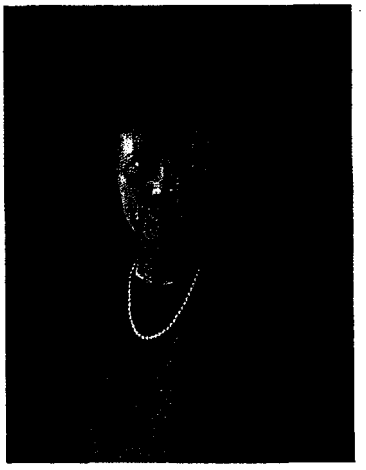
Comprehensive Environmental Inc.
President/CEO
Eileen Pannetier



Qualifications Summary

Ms. Pannetier's technical expertise is based on more than 20 years of experience in the field of water supply, water resources, and watershed management. She has special expertise as a water quality specialist, with a long career emphasis on projects related to the improvement of both raw and finished drinking water quality. She has worked on over a dozen water supply master plans during her career, the latest being plans for the Towns of Wilton and Milford, NH, Scituate, MA and a comprehensive plan for the Town of Orleans water supply. This project was initiated as a follow on to a biofilm study for the same community for the purpose of correcting any system deficiencies that might have brought on the biofilm problem.

Other relevant projects include:

- EPA Headquarters Expert Panel Testimony
- Distribution modeling of water quality
- Water quality monitoring and modeling programs
- Alternative source master planning
- Groundwater protection planning
- Well and water system evaluation
- Biofilm and biofouling studies and control
- Permitting experience in all phases of water resources and wetlands permits
- Safe Drinking Water Act and Clean Water Act issues.

Selected Project Experience

- Project Manager, Aquarion Water Company, various water supply projects
- Project Manager, Town of Milford Water Supply Master Plan
- Project Director, Town of Wilton Water Supply Master Plan
- Water Quality Expert, EPA Headquarters Panel, Review of New York City water supply
- Project Director, Pennichuck Water Works Management Plan. The development of a comprehensive management plan for a filtered water supply in southern NH serving over 100,000 people.
- Project Manager, Town of Orleans Water Supply Master Plan, Hydraulic Network Modeling and Capital Improvement Planning for the Town of Orleans Massachusetts
- Project Manager, Merrimack Village District Water Supply Master Plan, included hydraulic analysis and capital improvement plan.
- Project Manager, Tri-Town Master Plan Source Water Supply Evaluation, Towns of Braintree, Randolph, and Holbrook, Massachusetts's water supplies (about 80,000 persons).
- Project Manager, Development of Emergency Response Planning and Agricultural Best Management Practices for Quabbin, Wachusett and Ware River watersheds for MDC/MRWA
- Project Manager, Development of a surface water protection strategy statewide for the NH Department of Environmental Services to satisfy EPA's Source Water Assessment Program
- Project Manager, Review of Iron and Manganese Problems in Orleans, Massachusetts wells
- Project Manager, Evaluation of Groundwater Supply Sources for Town of Orleans, MA
- Project Manager, Evaluation of Emergency Water Source Planning, Sudbury Reservoir, Massachusetts Water Resources Authority
- EPA Headquarters, comment document for 10-state standards draft revisions

Comprehensive Environmental Inc.
President/CEO
Eileen Pannetier

Highlights

- *Over 20 years of experience in water supply/water resources*
- *Nationally recognized drinking water quality expert*
- *Broad background in issues related to water supply, particularly for microbiological issues, emergency planning, and Capital Improvement Planning*
- *Experience in biofilm analysis*
- *Experience in biofouling analysis*
- *Experience in identifying broad water supply treatment and supply options and other strategic planning*

Education

B.A. *Biology*
MESA College, Colorado
M.S. *Biology*
University of Northern Colorado

Employment

- *1987 – present, Comprehensive Environmental Inc., President/CEO*
- *1977 – 1987, Camp Dresser & McKee, Inc., Boston, MA, Project Manager*

Professional Certifications

- *Certificate of Training for "Mathematical Modeling of Water Quality," Reckhow and Chapra, Duke University*
- *ISO 14001 Trained Lead Auditor, 2003*

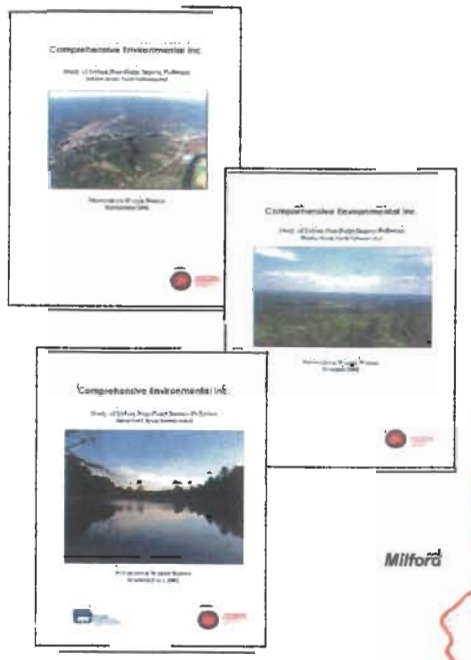
Memberships

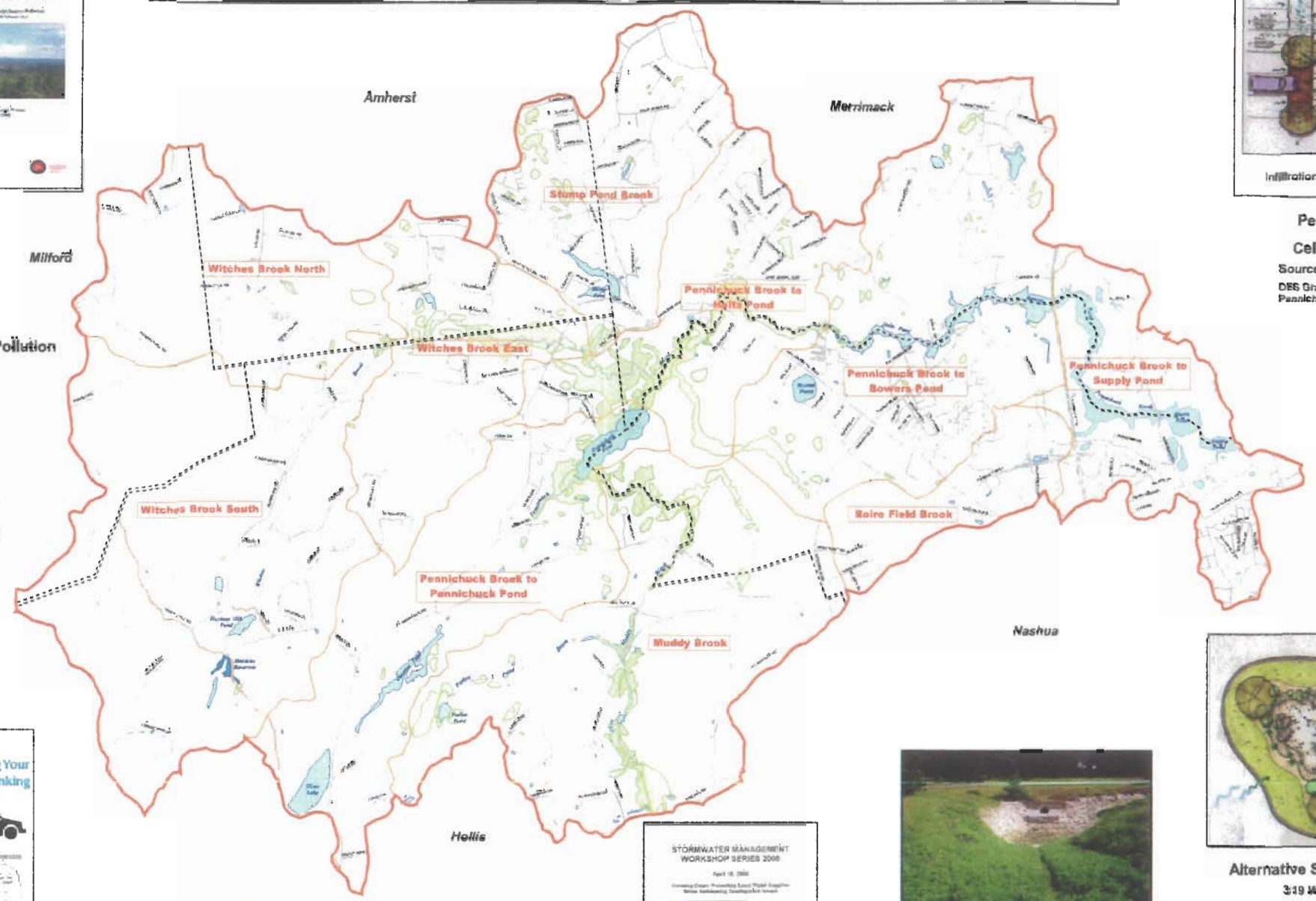
- *Member, EPA Headquarters Expert Panel for the Review of the New York City Filtration Exemption Application*
- *Chairman, NEWWA Water Resources Committee*
- *Recently received the Award of Merit for work on the NEWWA Water Resources Committee*
- *American Society of Civil Engineers*
- *North American Lake Management Society*
- *American Water Works Association*

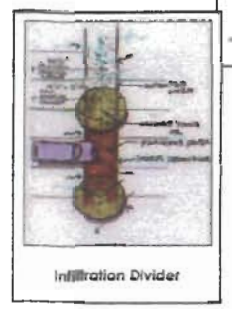
Selected Publications, Speeches & Moderations

- *Publisher and Editor:*
- *"The Safe Drinking Water Newsletter", 1989 to 1995.*
- *In-Press, NEWWA, "Water Supply Master Planning – What's Missing with Traditional Plans."*
- *In-Press, NEWWA, "Water Conservation by Demand Management."*
- *In-Press, NEWWA, "Modeling Biofilm Potential – A Start."*
- *In-Press, NHWWA, "Landscaping for Water Supply Recharge and Demand Management – A Demonstration Project."*
- *In-Press, NEWWA, "A Surprising Source of Bacteria."*
- *In-Press, NEWWA, "Population & Demand Projections – Political Corrections Can Benefit Your Case."*
- *Publisher and Editor: Dozens of CEI Technical Briefs on Water Supply and Master Planning*

Pennichuck Water Works Watershed Management Program



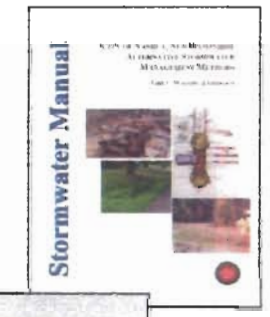


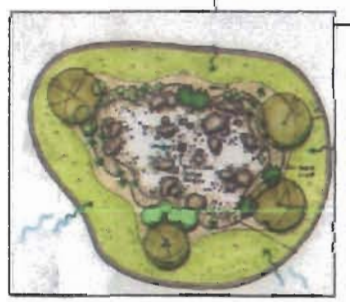


Pennichuck Square and Celina Avenue BMPs

Source Water Protection Grant

DES Grant: $28,500
Pennichuck Water Works: $27,500





Alternative Stormwater Management Manual

319 Watershed Assistance Grant

DES Grant: $40,000
Matching Contributions $58,500 by:
Pennichuck Water Works: $25,000
City of Nashua: $25,000
Comprehensive Environmental Inc.: $8,500

Cornerstone Site Structural BMP

319 Watershed Assistance Grant

DES Grant: $21,000
Pennichuck Water Works: $14,000

Studies of Urban Non-Point Source Pollution

Source Water Protection Grants

- Baire Field Brook: $14,580
- Pennichuck Brook to Bowers Pond: DES Grant $13,[illegible]00; Pennichuck Water Works $9,200
- Stump Pond Brook: DES Grant $15,000; Pennichuck Water Works $3,750
- Witches Brook East: DES Grant $15,000; Pennichuck Water Works $4,600
- Witches Brook North: DES Grant $15,000; Pennichuck Water Works $3,900
- Sediment Study: DES Grant $14,840; Pennichuck Water Works $8,000

319 Watershed Assistance Grant

- Remaining Five Sub-watersheds:

Muddy Brook,
Pennichuck Brook to Hollis Pond,
Pennichuck Brook to Pennichuck Pond,
Pennichuck Brook to Supply Pond,
Witches Brook South

DES Grant $19,[illegible]00
Pennichuck Water Works $28,600

Hot Spots Program

319 Watershed Assistance Grant

DES Grant: $15,000
Pennichuck Water Works: $8,300

Storm Drain Mapping & Marking Program

Source Water Protection Grant

DES Grant: $15,000
Pennichuck Water Works: $19,000

Stormwater Management Workshop Series

Source Water Protection Grant

DES Grant: $[illegible]0,000
Pennichuck Water Works: $8,000

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Eileen Pannetier
EP-3
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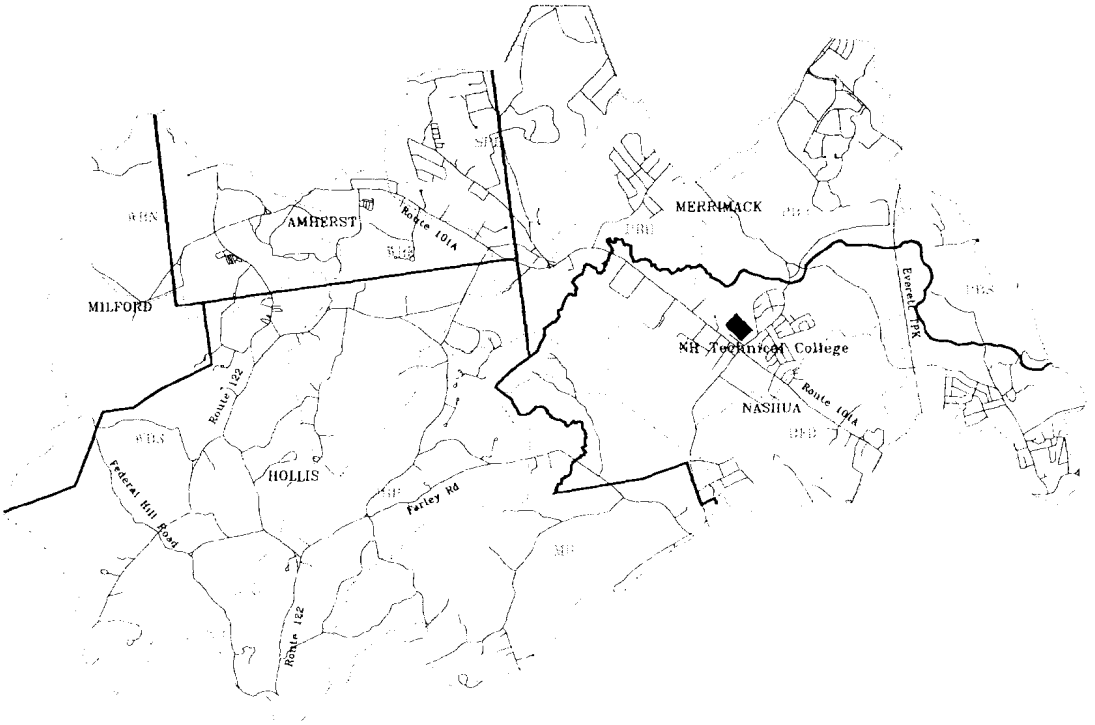
Pennichuck Water Works Watershed Management Plan



Prepared for:
Pennichuck Water Works Corporation
4 Water Street
Nashua, NH 03060

Prepared by:
Comprehensive Environmental Inc.
21 Depot Street
Merrimack, NH 03054

August 1998

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Water suppliers like Pennichuck Water Works Corporation are regulated under the Safe Drinking Water Act and Amendments of 1996. Future regulations under this act are expected to call for increased treatment for water systems on poor source waters, conversely, systems on high quality, protected source waters are believed to have a high level of public health protection. In addition to more future regulatory constraints, systems with poor source water quality also tend to have problems from off-taste and odors caused by the poor source water quality. To address these issues, Pennichuck Water Works Corporation created this Watershed Management Plan.

The plan is built on an approach that divides the watershed into manageable units called subwatersheds. The foundation of the plan is an analysis of watershed hydrology and pollutant loading by subwatershed. This allowed a critical comparison of how much each subwatershed produces in quantity of water and in quantity of pollutants. This comparison then allowed recommendations to focus on either prevention or remediation depending on whether the subwatershed is one which currently produces large quantities of clean water, or whether it is more highly developed and currently produces poor quality input to the system.

While most people in the communities in the watershed (Nashua, Hollis, Milford, Amherst, and Merrimack) are aware of the impact that the tremendous growth in Southern New Hampshire has had on traffic, fewer are aware of the impact that it has had on water resources. Both surface water and groundwater have been impacted by this growth. As houses, stores, industries and parking lots replace forest and farmland, more and more impervious area is created. This impervious area prevents natural recharge to groundwater from occurring, instead forcing it to run overland to the nearest stream channel in the form of stormwater.

As Southern New Hampshire develops, industries, retail businesses, and subdivisions create more impervious area and typically pipe the increased surface water runoff offsite, usually to the nearest stream or channel. Over time, this has greatly increased the intensity and force of stormwater flows while decreasing groundwater recharge. The decrease in groundwater recharge is particularly problematic since it ultimately reduces "baseflow".

Baseflow is the groundwater discharge into streams that occurs during dry weather and droughts. Thus, the same amount of precipitation falling on the watershed now leaves the watershed at a high rate in stormwater flow instead of recharging groundwater for a slow release. This ultimately damages both surface water and groundwater resources. Ultimately the most significant impacts on water resources include

1) reduced groundwater recharge that ultimately may result in long-term declining groundwater levels and impacts on private wells and public wells; and
2) increased stormwater flows loaded with pollutants that impact streams and ponds in the watershed that may eventually pose a public health

While most people in the communities in the watershed are aware of the impact that the tremendous growth in Southern New Hampshire has had on traffic, fewer are aware of the impact that it has had on water resources.

Executive Summary

threat and that now impact aquatic habitat, recreation and the aesthetic resources of the watershed.

The effects on groundwater are largely one of loss of recharge, although there are also impacts from industrial sites that directly pollute groundwater through illegal discharge or dumping. Surface water resources are more indirectly but nonetheless strongly impacted. Stormwater pollutants include petroleum hydrocarbons (oil and grease), toxic heavy metals, bacteria, viruses and other microbiological organisms, and nutrients (phosphorus and nitrogen). From the standpoint of water supply, the most serious of these pollutants are the microbiologicals, which pose a direct health threat, and nutrients.

A call to action is needed in all of the watershed towns to reduce the impact of existing development and to prevent future negative impacts.

Nutrients provide an indirect impact on water resources, particularly phosphorus, by encouraging aquatic plant growth. Although this may seem beneficial at first blush, an overabundance of aquatic vegetation and algae results in bloom and die-off conditions that can quickly clog waterways in an unsightly, odorous problem. This phenomenon is called "eutrophication" and it is happening already in the chain pond system used by Pennichuck Water Works.

The threats described above affect everyone in the watershed, whether or not Pennichuck supplies their water. A call to action is needed in all of the watershed towns to reduce the impact of existing development and to prevent future negative impacts. The recommendations of the report focus on the things that can be done by Pennichuck Water Works or by communities in the watershed. There is a common goal of increasing groundwater recharge and protection of streams and ponds in the watershed. Some of the recommendations in the plan include:

- The use of buffer zones and buffer strips wherever possible by community Planning Boards and Conservation Commissions;
- The reduction in impervious cover in new and/or modified developments, with increased groundwater recharge wherever possible;
- The use of setbacks for streams from livestock feeding and other activities potentially detrimental to water quality; and
- The recommendation that developers in each of the towns be required to provide control of post-development runoff so that it does not exceed pre-development conditions.

Many of the recommendations focus on either prevention of impacts through methods such as buffer strips and protected lands or remediation of existing pollution problems through the use of Best Management Practices such as infiltration basins and other water quality improvement controls.

The recommendations are summarized in the following table.

Pennichuck Watershed Management Plan Summary of Recommendations

Top 10 Problems	Recommended Actions
1. Storm Water Increased amount and poor quality of storm water flows. This problem also has led to a loss of baseflow and stream channel erosion that further results in declining water quality.	Reduce existing and future imperviousness • Require that post-development runoff equal predevelopment runoff. • Minimize parking lot impacts using permeable dividers, street buffer strips and modified landscaping. • Reduce transportation impacts of subdivisions by using skinny streets with grass swales • Use onsite infiltration whenever possible, including recharge of roof leaders and other drainage instead of connection with the existing or new storm drain systems. • Use clearing and grading plans that minimize site disturbance, require grading plans, erosion control plans and inspect progress during construction. • Minimize lawn sizes, encourage the use of native species for landscaping wherever possible and leave native vegetation in place as a buffer.
2. Minimal Protective Zones The ponds and tributary streams and wetlands have little protection from storm water impacts. Future development is likely to further increase the amount of poor quality storm water flows.	Require buffer zones around sensitive water resources and wetlands. Use a general guideline of a 400-foot buffer around the chain ponds unless all runoff can be infiltrated or otherwise treated. Use a general guideline of 200-feet around tributaries to the ponds. In some cases, such as steep slopes, a greater buffer may be needed, while in other flat areas and with significant protective measures, a lesser buffer width may be suitable. Buffers should be recorded on official maps and protected through perpetual conservation easements or restrictions as well as signage. They also need to be protected from channeled flow.
3. Pond Eutrophication The Pennichuck ponds are filling in rapidly. This will further exacerbate water quality and quantity problems.	Determine sediment depths in each of the ponds and dredge as needed to provide sedimentation capacity. This capacity will help protect the water supply and other downstream resources from development impacts.
4. Transportation Impacts. Transportation facilities in the watershed are widespread and have major impacts on water quality.	Work with Public Works Departments and the state Department of Transportation to avoid direct piping of runoff to streams and instead use infiltration technologies such as grassed swales and leaching catch basins. Work with watershed Fire Departments to address spill issues. Develop a monitored demonstration roadway for comparison to an old style roadway.
5. Agricultural Impacts. Livestock using tributary streams for watering may result in the introduction of undesirable contaminants.	• Provide education materials for agricultural landowners. • Request buffer strips or zones from livestock concentrations. • Purchase conservation easements where needed to protect from direct stream channel encroachment by livestock.
6. Hot Spots of Pollution Sources. Multiple "hot spots" in the watershed pose chemical risks to the water supply and may threaten biological activity that normally cleanses water quality.	Use infiltration controls at specific locations within the watershed where problems have been identified. Follow up on status of all hazardous waste sites in the watershed and request action timetables. Provide special educational materials to service stations, car dealerships and automotive or other repair shops because of their potential to create major water quality impacts.
7. Technical Education Needed. There is a general lack of understanding of watershed protection principles among regulatory, planning, public works and engineering.	• Hold a technical transfer workshop for Conservation Commissions, Planning Board members, Public Works staff, site developers and engineers.
8. Public Education Needed. There is a general lack of understanding of watershed protection principles among the watershed businesses and residents.	• Develop an educational questionnaire to gauge the level of understanding within the watershed communities both before and after the education program. • Develop a school age public education program for watershed schools.
9. Regulatory Authority Lacking Pennichuck Water Works Corporation lacks up to date regulatory authority within the water supply.	Modify watershed regulations or develop cooperative agreements with watershed towns.
10. Comprehensive Database Needed. The available database is lacking.	• Measure steam channels and imperviousness annually. • Conduct periodic sediment depth sampling of ponds. • Conduct storm water monitoring of demonstration projects. • Conduct a one-year intensive monitoring program for dry and wet weather water quality

1.0 Introduction

Pennichuck Water Works supplies the City of Nashua and several other communities with a filtered water supply that meets all state and federal water quality standards. However, future federally mandated water quality standards are expected to call for higher treatment standards in proportion to the raw water quality of the source. It is thus likely that water systems with better quality raw water sources will need less treatment while those with poor quality sources will need greater (and more expensive) treatment. This means that conventionally filtered systems like Pennichuck may have to add additional treatment if their raw water quality deteriorates. This can lead to expensive capital and operation costs to meet these standards.

