Tool and Machine Company & Distribute Education Materials to Business				○	None known. Sampling deferred to NPDES Phase II program requirements.		Distribute education materials to business.
6. Work with Towns to Require Licensing of Existing Junk Yards Such as the Junk Yard Along Witches Brook			○		None known.		Investigate and update status.
7. Provide Drainage Improvements in Drainage Easement Along Eastern Portion of Norwich Property as Needed as New Developments Along Manhattan Drive Occur			○		None known.		Investigate if new developments and drainage improvements have occurred and update status.
8. Incorporate Additional Stormwater Treatment Controls to Proposed Drainage for Addition at Poly-Ject Inc. at 8 Manhattan Drive			○		None known.		Investigate whether additional stormwater treatment controls were installed with new construction and update status.
9. Use Ordinances to Require O&M Plans (prompted by observation of detention areas in Mooar Hill Road area)		○			Deferred to NPDES Phase II program requirements.	Refer to Recommendation 4 under 2012 Restoration Plan.	
10. Require Developer to Clean Out BMPs on Emersen Road Prior to Issuing Certificate of Occupancy				○	Development has since been completed. It is not known if any actions were taken.		
11. Distribute Agricultural Education Materials to Woodmont Orchards – Hollis Farm and Perform Follow-up Correspondence		○			An agricultural educational brochure was sent to the orchard and CEI staff performed a follow up visit in 2002.		Periodically follow-up with property owner to discuss ongoing management practices.

Study & Recommendations					Actions Taken	Actions in Progress	Actions Needed/ Remarks
	Completed	In Progress / On-going	Incomplete / On Hold	Deferred / Removed			
Study of Urban Non-Point Source Pollution – Witches Brook North (WBN) Subwatershed, Summer 2002							
1. Stabilize Steep Grade Along Ponemah Hill Road			○		None known.		Investigate and update status.
2. Install Leaching Catch Basin at Rocky Hill Road and Stabilize Shoulder Along Route 122 in Vicinity of Rocky Hill Road			○		None known.		Investigate and update status.
3. Provide Educational Materials and Encourage Upgrading of ASTs at Patricia Lane Church			○		None known.		Provide educational materials to church and discuss status of tank.
4. Review and Comment on Irving Oil's Upcoming 2002 SPCC Update, Provide Signage Noting Proximity of Water Supply			○		None known.		Investigate and update status. Provide signage to Irving Oil.
5. General Recommendations							
a. Distribute Educational Brochures, Encourage Master Gardener Program and Host Topic-specific Seminars to Address Homeowner Impact		○					
i. Distribute Educational Brochures		○			A CBSM education program was completed for the Stump Pond Brook Watershed in 2009. Included workshop and distribution of educational materials on lawn care.		Distribute education materials on a watershed-wide basis.
ii. Encourage Master Gardener Program				○	None known. Replaced with distribution of education materials.		
iii. Host Topic-specific Seminars to Address Homeowner impacts				○	The CBSM experience revealed little participation in workshops and future efforts will focus on distribution of education materials through website and mailings, rather than holding workshops.		
b. Work with Towns to Institute Town-wide Recharge Requirements		○			Developed street specifications document with Nashua and distributed materials to other towns. This promotes the use of recharge BMPs.	Refer to Recommendation 4 under 2012 Restoration Plan.	
c. Develop More Stringent Steep Slope and Post Development Runoff Control Regulations		○			Deferred to NPDES Phase II program requirements.	Refer to Recommendation 4 under 2012 Restoration Plan.	
Study of Urban Non-Point Source Pollution – Stump Pond Brook (SPB) Subwatershed, Summer/Fall 2002							
1. Construct Sediment Forebay and Vegetated Swale to Handle Runoff from Route 101A and the Heritage Place Commercial Plaza, Install Bio-cells and Drywell at Heritage Place			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.
2. Stabilize Road Shoulder and Install Pond/Wetland Treatment with Sediment Forebay to Reduce Sediment Loadings into Wetland Near Boston Post Road			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.
3. Stabilize Road Shoulders and Install Shallow Containment Swales and Filter Berms to Reduce Erosion at Craftsman Lane Bridge			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.
4. General Recommendations							
a. Educate Public on Proper Lawn Practices		○			Refer to Recommendation 5.a.i under 2002 WBN study.		Distribute education materials on a watershed-wide basis.
b. Provide Funding to Homeowners to Reduce Pollutant Impacts From Their Properties				○	None known. Focusing on distribution of public education materials instead.		
c. Stabilize Roadside Shoulders Where Needed			○		None known.		Work with towns to reduce road shoulder erosion.
d. Encourage Towns to Adopt Stormwater Design Guidelines		○			Deferred to NPDES Phase II program requirements.	Refer to Recommendation 4 under 2012 Restoration Plan.	

Study & Recommendations					Actions Taken	Actions in Progress	Actions Needed/ Remarks
	Completed	In Progress / On-going	Incomplete / On Hold	Deferred / Removed			
Study of Urban Non-Point Source Pollution – PBS, PBH, PBP, WBS & MB, Winter - Spring 2004							
Pennichuck Brook to Supply Pond (PBS) Subwatershed							
1. Improve Tinker Road Detention Pond	○				Retrofits completed in summer of 2011.		
2. Construct Containment Swale for Turnpike Discharge	○				Retrofits completed in summer of 2011 with Tinker Pond.		
3. Divert Turnpike Bridge Discharge (Bowers Pond Crossing) into Sediment Basin			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.
Pennichuck Brook to Holts Pond (PBH) Subwatershed							
1. Evaluate PC Connection Detention Pond for BMP Options			○		The property owner expressed no interest in modification during past discussions (2004-2005). In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. The PC Connection Detention Pond was identified for improvements, however the property owner has not been contacted again to determine willingness to participate.	Focusing on working with Towns, public education and street sweeping/catch basin cleaning over the next few years, as these provide greater potential benefit for the dollar.	None at this time.
2. Review Future 101A Preservation Capacity Plans for Treating Stormwater Discharge from Greystone Plaza Parking Area & Continental Boulevard Intersection			○		None known.		Investigate & update status.
3. Create Demonstration Project for Pennichuck Square	○				Several LID techniques, including raingardens, bioretention, drywells for roof runoff & pervious pavement) installed in 2005.		
4. Treat Ciro's Restaurant Parking Lot Runoff			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.
5. Treat ASA Offices Parking Lot Runoff			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.
6. Treat Westside Plaza Parking Lot Runoff			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.
7. Treat Celina Avenue Runoff	○				Sediment forebay installed in 2005.		
8. Construct Snow Storage Area at Saturn Dealership			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. The Saturn Dealership was identified for improvements.	Focusing on working with Towns, public education and street sweeping/catch basin cleaning over the next few years, as these provide greater potential benefit for the dollar.	None at this time.
9. Construct Dumpster Storage Area at Greystone Plaza			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.
10. Improve Snow & Dumpster Storage Area Practices at DJ Square Plaza			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.
Pennichuck Brook to Pennichuck Pond (PBP), Witches Brook South (WBS), & Muddy Brook (MB) Subwatersheds							
1. Construct Containment Swale for Toddy Brook Road Discharge (WBS)			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.
2. Construct Containment Swale & Remove Debris Piles Near Silver Lake Road (WBS)			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts. This site did not make the top 10 list.	None at this time.	Re-evaluate after implementation of 2012 Restoration Plan recommendations.
General Recommendations							
1. Sponsor Homeowner Outreach Program		○			Refer to Recommendation 5.a.i under 2002 WBN study.		Distribute education materials on a watershed-wide basis.
2. Sponsor Master Gardener Program				○	None known. Replaced with distribution of education materials.		
3. Educate Stable Owners about Animal Manure Management		○			A brochure was created and mailed to agricultural businesses as part of the 2002 Hot Spots project, however, homeowners who own horses and livestock were not part of this program.		Encourage Towns to send out material to stable owners. Incorporate topics into Pennichuck outreach program.