Water systems that protect and improve raw water quality through watershed protection will be better able to protect public health and to minimize both capital and annual operation costs in the future.

The Pennichuck Water Works Watershed Study was developed with two objectives:

1. to improve public health protection and
2. reduce future treatment expenditures.

The basic steps in developing the program included:

1. **develop objectives** and a study plan;
2. **characterize** the watershed;
3. **assess water quality** compared to current surface water supply standards;
4. develop water and pollutant budgets to identify **water quality goals**
5. identify and assess existing and **potential sources of pollution**;
6. identify and analyze **existing protection measures**;
7. determine the **impacts of buildout** on the water supply;
8. prepare the **watershed protection program** that satisfies the objectives and the identified water quality goals.

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1.1 Watershed Characteristics

The Pennichuck watershed lies in five Southern New Hampshire towns including Nashua, Merrimack, Amherst, Milford, and Hollis. This watershed supplies the chain ponds with surface flow (runoff) and baseflow (groundwater). As the towns within the watershed develop, the amount of surface flow will increase, carrying with it land surface pollutants. Meanwhile the baseflow portion may decrease.

Conventionally filtered systems like Pennichuck may have to add additional treatment if their raw water quality deteriorates.

The type of land use and soils within each community affects the amount of surface flow and the amount of pollution reaching the ponds. Therefore, physical characteristics such as hydrology (how much water is contributed to the water supply by different portions of the watershed), soil types, and land uses in these towns play an important role in the water quality of the ponds. These relationships are discussed further in Section 2.0.

1.0 Introduction

For this study, the Pennichuck watershed was delineated using topographic data and local storm drain maps to define the area draining into the water supply. This watershed was then broken down into 10 smaller watersheds (subwatersheds) so areas of the watershed could be compared to one another to identify areas needing more attention. Section 2.0 explains these characteristics in more detail.

1.2 Water Quality

The water quality of the ponds was assessed to determine compliance with State and Federal drinking water regulations that are designed to protect the public health. Since there was limited historical data, additional limited sampling was conducted and a baseline sampling program was developed to obtain additional information.

Calculated pollutant loads were used to identify the subwatersheds that are the greatest threat to water quality.

Parameters tested include pH, conductivity, temperature, dissolved oxygen, turbidity, flow, fecal coliform, ammonia nitrogen, nitrate nitrogen, Total Kjeldahl nitrogen, and total phosphorus. Discussion of these parameters and results of the sampling are included in Section 3.0.

1.3 Hydrologic and Phosphorus Budgets

As discussed above, hydrology plays an important role in determining the water quality of a water system. In this study, precipitation data and data from the United States Geological Survey (USGS) were reviewed to define typical runoff flows for the average year in the Nashua area. This information was used to determine the total amount of water entering the water supply from each of the 10 subwatersheds. Subwatersheds were then prioritized by the percent of their runoff contribution to the water supply to determine which areas contributed the largest quantities of water. This is discussed in more detail in Section 4.0.

Phosphorus is also important to the water quality of the system. High levels of this nutrient can lead to excess algae and plant growth, which in turn can affect the systems' compliance with drinking water regulations and can also cause taste and odor problems. To address this, a theoretical model of nutrient (phosphorus) loading was also developed for Pennichuck watershed to determine which areas of the watershed were contributing the highest levels of phosphorus. *Eutromod Watershed and Lake Modeling Software* (Reckhow, 1990) was used for this analysis. This model uses the hydrologic budget, land use, and soils data to estimate theoretical loadings to the water supply. These theoretical pollutant loads were used to determine subwatersheds that are the greatest threat to water quality. More detail on both these analyses is included in Section 4.0.

1.4 Identification of Pollution Sources

To identify pollution sources, a database search was conducted and New Hampshire Department of Environmental Services (NHDES) files on sites and spills were reviewed. A field review was also conducted. Pollution sources were then mapped to evaluate their threat to the water supply. Potential pollution sources

1.0 Introduction

included landfills, junkyards, underground storage tanks, hazardous waste generators, Superfund sites, releases of hazardous waste materials, oil/gas spill sites, and discharge permits. More detail on the pollution sources found and their impacts to Pennichuck watershed is included in Section 5.0.

1.5 Protective Measures

The New Hampshire Department of Environmental Services and local towns have regulations dealing with the protection of water supplies. Most towns also have overlay protection zones and new development bylaws that may assist water quality protection. These were reviewed to identify the existing level of protection and to avoid duplication of efforts.

Land ownership by Pennichuck Water Works and each of the Town's Conservation Commissions were mapped since they may also offer a significant level of protection by remaining undeveloped. Section 6.0 discusses in detail the regulations, protective practices, and protected lands in each of the towns.

1.6 Buffer Zones

Buffer zones were evaluated as a BMP for all areas of the Pennichuck Water Works water supply watershed. A detailed evaluation of buffer zones is included in Section 7.0.

1.7 Buildout Analysis

A buildout scenario mimics the conditions that would exist if the towns developed to their highest potential in accordance with the zoning map. The buildout scenarios were modeled to determine the phosphorus impacts to the ponds should full development occur. This provides a "worst case" phosphorus loading to the ponds. The buildout analysis can be found in Section 8.0.

1.8 Recommendations

Based on the data collection and analysis efforts in this study, recommendations were developed to provide Pennichuck with information on additional needed protection in the watershed.

Steps in the Development of a Watershed Protection Plan
1. Develop objectives and a study plan.
2. Review and evaluate watershed characteristics.
3. Compare water quality to standards.
4. Identify water quality goals by developing hydrologic and nutrient budgets.
5. Identify pollution sources.
6. Evaluate existing protective measures.
7. Estimate impacts of future development.
8. Develop recommendations for meeting the objectives.

2.0 Watershed Characteristics

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The watershed land that surrounds and contributes water to the chain ponds that make up Pennichuck's water system lies in five towns including Nashua, Merrimack, Amherst, Milford, and Hollis. This watershed supplies the chain ponds with water through surface flow (runoff) and baseflow (groundwater). Figure 2-1 depicts a watershed simplified in graphic form.

Physical characteristics such as hydrology (how much water is contributed through rainfall and runoff), soil types and land uses in these town's play an important role in the water quality of the ponds. As the towns within the watershed develop, the amount of surface flow is expected to increase carrying with it the pollutants contained on these surfaces. Simultaneously, clean groundwater "baseflow" into the system of ponds and streams is likely to decrease as more and more areas are paved. Thus, both current and future land uses in each community have a significant effect on both the amount of surface flow and the amount of pollution reaching the ponds.

2.1 Water Supply

The primary Pennichuck Water Works water supply consists of about 351 acres of water in a series of chain ponds that include Supply Pond, Harris Pond, Bowers Pond, and Holts Pond. Stump Pond, Pennichuck Pond, and many smaller ponds also contribute water to Pennichuck's supply. The total pond acreage is just under 2% of the total watershed area. The sequence and sizes of these chain ponds is shown as Figure 2-2.

The supply is based on a series of natural ponds increased by the damming of Supply Pond at the Water Treatment Plant. Water is taken from Harris Pond 12 months of the year and supplemented with water from Supply Pond 6 months of the year. Water from the Merrimack River is taken into Bowers Pond, however, this study did not include the Merrimack River.

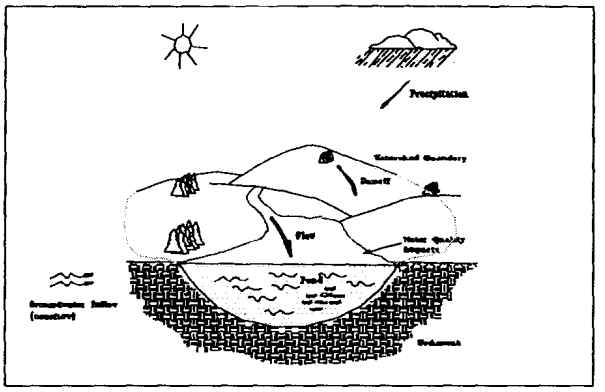


Figure 2-1. Simplified Watershed (adapted from A Watershed Approach to Urban Runoff: Handbook for Decisionmakers)

Table 2-1 summarizes pond characteristics for each of the chain ponds and for Pennichuck and Stump Ponds, including drainage area, water surface area and capacity (where known). Smaller ponds such as Dunklee Pond and Round Pond that are included in the total surface water figures above are not included here. There is no information on the storage capacity of Stump, Pennichuck, Holts and Supply Ponds.

For the purpose of this project, the total watershed tributary to Harris Pond and Supply Pond just upstream of the water treatment plant was subdivided into ten natural subwatersheds.

2.0 Watershed Characteristics

Table 2-1 Pond Characteristics			
Pond Name	Drainage Area (acres)	Pond Surface Area (acres)	Pond Storage (MG*)
Stump Pond	1,516	21	Unknown
Pennichuck Pond	4,295	57	Unknown
Holts Pond	14,171	23	Unknown
Bowers Pond	15,955	92	180 at full pond
Harris Pond	17,199	78 at spillover	340 at spillover
Supply Pond	17,598	16	Unknown

Table 2-2 Subwatershed Characteristics Pennichuck Water Works Watershed		
Subwatershed Name	Land Area (acres)	Water Surface Area (acres)
PBS - Pennichuck Brook to Supply Pond	1285	140
PBB - Pennichuck Brook to Bowers Pond	2390	94
PBH - Pennichuck Brook to Holt's Pond	1508	0
PBP– Pennichuck Brook to Pennichuck Pond	1978	89
WBE – Witches Brook East	1365	0
WBS – Witches Brook South	3193	0
WBN – Witches Brook North	1425	0
SPB – Stump Pond Brook	1516	21
BFB – Boire Field Brook	1006	0
MB1 - Muddy Brook	2317	7
Total Acreage	17,984	351

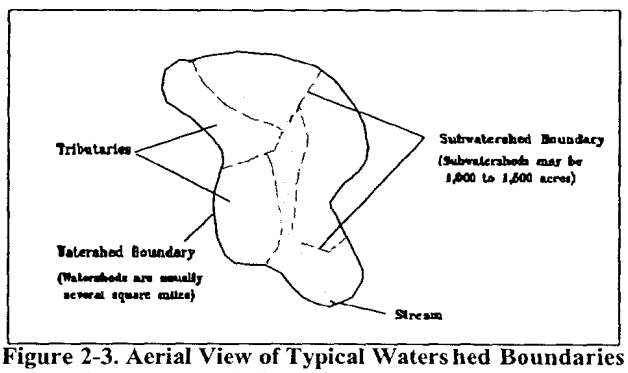


Figure 2-3. Aerial View of Typical Watershed Boundaries (adapted from *Watershed Protection Techniques*, V1, N4, 1995.*)*

A simplified graphic depiction of subwatersheds is shown in Figure 2-3. The purpose of dividing a watershed into subwatersheds is to compare characteristics such as drainage area, topography and water surface area of different portions of the watershed to allow later prioritization of recommendations. For example, various areas of the watershed can be compared for hydrologic (total water inputs) and certain pollutant inputs to determine which areas warrant the greatest levels of protection from future threats and which ones need correction of existing threats or insults.

The subwatershed delineations include four subdivisions of Pennichuck Brook, three subdivisions of Witches Brook, and separate subwatersheds for Stump Pond Brook, Boire Field Brook and Muddy Brook. Basic characteristics for each subwatershed are shown on Table 2-2. Figure 2-4 illustrates a basemap of the watershed including the breakdown of the subwatersheds.

2.2 Base Flow / Surface Flow

As watersheds become more developed, stormwater flows increase in intensity. This is because with development, impervious areas such as pavement, roofs, and streets slowly replace pervious agricultural lands and forests. Rainfall in impervious areas no longer penetrates and recharges groundwater, but instead runs overland into the nearest water course.

A 10-15% impervious cover can lead to noticeable changes in channel morphology. It also may affect biological populations in the streams,

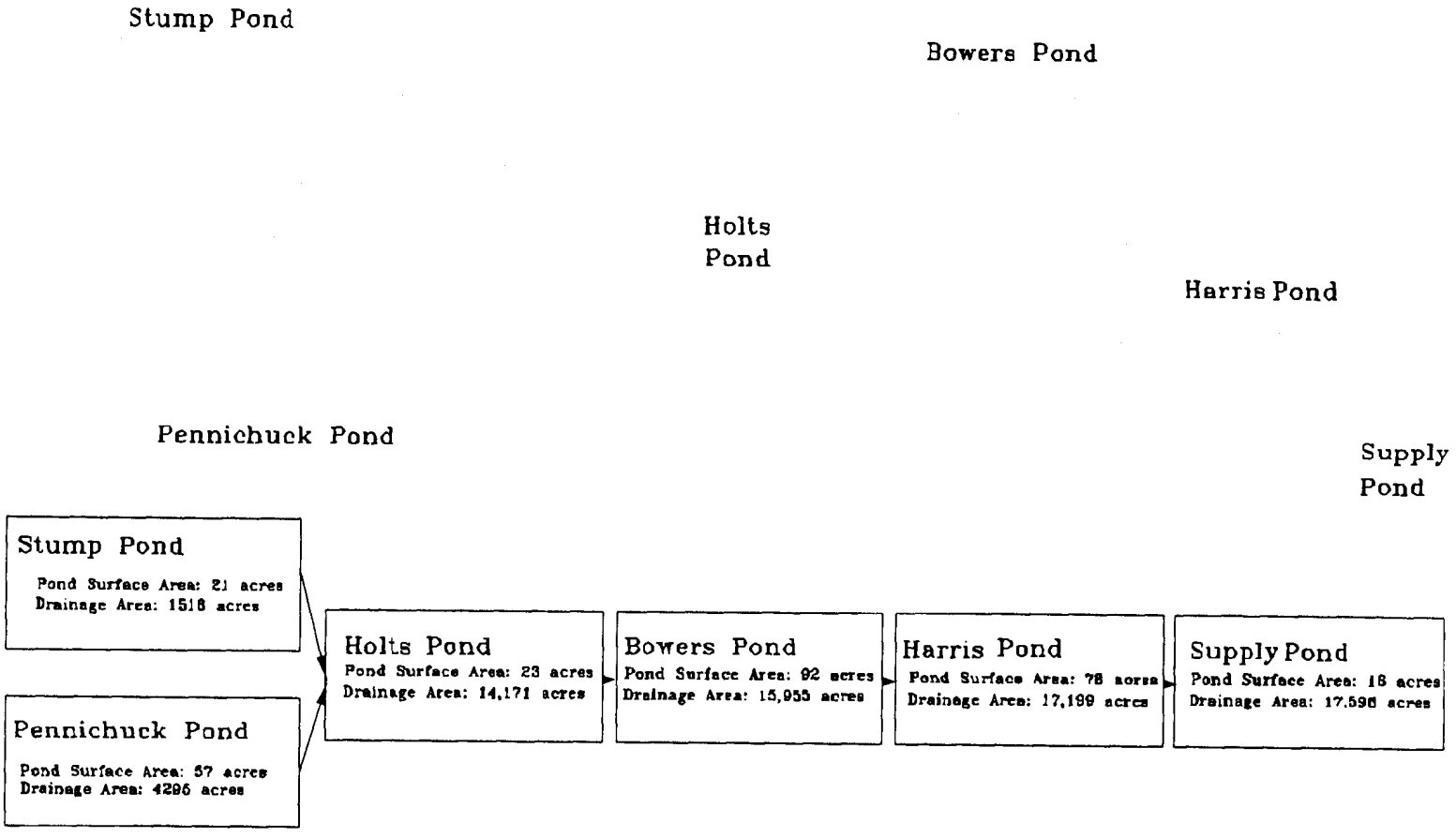


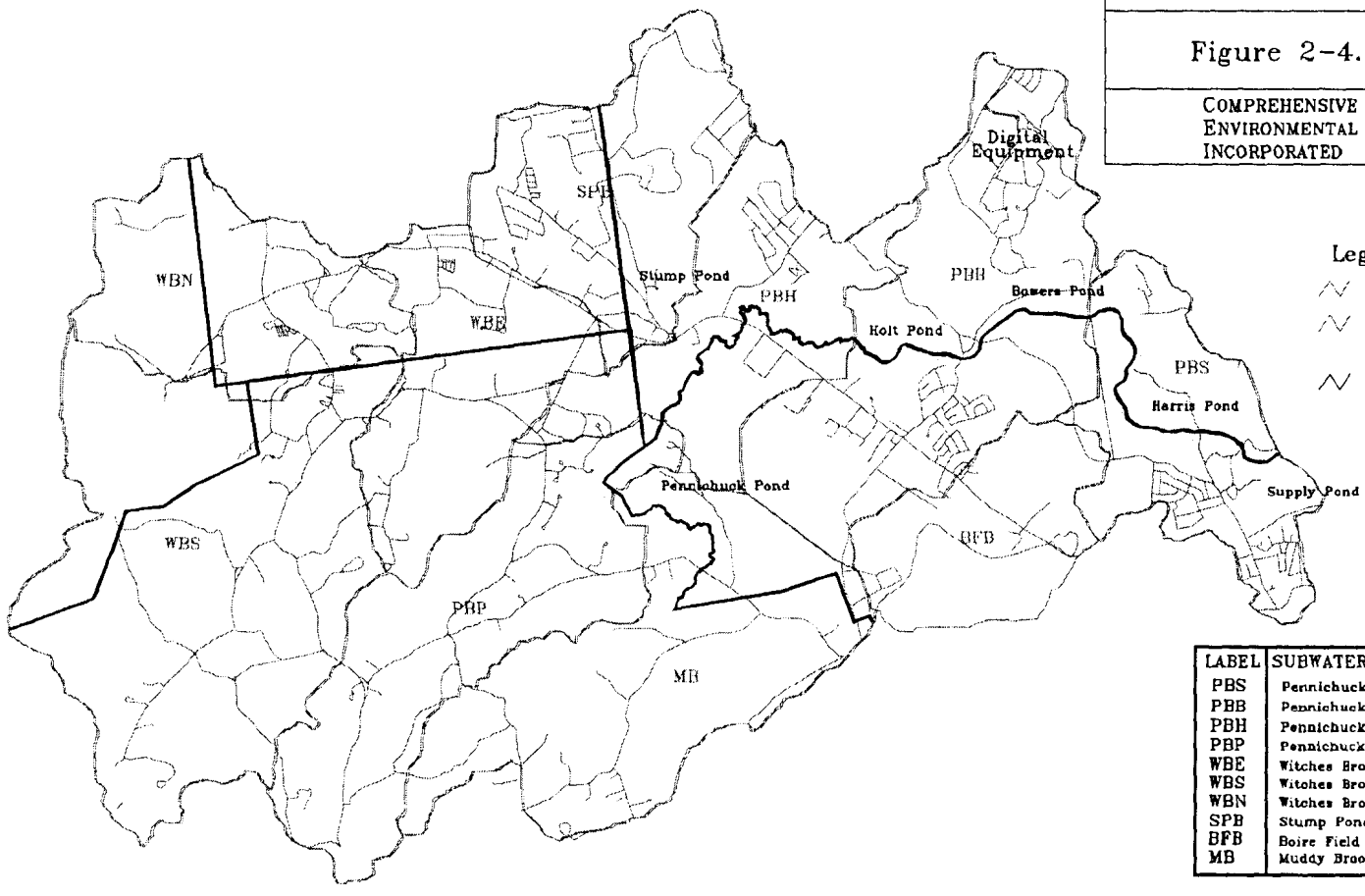
Figure 2-2. Chain Pond Schematic of Pennichuck Water Supply System

Pennichuck Water Works Watershed
Management Planning Study

Figure 2-4. Basemap

COMPREHENSIVE
ENVIRONMENTAL
INCORPORATED

Scale: 1" = 3600'



Legend

- Watershed Boundary
- Roads
- Water
- Town Lines

LABEL	SUBWATERSHED NAME
PBS	Pennichuck Brook to Supply Pond
PBB	Pennichuck Brook to Bowers Pond
PBH	Pennichuck Brook to Holt Pond
PBP	Pennichuck Brook to Pennichuck Pond
WBE	Witches Brook East
WBS	Witches Brook South
WBN	Witches Brook North
SPB	Stump Pond Brook
BFB	Boire Field Brook
MB	Muddy Brook

2.0 Watershed Characteristics

vegetative succession and water chemistry. (Booth and Reinelt, 1993). The volume of runoff is increased for all storms, and the frequency of occurrence of mid-bank full flow events also increases. This is significant in terms of the stream's capacity to transport sediment, increasing sediment transport. (Booth and Reinelt, 1993).

As more severe and more frequent floods occur, stream channels respond by increasing their cross-sectional area to accommodate higher flows. Stream banks may either widen or the stream bed may be down cut or both. This results in stream bank erosion and habitat degradation, as well as increased sediment transport to water bodies. (Schueler, 1994).

Imperviousness can easily be measured at all scales of development, according to Schueler (1994) as the percentage of area that is not "green".

Stream temperatures are also increased, and this is likely to affect the biological productivity of the stream, and may increase algae blooms and other eutrophication symptoms. Eutrophication is the process by which lakes and streams, because of pollutant inputs, are transformed from babbling brooks into odorous ponds of muck. This transformation goes hand-in-hand with the increase in storm flow and eventual decrease in groundwater base flows.

Groundwater base flow is the portion of the stream flow that is discharged from groundwater when groundwater levels are at a higher elevation than the base of the stream. Figure 2-5 shows a simplified diagram of groundwater base flow inputs to streams. These groundwater base flow inputs or discharges to streams are typically the component that allows streams to become perennial or year round streams as opposed to intermittent stormwater based streams that dry up without rain. Because of the cleansing effect of native soils, base flow inputs are typically very high quality, and even in contaminated areas, tend to be of higher quality than stormwater inputs.

Ponds and lakes with large base flow inputs, which typically also have small watersheds and thus small amounts of stormwater inflow, are typically much cleaner than ponds and lakes with large watersheds and low base flow inputs.