Study & Recommendations					Actions Taken	Actions in Progress	Actions Needed/ Remarks
	Completed	In Progress / On-going	Incomplete / On Hold	Deferred / Removed			
4. Erect Watershed Signs in High Traffic Locations Where Roads First Enter the Watershed and at each Point Where a Tributary is Crossed			○		None known.		Erect signs or work with Towns to erect signs.
Pennichuck Water Works Pennichuck Brook Watershed Restoration Plan, Final Report February 7, 2008							
1. Public Education							
a. Complete Part 2 of Community Based Education Program in Stump Pond Watershed	●				A CBSM program was completed for the Stump Pond Brook Watershed in 2009.		
b. Develop Watershed Website		○			Watershed website developed.	Implementation in progress with plans for annual updates.	
c. Develop and Install Door Hangers			○		Refer to Recommendation 1c under 2012 Restoration Plan.		
d. Develop and Implement School Education Program		○			Refer to Recommendation 1d under 2012 Restoration Plan.		
e. Coordinate with Phase II Coalition		○				Refer to Recommendation 4 under 2012 Restoration Plan.	
f. Encourage Local Garden Clubs to Visit Pennichuck Square and Participate in Development of Demonstration Raingardens Elsewhere				○	None known. Replaced with distribution of education materials.		
2. Increase Maintenance in Commercial Areas Through Purchase and Use of Street Sweeper and Vactor Truck		○			Refer to Recommendations 2 under 2012 Restoration Plan.		
3. Evaluate Existing Best Management Practices for Potential Retrofits and Identify Top 10	●				Completed in 2011-2012 with results included in 2012 Watershed Restoration Plan.	Refer to Recommendation 3 under 2012 Restoration Plan.	
4. Encourage LID in Commercial Redevelopment by Establishing Grant Program for Communities to Promote LID and through Review of Development Plans by Pennichuck				○	Decided to work directly with Towns, which meet both watershed protection and NPDES Phase II requirements. Refer to Recommendation 4 of 2012 Restoration Plan.		
5. Encourage Adoption of New State Stormwater Standards for New Developments		○				Refer to Recommendation 4 under 2012 Restoration Plan.	
6. Construct Improvements at Tinker Road Detention Pond	●				Retrofits completed in summer of 2011.		
7. Install Piezometers and Evaluate Phosphorus Levels in Groundwater		○				Refer to Recommendation 5 under 2012 Restoration Plan.	
8. Evaluate Sediment Accumulations in Water Supply Ponds		○			Refer to Recommendation 6 under 1998 Management Plan.	Refer to Recommendation 6 under 2012 Restoration Plan.	
9. Continue Aerating Harris Pond		○			Refer to Recommendation 7 under 2012 Restoration Plan.	Refer to Recommendation 7 under 2012 Restoration Plan.	
10. Prepare Watershed-based Initial Feasibility Analysis for Stormwater Utility				○	None. Decided to leave to individual Towns to develop their own stormwater fees. State also considering regional stormwater fees. Nashua performed feasibility study for stormwater fee in 2011.		
11. Continue Long-Term Monitoring Program		○			Refer to Recommendation 8 under 2012 Restoration Plan.	Refer to Recommendation 8 under 2012 Restoration Plan.	
Pennichuck Water Works Pennichuck Brook Watershed Restoration Plan, Draft Report: August 2012							
1. Public Education							
a. Perform Community Based Education Program in New Watershed Area			○		Decided to focus dollars on educating watershed residents through distribution of materials, rather than separate, individual CBSM programs.		
b. Maintain Watershed Website		○			Watershed website developed.	Website to be online in fall 2012.	Maintain website annually.
c. Develop and Install Door Hangers			○		None		Develop and install door hangers.

Study & Recommendations					Actions Taken	Actions in Progress	Actions Needed/ Remarks
	Completed	In Progress / On-going	Incomplete / On Hold	Deferred / Removed			
d. Develop and Implement School Education Program		○			Requested scope to develop & implement education program.	Pursuing education of 3rd and 4th grade classes in 5 Nashua schools in 2013 or 2014, depending on teacher schedules.	Meet with school district and teachers, develop and implement program.
e. Encourage Roof Leader Disconnection Program		○			Requested scope to develop roof leader disconnection program and materials.	Pursuing calculation of potential recharge from rooftop disconnection and meeting with watershed communities.	
f. Develop Spokesdog Contest			○		None	None	Develop contest.
2. Increase Maintenance in Commercial Areas Through Purchase and Use of Street Sweeper and Vactor Truck		○			Requested scope to evaluate feasibility of maintenance options.	Pursuing feasibility to identify private properties/large parking areas in the watershed, benefits of sweeping/cleaning, comparison of PWW buying equipment & providing services vs. group bid from vendors.	
a. Option 1. Purchase street sweeper and vacuum truck and perform street sweeping and maintenance activities for commercial and industrial properties for a fee		○					
b. Option 2. Develop a commercial/industrial maintenance program through existing street sweeping and catch basin cleaning vendors to offer discounted services to businesses		○					
3. Retrofit Detention Basins & BMPs			○		In 2011-2012, top ten sites for BMP retrofits were identified to focus and prioritize BMP construction efforts.	Focusing on working with Towns, public education and street sweeping/catch basin cleaning over the next few years, as these provide greater potential benefit for the dollar.	None at this time.
4. Encourage Local Adoption of State Stormwater Standards		○				Scheduled to meet with individual Towns in 2012 to discuss adoption of AoT Standards and low impact development (LID) practices at local level. Roof leader disconnection education scheduled for 2013.	Ongoing effort.
5. Evaluate Phosphorus in Groundwater		○				Working on installing piezometers near each tributary sampling point to collect groundwater samples.	
6. Evaluate Sediment Accumulations in Water Supply Ponds		○			Refer to Recommendations 6 under 1998 Management Plan.	Working on collecting sediment cores and installing permanent sediment sampling stations for annual measurement of sediment depths at select locations.	
7. Continue Aerating Harris Pond		○			Aeration and curtains installed in 2005.	Continued operation of aerator.	
8. Continue Long-Term Monitoring Program		○			Long-term monitoring program put in place in 2005 and refined in 2007 to include flow data and more sampling dates.	Annual monitoring performed.	
9. Update Watershed Restoration Plan Model			○		None		Scheduled for 2016.