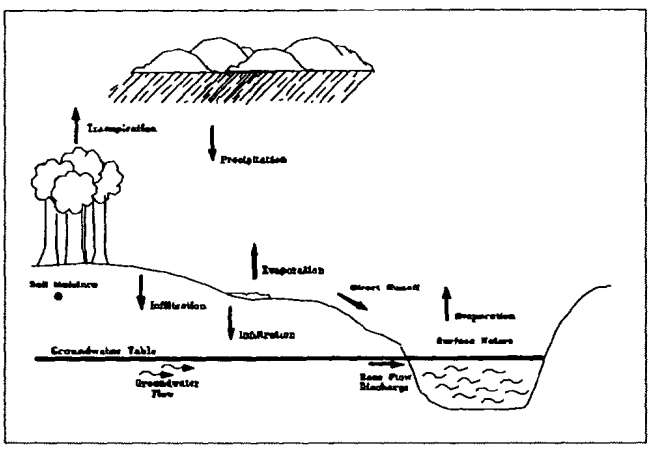


Figure 2-5. Simplified Groundwater Baseflow Diagram (adapted from *A Watershed Approach to Urban Runoff: Handbook for Decisionmakers*).

This highlights the importance of groundwater inflow into the Pennichuck Pond system of ponds and streams. However because of the increasing imperviousness of the watershed due to development, this

2.0 Watershed Characteristics

base flow appears to be decreasing. Studies in New York where sanitary sewers remove waste products from watersheds and transport them to ocean outfalls and where storm sewers transport water quickly to the nearest waterway, have shown significant reductions in base flow in streams. In Long Island, water supply to streams is 95% from groundwater in rural areas, 84% from groundwater in semi-urban areas (impervious cover, no sewers), and only 20% from groundwater in urbanized areas where there is impervious cover plus stormwater and sanitary sewers. (Dry Weather Flow in Urban Streams, Center for Watershed Protection, Volume 2, Number 1, Fall of 1995). The Pennichuck capacity to supply water from the Pennichuck Pond system has decreased as development has increased. Although there are no stream gauges available to chart the decline, base flow has decreased over time while stormwater impacts have heightened.

Table 2-3.
General Land Use Characteristics of Pennichuck Watershed Communities

Town	1996 Population	Land Use	Zoning	% of Watershed
Milford	12,000	Open space, residential	Residential	8%
Amherst	10,000	Residential, industrial	Residential, commercial industrial	11%
Merrimack	25,000	Residential, industrial, commercial, open space	Residential, industrial, commercial	19%
Hollis	6,420	Residential, agricultural, park, open space	Residential and Agriculture, Agriculture and Business, Recreational	40%
Nashua	81,000	Residential, commercial, industrial, open space	Residential, commercial, industrial	22%

2.3 Climate

The climate of the area is typically that of a North Temperate Zone with a mean annual temperature of about 46.4°F. The climate is humid and characterized by fairly uniform monthly precipitation, cold winters, and warm summers. The average annual precipitation for this region is about 43.07 inches. The growing season averages about 160-180 days and generally lasts from May to October. (Soil Survey of Hillsborough County, NH; 1981)

2.4 Land Uses

Five towns make up this watershed; Milford, Amherst, Merrimack, Hollis and Nashua. Each town has its own makeup of land uses determined by zoning laws. The general characteristics of each town are summarized in Table 2-3. A land use map is included as Figure 2-6.

2.5 Geology & Soils

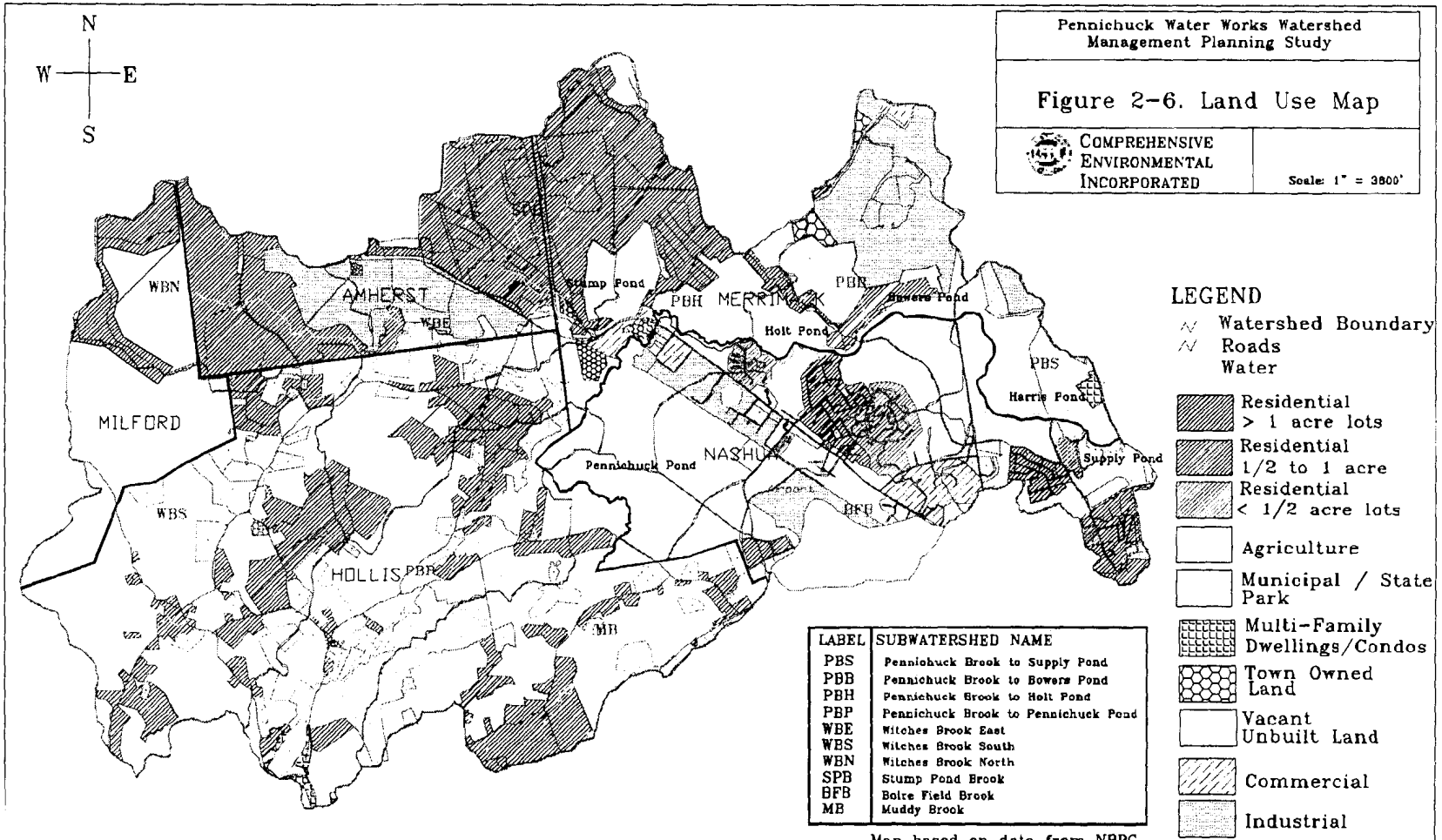
The soils and geology of the area play an important role in the determination of phosphorus loadings in the water supply. Phosphorus is one of the pollutants of concern because it can cause eutrophication of the ponds leading to algal blooms and taste and odor problems. Eutrophication also results in the filling in of ponds, which can reduce the detention the ponds normally provide. A more detailed discussion of the effects of phosphorus and its relationship to area soils can be found in Section 4.0.

Pennichuck Water Works Watershed Management Planning Study

Figure 2-6. Land Use Map

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

Scale: 1" = 3800'



LABEL	SUBWATERSHED NAME
PBS	Pennichuck Brook to Supply Pond
PBB	Pennichuck Brook to Bowers Pond
PBH	Pennichuck Brook to Holt Pond
PBP	Pennichuck Brook to Pennichuck Pond
WBE	Witches Brook East
WBS	Witches Brook South
WBN	Witches Brook North
SPB	Stump Pond Brook
BFB	Boire Field Brook
MB	Muddy Brook

Map based on data from NRPC.

2.0 Watershed Characteristics

Steep slopes, erosive soils and poorly drained soils also result in greater pollutant loads to the reservoir. Erosion allows sediment and attached pollutants to travel more quickly and easily to surface waters by providing channels for overland flow. Steep slopes increase the velocity of flow and do not allow significant time for infiltration. Poorly drained soils, such as clay, also keep runoff from infiltrating into the ground.

The soils of this area are underlain by metamorphic and igneous rocks. The metamorphic rocks are of the Littleton Formation, which is composed of gray mica schist, and of the Merrimac Group, which is composed of pinkish brown granulite and gray phyllite. Several areas of granite, quartz monzonite, and granodiorite have been forcibly injected up through the metamorphic rocks in this area. A detailed map of the soils in the watershed is included in Appendix A. The general soil types of the area include:

- Hinkley-Windsor: deep, nearly level to steep, excessively drained, gravelly and sandy soils on terraces;
- Canton-Chatfield: deep and moderately deep, nearly level to moderately steep, well drained, loamy soils on hilly uplands;
- Bernardston Variant-Pennichuck-Canton: deep and moderately deep, nearly level to sloping, well drained loamy soils on rolling uplands; and
- Urban Land-Windsor-Canton: urbanized areas and deep, nearly level to sloping, excessively drained, sandy and loamy soils on terraces and uplands.

2.6 Ponds and Channel Characteristics

Chain pond systems characteristically are cleanest in the most downstream pond. This is because upstream ponds collect pollutants and trap them. There they are subject to biological degradation, unless excessive. In the Pennichuck watersheds, there are a series of ponds that trap many of the urban pollutants that have entered over the years. However, it appears that some of these ponds are becoming full of sediment, resulting in washover of polluted sediments and reduction in capacity.

Table 2-4.
Summary of Effects of Watershed Characteristics on Water Quality

Physical Characteristics	Relationship to Water Quality
Subwatersheds/ Drainage Areas	Subwatershed size, soils, slope, and hydrologic features have significant effects on water quality both in natural and developed watersheds. Large drainage areas tend to have poorer water quality because of large stormwater inputs.
Climate	The amount of rainfall, seasonal variations in temperature, and rainfall patterns have a strong effect on both natural and urban watersheds.
Land Use	Watershed land use has a strong effect on water quality, with forests generally filtering out pollutants while urban uses create many pollutants and increase stormwater levels.
Stormwater/ Base Flow	Stormwater tends to be very poor quality from urban areas, while there is lesser stormwater impact in undeveloped areas.
Geology and Soils	The geology and soils may affect water quality because of the dissolved minerals that affect alkalinity, pH and other natural features, including water bodies natural ability to process pollutants.
Ponds/Channel Characteristics	Ponds located in watersheds trap pollutants, making downstream areas cleaner. Channel characteristics change over time as urbanization increases stormwater flows, widening and deepening while transporting more sediments

The loss of these ponds also affects overall watershed storage for water. This loss of water storage ultimately affects both the quantity and quality of water, and the ponds must be maintained in order to maintain good water quality in the water supply.

2.0 Watershed Characteristics

Channel characteristics are dependent on the area of the watershed. In more urban areas of the watershed, such as in the lower portions of Nashua, the channels have scoured and widened, although little survey data exists. It is likely that as the watershed urbanizes further, that the stream channels will become wider and deeper and transport more sediment.

3.0 Water Quality

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3.2 Regulatory Background --3-1
3.3 Watershed Water Quality 3-3

3.1 Introduction

Both raw and finished water quality are important in drinking water sources. Raw water is water before the treatment process begins. Finished water is the water that leaves the water treatment plant and ends up at the customer's tap. It is important to maintain good water quality at both these stages since good raw water quality can mean lower treatment costs and reduced taste and odor problems. Good finished water quality is essential for public health.

An overview of Federal and State regulations on water quality is included in this section. This is compared with Pennichuck's historical raw and finished water quality data and with baseline sampling conducted by CEI for this project. Analysis of this data indicates problem areas and potential pollution sources as discussed in Section 3.3 and later in Section 5.0.

3.2 Regulatory Background

Drinking water regulations are based on the Federal Safe Drinking Water Act and amendments of 1986 and 1996. The Act requires that each state adopt standards that are no less stringent than the federal regulations.

Surface water quality in the United States is protected under the Clean Water Act. These federal standards have been adopted by the State of New Hampshire in the form of Surface Water Standards designed to protect fisheries and recreational water resources. These standards apply to all waters in the Pennichuck watershed, although they are geared more to protect aquatic habitat, fisheries and recreation than drinking water quality. These are also described below.

Drinking Water Regulations

Both the Federal Safe Drinking Water Act and New Hampshire Drinking Water Quality Standards identify maximum contaminant levels (MCLs) that finished water must meet. Below is a brief discussion of each.

Safe Drinking Water Act

The Federal Safe Drinking Water Act (SDWA), enacted in 1974, was amended in 1986 and 1996. SDWA directs the Environmental Protection Agency (EPA) to develop primary drinking water regulations that incorporate maximum contaminant levels (MCLs), maximum contaminant level goals (MCLGs), and treatment techniques for dozens of contaminants to protect public health.

Good raw water quality can mean lower treatment costs and reduced taste and odor problems.

Some contaminants' health effects are long-term, such as cancer or liver damage. Exposure to these contaminants over a long period of time will increase the consumer's chance of contracting such diseases. Consequently, the MCLs for contaminants that have long-term (chronic) health effects are based on exposure to contaminants over a lifetime. Regulations are then set with the assumption that drinking water sources will be consumed regularly over an average lifespan of 70 years.

3.0 Water Quality

Other contaminants, such as microbiologicals, have "acute" health effects (those that occur immediately or shortly after consumption). Only short-term exposure to these contaminants is needed before the consumer becomes ill but there is little or no lifetime cancer risk. These contaminants are also regulated to assure public health safety.

New Hampshire Department of Environmental Services (NHDES) Drinking Water Quality Standards

The New Hampshire Drinking Water Regulations (Env-Ws 310) mirror the SDWA regulations in a series of Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs). They address the quality of water after treatment (finished water) before it reaches the consumer. Table 3-1 shows the MCLs and MCLGs of some common contaminants compared to Pennichuck's finished water quality.

The number of regulated drinking water contaminants has increased from less than 20 to more than 100 in the last 10 years.

Surface Water Quality Regulations

NHDES also has surface water quality regulations (Env-Ws 432) that reflect the federal Clean Water Act requirements. The purpose of these rules is to establish standards based on the designated use of the surface water. The rules provide for the protection of aquatic organisms and wildlife and provide for recreational activities within the state's waters. The Surface Water Quality Regulations also apply to all point (piped) and non-point (stormwater) source discharges of pollutants (discussed further in Section 5).

State surface waters are broken into three classes (A, B, and C). The classification of the water body is dependent on the most sensitive use to be protected: Class A is the most protected and is generally for drinking water supplies; Class B waters are generally for recreational use. Class C waters consist of all surface waters not classified as Class A or B and are the least protected. In addition, each surface water body, regardless of classification, must meet the following water quality criteria:

- The presence of pollutants in receiving waters is not the basis for further introduction of pollutants. The failure of waters to meet certain criteria due to natural causes does not necessitate the modification of the assigned water use classification.
- All waters shall be free from pollutants in concentrations or combinations that settle to form harmful deposits; float; produce odor, color, taste, or turbidity that is not naturally occurring; result in the dominance of nuisance species; or prevent recreational activities.
- The level of radioactive materials shall not be in concentrations or combinations that would be harmful to human, animal, or aquatic life; would result in radionuclides in aquatic life exceeding recommended limits for consumption by humans; or would exceed EPA's Drinking Water Regulations.
- Tainting substances shall not be present in combinations that individually or in combination

3.0 Water Quality

Table 3-1. NHDES Drinking Water Standards Compared to Pennichuck Finished Water

	MCLG	MCL	Pennichuck Finished Water[1]	Notes
Total Coliform	0 mg/l	Absence	Absence	For systems collecting at least 40 samples per month, no more than 5% can be total coliform positive. For systems collecting less than 40 samples per month, no more than one sample can be coliform positive.
Fecal Coliform	0 mg\l	Absence	Absence	Any positive sample must be reported.
Giardia Lamblia	0 mg/l	0 mg/l	~	Microbiological contaminants only monitored after disease outbreaks.
Viruses	0 mg/l	0 mg/l	~	
Legionella	0 mg/l	0 mg/l	~	
Cryptosporidium	0 mg/l	0 mg/l	~	
Heterotrophic Plate Counts	0 mg/l	0 mg/l	<1	
Turbidity	1 NTU	1 NTU	0.3 NTU / 0.05 before lime	Turbidity is measured at representative entry points. Five NTU may be permitted if higher turbidity does not result in interference with disinfection or microbiological determinations.
Adjusted Gross Alpha	0 piC/l		~	Alpha radionuclides, not usually a concern in surface water supplies.
Gross Alpha	0 piC/l	15 piC/l	~	
Radium 226 + 228	0 piC/l	5 piC/l	~	
Radon	0 piC/l		~	
Uranium	0 piC/l		~	
Beta Particles and Photon Radioactivity		4 mrem/year	~	This is an average annual concentration from man made radionuclides, not usually a problem in surface water supplies.
Gross Beta	0 piC/l		~	Beta radionuclides are not usually a problem in surface water supplies.
Radium 228	0 piC/l		~	
Tritium	0 piC/l	20,000 piC/l	~	
Strontium 90	0 piC/l	8 piC/l	~	
Arsenic		0.05 mg/l	<0.005	Inorganic metals contaminants
Asbestos	7 million fibers/l	7 million fibers/l	~	
Barium	2.0 mg/l	2.0 mg/l	<0.002	
Cadmium	0.005 mg/l	0.005 mg/l	<0.0025	
Chromium	0.1 mg/l	0.1 mg/l	<0.05	
Copper	1.3 mg/l	1.3 ppb	<0.10	The MCL indicated here is actually the action level. When copper concentrations exceed 1.3 ppb in more than 90% of their samples, action must be taken for treatment. Copper usually comes from homeowners plumbing.
Fluoride	4.0 mg/l	4.0 mg/l	<1.0	Limitation for treatment level.
Lead	0 mg/l	0.15 mg/l	<0.005	When lead concentrations exceed 15 ppb in more than 90% of their samples, action must be taken for treatment. Lead problems usually come from home plumbing.
Mercury	0.002 mg/l	0.002 mg/l	<0.001	Inorganic contaminant

3.0 Water Quality

Table 3-1. NHDES Drinking Water Standards Compared to Pennichuck Finished Water

	MCLG	MCL	Pennichuck Finished Water[1]	Notes
Nitrate	10 mg/l	10 mg/l	0.66	The total for nitrate and nitrite cannot exceed 10 mg/l, which is not usually a problem in surface waters.
Nitrite	1.0 mg/l	1.0 mg/l	<0.005	
Selenium	0.05 mg/l	0.05 mg/l	<0.025	Inorganic contaminants.
Antimony	0.006 mg/l	0.006 mg/l	<0.003	
Beryllium	0	0.004 mg/l	<0.002	
Cyanide	0.2 mg/l	0.2 mg/l	<0.001	
Nickel	0.1 mg/l	0.1 mg/l	<0.05	
Thallium	0.0005 mg/l	0.002 mg/l	<0.001	
Benzene	0 mg/l	0.005 mg/l	BDL	Organic contaminants, mostly volatile and not usually a problem in surface waters.
Carbon tetrachloride	0 mg/l	0.005 mg/l	BDL	
1,2 dichloroethane	0 mg/l	0.005 mg/l	BDL	
Trichloroethylene	0 mg/l	0.005 mg/l	BDL	
Para dichlorobenzene	0.075 mg/l	0.075 mg/l	BDL	
1,1 dichloroethylene	0.007 mg/l	0.007 mg/l	BDL	
1,1,1 trichloroethane	0.2 mg/l	0.2 mg/l	BDL	
Vinyl chloride	0 mg/l	0.002 mg/l	BDL	
Cis 1,2 dichloroethylene	0.07 mg/l	0.07 mg/l	BDL	
1,2 dichloropropane	0 mg/l	0.005 mg/l	BDL	
Ethylbenzene	0.7 mg/l	0.7 mg/l	BDL	
Monochlorobenzene	0.1 mg/l	0.1 mg/l	BDL	
0 Dichlorobenzene	0.6 mg/l	0.6 mg/l	BDL	
Styrene	0.1 mg/l	0.1 mg/l	BDL	
Tetrachloroethylene	0 mg/l	0.005 mg/l	BDL	
Toluene	1 mg/l	1 mg/l	BDL	
Trans 1,2 dichloroethylene	0.1 mg/l	0.1 mg/l	BDL	
Xylene, Total	10 mg/l	10 mg/l	BDL	
Dichloromethane	0 mg/l	0.005 mg/l	BDL	
1,2,4 Trichlorobenzene	0.009 mg/l	0.07 mg/l	BDL	
1,1,2 Trichloroethane	0.003 mg/l	0.005 mg/l	BDL	
Alachlor	0 mg/l	0.002 mg/l	BDL	Synthetic organic contaminants (mostly pesticides). Usually a greater problem in heavy agricultural areas of the midwest.
Aldicarb	0.001 mg/l	0.003 mg/l	BDL	
Aldicarb sulfoxide	0.001 mg/l	0.004 mg/l	BDL	
Aldicarb sulfone	0.001 mg/l	0.002 mg/l	BDL	
Atrazine	0.003 mg/l	0.003 mg/l	BDL	
Carbofuran	0.04 mg/l	0.04 mg/l	BDL	
Chlordane	0 mg/l	0.002 mg/l	BDL	
Dibromochloropropane	0 mg/l	0.0002 mg/l	BDL	
Ethylene Dibromide	0 mg/l	0.00005 mg/l	BDL	
Heptachlor	0 mg/l	0.0004 mg/l	BDL	
Heptachlor Epoxide	0 mg/l	0.0002 mg/l	BDL	
Lindane	0.0002 mg/l	0.0002 mg/l	BDL	
Methoxychlor	0.004 mg/l	0.04 mg/l	BDL	
PCBs	0 mg/l	0.0005 mg/l	BDL	
Pentacholophenol	0 mg/l	0.001 mg/l	BDL	
Toxaphene	0 mg/l	0.003 mg/l	BDL	

3.0 Water Quality

Table 3-1. NHDES Drinking Water Standards Compared to Pennichuck Finished Water

	MCLG	MCL	Pennichuck Finished Water[1]	Notes
2,4,5 TP	0.05 mg/l	0.05 mg/l	BDL	Synthetic organic contaminants (mostly pesticides). Usually a greater problem in heavy agricultural areas of the midwest.
2,4 D	0.07 mg/l	0.07 mg/l	BDL	
Dalapon	0.2 mg/l	0.2 mg/l	BDL	
Di(ethylhexyl)adipate	0 mg/l	0.4 mg/l	BDL	
Di (ethylhexyl) phthalate	0 mg/l	0.006 mg/l	BDL	
Butylbenzylphathalate	0.04 mg/l	0.007 mg/l	BDL	
Dinoseb	0.007 mg/l	0.007 mg/l	BDL	
Diquat	0.02 mg/l	0.02 mg/l	BDL	Synthetic organic contaminants (mostly pesticides). Usually a greater problem in heavy agricultural areas of the midwest.
Endothall	0.1 mg/l	0.1 mg/l	BDL	
Endin	0.002 mg/l	0.002 mg/l	BDL	
Glyphosate	0.7 mg/l	0.7 mg/l	BDL	
Hexachlorobenzene	0.05 mg/l	0.001 mg/l	BDL	
Hexachlorocyclopentadiene	0.05 mg/l	0.05 mg/l	BDL	
Oxamyl	0.2 mg/l	0.2 mg/l	BDL	
PAH	0 mg/l	0.00002 mg/l	BDL	
Picloram	0.5 mg/l	0.5 mg/l	BDL	
Simazine	0.001 mg/l	0.004 mg/l	BDL	
2,3,7,8 TCDD Dioxin	0 mg/l	.00000003 mg/l	~	
Bromodichloromethane			3	Trihalomethanes (THMs), monitoring is required in systems that serve 10,000 or more.
Dibromochloromethane			<1	
Tribromomethane		Total of 100	<0.1	
Trichloromethane		ppb	20	
Chloroform	0 mg/l		0.02	Maximum Disinfection Byproducts.
Bromodichloromethane	0 mg/l		0.003	
Bromoform	0 mg/l		<0.0001	
Bromate	0 mg/l		~	
Dichloroacetic Acid	0 mg/l		0.011	
Trichloroacetic Acid	0.1 mg/l		0.009	
Chloral Hydrate	0.005 mg/l		~	
Chlorite	0.3 mg/l		~	
Dibrochloromomethane	0.06 mg/l		~	
Chlorine	4 mg/l		0.85	Chlorine Disinfectant Residuals.
Chloramines	4 mg/l		~	
Chlorine Dioxide	0.8 mg/l		~	
Acrylamide	0 mg/l	0.05% dose at 1 mg/l	~	Limitations for Treatment Chemicals.
Epichlorohydrin	0 mg/l	0.01% dose at 20 mg/l	~	

~ Not sampled — mg/l - milligrams per liter

BDL - Below Detection Limit — ppb - parts per billion

1.) Pennichuck Samples represent an average of the finished water at Harris Pond taken since 1991.

produce undesirable flavors in aquatic organisms.

- Toxic pollutants, unless naturally occurring, shall be in concentrations that will not injure plants, animals, humans or aquatic life; persist in the environment; or accumulate to harmful levels in aquatic organisms.

The chain ponds that consist of Pennichuck Water Works' supply are classified as Class A water bodies and must meet the criteria provided in Table 3-2. Table 3-2 is a comparison of Pennichuck's current water quality and these criteria.

3.3 Watershed Water Quality

The most useful parameters for gauging watershed health are not all regulated. Table 3-3 describes some of the most useful watershed management parameters. Data on these parameters (some regulated, some not) is discussed below.

Pennichuck Water Works has conducted historical sampling of several parameters in the watershed. Historical sampling data and a map of their locations is included in Appendix B.

Baseline sampling was conducted during the months of July, August, and December. The results of this sampling are included in Appendix C.

Limited additional sampling was conducted for this study to supplement existing data for nutrients and pathogens, two of the most detrimental contaminants to a surface water supply. Sampling parameters included a field analysis of pH, conductivity, turbidity, dissolved oxygen (DO), temperature and flow rate. Laboratory analysis was conducted for fecal coliform, ammonia, Total Kjedhal Nitrogen (TKN), total phosphorus, and nitrate.

Based on the hydrologic budget and breakdown of subwatersheds, 13 key locations in the watershed were identified for sampling. Sampling was done at four dams (SW1, SW2, SW4, and SW6) and nine tributaries (SW3, SW5 and SW7-SW13). Locations of these sampling points can be seen in Figure 3-1. The relationship of these locations to historically sampled locations is described in the appendix.

Some of the most useful parameters for gauging watershed health are not regulated.

Fecal Coliform

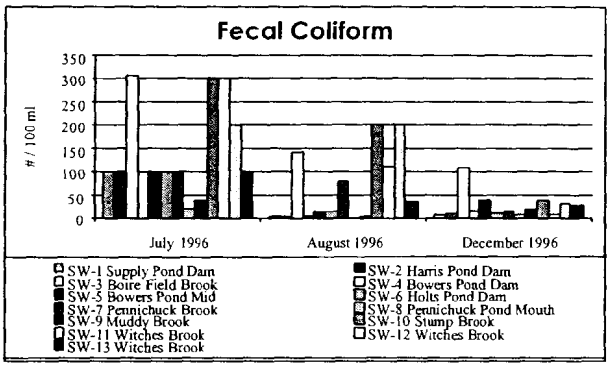
Fecal coliform is typically used as indicators of bacteriologic pollution in water. These bacteria may indicate animal and/or human fecal wastes that can be identified and potentially eliminated or minimized to improve water quality. However, there are many limitations in the accuracy of these "indicators" because some bacteria in the coliform group are not of fecal origin. Thus, the test can give misleading results, particularly when counts are fairly low (<100 per ml) in untreated surface water.

Pets in densely populated areas, livestock and sewage leaks near surface waters are typical sources of fecal coliform. Fecal coliform is also used to indicate whether other pathogens may be present; pathogens that may include viruses, bacteria, and protozoans like *Giardia* and

3.0 Water Quality

Cryptosporidium. Some of these pathogens are difficult to treat, particularly the protozoans, and may lead to severe cases of diarrhea or dehydration (which can be fatal to the immuno-compromised). These pathogens are not typically tested for because reliable methods are not generally available.

Figure 3-2. Results of 1996 Fecal Coliform Analysis



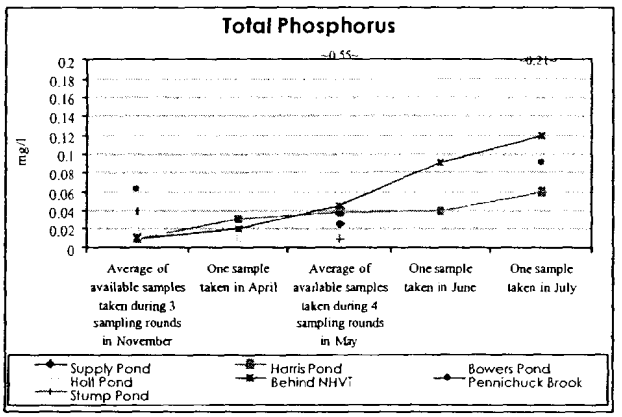


Figure 3-3. Historical Phosphorus Levels

Some researchers are currently close to completing work in better "indicator" organisms that can be used as an adjunct to fecal coliform counts. Meanwhile, fecal coliform analysis supplemented with analysis for *Escherischia coli (E. coli)* are the most reliable indicators available for identifying fecal wastes.

Fecal coliform data from January 1991 to July 1996 indicates specific areas of the watershed with frequently high fecal counts (>100 per ml), with the highest counts generally occurring during the summer months.

Review of the six years of data suggests an increase in fecal counts in most locations over time.

High fecal coliform counts were identified at Boire Field Brook (SW3), Stump Pond (SW10), and Witches Brook (SW11 and SW12), with counts remaining above 100 from Boire Field Brook during the winter months when lower counts are expected. Possible sources for these high counts are sewer breaks, illegal waste discharges or pets in densely populated areas. Figure 3-2 shows the results of fecal coliform sampling.

Phosphorus

Phosphorus is considered a limiting nutrient for plant life to grow. However, if excessive phosphorus can cause ponds to fill in and become eutrophic with algae blooms that lead to taste and odor problems in water supplies. Generally, phosphorus levels under 0.02 – 0.03 mg/l will not lead to eutrophication or algae blooms. Limited phosphorus data taken since November 1995 shows values as high as 0.21 mg/l. As can be seen from Figure 3-3, the highest phosphorus levels occur in Bowers Pond, Pennichuck Brook and the Merrimack River, with significant

3.0 Water Quality

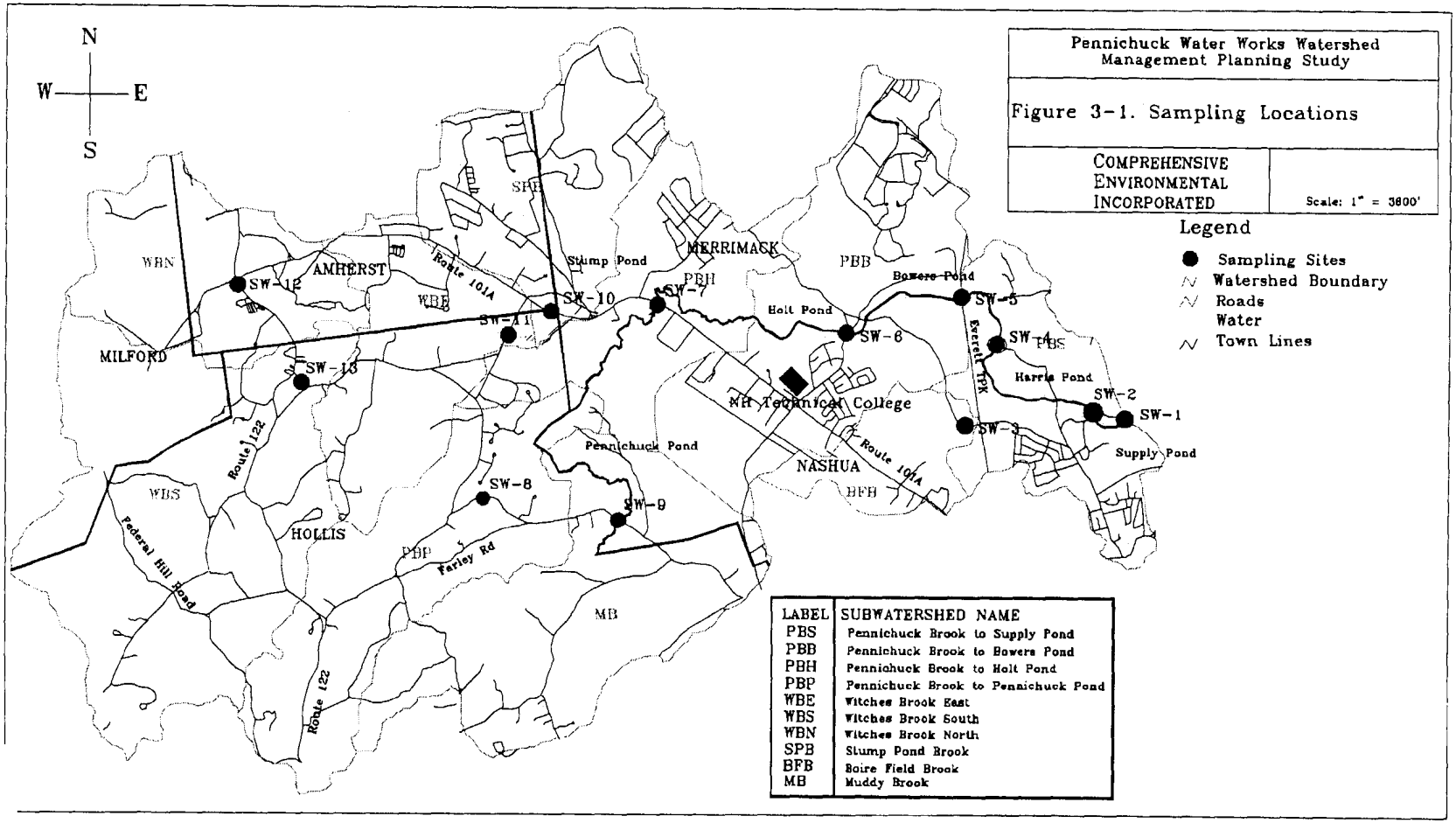
Table 3-2. NHDES Class A Surface Water Quality Standards Compared to Pennichuck Raw Water

Parameter	Standard	Values Found in PWW System
Dissolved Oxygen	DO = 75% saturation for 16 hours/day, not less than 6 mg/l unless naturally occurring.	Typical DO values range from 8-10 mg/l in cold, well-aerated streams and from 3-5 mg/l in warm streams. DO values during CEI's sampling rounds ranged between 2.8 mg/l and 11.9 mg/l. Low values may suggest oxygen depletion and potential for fishkills. High values may suggest excessive algae.
Benthic Deposits	No benthic deposits unless naturally occurring.	NS*
Coliform	No coliform in quantities that will impair water uses.	Typically, for drinking water, fecal values should be absent. High fecal counts occurred at Boire Field Brook, Stump Pond, and Witches Spring Brook.
Oil and Grease	No oil or grease, unless naturally occurring.	NS*
Color	No color unless naturally occurring	Color values in 1996 ranged from < 1 color unit to 73 color units. Color does not pose a health threat, however it may be an aesthetic problem. Most colors result from decaying plants and may not represent a pollution issue.
Turbidity	No turbidity unless naturally occurring.	Turbidity indicates the amount of total suspended solids in water. High turbidity may interfere with treatment. Harris Pond, Bowers Pond, and Boire Field Brook showed high turbidity values at times.
Slicks, Odors, and Surface Floating Solids	No slicks, odors, or surface floating solids.	None noted.
Temperature	No artificial rise in temperature.	None noted.
Phosphorus	No phosphorus unless naturally occurring.	Phosphorus levels range from 0.02 to 0.21 mg/l in the chain ponds. Desired levels are usually around 0.02 to 0.03 mg/l in a stream system like this. High levels may lead to eutrophication of the ponds. Modeling indicated high values may occur at PBB and SB.
Gross Beta Radioactivity	< 1000 picocuries per liter	NS*
Stronium-90	< 10 picocuries per liter	NS*
Radium-226	< 3 picocuries per liter	NS*
pH	As naturally occurs.	Over-productive reservoirs may see fluctuations in pH as vegetation and algae photosynthesize (high pH) and respire (low pH). pH ranged from 4.0 to 10.5 at various locations in the watershed. High or low pH may also indicate industrial discharges.
Toxic Substances	Ambient water concentration should be zero, however, as this is not attainable, a risk factor of 10-6 is used.	NS*
Dioxin (2,3,7,8 - TCDD)	< 0.001 mg/l	NS*
Mixing Zones	Not allowed in Class A waters.	NS*
Antidegradation	No discharge of sewage or wastes into Class A waters. Degradation of water quality is prohibited.	No point discharges noted.

NS* These parameters are not typically sampled (or are not sampling parameters) unless a specific indisutrial discharge were suspected.

3.0 Water Quality

Table 3-3. Useful Watershed Water Quality Parameters and Their Meaning	
Parameter	**Importance to Surface Water Supply**
pH	A measure of the concentration of ions (H+) in water. Over-productive reservoirs may see fluctuations in pH as vegetation and algae photosynthesize (high pH) and respire (low pH). Excessively high (≥9) or low (≤4) pH may also suggest industrial wastes.
Temperature	Typically, in winter months, temperatures range from 0-3° C, in summer months, temperatures range from 23-27° C. Variations in temperature may be an indication of wastewater discharges. Stream temperatures that are low in the summer can also suggest a groundwater baseflow influence, usually a positive factor. Urban development tends to increase overall stream temperatures by removing shade trees and by long-term loss of baseflow.
Turbidity	Turbidity is a measure of the total suspended solids in water and is used to assess the clarity of water. Erosion and algal blooms from construction projects are common causes of high turbidity in ponds and streams. Construction erosion is particularly problematic because many pollutants adsorb to soil particles and are carried along. It also causes sediment build up in ponds.
Conductivity	Conductivity is a measure of the ability of water to conduct electricity, also a measure of the total dissolved solids in water. Higher than background levels may suggest sewage or other pollutant inputs.
Color	Color results from dissolved materials in water. Most colors in natural waters result from tannins extracted from decaying plants.
Alkalinity	A measure of the water's ability to neutralize acids or buffering capacity. Indicates the water's ability to resist pH change. pH changes may strongly affect other parameters. For example, low pH may cause release of heavy metals from sediments.
Dissolved Oxygen (DO)	The presence of DO is important to maintain aquatic life in waters. Typical DO values range from 8-10 mg/l in cold, well-aerated streams, in warm streams, 3-5 mg/l. Very high summer DO may suggest algal blooms. The algal bloom may add to oxygen levels in the daytime, but oxygen demand from decomposing sediment materials causes associated nighttime crashes. This condition can lead to fish kills and other undesirable water quality effects such as the release of manganese and phosphorus from sediments.
Fecal Coliform	The presence of fecal coliform in high numbers may be an indication of feces from animal or human waste.
Escherischia coli (E. coli)	This analysis may be used to confirm whether a suspected fecal coliform problem is really from fecal wastes. It is an enteric bacteria from warm blooded animals or humans.
Coliphages	This test is now under development and will help differentiate between human and animal wastes. It is not yet readily available commercially.
Phosphorus	Phosphorus is an essential element for the growth of algae and other aquatic plant life. In high concentrations that often result from development, it leads to eutrophication. Eutrophication is the process where excessive algae and aquatic plant growth may choke waterways and may cause fish kills and unpleasant odors.
Total Kjeldahl Nitrogen (TKN)	TKN comprises nitrogen in all its forms, organic, ammonia, and nitrate. High TKN values may indicate a nitrogen source. However, ammonia nitrogen and/or nitrate nitrogen may also be sampled to help identify a specific source.
Ammonia	Ammonia occurs in anaerobic conditions and is readily used by aquatic vegetation. Ammonia is a naturally-occurring form of nitrogen, but there are also several manmade sources. Common sources of ammonia are urea and anhydrous ammonia (fertilizer). Ammonia is found in the highest concentrations below wastewater discharges. High levels of this may indicate a nearby pollution source (waste discharge or fertilizer near a stream).
Nitrate	Nitrate is a soluble form of nitrogen. Ammonia is converted to nitrate by bacteria and plants and occurs in almost all natural waters. Levels of nitrate seldom exceed 3 or 4 mg/l by natural occurrence in New England. High nitrate levels may indicate contamination from fertilizers, municipal wastewaters, feedlots, or septic systems.


N
W
E
S
Pennichuck Water Works Watershed
Management Planning Study
Figure 3-1. Sampling Locations
COMPREHENSIVE
ENVIRONMENTAL
INCORPORATED
Scale: 1" = 3600'
Legend
Sampling Sites
Watershed Boundary
Roads
Water
Town Lines
WBN
AMHERST
MILFORD
WBE
SPB
Route 101A
Stump Pond
MERRIMACK
PBH
PBB
Bowers Pond
Holt Pond
Everett Tpk
Harris Pond
PBS
NH Technical College
NASHUA
Pennichuck Pond
Supply Pond
WBS
HOLLIS
PBP
Route 122
Federal Hill Road
Farley Rd
BFB
MB
SW-1
SW-2
SW-3
SW-4
SW-5
SW-6
SW-7
SW-8
SW-9
SW-10
SW-11
SW-12
SW-13
LABEL | SUBWATERSHED NAME
PBS | Pennichuck Brook to Supply Pond
PBB | Pennichuck Brook to Bowers Pond
PBH | Pennichuck Brook to Holt Pond
PBP | Pennichuck Brook to Pennichuck Pond
WBE | Witches Brook East
WBS | Witches Brook South
WBN | Witches Brook North
SPB | Stump Pond Brook
BFB | Boire Field Brook
MB | Muddy Brook

levels in Bowers Pond after heavy rainfall (5/1/96 and 5/2/96), indicating the impacts stormwater has in this area.

Since phosphorus is the limiting nutrient for freshwater aquatic plants (they typically run out of this before other nutrients), most watershed programs are aimed at reducing its levels as the most effective method of preserving the watershed. Further, in order to limit this nutrient, its sources must be known. Since this would take years of intensive sampling to identify through direct analysis, theoretical models are often used to shorten the process of identifying the best targets for prevention and remediation efforts. Since most of these models are based on land use, they can also provide a more accurate long-term projection of phosphorus loads. They can also be used, as they were here, to predict future water quality based on current zoning and the "buildout" of communities under this zoning.

The theoretical model used for the Pennichuck system helped to determine phosphorus loads to the chain ponds in Pennichuck's system. This model highlighted areas of greater phosphorus load and helped pinpoint sources of pollution. Section 4 discusses the phosphorus loading model in detail. Common sources of phosphorus are urban development, gravel operations, agriculture and logging.

The phosphorus model is best used to compare various areas of the watershed to one another to identify potential problem areas. It does not take the place of actual data, rather it supplements data collection efforts. A long-term monitoring plan is also recommended to more accurately assess the health of the ponds and surrounding watersheds. This is discussed further in the recommendations section.

Nitrate

Nitrate occurs in most natural waters, however, too much nitrate in surface waters has the same result as phosphorus algae blooms and excess plant growth that may choke waterways. Boire Field Brook, Stump Pond and Witches Brook show the highest nitrate levels. Although the quantities are not large enough to present a compliance problem, they may lead to the eutrophication of the ponds. These subwatersheds are the most developed areas in the watershed. Some common sources of nitrate are contamination from fertilizers, municipal or livestock wastewater, and leaking septic systems.

In summary, while Pennichuck easily meets all drinking water standards, raw water bacteria and nutrients are troublesome and may lead to increased treatment costs in the future. Even more critical is the increasing inability to "store" water in the watershed. Urbanization will continue to reduce the available water supply.

4.0 Hydrology and Nutrient Modeling

Section Contents

4.1 Hydrology ---------- 4-2
4.2 Nutrient Analysis-------- -4-3

A hydrologic budget of the watershed, using precipitation and gaging station flow correlations, was developed to identify the total runoff (surface and base flow) entering the chain pond system from the individual subwatersheds. This is critical because it allows the subwatersheds to be prioritized based on the amount of water contributed to the chain pond system from each, with larger contributors being more critical to the system. For example, a subwatershed contributing 28% of the total flow into the ponds is more critical than a subwatershed contributing only two percent of the total flow because its impacts on the final water quality of the ponds are greater.

The precipitation data used in the hydrologic analysis was then used for further modeling calculations of pollutant loadings of the critical parameter phosphorus. Phosphorus is critical because it is the limiting nutrient in a fresh water system, and it is important to reduce its loading into the ponds to minimize algal blooms and associated taste and odor problems. It is also critical to reduce phosphorus because excess amounts lead to eutrophication, the rapid filling-in of water bodies with dead plant materials and the associated loss of capacity (and other problems).

The phosphorus modeling gives a picture of the anticipated overall quality of water in each of the chain ponds and the major contributions to that water quality from various portions of the watershed. It allows for each of the subwatersheds to be prioritized based on the phosphorus loadings each contributes so that specific subwatersheds may be identified for preventive and remedial efforts. For example, a subwatershed that contributes 18% of the total phosphorus loadings is more critical to the system than a subwatershed that contributes only five percent of the total phosphorus loadings, and consequently should receive more effort for preventive and remedial efforts.