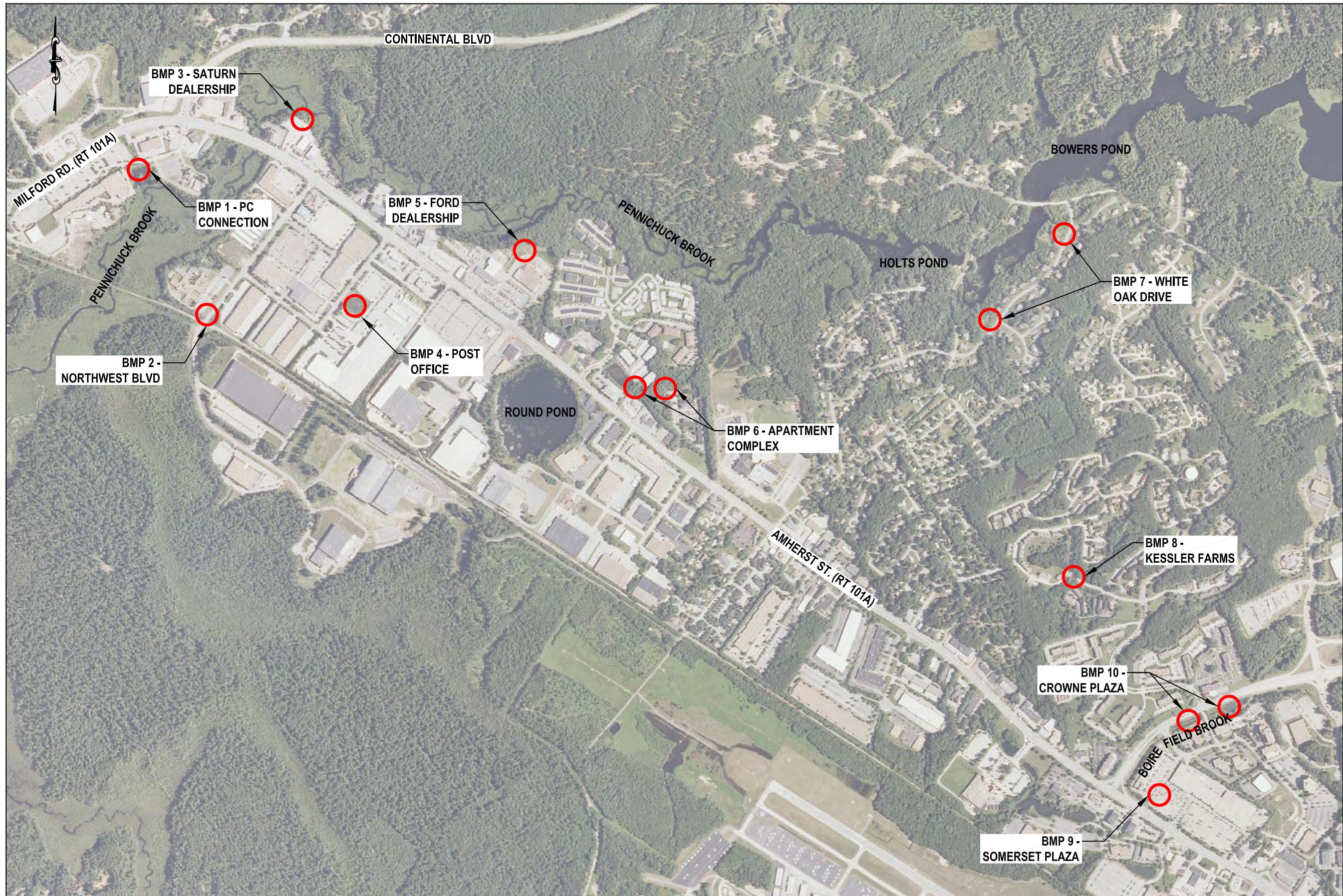


Appendix H

Proposed BMP Retrofits

BMP #	BMP Description	Proposed Retrofit	Drainage Area (Acres)	Estimated Impervious Area (Acres)	Majority Land Use	Estimated Annual TSS Removed (lbs)	Estimated Annual TP Removed (lbs)	Estimated Volume of Runoff Treated (cf)	Estimated Inches of Runoff Treated from Impervious Area (in)	Estimated Volume of Runoff Infiltrated (cf)	Estimated Inches of Runoff Recharged from Impervious Area (in)	Estimated BMP Retrofits Cost	Approx. Distance to Water body (feet)	Name of Water body	Discharge Path into Water body
6	Blackstone Apartment Complex Wet Pond	Install Gravel Wetland. Add Forebays and Deep Sump Catch Basins with Perforated Pipe for Infiltration.	43.9	22.2	High Density Residential	33,533	11	40,000	0.49	-	-	\$456,950	1,250	Holts Pond	Discharges into stream channel
	& Amherst Park Stream Channel	Add Pretreatment Sediment Forebays.	20.6	11.6				500	0.12 Pretreatment		-		1,050		Stream channel meanders through woods, outlets into Holts Pond
	& Amherst Park Stream Channel														
9	Somerset Plaza Swale	Install Vegetated Parking Lot Dividers, and Porous Pavement. Add Sediment Drop Area at Culverts.	25.7	21.9	Commercial	29,689	9	47,050	0.59	44,050	0.56	\$428,692	50	Boire Field Brook	Direct discharge into brook
10	Crowne Plaza Wet Pond	Add Forebays, and Vegetated Treatment Swale.	57.6	24.7	Commercial	13,582	19	62,000	0.65	-	-	\$445,643	50	Boire Field Brook	Direct discharge into brook
	& Swale	Install Vegetated Parking Lot Dividers, and Porous Pavement.	25.5	21.1	High Density Residential			41,750	0.56	41,750	0.56		-		Direct discharge into brook
1	PC Connection Wet Pond	Add Forebay and Flow Through Berm, Regrade & Stabilize Bank Erosion. Install Vegetated Parking Lot Dividers, and Porous Pavement.	27.6	21.9	Commercial	42,367	15	95,500	1.21	45,500	0.57	\$524,985	100	Pennichuck Brook	Direct discharge into brook
3	Abandoned Saturn Dealership Swale	Install Vegetated Parking Lot Dividers, and Porous Pavement. Install Depressed Vegetated Buffer Zone Pockets. Add Forebay, Check Dams and Vegetated Treatment Swale.	2.9	2.5	Commercial	6,578	2	19,250	2.14	18,250	2.03	\$199,999	100	Pennichuck Brook	Direct discharge into brook
2	Northwest Blvd/ RR-Xing Wetland Polishing Pond	Add Sediment Trap.	0.5	0.5	Industrial	7,553	2	120	0.11 Pretreatment		-	\$91,068	600	Pennichuck Brook	Discharges into swale
	& Swale	Add Sediment Trap, Bioretention Area, and Vegetated Treatment Swale with Sediment Plunge Pool.	4.1	3.5				9,500	0.77	2,000	0.16		450		Enters small wetland pond that discharges into brook
7	White Oak Drive Residential Detention Basin 1	Add Sediment Forebay, Raise Low Flow Outlet to Increase WQv Treatment. Install Gravel Flow Through Channel.	9.3	2.9	Low Density Residential	18,774	5	9,000	0.90	9,000	0.90	\$42,880	150	Bowers Pond	Discharges into Bower Pond
	White Oak Drive Residential Detention Basin 2	Add Sediment Forebay, Raise Low Flow Outlet to Increase WQv Treatment. Install Gravel Flow Through Channel.	16.1	3.5				9,000	0.67	9,000	0.67		150		Discharges into Bower Pond
5	Ford Dealership Swale	Add Forebays and Check Dams.	13.1	9.0	Commercial	22,610	6	38,000	1.24	-	-	\$172,175	200	Pennichuck Brook	Discharges into Basin
	& Detention Basin	Add Riprap Apron and Install Pocket Wetland. Install Vegetated Buffer Zone.			Industrial								375		Overflow discharge through wooded buffer into brook
8	Kessler Farms Detention Basin	Retrofit Existing Basin into Sediment Forebay. Install Pocket Wetland.	25.4	10.4	High Density Residential	14,712	4	23,000	0.56	-	-	\$174,600	1,800	Boire Field Brook	Discharges into channel through woods, into closed drainage system, outlets into brook
4	Post Office Detention Basin	Add Forebays, Vegetation.	24.4	18.3	Industrial	15,317	2	60,000	0.94 (Existing)	60,000	0.94 (Existing)	\$32,300	1,275	Pennichuck Brook	Discharges into closed drainage system, outlets into drainage channel to brook

BMP #	BMP Description	Sub-watershed	Current Site Condition	Comments	Site Plans Available at the Planning Board	Planning Board Approval Date	BMP Site Address	City/Town	Owner	Owner Address	Owner City, State Zip
6	Blackstone Apartment Complex Wet Pond	PBB	Parking lot pavement appeared older, cracking.	No pretreatment provided; Sediment build up at inlets slowly filling pond; Woody vegetation around inlets; Goose droppings along banks; Bank erosion/channelization due to clogged parking lot drains	Yes	9/20/1984	Blackstone Drive	Nashua	Millstone I Condo's & City of Nashua (easement?)	229 Main St. PO Box 2019	Nashua, NH 03061
	& Amherst Park Stream Channel		Wooded area at outfalls, overgrown and lots of debris.	No treatment provided at outfalls; Overgrown/Debris filled channel	Yes, will need to view updated plans	4/1/1970	525 Amherst St		525 Amherst Street LLC C/O John M Corcoran & Co	100 Grandview Rd Ste 205	Braintree, MA 02184
	& Amherst Park Stream Channel										
9	Somerset Plaza Swale	BFB	Parking lot pavement is in good shape. Several landscaped islands exist throughout the parking lot, in areas of proposed BMPs.	No pretreatment provided; Thick vegetation within swale; Trash/Debris; Goose droppings along banks	Yes, will need to view updated plans	6/21/1989	379 Amherst St	Nashua	Demoulas, Telemachus Trustee Delta & Delta Realty	875 East St	Tewksbury, MA 01876
10	Crowne Plaza Wet Pond	BFB	Parking lots in apartment complexes appears to be good. Lawns are well landscaped.	No pretreatment provided; Heavy sediment blocking pipes; Erosion of banks; Trash/Debris; Goose droppings along banks	Yes, will need to view updated plans	1/21/1999* Plan to add boat within the pond	2 Somerset Pkwy	Nashua	Sam Hospitality Corp	2 Somerset Pkwy	Nashua, NH 03063
	& Swale		The majority of the parking lot pavement appears to be in good shape.				4 Trafalgar Sq.		James K. Stellos	125 Northeastern Blvd.	Nashua, NH 03062
1	PC Connection Wet Pond	PBH	Parking lot pavement appeared older, cracking.	No pretreatment provided; Flow short circuits around pond; Sediment build up at inlets; Goose droppings along banks; bank erosion/channelization and depressions; Lilies/Vegetation within the pond	No		730 Milford Rd	Merrimack	G H Post, LLC C/O PC Connections	730 Milford Rd	Merrimack NH 03054-4631
3	Abandoned Saturn Dealership Swale	PBH	Abandoned parking lot is old and shows some cracking. Overgrown vegetation along back buffer area between parking lot and brook.	No pretreatment provided; High discharge velocity; Large amount of sediment build up, outfall partially buried; Trash/Debris, Overgrown vegetation	Yes	5/15/1993	635 Amherst St	Nashua	International Cars LTD INC Saturn of Nashua	170 Auto Center Rd.	Manchester, NH 03103
2	Northwest Blvd/ RR-Xing Wetland Polishing Pond	PBH	A lot of sediment in the parking lot, appears fairly new.	Sediment build up along curb cut, and along wetland banks; Trash/Debris	Yes	3/16/2000	18 Celina Ave	Nashua	1987 Tamposi Limited Partnership	20 Trafalgar Sq. U-602	Nashua, NH 03063
	& Swale		Parking lot pavement is in good condition. Puddling on roadway is a hazard at the curb cut.	Sediment build up along curb cut, at inlets, in catch basin; Flooding in roadway due to built up sediment in drainage channel; Trash/Debris and grass clippings; Overgrown vegetation	Yes	8/18/1988	29 Northwest Blvd		Southern New Hampshire Medical	8 Prospect St	Nashua, NH 03060
7	White Oak Drive Residential Detention Basin 1	PBB	Residential neighborhood with closed drainage system. Outlets to existing basins. Basins are overgrown with vegetation.	No pretreatment provided; High discharge velocity causing channeling and displaced riprap; Low flow orifice not providing WQv; Overgrown invasive vegetation; Dry weather flow from inlet has given the basin wetland characteristics	Yes	5/4/2000	White Oak Rd	Nashua	Michael D. Tancreti & Barbara A. Denault Trustee	11 Flagstone Dr.	Hudson, NH 03051
	No pretreatment provided; Overgrown vegetation along banks; Channeling and short circuiting flow path; Low flow orifice not providing WQv			Yes							
5	Ford Dealership Swale	PBH	Parking lot pavement is in good condition.	No pretreatment provided; High discharge velocity; Sediment build up; Trash/Debris; Bank erosion	Yes	7/12/2001	581 Amherst St	Nashua	Five Seven Nine Amherst Street Realty Trust	579 Amherst St	Nashua, NH 03063
	& Detention Basin			No pretreatment provided at parking lot inlet; Trash/Debris; Bank erosion/ channelization; Water ponding within basin, not infiltrating within 72 hours			575 Amherst St		Nim-Cor Inc	575 Amherst St	Nashua, NH 03063
8	Kessler Farms Detention Basin	BFB	Parking lots in the nearby apartment complexes were recently repaved. Wooded areas are in poor condition.	No pretreatment provided; Short circuiting flow path for one inlet; Sediment accumulation within pond	Yes, will need to view updated plans	8/16/1984	71 Kessler Farm Dr.	Nashua	Kessler Farms Condo's & City of Nashua (easement?)	229 Main St. PO Box 2019	Nashua, NH 03061
4	Post Office Detention Basin	PBH	Large impervious parking areas around the basin. A lot of sediment in the parking lots. Pavement is in decent condition.	No pretreatment provided; Sediment build up at inlets and due to use as snow storage; Trash/Debris; Overgrown vegetation within basin	Yes	8/14/1997	10-12 Celina Ave	Nashua	GPT Properties Trust C/O Thomson Reuters	PO Box 52136	Boston, MA 02205



General Notes

○ BMP LOCATIONS

NOT FOR CONSTRUCTION

No.	Revision/Issue	Date

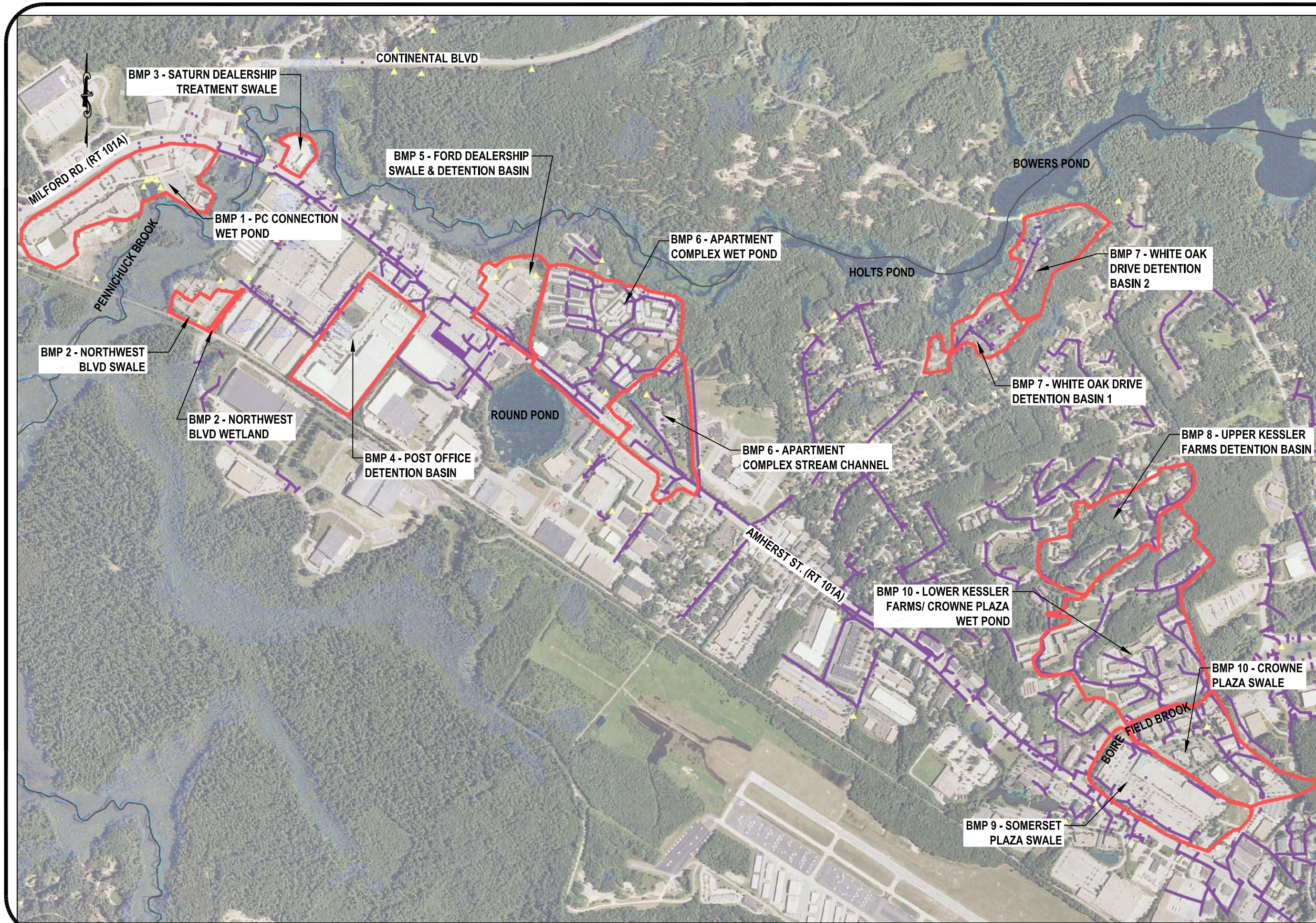
COMPREHENSIVE ENVIRONMENTAL
INCORPORATED



225 CEDAR HILL ST.
MARLBOROUGH, MA 01752
21 DEPOT ST.
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT
BMP LOCUS MAP

Project No. 131-32	Sheet
Date:	C-1
DRAWING BY: SS	
CHECKED BY: RB	
SCALE: 1"=1000'	



General Notes

- BMP CATCHMENT AREAS
- EXISTING DRAIN LINES
- EXISTING DRAINAGE STRUCTURE
- EXISTING DRAINAGE OUTFALL
- TOWN BOUNDARIES

NOT FOR CONSTRUCTION

No.	Revision/Issue	Date

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

225 CEDAR HILL ST.
MARLBOROUGH, MA 01752
21 DEPOT ST.
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT
BMP SUBCATCHMENT
MAP

Project No. 131-32	Sheet
Date:	C-2
DRAWING BY: SS	
CHECKED BY: RB	
SCALE: 1"=1000'	



General Notes		
-- EXISTING DRAIN SYSTEM		
-- PROPOSED DRAIN SYSTEM		
[Pattern] PROPOSED BMP		
[Pattern] PROPOSED RIPRAP STONE		
[Pattern] PROPOSED REGRADE AREA		
[Arrow] EXISTING FLOW DIRECTION		
Note: BMP contour lines at 1-foot interval		
NOT FOR CONSTRUCTION		
No.	Revision/Issue	Date

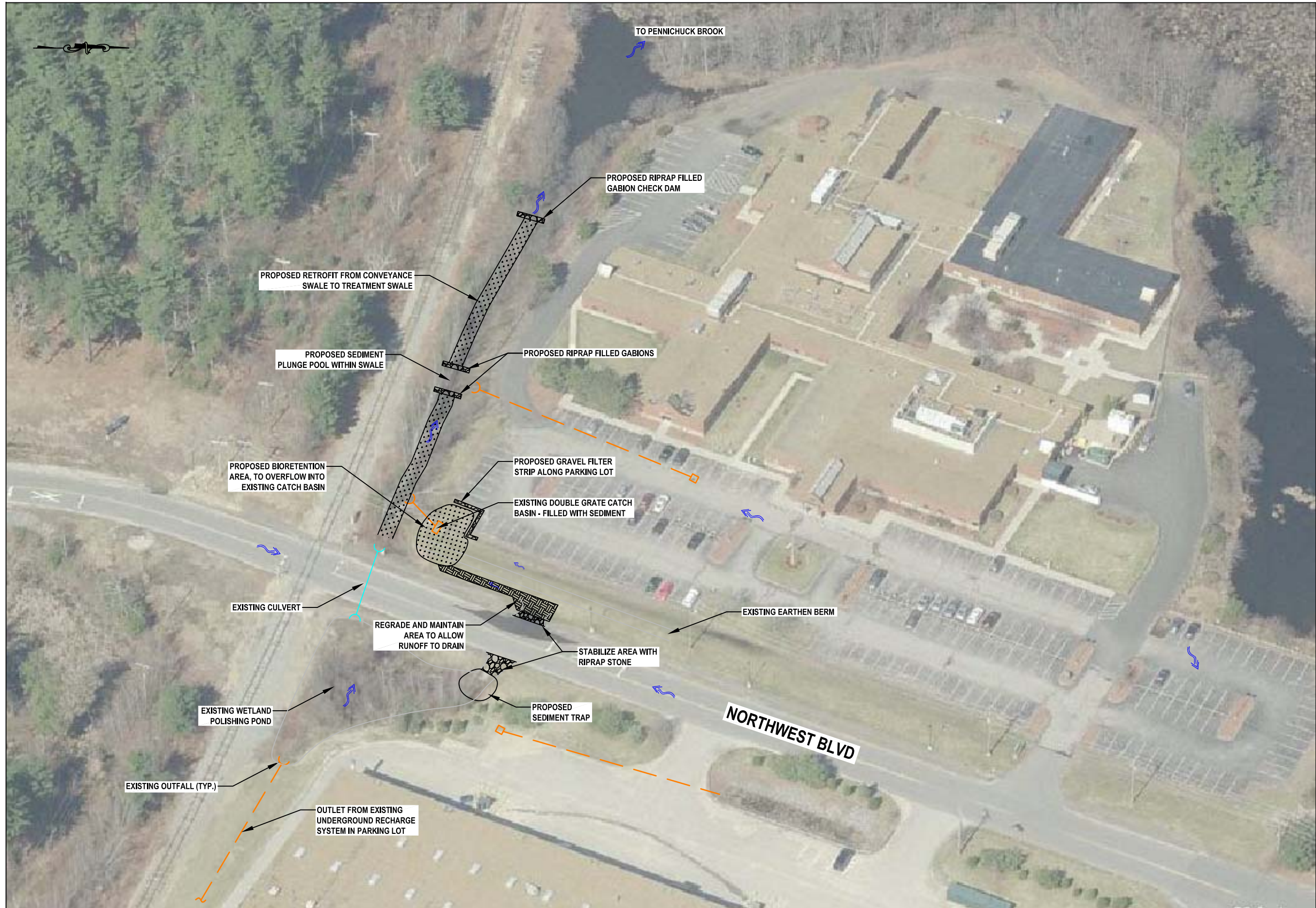
COMPREHENSIVE ENVIRONMENTAL
INCORPORATED



225 CEDAR HILL ST.
MARLBOROUGH, MA 01752
21 DEPOT ST.
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT
PC CONNECTION