In summary, the hydrologic and nutrient budgets allow for later prioritization of efforts. Table 4-1 outlines the purpose of the hydrologic and nutrient budgets.

Table 4-1 Purpose of Hydrologic/Nutrient Budgets

Allows Comparison of Subwatersheds	The hydrologic contributions from each subwatershed can be compared and projects can be focused in areas that contribute the greatest amount of water;
Allows Focus on Problem Areas for Remediation	The nutrient budget shows areas contributing the highest amounts of phosphorus, a critical nutrient in the long-term health of fresh surface water bodies;
Allows Focus on Good Quality Areas for Prevention/ Protection	Remediation projects can be focused in the areas of high phosphorus contribution, while prevention projects can be targeted to areas of high volume and low phosphorus contribution.

4.0 Hydrology and Nutrient Modeling

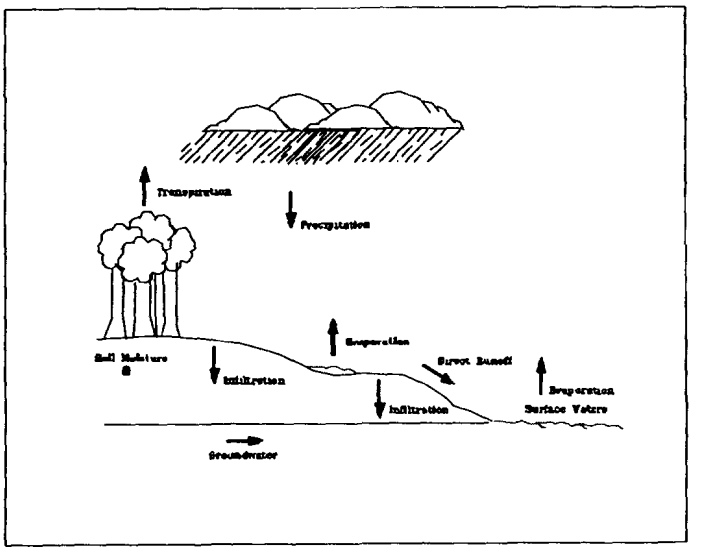


Figure 4-1. Typical Hydrologic Cycle

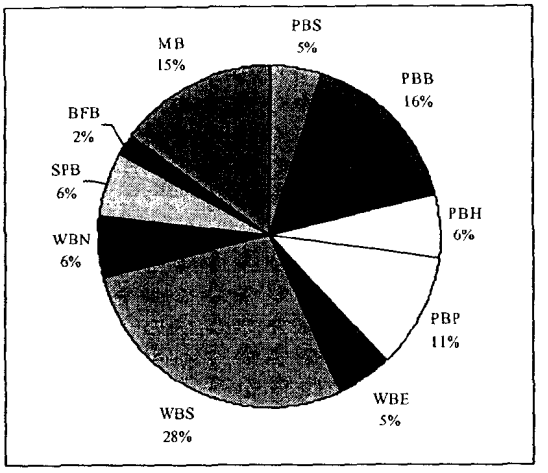


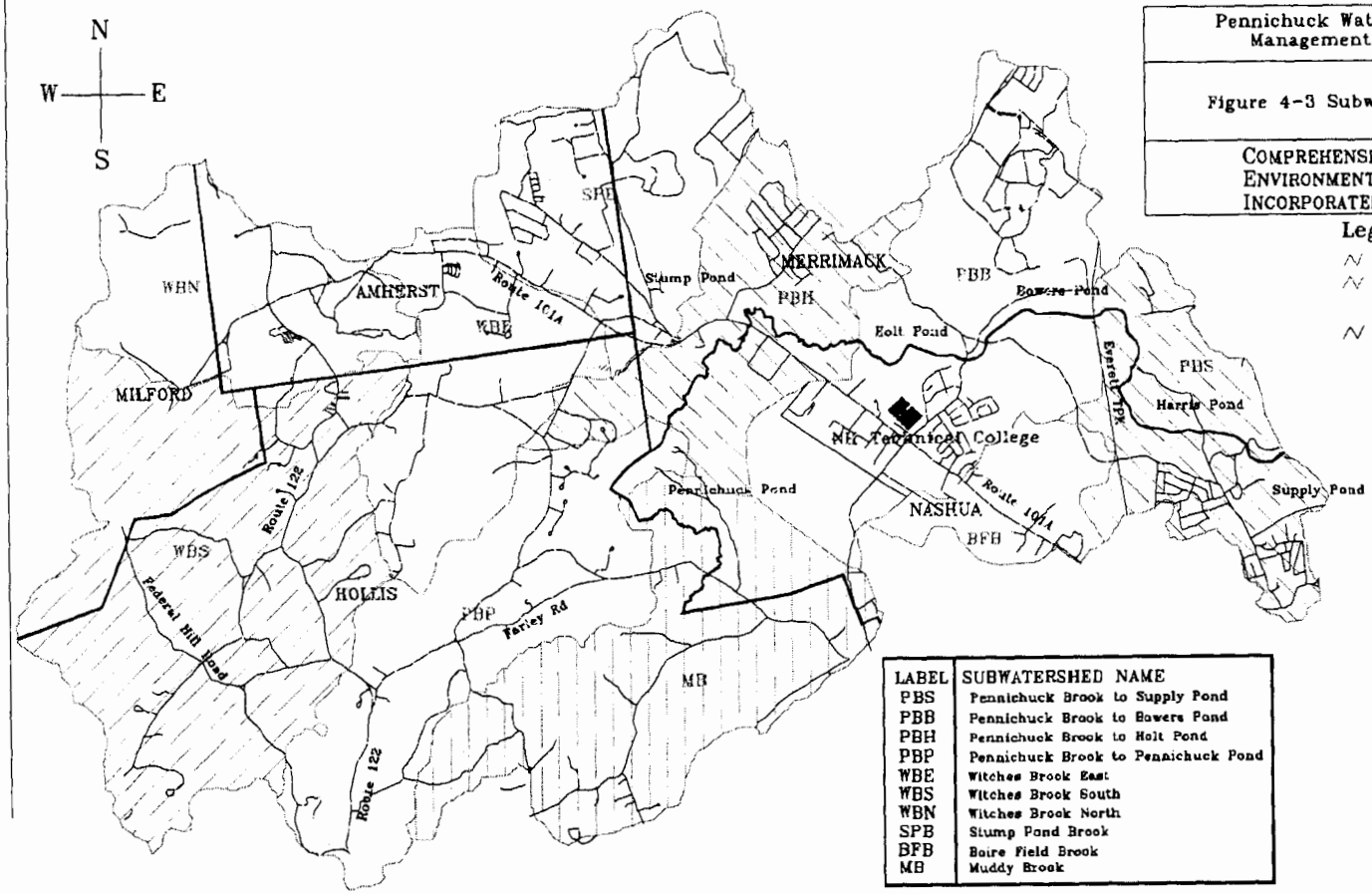
Figure 4-2. Percent Hydrologic Contribution

4.1 Hydrology

Hydrology refers to the occurrence, circulation and distribution of surface and ground waters. A hydrologic budget is performed to identify the amount of water entering a surface water body. Water may enter through runoff as surface flow in streams, sheet flow over land, and groundwater flow through the subsurface. Additionally, it may enter through direct precipitation. It "exits" the watershed via evaporation and transpiration and outflow. A graphical depiction of water contribution is shown in Figure 4-1. Calculating the components on each side of the equation can be used to develop a "budget" as is described below.

The hydrologic analysis conducted for this study consisted of the delineation of several subwatersheds and an analysis of gaging station and precipitation data to determine the total runoff (surface and baseflow) from each subwatershed into the chain ponds. The estimated percent hydrologic contribution into Supply Pond by subwatershed is shown on Figure 4-2. The subwatershed delineations are shown on Figure 4-3.

The estimated runoff from the total watershed for a series of varied conditions was determined by analyzing available precipitation and runoff records for the local area. Monthly precipitation records for Nashua, covering a 74-year period, from 1922-1995, were used in the analysis, with a focus on the 30-year period of 1966-1995. Runoff estimates for the area were based on analysis of several gaging station



Pennichuck Water Works Watershed Management Planning Study

Figure 4-3 Subwatershed Delineation

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

Scale: 1" = 3600'

Legend

- Watershed Boundary
- Roads
- Water
- Town Lines

LABEL	SUBWATERSHED NAME
PBS	Pennichuck Brook to Supply Pond
PBB	Pennichuck Brook to Bowers Pond
PBH	Pennichuck Brook to Holt Pond
PBP	Pennichuck Brook to Pennichuck Pond
WBE	Witches Brook East
WBS	Witches Brook South
WBN	Witches Brook North
SPB	Stump Pond Brook
BFB	Boire Field Brook
MB	Muddy Brook

4.0 Hydrology and Nutrient Modeling

records as obtained by the U.S. Geological Survey.

The runoff values used for the Pennichuck watershed were derived from a study of records compiled by the U.S. Geological Survey from certain continuous record streamflow monitoring stations including a gaging station on the Souhegan River at Merrimack, N.H. and a gaging station at Beaver Brook at North Pelham on the Pelham-Windham town line. These data records were used to derive relationships between flow data recorded and monthly and annual precipitation.

A study of annual precipitation at Nashua and flow data at the Souhegan River at Merrimack for the 54-year period (1923-1976) shows a very distinct relationship between precipitation and flow contribution as with 49 of the 54 years falling within the 90% probability range as shown in more detail in Appendix D. This relationship can be used to estimate the annual runoff from the watershed given a value for precipitation. For example, the average annual precipitation of 43.66 inches for the 30-year period (1966-1995) would be expected to yield an average runoff value of 25.65 inches with a 90% probability that the annual rainfall producing this contribution would fall within the range of 37.8 to 49.5 inches. A frequency analysis for this 54-year period of rainfall shows the results in Table 4-2.

The runoff values determined through this analysis were applied to the Pennichuck water supply watershed to determine the percent hydrologic contributions from each subwatershed as depicted in Figure 4-2. A more detailed description of the hydrologic analysis is provided in Appendix D.

4.2 Nutrient Analysis

A nutrient analysis of the watershed, using phosphorus, was conducted to show: (1) the total loadings into the chain pond system from each of the subwatersheds and (2) the in-pond concentrations from each of the chain ponds based on these total loadings. The analysis was conducted using a phosphorus model that projects estimated phosphorus loadings from various portions of the watershed based on land use and soils data. Modeling is especially useful in watersheds where there is limited sampled phosphorus data. However, modeling provides only a rough

Table 4-2. Frequency Analysis of 54-year Period of Precipitation

% of Time Annual Precipitation is Less Than Stated	Amount of Precipitation (inches)
1%	27.5
2%	28.8
5%	30.9
10%	32.9
20%	35.4
30%	37.2
70%	44.5
80%	47.2
90%	50
95%	54
98%	57
99%	60.2

4.0 Hydrology and Nutrient Modeling

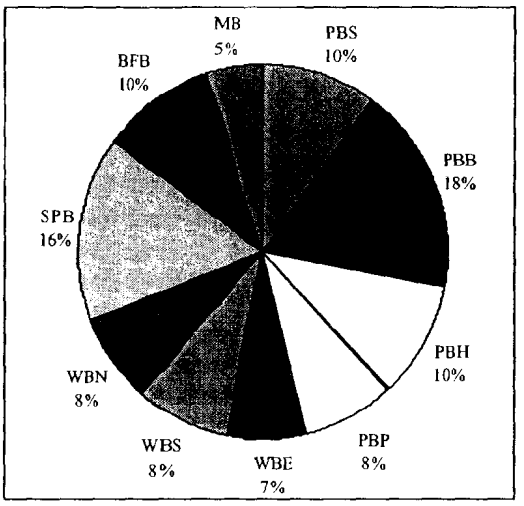


Figure 4-4. Percent Phosphorus Contribution

Table 4-3. Comparison of Hydrologic and Phosphorus Contributions by Subwatershed

Subwatershed	% Hydrologic Contribution	Percent Phosphorus Contribution
PBS Pennichuck Brook to Supply Pond	5%	10%
PBB Pennichuck Brook to Bowers Pond	16%	18%
PBH Pennichuck Brook to Holt's Pond	6%	10%
PBP Pennichuck Brook to Pennichuck Pond	11%	8%
WBE Witches Brook East	5%	7%
WBS Witches Brook South	28%	8%
WBN Witches Brook North	6%	8%
SBP Stump Brook Pond	6%	16%
BFB Boire Field Brook	2%	10%
MB Muddy Brook	15%	5%

estimate of pollutant loadings in the reservoir and is better used to compare various portions of the watershed to one another.

Since the Pennichuck watershed is divided into 10 subwatersheds, the phosphorus loadings from each of these subwatersheds was estimated to identify which areas contribute the most phosphorus. Thus, these areas could become the focus for later prioritization efforts. Figure 4-4 summarizes the percent phosphorus contribution of each of the subwatersheds to the chain ponds. Table 4-3 shows the same subwatersheds compared for both hydrologic and nutrient contributions.

The Eutromod Watershed and Lake Modeling Software (Reckhow, 1990) was used for determining phosphorus contributions in the Pennichuck watershed. The model uses information pertaining to land uses, soils, stormwater pollutant concentrations, and pond characteristics to estimate phosphorus loadings and in-pond phosphorus concentrations. This model was selected because it was developed to determine phosphorus loadings from both rural and urban settings, while many models focus only on urban watersheds.

The model considers phosphorus loadings from agricultural areas, since they may contribute more than another type of land use of similar size. The model also accounts for phosphorus loadings from forested areas, considering the phosphorus content of the regional soils. This is

4.0 Hydrology and Nutrient Modeling

important because some of the Pennichuck watershed is very rural with small tracts of agricultural land and large tracts of undeveloped forested land, while other parts are rapidly urbanizing. Thus this model was appropriate for this watershed. Additionally, Pennichuck zoning reveals that some areas of the town of Hollis may develop as agricultural land in the future. Several of the urban models do not recognize the high loadings that may be seen from these agricultural areas. In addition to calculating loadings from various land uses, the model also uses these estimated loadings to determine theoretical in-pond phosphorus concentrations.

Phosphorus Loadings

The Eutromod model requires an extensive inventory of the watershed to identify the watershed specific parameters to successfully run the model. The parameters needed to run the model are summarized in Table 4-4. Specific factors applied for each of the parameters in each subwatershed can be found in Appendix E.

The first step for using the model is to define the various land uses within the watershed by land area. This data was obtained from the Nashua Regional Planning Commission (NRPC) for 1994 and is shown as Figure 4-5. Land areas for each land use in each subwatershed are summarized in Table 4-5. Note that about half of the watershed is undeveloped forested land (vacant land), which, in itself, provides a significant level of protection as long as it is not developed. Additionally, about 19% of the watershed is developed as residential lots greater than one acre in size. Although this land use does not provide the same level of protection as forested lands, it is one of the more desirable developed land uses since the amount of impervious area remains relatively low in comparison to dense residential, industrial and commercial areas.

In addition to land use data, soils data was also defined for use in the model. This was obtained through the UNH GRANITNET database and is provided in Appendix A. These land areas and soils data are used to determine literature based surface runoff coefficients for urban and rural areas of the watershed (obtained from Reckhow, 1990). Runoff coefficients for the rural areas within the watershed were estimated based on literature coefficients for specific soil types. For urban areas, these coefficients are based on the percent impervious area, identified in the literature for individual urban land uses including commercial, industrial and various densities of residential. These impervious areas have been correlated with runoff coefficients. The model uses these runoff coefficients to determine the total surface runoff within a given area. The land use data is also used to identify literature-based phosphorus concentrations for stormwater runoff from various land uses.

Phosphorus is critical because it is the limiting nutrient in a fresh water system, and it is important to reduce its loading into the ponds to minimize algal blooms and associated taste and odor problems.

4.0 Hydrology and Nutrient Modeling

The model estimates phosphorus loadings from a given area by multiplying the quantity of surface runoff by the phosphorus concentrations for specific land uses. The model also uses the universal soil loss equation (USLE) to determine the amount of eroding soil in the rural areas of the watershed including agricultural and forested lands to account for the phosphorus content that may be transported in the surface runoff from these areas. The equation uses various factors based on the type and slope of the soils. The local Soil Conservation Service was contacted to assist in the use of this equation. The purpose of the USLE is to determine the soil attached phosphorus loadings due to erosion. These are estimated with the use of literature based coefficients for soils in the area.

Approximately 7,000 pounds per year of phosphorus are contributed to the chain pond system from the watershed.

Finally, the model allows for a trapping factor, which estimates the amount of soil or pollutants that will not make it to the tributary or pond. The trapping factor is primarily used for agricultural lands where a significant amount of soil erosion is expected to occur. However, not all of that soil will reach a stream or pond due to low sloping land and natural depressions that may exist and the distance it must travel to reach there. Thus, the trapping factor allows an estimation of the amount of soil that will not reach a tributary based on the distance from the nearest downgradient water body. A trapping factor is also applied to forested lands since not all of the eroded soils will reach a stream or water body. Due to the dense cover on forested lands, little soil erosion is expected to occur in the forested areas.

For urban areas, it is generally assumed that all of the stormwater and its pollutants will reach the stream since pipes are available to carry the stormwater into the tributary. However, there is no storm drain system in portions of the watershed so a trapping factor was applied for the developed areas within these subwatersheds to account for runoff onto pervious surfaces, where some of the surface flow infiltrates into the ground.

Using the information provided in Appendix E and described in Table 4-4, the model was run and phosphorus loadings by subwatershed and by type of land use were estimated. These are summarized in Table 4-6. Based on the results of the model, a total of approximately 7,000 pounds of phosphorus per year are contributed to the chain pond system from the watershed (see Figure 4-4 for the percent contribution by subwatershed).

As shown on Figure 4-4, subwatersheds PBB, SPB, BFB, PBH and PBS contribute the largest quantity of phosphorus to the Pennichuck water supply. These areas correspond to some of the most developed urban areas in the watershed. Urban areas in the watershed contribute higher phosphorus loadings than the rural areas due to the increased impervious surfaces. The increase in impervious

Table 4-4. Eutromod Modeling Parameters

Modeling Parameter	Description	Purpose	Resource
Land use	Breakdown of land use categories in the watershed.	Used in determining runoff coefficients and phosphorus to determine pollutant loadings.	NRPC digitized mapping and aerial photographs (1994)
Septic tanks	All potential septic tanks within 200 meters of any of the chain ponds.	To determine the total phosphorus contributed from septic systems.	USGS (1985), NRPC aerial photographs (1994), and local town sewer locations
Nutrient contribution (kg/capita-yr)	Phosphorus loadings contributed from the number of people living in homes that potentially have septic systems.	To provide a basis for estimating the total phosphorus contributed from septic systems.	Reckhow, 1983
Nutrient soil retention	Percent of phosphorus the soil is likely to bind and retain therefore never reaching the pond.	To determine quantity of phosphorus from septic systems that will not reach the ponds.	Estimated using Reckhow, 1983 & Reckhow, September 1990
Precipitation	Average annual rainfall over a 30-year period.	Used with runoff coefficient to estimate surface runoff in watershed.	Pennichuck Water Works, Inc. (for Nashua area)
Runoff coefficient	Percent of precipitation resulting in surface water runoff based on soils and land use. Estimated using percent impervious area for urban land uses and soil type, slope and cover for rural land uses.	To estimate surface water runoff for each subwatershed to calculate total phosphorus loadings contributed from surface runoff.	Reckhow, August 1990
Phosphorus loading concentrations	Dissolved (mg/l) and sediment bound (mg/kg) phosphorus concentrations based on specific land uses.	Used with runoff coefficients and precipitation to determine the phosphorus loadings for specific land uses within the watershed.	Reckhow, August 1990
Rainfall Erosivity (RE)	A measure of the energy of rainfall and runoff which cause erosion (MJ-mm/ha-h).	Used in the Universal Soil Loss Equation (USLE) which estimates soil loss for the sediment attached nutrient loading function.	State Soil Conservation Service
Soil Erodibility (K)	The average soil loss under specified conditions of hillslope length and gradient.	Used in the USLE (see above)	State Soil Conservation Service
Topographic Factor (LS)	Factor reflecting both area slope length and steepness.	Used in the USLE (see above)	Estimated using slope and length data obtained from the State Soil Conservation Service
Cropping Factor (C)	Factor describing the protective effects of vegetative cover, crop residues, tillage practices, and mulches.	Used in the USLE (see above)	State Soil Conservation Service
Erosion Control Practice Factor	Describes efforts to control erosion through contouring and terracing. Scaled zero to one, where 0 represents good practices and 1 represents poor practices. State Soil Conservation Service recommended using a value of 1.0 for the entire watershed.	Used in the USLE (see above)	State Soil Conservation Service
Pond Characteristics	Mean depth and surface area of ponds.	Used to calculate detention time to help determine in-pond phosphorus calculations.	Pennichuck Water Works, Inc. (some values were estimated)
Trapping Efficiency	The percent of pollutants contributed from surface water that is trapped before entering a tributary or pond. Trapping efficiencies are scaled zero to one. Zero assumes tributaries and/or ponds receive all pollutants. One assumes that tributaries and/or ponds receive no pollutants.	To estimate the quantity of phosphorus entering the pond so that in-pond concentrations may be determined.	Estimated based on guidance from Reckhow, 1990