Project No. 131-32	Sheet C-3
Date:	
DRAWING BY: SS	
CHECKED BY: RB	
NOT TO SCALE	



General Notes		
-- EXISTING DRAIN SYSTEM		
— PROPOSED DRAIN SYSTEM		
[Pattern] PROPOSED BMP		
[Pattern] PROPOSED RIPRAP STONE		
[Pattern] PROPOSED REGRADE AREA		
[Arrow] EXISTING FLOW DIRECTION		
Note: BMP contour lines at 1-foot interval		
NOT FOR CONSTRUCTION		
No.	Revision/Issue	Date

COMPREHENSIVE ENVIRONMENTAL
INCORPORATED



225 CEDAR HILL ST.
MARLBORD, MA 01752
21 DEPOT ST.
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT
NORTHWEST BLVD

Project No. 131-32	Sheet
Date:	C-4
DRAWING BY: SS	
CHECKED BY: RB	
NOT TO SCALE	



General Notes

- EXISTING DRAIN SYSTEM
- PROPOSED DRAIN SYSTEM
- PROPOSED BMP
- PROPOSED RIPRAP STONE
- PROPOSED REGRADE AREA
- EXISTING FLOW DIRECTION

Note: BMP contour lines at 1-foot interval
NOT FOR CONSTRUCTION

No.	Revision/Issue	Date

COMPREHENSIVE ENVIRONMENTAL
INCORPORATED



225 CEDAR HILL ST.
MARLBORO, MA 01752
21 DEPOT ST.
MERRIMACK, NH 03054

**PENNICHUCK BMP RETROFIT
SATURN DEALERSHIP**

Project No. 131-32	Sheet
Date:	C-5
DRAWING BY: SS	
CHECKED BY: RB	
NOT TO SCALE	



General Notes

- EXISTING DRAIN SYSTEM
- PROPOSED DRAIN SYSTEM
- ▨ PROPOSED BMP
- ▨ PROPOSED RIPRAP STONE
- ▨ PROPOSED REGRADE AREA
- ↗ EXISTING FLOW DIRECTION

Note: BMP contour lines at 1-foot interval
NOT FOR CONSTRUCTION

No.	Revision/Issue	Date

COMPREHENSIVE ENVIRONMENTAL INCORPORATED



225 CEDAR HILL ST.
MARLBOROUGH, MA 01752
21 DEPOT ST.
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT
POST OFFICE

Project No. 131-32 Date:	Sheet C-6
DRAWING BY: SS CHECKED BY: RB	
NOT TO SCALE	



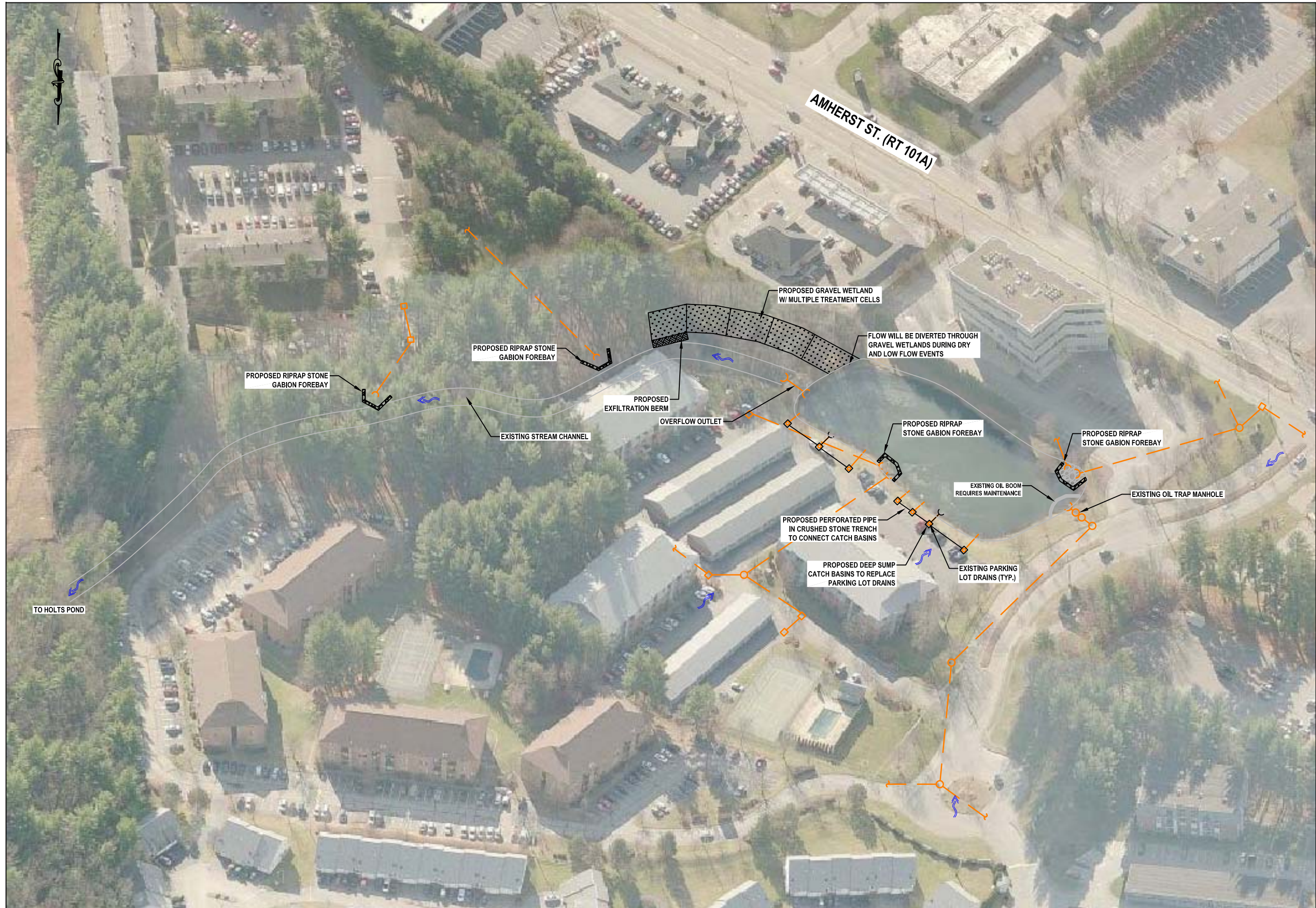
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-- PROPOSED DRAIN SYSTEM		
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[Pattern] PROPOSED RIPRAP STONE		
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Note: BMP contour lines at 1-foot interval		
NOT FOR CONSTRUCTION		
No.	Revision/Issue	Date

COMPREHENSIVE ENVIRONMENTAL
INCORPORATED

225 CEDAR HILL ST.
MARLBOROUGH, MA 01752
21 DEPOT ST.
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT
FORD DEALERSHIP

Project No. 131-32	Sheet C-7
Date:	
DRAWING BY: SS	
CHECKED BY: RB	
NOT TO SCALE	



General Notes

- EXISTING DRAIN SYSTEM
- PROPOSED DRAIN SYSTEM
- [Pattern] PROPOSED BMP
- [Pattern] PROPOSED RIPRAP STONE
- [Pattern] PROPOSED REGRADE AREA
- [Arrow] EXISTING FLOW DIRECTION