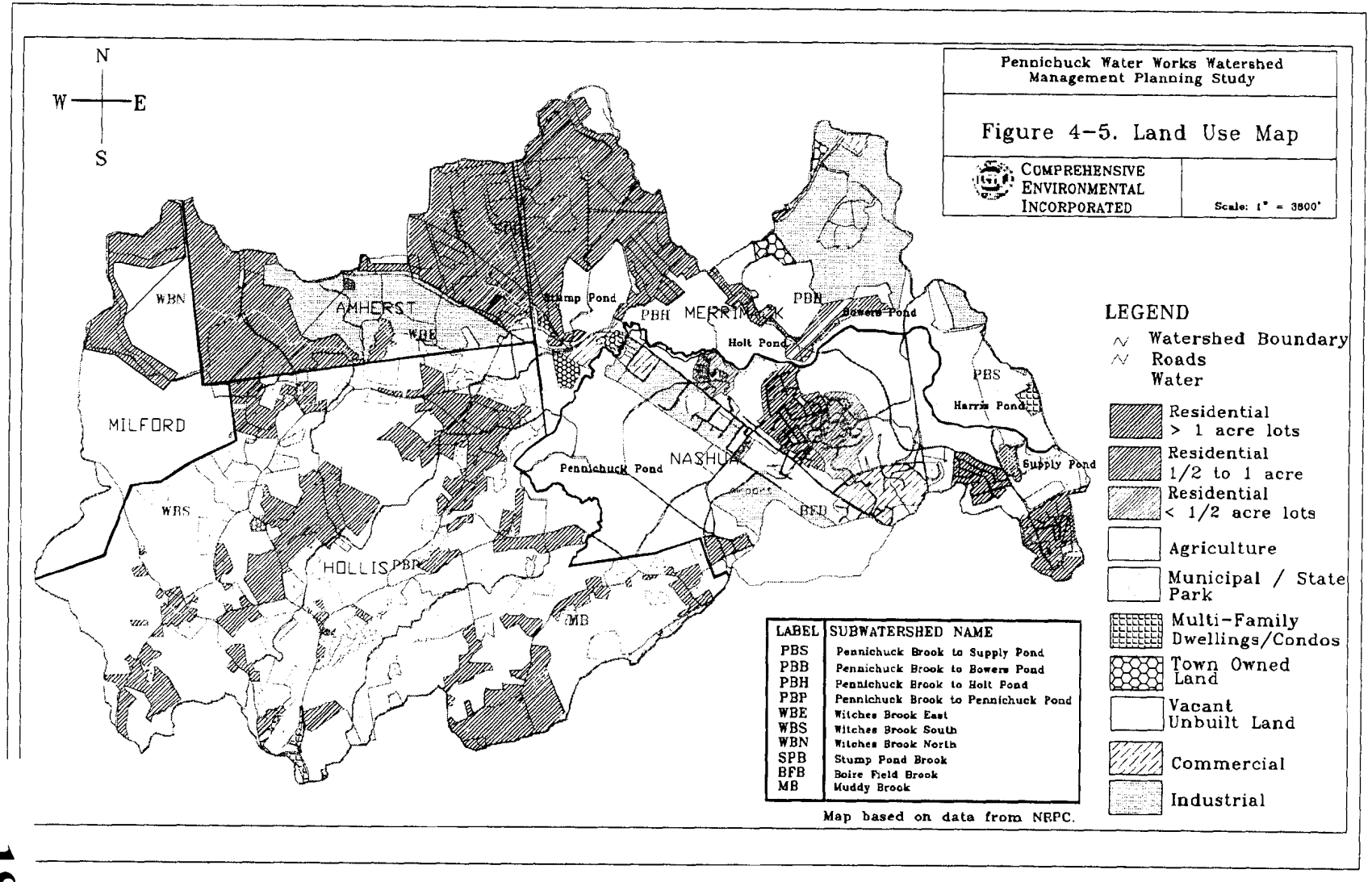
4.0 Hydrology and Nutrient Modeling

Table 4-5. Land Use Areas Within the Pennichuck Watershed (acres)

	Residential (>1 acre)	Residential (1/2-1 acre)	Residential (<1/2 acre)	Condominium	Parks & Town Owned	Commercial	Industrial	Forest	Orchard	Crop	Pasture	Total Subwatershed Area	Percent of Watershed (by subwatershed)
PBS	0	354	0	23	40	43	47	778	0	0	0	867.84	5%
PBB	0	300	107	0	34	0	785	1164	0	0	0	1949.48	11%
PBH	116	268	23	0	90	65	81	846	0	9	9	1010.92	6%
PBP	308	0	0	28	85	3	0	1333	159	31	31	1557.18	9%
WBE	308	10	0	0	59	5	336	582	0	32	32	987.6	6%
WBS	616	0	0	0	99	0	0	2328	75	37	37	2477.64	14%
WBN	901	0	0	0	0	0	175	349	0	0	0	523.86	3%
SPB	672	665	0	0	8	2	12	157	0	0	0	171.31	1%
BFB	19	13	104	0	0	148	118	218	0	0	0	484	3%
MB	450	0	0	0	401	0	0	1296	11	80	80	1465.9	8%
Total	3390	1611	233	52	816	266	1554	9052	245	190	190	11495.73	
Percent of Watershed (by land use)	19.3%	9.2%	1.3%	0.3%	4.6%	1.5%	8.8%	51.4%	1.4%	1.1%	1.1%		

Table 4-6. Phosphorus Loadings by Land Use for the Pennichuck Watershed

	PBS	PBB	PBH	PBP	WBE	WBS	WBN	SPB	BFB	MB	Total
	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
Residential (>1 acre)	0	0	63	131	144	261	403	486	14	193	1695
Residential (1/2 - 1 acre)	330	280	250	0	5	0	0	320	12	0	1197
Residential (<1/2 acre)	55	132	28	16	0	0	0	0	129	0	360
Parks and Town Owned	1	1	13	5	17	28	0	2	0	48	114
Commercial	70	0	105	5	2	0	0	3	239	0	424
Industrial	123	618	213	0	308	0	121	8	310	0	1700
Forest	12	19	10	38	11	74	12	3	4	43	226
Orchard	0	0	0	202	0	129	0	0	0	23	354
Crop	0	0	4	25	13	32	0	0	0	33	107
Pasture	0	0	4	24	11	34	0	0	0	35	108
Septic	0	85	0	18	0	0	0	253	0	0	356
Precipitation	121	81	0	56	0	0	0	21	0	0	278
Total	712	1215	691	519	511	558	536	1096	707	374	6919
Percent Contribution	10%	18%	10%	8%	7%	8%	8%	16%	10%	5%	


Pennichuck Water Works Watershed
Management Planning Study
Figure 4-5. Land Use Map
COMPREHENSIVE
ENVIRONMENTAL
INCORPORATED
Scale: 1" = 3800'
N
W
E
S
WBN
AMHERST
WBE
SPB
Stump Pond
PBH
MERRIMACK
PBB
Bowers Pond
Holt Pond
PBS
Harris Pond
Supply Pond
MILFORD
NASHUA
Pennichuck Pond
BFB
WBS
HOLLIS
PBP
MB
LEGEND
Watershed Boundary
Roads
Water
Residential > 1 acre lots
Residential 1/2 to 1 acre
Residential < 1/2 acre lots
Agriculture
Municipal / State Park
Multi-Family Dwellings/Condos
Town Owned Land
Vacant Unbuilt Land
Commercial
Industrial
LABEL | SUBWATERSHED NAME
PBS | Pennichuck Brook to Supply Pond
PBB | Pennichuck Brook to Bowers Pond
PBH | Pennichuck Brook to Holt Pond
PBP | Pennichuck Brook to Pennichuck Pond
WBE | Witches Brook East
WBS | Witches Brook South
WBN | Witches Brook North
SPB | Stump Pond Brook
BFB | Boire Field Brook
MB | Muddy Brook
Map based on data from NRPC.

4.0 Hydrology and Nutrient Modeling

surfaces allows for more surface water runoff, carrying any contaminants that are deposited onto these surfaces. As a result, developed areas typically show a larger contaminant loading, as shown through the results of the model.

In-pond Phosphorus Concentrations

The model is also capable of estimating the in-pond concentration of the various ponds in the watershed based on the amount of phosphorus entering the pond and the volume of water entering the pond over a specific time period. The model considers the settling of phosphorus into the sediments in the pond to develop an appropriate in-pond concentration. However, the model does not consider internal phosphorus loadings from the sediments that may occur during the summer months. This factor is discussed further in the recommendations section.

In many surface water supplies there is one lake or reservoir with a surrounding watershed and the hydrologic and phosphorus contribution from the entire watershed are used to determine the in-lake concentration. In the Pennichuck watershed, there are a series of ponds that make up the water supply, each capable of providing detention to remove some of the phosphorus loadings. Thus, to more accurately define the in-pond concentration for each pond, each pond is looked at on an individual basis to account for the detention that is occurring.

The chain pond system provides the extra benefit of settling out some of the phosphorus that enters the system so that the phosphorus loading going from one pond to the next is significantly less than if they were entering the pond from a tributary and its surrounding watershed. This results in a lower phosphorus concentration in Harris and Supply Ponds since they are the last ponds in the series. However, if these upper watershed chain ponds fill up with sediments and nutrients, their detention will be decreased and the sediments may even become a source of nutrients into the drinking water. Thus, it is important to maintain the capacity of these ponds and the ponds may have to be cleaned out when they approach capacity.

If the chain ponds fill in with sediments and nutrients, their detention will decrease and the sediments may become a source of nutrients into the drinking water.

In-pond concentrations were first calculated for Pennichuck Pond and Stump Pond, which receive water and loadings from their tributaries and surrounding areas. Based on the hydrologic budget, the average yearly volume of water leaving these water bodies was used to determine the total phosphorus loadings (in pounds) leaving these ponds and entering into Holts Pond. Thus the in-pond phosphorus concentration of Holts Pond could be calculated with a better representation of pollutants entering the pond and by taking in the effects of detention that took place in the preceding ponds (Pennichuck and Stump Pond). Bowers, Harris and

4.0 Hydrology and Nutrient Modeling

Supply Pond concentrations were then calculated in sequence using the same approach to include the effects of detention from their preceding ponds.

Results of in-pond concentrations are summarized in Table 4-7 with comparisons made to 1996 average concentrations in Table 4-8. Since the intake to the water supply distribution is primarily from Harris Pond, this pond is the focus for maintaining a reasonable water quality phosphorus goal.

As shown in the table, the phosphorus concentration in Harris Pond during an average year is estimated at 0.033 mg/l, which is comparable to the 1996 average of 0.04. This is about one and one half times the desired phosphorus level of 0.02 mg/l. This estimated concentration was calculated with consideration for the detention that each pond may be providing. As discussed above, if the ponds fill in with sediments and nutrients, this detention may be lost resulting in increased levels of phosphorus in each of the ponds. The expected in-pond concentrations with no added detention is also provided in Table 4-8. The results show a significant increase in phosphorus levels in each of the ponds. This data emphasizes the added benefit the chain ponds have on phosphorus levels and indicate the importance of maintaining the pond capacity.

Table 4-8. Comparison of Estimated Phosphorus Levels (with and without detention) to Average Phosphorus Data for 1996

Pond	Estimated Modeled Concentration Considering Detention from the Ponds (mg/l)	Estimated Modeled Concentration if No Detention is Provided from Ponds (mg/l)	Average Sampled Concentration (1996) (mg/l)
Stump Pond	0.073	0.073	0.01 (based on only one sample)
Pennichuck Pond	0.028	0.028	No data
Holts Pond	0.046	0.056	0.05
Bowers Pond	0.039	0.047	0.12
Harris Pond	0.033	0.049	0.04
Supply Pond	0.029	0.099	0.03

Although 0.02 mg/l is a desirable in-pond maximum for phosphorus in an unfiltered water supply, it is probably not realistically achievable or affordable for the Pennichuck chain pond system because of the already urbanized nature of portions of the watershed. A more realistic goal of about 0.025 mg/l may be achievable using a combination of mostly low cost prevention best management practices (BMPs) and higher cost remediation BMPs[1].

To reduce the in-pond concentration to 0.025 mg/l, approximately 2,200 pounds of phosphorus will need to be removed from the watershed, upgradient of Harris Pond. Because it is a chain pond system, the quantity of phosphorus removed from each subwatershed is important in terms of the impact it has on the in-pond concentrations. For example, phosphorus removed from the drainage area into Holts Pond not only impacts the in-pond

4.0 Hydrology and Nutrient Modeling

Table 4-7. Modeled In-pond Phosphorus Concentrations and Parameters for Pennichuck Water Supply System - Existing Situation						
	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	1.22	1.83	4.08	3.60
Watershed area (km2)	6.14	17.38	57.35	64.57	69.61	70.27
Precipitation volume (10^6 m3)	0.09	0.25	0.10	0.41	0.35	0.07
Evaporation volume (10^6 m3)	0.05	0.13	0.05	0.21	0.18	0.04
Precipitation loading (kg/yr)	9	26	10	41	35	7
Land use phosphorus loadings (kg/yr)	488	381	1146	467	433	98
Land & precipitation phosphorus loadings (kg/yr)	497	406	1156	508	468	105
Phosphorus loadings from Merrimack River (kg/yr)	0.00	0.00	0.00	177.46	0.00	0.00
Phosphorus loadings from preceding pond(s) (kg/yr)	0	0	496	1334	1383	657
Total phosphorus loadings (kg/yr)	497	406	1653	2020	1851	763
Stream runoff (m/yr)	0.509	0.509	0.509	0.543	0.540	0.293
Lake volume (10^6 m3)	0.13	0.35	0.11	0.68	1.29	0.23
Detention time (years)	0.04	0.04	0.00	0.02	0.03	0.01
Volumetric waterload (10^6 m3/yr)	3	9	29	36	38	21
Total P-in (mg/l)	0.152	0.044	0.056	0.057	0.049	0.037
In-pond Phosphorus (mg/l)	**0.073**	**0.028**	**0.046**	**0.039**	**0.033**	**0.029**
P leaving pond (kg/yr)	238	258	1334	1383	657	N/A

* Values are for existing estimated conditon.

concentration of Holts, but also impacts the in-pond concentration of downgradient ponds including Bowers, Harris and Supply Pond. Additionally, the majority of phosphorus enters Holts Pond directly through its tributaries, whereas the downgradient ponds receive most of their loadings from the preceding pond.

Based on this information, it is recommended that the majority of the phosphorus be removed from the drainage area into Holts Pond (including WBE through WBN and PBH) and from PBS, PBB, and BFB. The more costly remedial measures should be focused on PBS, PBB, PBH, and BFB while the less expensive preventative measures are more appropriate for the other subwatersheds.

Removal efforts are less of a priority in subwatershed PBP, MB and SPB (even though SPB was identified as one of the highest pollutant contributors) since the phosphorus loadings from these tributaries goes through detention in Pennichuck and Stump Ponds and has a minimal impact on the in-pond concentration of Harris and Supply Ponds. However, low cost preventative measures should be applied in these subwatersheds to minimize the loadings into these ponds.

Based on the theoretical modeling data, focusing efforts in this manner should help Pennichuck meet a water quality goal of 0.025 mg/l in Harris Pond. The concentrations that are likely to be achieved in each of the other ponds are summarized in Table 4-9, which shows the allowable land use phosphorus loading into each pond to obtain these in-pond concentrations. However, the data used to calculate these in-pond concentrations was based on some assumptions where data was missing, such as mean depths or pond capacities. Additionally, filling of the ponds may result in the sediments contributing phosphorus to the water quality and could reduce the detention provided.

Actual data is needed to verify the results of the model to better define specific sources of phosphorus. Potential pollution sources based on database searches and field reviews are identified in Section 5.0.

Approximately 2,200 pounds per year of phosphorus need to be removed from the watershed to achieve an in-pond concentration of 0.025 mg/l in Harris Pond.

[i] Best management practices (BMPs) consist of activities that are used to reduce the pollutant loadings entering the ponds. BMPs may be regulatory in nature or consist of structural measures to capture and treat stormwater before discharge into the ponds or tributaries. Recommended BMPs for the watershed are discussed in more detail in the recommendations section.

4.0 Hydrology and Nutrient Modeling

Table 4-9. Desirable In-Pond Phosphorus Concentrations and Parameters for Phosphorus Reduction in the Pennichuck Water Supply System

	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	1.22	1.83	4.08	3.60
Watershed area (km2)	6.14	17.38	57.35	64.57	69.61	70.27
Precipitation volume (10^6 m3)	0.09	0.25	0.10	0.41	0.35	0.07
Evaporation volume (10^6 m3)	0.05	0.13	0.05	0.21	0.18	0.04
Precipitation loading (kg/yr)	9	26	10	41	35	7
Land use phosphorus loadings (kg/yr)	388	281	746	267	233	98
Land & precipitation phosphorus loadings (kg/yr)	297	307	756	308	268	105
Phosphorus loadings from Merrimack River (kg/yr)	0	0	0	177	0	0
Phosphorus loadings from preceding pond(s) (kg/yr)	0	0	366	938	1027	486
Total phosphorus loadings (kg/yr)	297	307	1122	1424	1295	591
Stream runoff (m/yr)	0.509	0.509	0.509	0.543	0.540	0.293
Lake volume (10^6 m3)	0.13	0.35	0.11	0.68	1.29	0.23
Detention time (years)	0.04	0.04	0.00	0.02	0.03	0.01
Volumetric waterload (10^6 m3/yr)	3	9	29	36	38	21
Total P-in (mg/l)	0.091	0.033	0.038	0.040	0.034	0.029
In-pond Phosphorus (mg/l)	**0.049**	**0.022**	**0.032**	**0.029**	**0.024**	**0.023**
P leaving pond (kg/yr)	162	205	938	1027	486	N/A

*Values are projected to simulate conditions if phosphorus reductions are made.

5.0 Pollution Sources

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5.1 The Pollutants

There is an extremely close relationship between the water quality of a pond or reservoir and its watershed. The surrounding watershed is responsible for contributing the water required to maintain water levels and also contributes most of the pollutant loads. Water quality is a direct reflection of watershed land use and hydrology.

The water quality threats in the Pennichuck watershed were identified and prioritized based on their relative risks. These sources are the most likely to interfere with the quality of Pennichuck's supply. The general categories of pollutants are summarized below:

1. **Microbiological contaminants**, particularly pathogenic protozoans such as *Giardia* and *Cryptosporidium* pose the greatest threat to water quality because they are so difficult to treat effectively. Viruses and bacteria, although more easily treated by disinfection, may also pose a threat.

   Typical sources of these pathogens include livestock and pets, sewer line breaks, cross connections to storm water systems, and any other sources of human and animal fecal waste. With the exception of wildlife waste, which is typically insignificant (except for direct waterfowl input) these factors are usually linked directly with the level of watershed development.

2. **Nutrients,** particularly nitrogen and phosphorus may enter waterways in high concentrations from fecal wastes, fertilizers, and roadway runoff, providing food for excess aquatic plant and algae growth. Nitrogen and phosphorus are essential nutrients required by plants to grow. Gardeners are probably familiar with the term "NPK" (Nitrogen/Phosphorus/Potassium) since most fertilizers are based on different ratios of these elements. Excess levels of the two primary nutrients, nitrogen and phosphorus are typically found in agricultural and urban runoff. High levels of these nutrients can cause rapid choking and clogging of waterways and intakes, foul tastes and odors, and accelerated filling-in of the ponds and streams. Ultimately, this process (called eutrophication) can interfere with the system's operability. Although all of these nutrients provide a food source for aquatic plants and algae, phosphorus is the nutrient of highest concern in freshwater systems.

   The control of phosphorus is extremely important because it is the "limiting nutrient" in a fresh water system. Nitrogen, as with phosphorus, may also result in excess vegetative growth. However, even if all waste sources of nitrogen were eliminated, some plant species can fix nitrogen from the

Water quality is a direct reflection of watershed land use and hydrology.

atmosphere and add to the nitrogen pool if nitrogen is short in supply. Phosphorus is not usually available from the atmosphere in large quantities so limiting the phosphorus supply will theoretically limit the algae blooms and other explosive plant growth.

Nitrogen is also a nutrient of concern. In its nitrate form, it has a maximum contaminant level (MCL) of 10 mg/l and is the most commonly exceeded MCL in groundwater systems. It is typically contributed to surface waters by human and animal wastes that are high in nitrogen and can usually be found in excess levels in urban runoff. Even though exceedance of the 10 mg/l limit is unlikely in surface water, much lower levels can still contribute to excess vegetative growth.

Limiting phosphorus supply will theoretically limit the algae blooms and other explosive plant growth characteristic of eutrophication.

3. **Sediments** from disturbed areas, other erosion, and road salting/sanding also are a threat to water supplies. In addition to the loss of storage capacity caused by these sediments, they also carry particulate contaminants such as phosphorus, pesticides and heavy metals into the water supply. Activities like construction that disturb vegetation and natural soil profiles are major sources of sediment.

4. **Turbidity** levels in water are caused by the presence of suspended matter. Water sources typically become turbid as a result of runoff from disturbed or eroding watersheds, waste discharges, aquatic weeds, algae and products of their breakdown, humic acids and other organic compounds resulting from decay of plants, leaves, etc. in water sources, and high iron concentrations. A watershed with land development activities, agricultural practices and industrial effluents may cause elevated turbidity levels in the receiving waters. It is particularly important to control turbidity levels in drinking water because elevated levels can interfere with disinfection by sheltering microbes and reducing their exposure to chlorination, potentially allowing disease-causing pathogenic organisms to enter the distribution system.

5. **Hazardous materials** also pose a significant threat. The sources of these materials are as diverse as the chemical compounds, ranging from petroleum hydrocarbons entering from roadways or from spills to essentially any chemicals (industrial or otherwise) that could be spilled in railroad or other transportation accidents.

5.2 Pollution Sources

Identification of the potential pollution sources in the watershed is one step in determining where remedial and preventative measures should be focused to minimize contaminant impacts on the receiving water body. Once the locations where these measures need to be applied are identified, specific measures may then be developed to meet water quality goals.

5.0 Pollution Sources

Two types of pollution were reviewed: point and non-point sources.

- Point Source Pollution is a source that enters waterways via a pipe or is otherwise a defined "source".
- Non-point Sources of Pollution enter waterways with overland runoff. They are too widespread to pinpoint as to exact source, e.g. lawn fertilization is a non-point source of pollution.

Point sources of pollution were identified in the watershed through:

1. field surveys,
2. review of aerials,
3. database searches, and
4. a review of federal/state records.

This review identified subwatersheds that contain several pollution sources so that their relation to the overall water quality of the pond system could be further defined. Figures 5-1 and 5-2 show all of the point sources of pollution sources identified through the above measures, plus some non-point sources that are mappable.

Point sources of pollution are usually directly piped, often require permits and may include:

- Point sources covered by the National Pollutant Discharge Elimination System (NPDES) Permits
- Point sources covered by Groundwater Discharge Permits
- State and Federal listed hazardous waste sites

A database search and a state file review were conducted through GRANITNET to determine the locations of sites with known hazards. Sites from the *Groundwater Hazard Inventory* (including automobile salvage yards and underground storage tanks) and the National Pollutant Discharge Elimination System (NPDES) permit databases were located. There were a number of *Groundwater Hazard Inventory* sites within the watershed, however, no automobile salvage yards or NPDES sites were identified through the search. Figure 5-1 shows the location of these and other potential pollution sites.

A file search was also completed through the NH Department of Environmental Services (NHDES) to determine additional sites that GRANITNET may not have indicated. Conversations were held with both the Groundwater Protection Bureau and Hazardous Waste Division of NHDES to help identify potential threats to the water supply and an All Sites List was obtained (a list of all hazardous waste, leaking underground storage tanks, landfills, etc in the state) and reviewed. A list of sites found both during the state file review and the database search and their status is in Appendix F.

Many of the sites found during the search and file review are identified by NHDES as "backlog", which means that NHDES does not consider them priority sites and a project manager has not been assigned yet. There are eight groundwater discharge permits within the watershed and five sites are ongoing and considered priority by NHDES. All other sites within the watershed

5.0 Pollution Sources

have been remediated and/or closed. Currently, the sites within the watershed that are ongoing and assigned a project manager include:

1. Site #910623: Bellemore Heating Oil Co.; 21 Old Nashua Road, Amherst; Project manager: Willis.

Several hazardous waste sites provide potential point sources of pollution.