Note: BMP contour lines at 1-foot interval

NOT FOR CONSTRUCTION

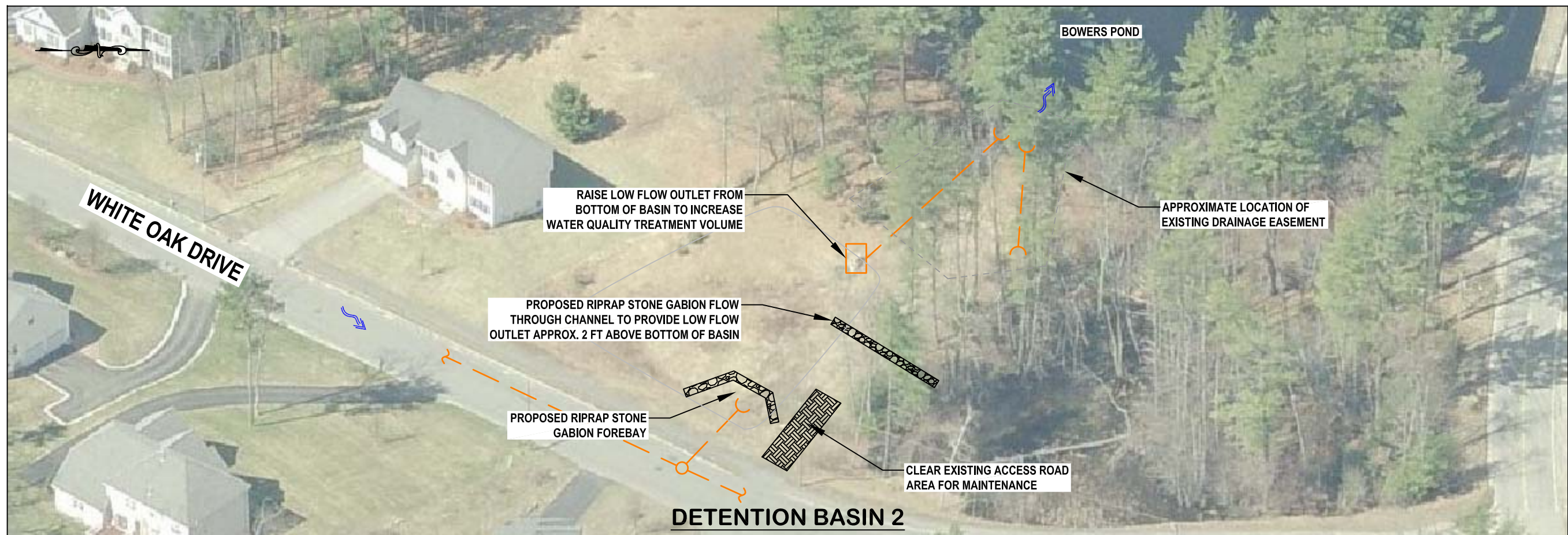
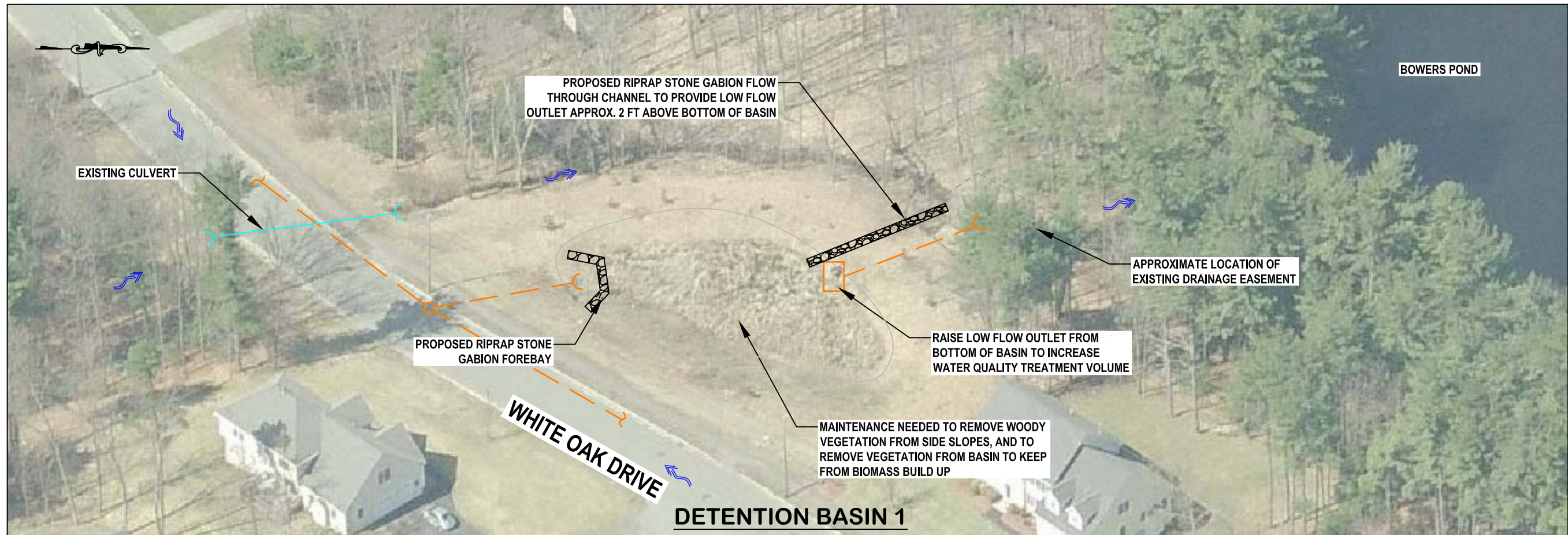
No.	Revision/Issue	Date

COMPREHENSIVE ENVIRONMENTAL
INCORPORATED

225 CEDAR HILL ST.
MARLBOROUGH, MA 01752
21 DEPOT ST.
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT
BLACKSTONE &
AMHERST PARK
APARTMENT COMPLEXES

Project No. 131-32 Date:	Sheet C-8
DRAWING BY: SS CHECKED BY: RB	
NOT TO SCALE	



General Notes		
---	EXISTING DRAIN SYSTEM	
---	PROPOSED DRAIN SYSTEM	
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[Pattern]	PROPOSED RIPRAP STONE	
[Pattern]	PROPOSED REGRADE AREA	
[Arrow]	EXISTING FLOW DIRECTION	
Note: BMP contour lines at 1-foot interval		
NOT FOR CONSTRUCTION		
No.	Revision/Issue	Date

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

225 CEDAR HILL ST.
MARLBOROUGH, MA 01752
21 DEPOT ST.
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT
WHITE OAK DRIVE

Project No. 131-32	Sheet
Date:	
DRAWING BY: SS	C-9
CHECKED BY: RB	
NOT TO SCALE	



General Notes		
-- EXISTING DRAIN SYSTEM		
-- PROPOSED DRAIN SYSTEM		
[Pattern] PROPOSED BMP		
[Pattern] PROPOSED RIPRAP STONE		
[Pattern] PROPOSED REGRADE AREA		
[Arrow] EXISTING FLOW DIRECTION		
Note: BMP contour lines at 1-foot interval		
NOT FOR CONSTRUCTION		
No.	Revision/Issue	Date

COMPREHENSIVE ENVIRONMENTAL
INCORPORATED



225 CEDAR HILL ST.
MARLBOROUGH, MA 01752
21 DEPOT ST.
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT
KESSLER FARMS

Project No. 131-32	Sheet C-10
Date:	
DRAWING BY: SS	
CHECKED BY: RB	
NOT TO SCALE	



General Notes		
-- EXISTING DRAIN SYSTEM		
-- PROPOSED DRAIN SYSTEM		
[Pattern] PROPOSED BMP		
[Pattern] PROPOSED RIPRAP STONE		
[Pattern] PROPOSED REGRADE AREA		
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Note: BMP contour lines at 1-foot interval		
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No.	Revision/Issue	Date