2. Site #861101: Merrimack Well #6 (Merrimack Industrial Metals); off Milford Road, Merrimack; Project manager: Wickson.

3. Site #940966: Post Road Plaza; Route 101A, Merrimack; Project manager: Wickson.

4. Site #941134: Connell Shopping Plaza; Rte 3, Merrimack; Project manager: Berry.

5. Site #880316: Coca-Cola; 600 Amherst Street, Nashua; Project Manager: Willis.

The RCRA (hazardous waste generators) and provisional lists were also obtained from NHDES and reviewed to identify other potential threats to the watershed. There are 112 sites within the watershed on the provisional list. The provisional list consists of one-time hazardous waste generators. Most of these sites are located along Route 101A and are not included on the map since they probably do not pose a significant threat to the watershed. A copy of the provisional list and the RCRA generators is included in the appendix. Locations of the RCRA sites can be seen in Figure 5-2, addresses are included in Appendix F. Small and large quantity generators should not be a problem if they are managed properly.

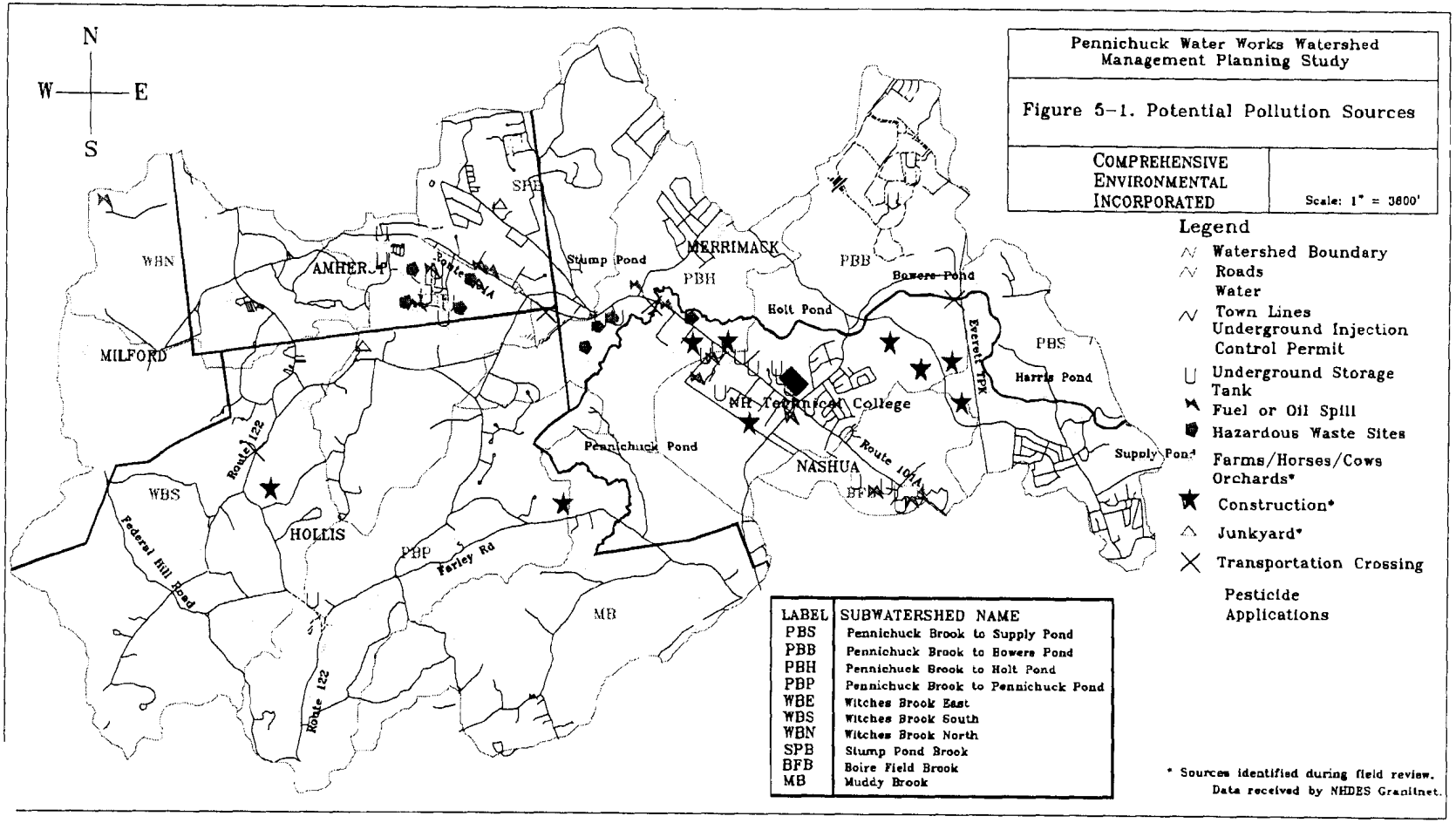
Many of these point sources of pollution are already being remediated. Often, the largest pollutant contributions are associated with non-point pollution. Measures currently in place that provide some level of protection to the ponds are discussed in Section 6.0. These include some of the preventative efforts the state, local authorities, and Pennichuck Water Works have incorporated to deal with non-point source issues.

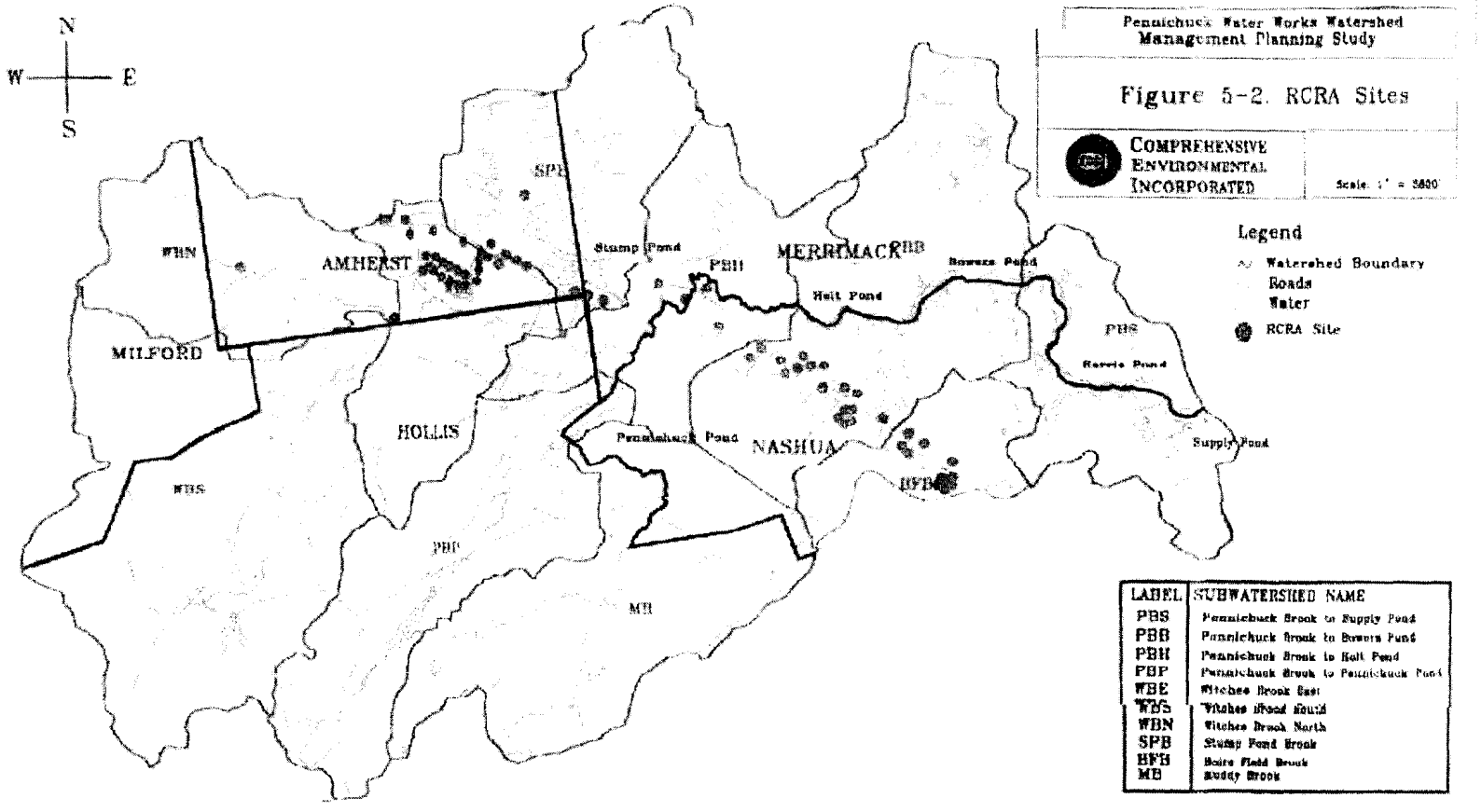
Non-Point (Stormwater) Sources

Non-point sources include a wide variety of pollution sources that enter the water body through stormwater runoff from storm drains or overland runoff and may include:

- Industrial and commercial land uses
- Dense residential land uses
- Intensive agriculture, including nurseries and golf courses
- Transportation activities
- Construction activities
- Landfills
- Sand and gravel operations
- Airports

Non-point sources of pollution contribute bacteria, nutrients (mostly nitrogen and phosphorus), heavy metals, oil, grease, and many other pollutants to the water supply through runoff from stormwater. Although all of these pollutants are important, phosphorus was the focus of this analysis because it is the most important freshwater nutrient and is the most readily and frequently modeled non-point source indicator.


N
W
E
S
WBN
MILFORD
AMHERST
Route 101A
SPB
Stump Pond
MERRIMACK
PBH
Holt Pond
PBB
Bowers Pond
Everett Tpk
PBS
Harris Pond
Supply Pond
NH Technical College
NASHUA
Route 101A
BFB
Pennichuck Pond
Route 122
WBS
Federal Hill Road
HOLLIS
PBP
Farley Rd
MB
Route 122
Pennichuck Water Works Watershed
Management Planning Study
Figure 5-1. Potential Pollution Sources
COMPREHENSIVE
ENVIRONMENTAL
INCORPORATED
Scale: 1" = 3600'
Legend
Watershed Boundary
Roads
Water
Town Lines
Underground Injection
Control Permit
Underground Storage
Tank
Fuel or Oil Spill
Hazardous Waste Sites
Farms/Horses/Cows
Orchards*
Construction*
Junkyard*
Transportation Crossing
Pesticide
Applications
LABEL SUBWATERSHED NAME
PBS Pennichuck Brook to Supply Pond
PBB Pennichuck Brook to Bowers Pond
PBH Pennichuck Brook to Holt Pond
PBP Pennichuck Brook to Pennichuck Pond
WBE Witches Brook East
WBS Witches Brook South
WBN Witches Brook North
SPB Stump Pond Brook
BFB Boire Field Brook
MB Muddy Brook
* Sources identified during field review.
Data received by NHDES Granitnet.



Pennichuck Water Works Watershed Management Planning Study

Figure 5-2. RCRA Sites

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

Scale: 1" = 5800'

Data received by NHDES Granitnet.

5.0 Pollution Sources

Further, phosphorus is typically the "limiting" nutrient in freshwater systems. Other non-point sources of pollution are also critical but either do not lend themselves to modeling because of complex behavior (bacteria) or are difficult to model because of a lack of data on typical runoff values (metals).

An important factor in determining the threat of pollution from an area is the relative flow contribution each subwatershed makes to the overall system in relation to the overall phosphorus contribution of that subwatershed. For example, subwatersheds that contribute only a small fraction of the total storm water input may be less important than those that contribute a large fraction of the total storm water input.

Phosphorus contributions calculated for this watershed are based on total pounds of phosphorus loadings and have already taken runoff into consideration in determining these loads. Thus, the most important subwatersheds are those that contribute the greatest loadings. Results of the two analyses have shown that those subwatersheds with the greatest hydrologic contribution do not necessarily contribute the greatest phosphorus loadings. In other words, some subwatersheds contribute little flow but lots of pollution, suggesting that pollution remediation efforts should be the focus in this area. For example, subwatershed SPB contributes only about 6% of the total inflow to the reservoir but an estimated 16% of the phosphorus load because of urbanized land use. Similarly, subwatershed BFB contributes about 2% of the flow but nearly 10% of the phosphorus load. Conversely, relatively undeveloped subwatersheds have a positive contribution to the reservoir. For example, subwatershed MB1 contributes 15% of the inflow but only 5% of the pollutant load.

This subwatershed contributes little pollution but lots of water to the system, suggesting that pollution prevention efforts may be more appropriate in this area than the more expensive remedial measures. Table 5-1 indicates which subwatersheds should be focused on remediation and prevention.

Table 5-1. Remediation vs. Prevention Measures for the Pennichuck Watershed

Subwatershed	Hydrologic Load	Phosphorus Load	Focus of Efforts
PBS-Pennichuck Brook to Supply Pond	Low (5%)	High (10%)	Remediation
PBB-Pennichuck Brook to Bowers Pond	High (16%)	High (18%)	Remediation
PBH-Pennichuck Brook to Holt Pond	Low (6%)	High (10%)	Remediation
PBP-Pennichuck Brook to Pennichuck Pond	High (11%)	Low (8%)	Prevention
BFB-Boire Field Brook	Low (2%)	High (10%)	Remediation
MB1-Muddy Brook	High (15%)	Low (5%)	Prevention
WBE-Witches Brook East	Low (5%)	Low (7%)	Prevention
WBS-Witches Brook South	High (28%)	Low (8%)	Prevention
WBN-Witches Brook North	Low (6%)	Low (8%)	Prevention
SPB-Stump Pond Brook	Low (6%)	High (16%)	Prevention

5.0 Pollution Sources

Although SPB is identified as a major contributor of pollution, it is not identified as a priority for remediation efforts. This is due to the detention that Stump Pond and the other ponds in the chain provide before the pollutants reach Harris and Supply Ponds. Results of the modeling show that removal of phosphorus in SPB will not have a significant impact on the water quality in Harris or Supply Ponds. However, as the ponds fill in, this detention will be minimized and more pollutants will reach the intake, at which point remedial efforts may be necessary at SPB. This points out the importance of prevention efforts, which are typically free or very low cost as opposed to expensive remediation efforts.

Prevention efforts are typically much lower cost than remediation efforts.

Specific non-point pollution sources identified in the Pennichuck watershed are provided below along with the threats they pose to the reservoir.

Industrial and commercial land uses

Industrial and commercial land uses contain potential sources of pollution due to the larger impervious areas that contribute greater stormwater surface runoff. Impervious areas increase the volume and velocity of flow. Water can not infiltrate into the ground so sediment and attached pollutants in this flow are increased. These sources generally also have a stormwater collection and discharge system that carry stormwater and its pollutants directly to a tributary or pond.

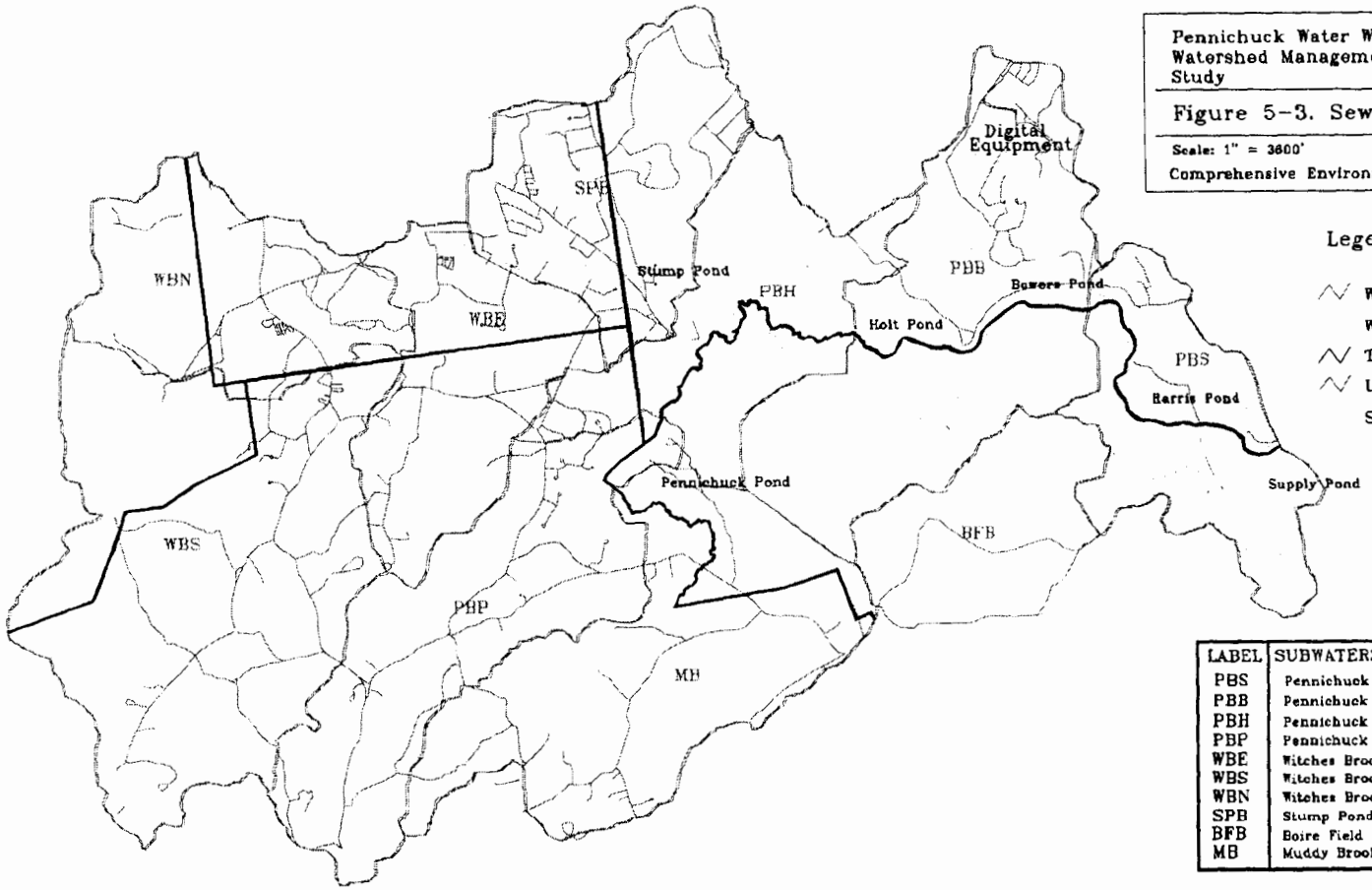
In addition to typical airborne particulates and pollutants that collect on impervious surfaces, industrial sites may also contribute other forms of pollutants such as hazardous materials. For example, if a spill occurs during dock loading and unloading and is not contained and cleaned immediately, residual contamination may introduce contaminants into stormwater during rain events. There may also be contaminants from stack emissions.

Dense residential land uses

Potentially large contributors to pollution are sewered and unsewered dense residential and commercial areas close to the ponds and tributaries. Each of the towns was contacted to help identify which areas of the watershed are sewered (Figure 5-3). All of Nashua and approximately 42% of the roads in Merrimack that fall within the watershed are sewered. Neither Hollis nor Milford have any roads that are sewered within the watershed. Amherst does not have a sewer system, however, Route 101A, which has commercial areas is sewered (this comprises approximately 10% of the Amherst portion of the watershed). Sewered and non-sewered areas are differentiated because they represent different types of threats.

Unsewered residential areas rely on individual septic systems for wastewater treatment. Significant water quality problems have been associated with septic systems if there is a lack of adequate soil for treatment and/or high ground water levels and/or shallow depth to bedrock.

Septic systems located closer to Pennichuck's water supply have a



Pennichuck Water Works
Watershed Management Planning Study

Figure 5-3. Sewered Roads

Scale: 1" = 3600'

Comprehensive Environmental Inc.

Legend

- Watershed Boundary
- Water
- Town Lines
- Unsewered Roads
- Sewered Roads

LABEL	SUBWATERSHED NAME
PBS	Pennichuck Brook to Supply Pond
PBB	Pennichuck Brook to Bowers Pond
PBH	Pennichuck Brook to Holt Pond
PBP	Pennichuck Brook to Pennichuck Pond
WBE	Witches Brook East
WBS	Witches Brook South
WBN	Witches Brook North
SPB	Stump Pond Brook
BFB	Boire Field Brook
MB	Muddy Brook

5.0 Pollution Sources

greater chance of contributing microbiological contaminants such as bacteria and viruses and nutrients such as nitrogen and phosphorus through entrainment in runoff (in cases where there is a breakout of effluent on the ground surface), or through the contribution of contaminated groundwater baseflow to the ponds.

Other concerns include bedrock outcrops or areas with a lot of stones, steep slopes, and low lying areas exhibiting signs of influence of surface water runoff. These areas may adversely affect the functioning of the systems, increasing the chance of pathogens entering the system. This is a typical problem in older "grandfathered" systems, but is usually not a significant concern in newer systems that now meet standards that are more rigorous.

Densely populated commercial and residential sewered areas, as seen in Nashua, often contribute significantly to pollution to a watershed. Possible sources of pollution in sewered areas include large impervious areas, contamination from automobiles, possible breaks in sewer lines, intensive / excessive lawn care practices, car washing (both commercial and home), and pet wastes among others. Together, these potential pollution sources typically contribute significant levels of bacteria and nutrient loadings to the receiving water body by direct overland runoff or through stormwater collection systems.

Densely populated areas such as the residential areas in Nashua, are considered a more significant threat, due to increased imperviousness which in turn increase the surface water runoff and pollutants carried into the Supply Pond chain.

Intensive agriculture

Agricultural farms and animal waste also contribute pollutants to the watershed. The land use types of concern include nurseries, golf courses, and farms. These sites were identified because of the potential threat of pollutants from animal wastes or the application of pesticides and fertilizers. These applications may result in the discharge of microbiological contaminants, nutrients, and toxic materials that could lessen the quality of the water supply. Pets in dense residential areas also have the potential to increase microbiological contaminants and nutrients to the reservoir. Agricultural uses in the watershed are indicated on the pollution sources map, Figure 5-1. Also included on this map are areas where there is known pesticide use. There are no golf courses or nurseries in the watershed, however, there may be in the future.

Densely populated commercial and residential areas may contribute significantly to water quality problems.

Transportation activities

Transportation spill risks in each of the towns were also identified. Transportation spills are most likely to come from the roadways or railways that intersect a tributary to the water supply or the supply itself. Another source is airports. If a spill occurs at these locations, there is little time to take remedial action before it enters the supply. The major roadway

and railways in the watershed that crossed Pennichuck's system include the Daniel Webster Highway, the Everett Turnpike, and Routes 101A and 122. Each of these roads traverse a significant portion of the watershed and cross Pennichuck's system at more than one point. Spills at any of these locations may result in hazardous materials coming in direct contact with the receiving waters with little time to react to contain or remediate the incident.

Construction activities may bring significant sediment loads, with many attached pollutants, into the water supply.