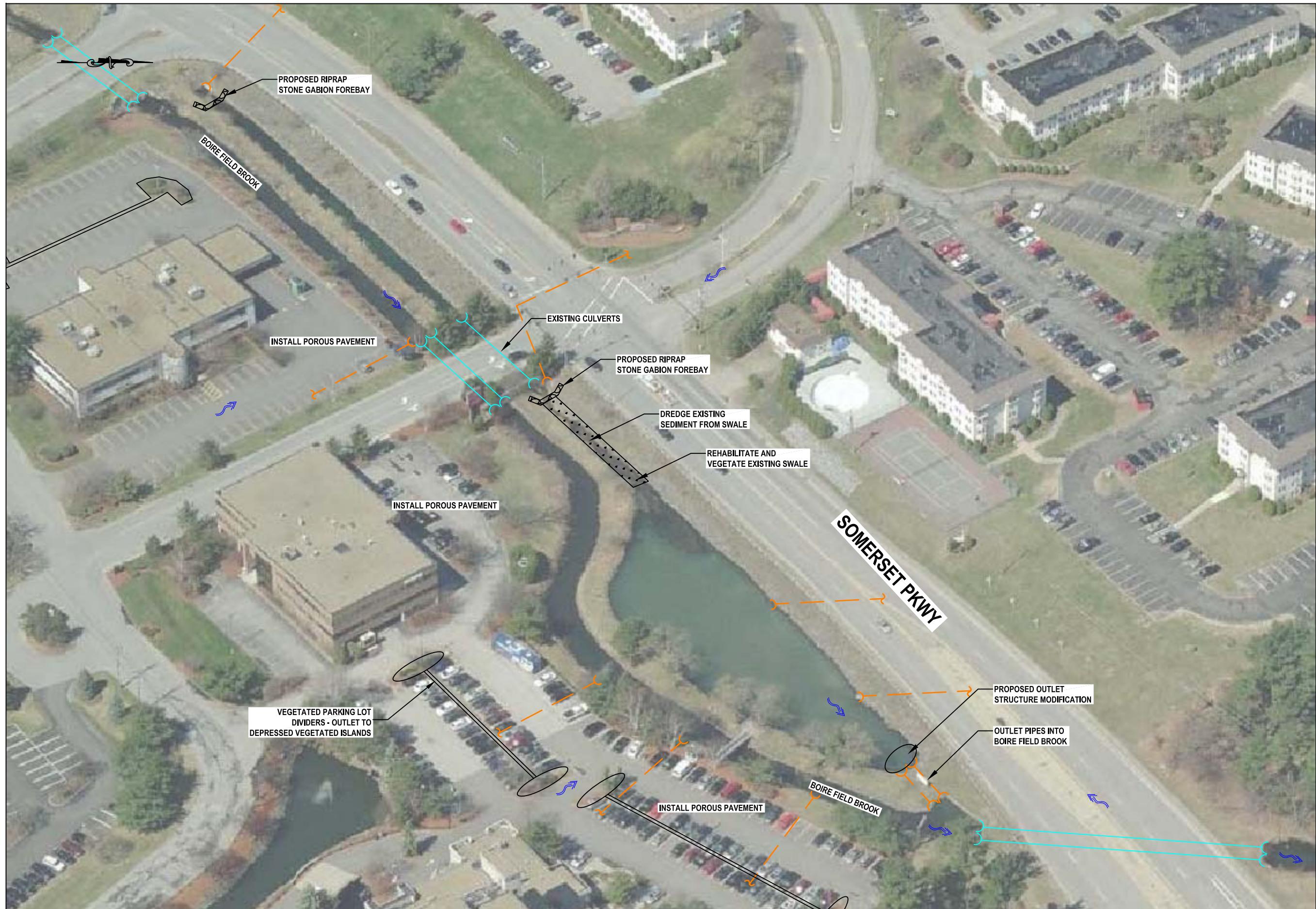
COMPREHENSIVE ENVIRONMENTAL
INCORPORATED



225 CEDAR HILL ST.
MARLBOROUGH, MA 01752
21 DEPOT ST.
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT
SOMERSET PLAZA

Project No. 131-32	Sheet
Date:	C-11
DRAWING BY: SS	
CHECKED BY: RB	
NOT TO SCALE	



General Notes

- EXISTING DRAIN SYSTEM
- PROPOSED DRAIN SYSTEM
- PROPOSED BMP
- PROPOSED RIPRAP STONE
- PROPOSED REGRADE AREA
- EXISTING FLOW DIRECTION

Note: BMP contour lines at 1-foot interval
NOT FOR CONSTRUCTION

No.	Revision/Issue	Date

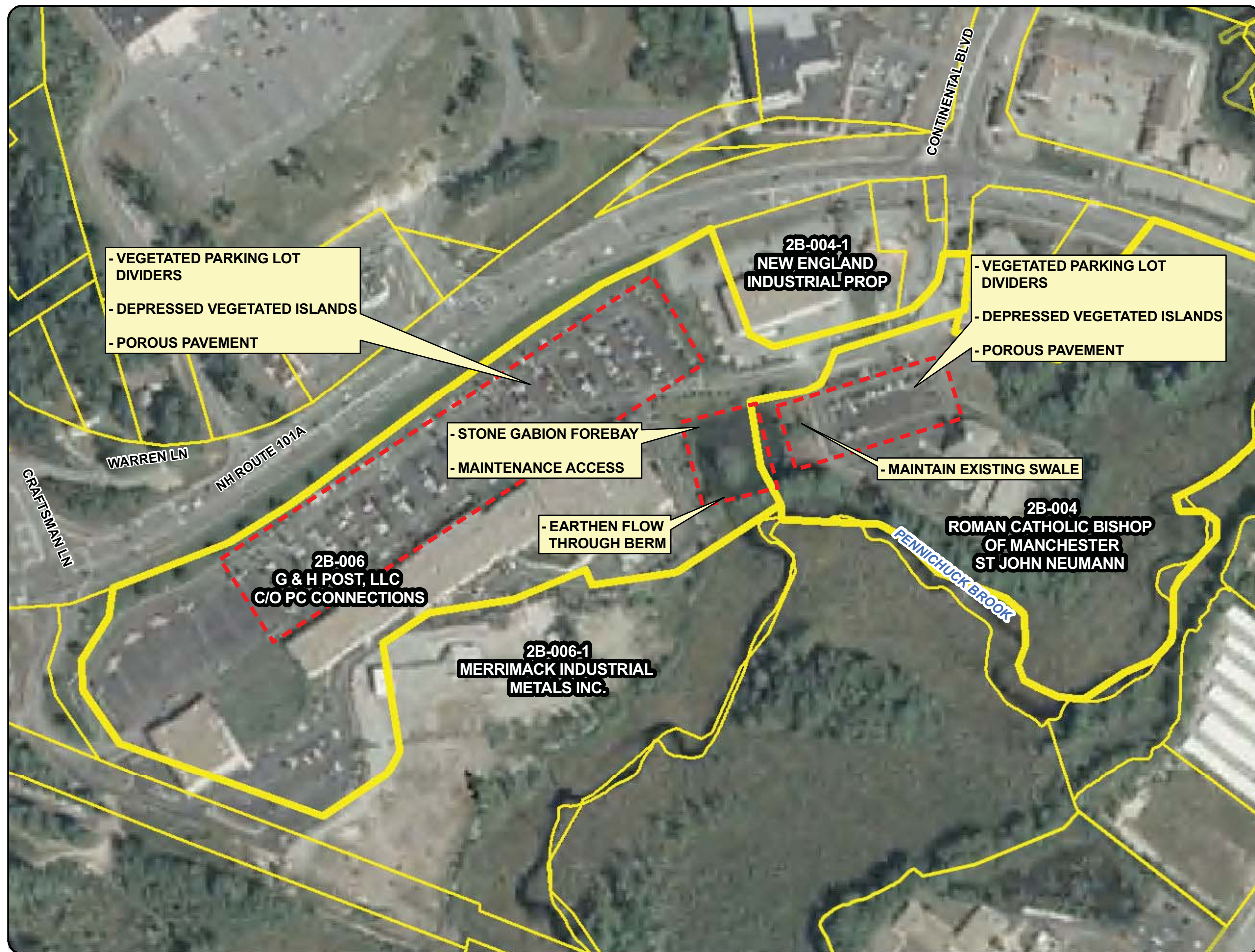
COMPREHENSIVE ENVIRONMENTAL INCORPORATED



225 CEDAR HILL ST.
MARLBOROUGH, MA 01752
21 DEPOT ST.
MERRIMACK, NH 03054

**PENNICHUCK BMP RETROFIT
CROWNE PLAZA**

Project No. 131-32	Sheet
Date:	C-12
DRAWING BY: SS	
CHECKED BY: RB	
NOT TO SCALE	



LEGEND

-  BMP Retrofit Area
-  Parcel Boundary



COMPREHENSIVE ENVIRONMENTAL
INCORPORATED



21 DEPOT STREET
MERRIMACK, NH 03054

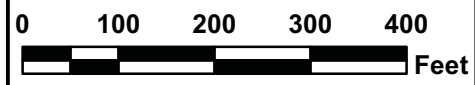
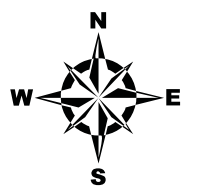
PENNICHUCK BMP RETROFIT

PC CONNECTION



LEGEND

-  BMP Retrofit Area
-  Parcel Boundary



**COMPREHENSIVE ENVIRONMENTAL
INCORPORATED**



21 DEPOT STREET
MERRIMACK, NH 03054

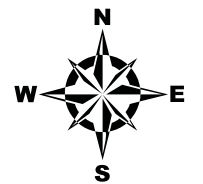
PENNICHUCK BMP RETROFIT

NORTHWEST BLVD



LEGEND

-  BMP Retrofit Area
-  Parcel Boundary



0 100 200 300 400 Feet

COMPREHENSIVE ENVIRONMENTAL
INCORPORATED



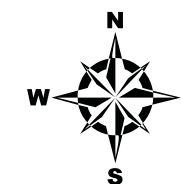
21 DEPOT STREET
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT
SATURN DEALERSHIP



LEGEND

-  BMP Retrofit Area
-  Parcel Boundary



COMPREHENSIVE ENVIRONMENTAL
INCORPORATED



21 DEPOT STREET
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT

POST OFFICE



LEGEND

- BMP Retrofit Area
- Parcel Boundary



0 100 200 300 400 Feet

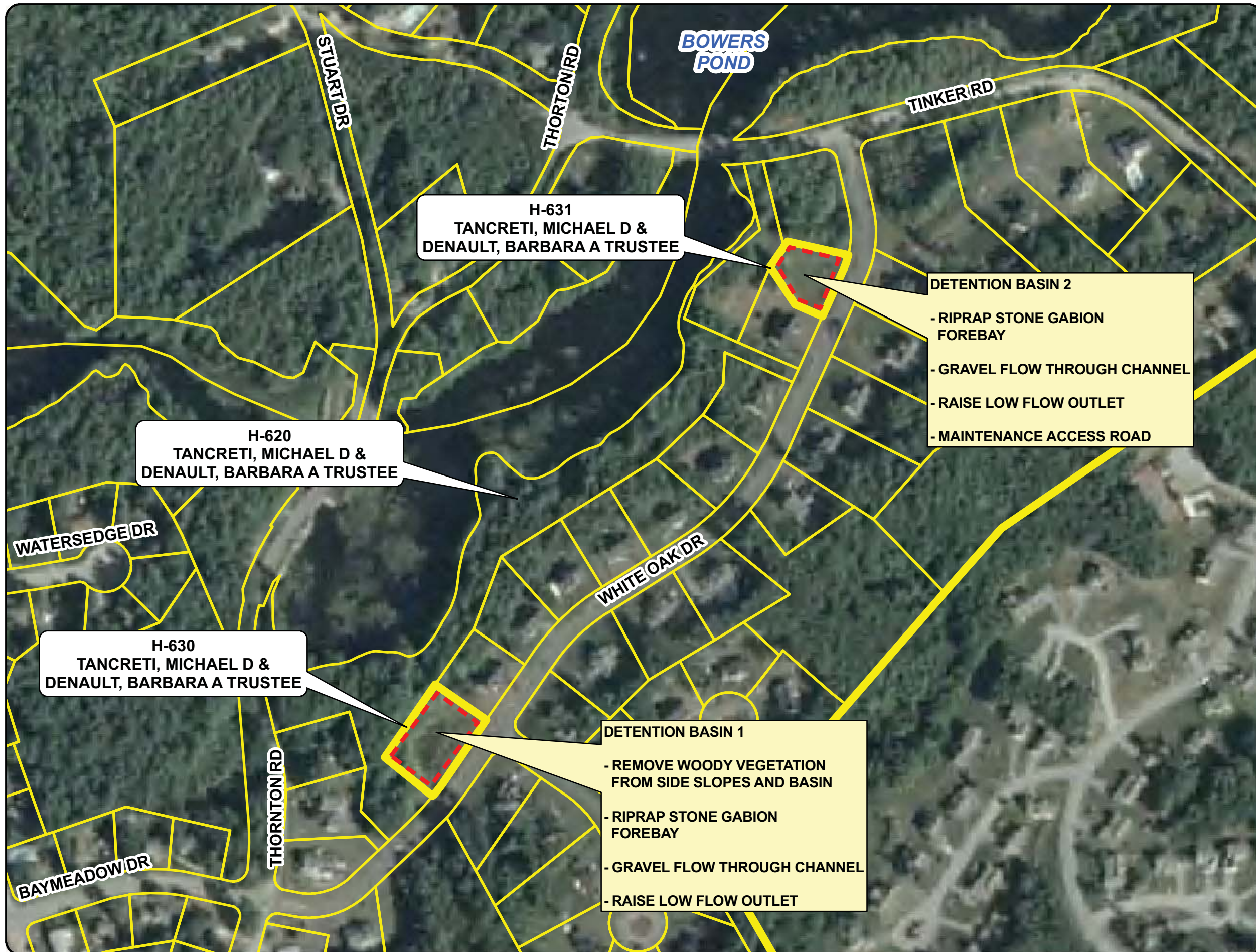
COMPREHENSIVE ENVIRONMENTAL
INCORPORATED



21 DEPOT STREET
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT
FORD DEALERSHIP





H-631
TANCRETI, MICHAEL D &
DENAULT, BARBARA A TRUSTEE

H-620
TANCRETI, MICHAEL D &
DENAULT, BARBARA A TRUSTEE

H-630
TANCRETI, MICHAEL D &
DENAULT, BARBARA A TRUSTEE

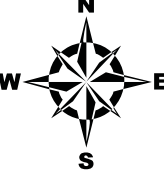
- DETENTION BASIN 2
- RIPRAP STONE GABION FOREBAY
 - GRAVEL FLOW THROUGH CHANNEL
 - RAISE LOW FLOW OUTLET
 - MAINTENANCE ACCESS ROAD

- DETENTION BASIN 1
- REMOVE WOODY VEGETATION FROM SIDE SLOPES AND BASIN
 - RIPRAP STONE GABION FOREBAY
 - GRAVEL FLOW THROUGH CHANNEL
 - RAISE LOW FLOW OUTLET

LEGEND

 BMP Retrofit Area

 Parcel Boundary



 0 100 200 300 400 Feet

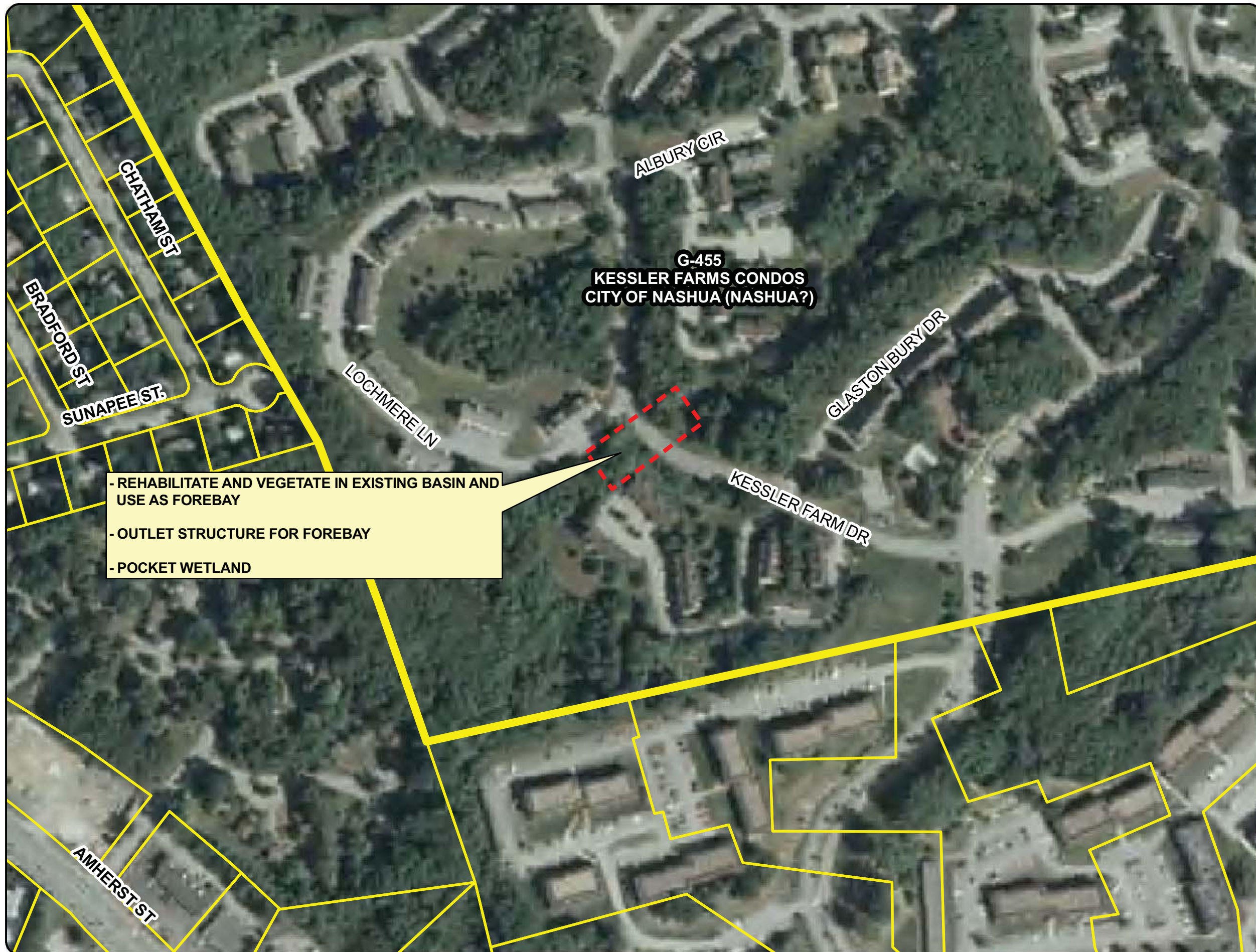
COMPREHENSIVE ENVIRONMENTAL
INCORPORATED



21 DEPOT STREET
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT

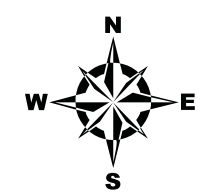
WHITE OAK DRIVE



- REHABILITATE AND VEGETATE IN EXISTING BASIN AND USE AS FOREBAY
- OUTLET STRUCTURE FOR FOREBAY
- POCKET WETLAND

LEGEND

- BMP Retrofit Area
- Parcel Boundary



COMPREHENSIVE ENVIRONMENTAL
INCORPORATED



21 DEPOT STREET
MERRIMACK, NH 03054

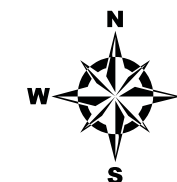
PENNICHUCK BMP RETROFIT

KESSLER FARMS



LEGEND

- BMP Retrofit Area
- Parcel Boundary



0 100 200 300 400
Feet

COMPREHENSIVE ENVIRONMENTAL
INCORPORATED



21 DEPOT STREET
MERRIMACK, NH 03054

PENNICHUCK BMP RETROFIT

**SOMERSET PLAZA &
CROWNE PLAZA**