Airport maintenance facilities generate pollutants such as aviation fuel waste oil, hydraulic fluid, cleaning lubricants, and degreasing solvents. Fuel trucks often refuel the planes at the loading gates and overfills are a common problem. In colder months, deicing chemicals are used for safety on the runways, often with chemicals that contain urea, a nitrogenous compound that could contribute to the eutrophication of surface waters. To control plant and weed growth, pesticides and herbicides may be used on the grounds surrounding the runways. Storage areas for petroleum products, solvents, pesticides and road salt are also a potential threat to surface water quality. The Boire Field Airport in Nashua is located in the BFB subwatershed, so there is potential for some of these activities to contribute to the pollutant load.

Residential roadways are not included because large commercial trucks transporting hazardous materials are not expected to travel on these roadways. However, the roads do increase the imperviousness of the watershed and add many non-point source pollutants.

In addition to spill risks, most roadways may also contribute general non-point source pollution including nutrients, heavy metals, oil and grease, and sediments from roadway sanding and salting.

Construction activities

Construction activities are considered potential pollution sources due to the potential for erosion and sedimentation. The land clearing during construction activities leads to reduced canopy cover from trees, resulting in rain directly contacting the soils, which increases stormwater runoff volume and velocity. Erosion is the result. Smoothing of land surfaces, compaction, increased impervious areas, and filling of wetland areas all combine to increase the amount of surface runoff. Therefore, suspended sediments and attached nutrients are transported to the streams.

6.0 Existing Protection Measures

Section Contents

6.1 Regulatory Protection ------ 6-1
6.2 Town Wide Land Use Controls ---------- 6-3
6.3 Land Ownership.....6-15
6.4 Pennichuck Water Works.6-15
6.5 Town Ownership.....6-16
6.6 Other Protective Measures6-17

In addition to the regulatory measures discussed in Section 3, there are many existing protection measures in place by Pennichuck Water Works and the local municipalities. This section provides information on:

- local regulatory controls including land use controls,
- regulatory controls, and
- land ownership, and other protection measures.

Additionally, the chain pond system lends natural protection to the water quality of the ponds by allowing pollutants to settle out through the natural detention that is offered. Unfortunately, this source of protection has decreased as the ponds fill in and sediments may eventually become a source of pollution.

6.1 Regulatory Protection

Local regulations help protect the Pennichuck watershed by controlling land use activities and limiting development in the watershed. Controls include zoning bylaws and ordinances, subdivision regulations, site plan reviews, and protection overlay districts.

Zoning

Zoning can be a useful protection measure by controlling the future development of specific areas. The degree of protection zoning provides is directly related to the type of zoning allowed within the watershed. For example, land uses with large impervious areas, such as commercial and industrial areas, are expected to contribute more stormwater runoff, which in turn results in a degradation of water quality due to the pollutants carried in the stormwater. Thus, areas zoned conservation will provide more protection than areas zoned industrial.

The most desirable zoning is conservation since it minimizes the impervious fraction of land and buffers the ponds from stormwater pollutants. Next is low-density residential zoning (>2 acre lots) which is also relatively desirable from a water quality standpoint, since the impervious area is kept to a minimum. As residential zoning becomes more dense (less than one acre lots) water quality impacts tend to increase from more cars, more roads, more pets and other sources of waste material. The least desirable zoning classifications are commercial and industrial, as these tend to have large parking lots and greater amounts of impervious areas resulting in large contributions. They also tend to produce the largest amounts of "unfiltered" storm water.

The chain pond system provides the best protection through natural detention. Open space, forested lands and low density residential zoning also provide some protection.

Zoning information was automated to produce a composite zoning map for the entire watershed (Figure 6-1). Zoning information from the five cities/towns was aggregated into the following categories: residential A (>2 acre lots), residential B (1/2 - 2

6.0 Existing Protection Measures

acre lots), residential C (< 1/2 acre lots), planned unit development, commercial, industrial, agriculture and business, residential and agriculture, and recreational.

Zoning can provide a good overview of the watershed and signifies buildout conditions, but in order to determine more effectively the area of protection already in place within the watershed, current planning restrictions can affect the outcome. For instance, when industrial and residential zoned lands are slated for development, concessions to provide buffers or other restrictions may be sought by local Boards, since the impacts on the environment and infrastructure may be significant.

Subdivision regulations can encourage cluster development, which tends to minimize imperviousness.

Subdivision Regulations

Subdivision regulations play an important role in providing protection for the watershed. They are enacted to protect the safety, convenience, and welfare of the inhabitants of the towns they relate to. Although they are not specifically geared towards protecting the water supply, many limit septic system use and/or development within areas of poorly drained soil; some require an environmental impact review; many require open space in any new developments, reducing the amount of impervious areas; stormwater runoff and drainage is tightly monitored; and in many cases, developments are not allowed in places subject to flooding, poor drainage, or other hazardous conditions.

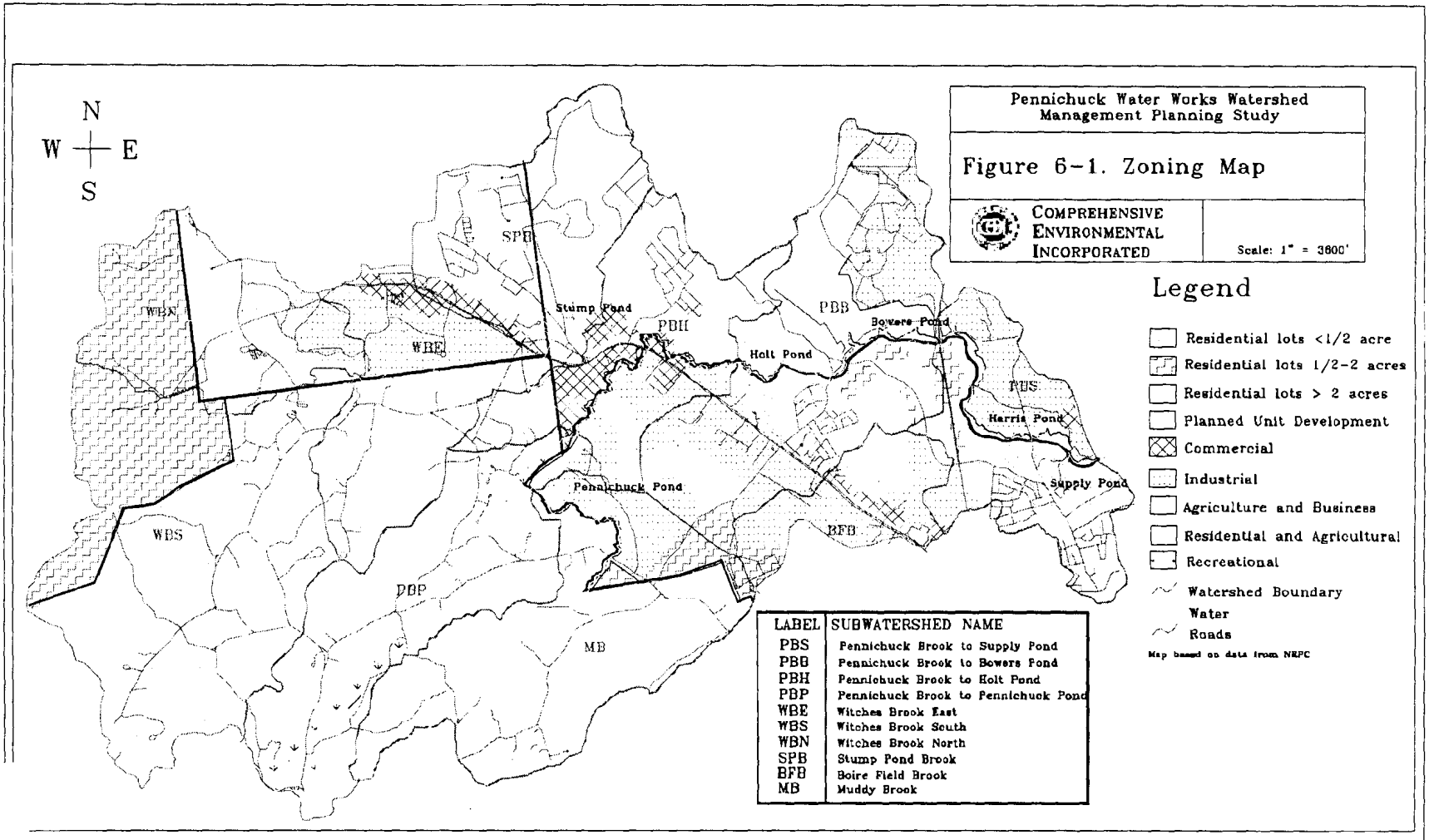
One way subdivision regulations can help protect natural resources is by encouraging cluster development, which requires the use of open space, decreasing the amount of impervious area and as a result, will also decrease stormwater pollution. Another method is to require that post-development groundwater recharge be equal to or exceed predevelopment discharge. Provisions included in the subdivision regulations for each of the towns is discussed in more detail below.

Site Plan Review

Site Plan Reviews offer a different type of protection. Site Plan Reviews are required for any significant development in all towns of the watershed. The intent is to encourage a desirable and compatible character of development within the towns. Most of these center on residential development and require an environmental impact study prior to construction. In most cases Site Plan Reviews require that developments provide adequate provisions for environmental factors such as pollution, odor, noise, and the protection of natural features and sediment and erosion control. Adequate provisions for solid waste and wastewater disposal are also required.

Protection Overlay Districts

Protection Overlay Districts provide specialized protection of wetlands, floodplains, water supplies, aquifers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W
E
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Pennichuck Water Works Watershed
Management Planning Study
Figure 6-1. Zoning Map
COMPREHENSIVE
ENVIRONMENTAL
INCORPORATED
Scale: 1" = 3600'
Legend
Residential lots <1/2 acre
Residential lots 1/2-2 acres
Residential lots > 2 acres
Planned Unit Development
Commercial
Industrial
Agriculture and Business
Residential and Agricultural
Recreational
Watershed Boundary
Water
Roads
Map based on data from NEPC
SPB
WBN
WBE
Stump Pond
PBH
PBB
Bowers Pond
Holt Pond
PBS
Harris Pond
Supply Pond
Pennichuck Pond
BFB
WBS
PBP
MB
LABEL
SUBWATERSHED NAME
PBS Pennichuck Brook to Supply Pond
PBB Pennichuck Brook to Bowers Pond
PBH Pennichuck Brook to Holt Pond
PBP Pennichuck Brook to Pennichuck Pond
WBE Witches Brook East
WBS Witches Brook South
WBN Witches Brook North
SPB Stump Pond Brook
BFB Boire Field Brook
MB Muddy Brook

6.0 Existing Protection Measures

and/or watershed protection. Each town within the Pennichuck watershed has specific overlay districts that provide additional protection for critical areas and/or resources within their towns. Where land in the watershed falls under these overlay districts, the protection may be increased.

Septic Systems

Septic systems are potential pollution threats, but if maintained properly, and set back from surface waters, the risk is significantly reduced. Both state and local septic system regulations are written to ensure this protection. Current septic system regulations within all the towns do not allow septic systems in inadequate soils. Some of the older septic systems however, may be ineffective, particularly for commercial / industrial use or in densely populated or shoreline areas.

The NH Code of Administrative Rules, Env-Ws 1008.03 states that the minimum setback distance of a septic tank from surface water must be 75'. In addition to this each town has additional regulations regarding the use of septic systems.

- Amherst, Milford, and Hollis all require approval of the NH Water Supply and Pollution Control for any proposed septic system.
- Merrimack's zoning ordinance states that all septic systems must be placed on the least severe soils on the lot. Also, septic systems cannot be located less than 20' from any property line.
- Within its residential districts, Milford requires larger minimum lot sizes where there is no access to public sewer. Lot sizes are also required to be larger where there are more severe soils. There are additional regulations regarding setbacks to the town wells, however, there are no additional setback requirements for other bodies of water.
- The Town of Hollis does not allow the placement of septic systems within 75' of the edge of a public body of water or from a well. They also require that soils are adequate to handle individual septic systems.
- Nashua has a minimum lot size requirement of 40,000 square feet where individual septic systems are proposed.

The undeveloped land surrounding the water supply provides a natural buffer.

6.2 Town Wide Land Use Controls

The zoning and subdivision regulations of each city/town were reviewed to determine the amount of protection provided through each of the cities/towns that make up the watershed. A review of the land use and zoning maps (Figures 2-2 and 6-1 respectively) reveals that much of the watershed is currently vacant or residentially developed (>2 acre lots) and/or zoned land. In addition, much of the land surrounding the water supply is owned and protected by Pennichuck Water Works, providing a natural buffer between the water

6.0 Existing Protection Measures

supply source and the developed areas of the watershed. However, a review of the zoning map reveals that considerably more dense development could be allowed through much of the watershed in the future.

Table 6-1 shows the percentage of each zoning designation in the watershed along with the level of potential protection it provides. The land directly abutting the ponds, brooks and streams are the most susceptible to pollution that leads to poor water quality.

Amherst requires that all drainage must be carried to existing watercourses.

- In Merrimack, roughly 43% of the land abutting the water supply is residential >2 acre lots, 36% is zoned industrial, and 21% is zoned commercial.
- In Nashua, 47% of the land abutting the ponds and streams is zoned residential 1/2 - 2 acre lots, 11% is zoned residential <1/2 acre lots, 36% is zoned industrial, and 6% is zoned commercial.
- In Hollis, the land directly abutting the ponds are zoned as recreation, the lands surrounding the streams are zoned residential and agriculture or residential > 2 acre lots.
- A small portion of Witches Spring Brook travels through an industrial zoned area of Amherst. Stump Pond and its tributaries are surrounded by residentially zoned areas > 2 acre lots.
- There is one stream within Milford that travels to the water supply. The land surrounding it is zoned residential 1/2 to 2 acre lots and is sparsely populated at this time.

Each of the towns' specific regulations is discussed in more detail below.

Amherst

Amherst divides its zoning bylaws into 13 types; Aquifer Conservation District, Commercial Zone, Flood Plain Conservation District, General Office, Historic District, Industrial Zone, Limited Commercial Zone, Northern Rural Zone, Northern Transitional Zone, Planned Office Development, Residential/Rural Zone, Wetland Conservation District, and Watershed Protection District. The land within the Pennichuck watershed is zoned as Residential/Rural, Industrial, and Commercial.

Subdivision Regulations

- Any new development requires a review of the impact on the environment and water supply.
- Any proposed septic system requires the approval of the NH Water Supply and Pollution Control.
- Alteration of any natural man made water course requires the approval of the NH Special Board or Zoning Board of Adjustment.
- Open space may be required in the residentially zoned areas of town. There is a provision within the subdivision regulations that

6.0 Existing Protection Measures

Table 6-1 Zoning Designations		
Zone	**Percent of Watershed**	**Level of Protection**
Residential - > 2 acre lots	30	Less dense residential lots provide less impervious areas for runoff to flow over. Of the three residential zones, this one is most preferable.
Residential - 1/2 - 2 acre lots	6.4	Residential zoning is preferable over industrial and commercial due to the amount of impervious area provided. The less dense the lots, the better the protection.
Residential - < 1/2 acre lots	3.1	Both dense residential and planned unit development areas have a greater amount of imperviousness than other residentially zoned areas. Since there is relatively little dense residential zoned areas in the watershed, these not pose a significant threat at present.
Planned Unit Development	1	
Recreation	2.4	Recreational uses often come with vast areas of open space or forest, which provide a buffer for potential pollutants to travel through prior to reaching the streams.
Residential/Agriculture	31.5	Residential agricultural land is the highest zoned area in the watershed. This zone provides some protection in that the residential lots cannot be less than 2 acres. If agricultural lands are well maintained and best management practices are used, this land will provide a good amount of protection.
Agriculture/Business	0.1	This land probably does not pose a significant threat because there is so little of it in the watershed. The zone is located in Hollis, on the border of Amherst. As it is not located adjacent to any streams the level of protection is good.
Commercial	3.2	Commercial and industrial lands provide little protection in the watershed. Impervious areas tend to be great, increasing the volume and velocity of runoff to the streams. State and local regulations provide some protection from industries and commercial areas, but the overall impact tends to be negative unless significant measures to reduce imperviousness and infiltrate stormwater from roofs and parking lots are taken.
Industrial	18	

states that if the Board deems it essential, a final plan must show an area of open space, not to exceed 15% of the total area of the land.

- Drainage must be carried to existing water courses.
- Excavation of soils is allowed with a permit in any district except the Historic District and the Wetlands Conservation District.
- Special Exceptions to the regulations are permitted as long as the proposed use will not adversely affect the groundwater of Amherst, particularly in the Aquifer Conservation District. Uses permitted by special exception include religious, nursing homes, elderly housing, multi-unit housing, private schools, hospitals, outside storage of equipment and materials, outside recreation, professional offices, funeral homes, sawmills and kennels.
- All land to be subdivided must be adequate for building without endangering the public health, safety or the environment.
- Land subject to flooding, poor drainage, or other hazardous conditions cannot ordinarily be subdivided.
- Land inadequate for sanitary sewage disposal cannot be subdivided.
- The preservation and protection of existing natural features should be given due regard.
- Planned residential developments allow for somewhat denser development than would otherwise be allowed. Open space is encouraged, at least 40% of the tract is required for open space.
- Mobile homes are allowed in all residentially zoned areas.
- A "right to farm" ordinance is included to protect farms and farming. Farming is permitted in all residentially zoned areas.
- Non-Residential Site Plan Reviews require adequate provisions for environmental factors such as pollution, odor, noise, and the protection of natural features. Adequate provisions for solid waste and wastewater disposal are also required.

Zoning Bylaws / Protection Districts

Floodplain Protection District: Permitted uses within the Floodplain Protection District, which do not result in the erection of any structures include: minor fences, docks, wharves, and boathouses; agriculture; forestry; recreation; golf; parking lots; driveways and roads; or other recreational use such that it does not contribute to pollution of ground or surface water; damage or destroy habitats; or disturb or reduce the natural cleansing features of the wetlands, streams, and floodplain areas.

Wetland Regulations: Wetlands are identified as poorly drained or very poorly drained soils. The intent of this regulation is to prevent the development of buildings and land use on naturally occurring wetlands which would contribute to the pollution of surface or ground waters; and to prevent the destruction

6.0 Existing Protection Measures

of natural wetlands which provide flood protection, recharge of groundwater supply, and augmentation of stream flow during dry periods. No wetland may be used to satisfy minimum lot requirements; no septic tank or leach field may be located closer than 75' to any wetland; and no structure shall be located within 50' of a wetland.

Water Pollution Control Regulations: These regulations are provided to prevent pollution in the water supply, surface and ground waters of the town by inadequate sewer or waste disposal systems. No buildings with on-site discharge are allowed without prior approval from the town, and the NH Water Pollution Control Commission. Procedures for test pits, perc tests, filling, installation and other specific requirements are included in these regulations, which are stricter than state regulations.

Hollis requires that all new subdivisions have provisions for sedimentation and erosion control.

Watershed Protection District This district is provided to control building and land use to prevent pollution of surface and ground water and to prevent the destruction of watershed areas that provide flood protection, recharge of groundwater supply or stream flow during dry periods. No septic systems and no buildings are allowed to be constructed within the watershed protection district.

Aquifer Conservation District This is to provide for the protection of the water resources from contamination by polluting hazardous, or toxic materials. The discharge of hazardous or toxic waste from industrial and commercial buildings is prohibited. Other prohibited uses include the outdoor storage of salt or deicing chemicals; solid waste or septage disposal sites; automotive repair shops; junkyards; on-site storage of hazardous or toxic materials; residential USTs; and filling stations or gas stations. Monitoring wells must be installed and tested for compliance with Drinking Water Standards monthly on industrial and commercial properties. The Board of Health controls the use of pesticides, herbicides, fertilizers, etc. No more than 70% of any lot may be rendered impervious within this district.

Hollis

Hollis divides its zoning bylaws into 11 different districts, the Agricultural and Business Zone, Flood Plain, Historical Center Zone, Industrial Zone, Mobile Home Zone, Recreational Zone, Residential and Agricultural, Rural Lands Zone, Trailer (Mobile Home) Park Zone, Water Supply Conservation Area, and Wetland Conservation Areas.

The land in the Pennichuck watershed is zoned as Rural Lands, Residential and Agricultural, Agricultural and Business, and Recreational.

6.0 Existing Protection Measures

Subdivision Regulations

- All subdivisions require a Site Plan Approval with provisions for erosion and sedimentation control.
- Drainage must be carried to existing watercourses.
- Open Space and Planned Development is included to provide for a more efficient use of land while protecting existing and potential water supplies, and while promoting the preservation of open space, farmland, recreationares, green space, fields and woods, valuable wildlife habitats, and natural and historic features.
- Soils must be adequate to handle individual septic systems.
- Excavation is prohibited within the water supply conservation, agriculture and business, recreational, historical, trailer park and mobile home districts. Excavation is also prohibited where it would pose a threat to a known major water supply; and beneath or adjacent to inland surface waters such that state and federal agencies require a permit.
- Uses permitted in the Mobile Home Zone, other than mobile homes, are farms, the sale of farm products, stables, subsidized housing for the elderly, open space and planned development, condominiums, and home occupations.
- Any development for the elderly must be within one mile of the Town Monument.
- Land along Silver Lake Road and Ames road is zoned Agriculture and Business. Buildings in the commercial areas used for commercial purposes shall occupy no more than 50% of the lot upon which they are located. Twenty percent of the total lot area must be landscaped open space. No outdoor storage of any material shall be permitted, except within enclosed containers and/or visually screened areas.
- A recreational zone exists within 600' of the shores of Silver Lake, Pennichuck Pond, and Rocky Pond. This zone is intended to allow residential and recreational development around local bodies of water while protecting water quality and the recreational aspects of the area. Permitted uses include single and two family dwellings; farming; open space and planned development; condominiums; and home occupations. Publicly owned parks, playgrounds, golf courses, pools, and libraries as well as privately owned golf courses; country clubs; pools; tennis courts and fishing lakes and clubs are acceptable with a Site Plan Approval from the Planning board within this district.

Hollis subdivision regulations call for stormwater to be carried to existing watercourses.

Zoning Bylaws / Protection Districts

Open Space: Buildings in the industrial and commercially zoned districts cannot occupy more than 50% of the lot they are located on.

6.0 Existing Protection Measures

Floodplain Protection District: Assurance must be provided to the Building inspector that water and sewer systems are designed to minimize or eliminate infiltration of flood waters into the system or discharge of wastes into the flood waters. On-site disposal systems must be located to avoid impairment to them or contamination from them during periods of flooding. Section 404 of the Federal Water Pollution Control Act must be complied with. Prior to the alteration or relocation of a watercourse, the Wetlands Board of the NH Department of Environmental Services must be notified.

Along watercourses with a designed Regulatory Floodway no encroachments, including fill, new construction, substantial improvements, or other development are allowed within the floodway that would result in any increase in flood discharge.

Industrial: Prohibited uses in the Industrial Zoned districts include: abattoir operations, any use which consumes large quantities of water or which requires special waste treatment; cremation; electroplating; industrial fermentation; kiln firing or drying of materials other than wood; leather tanning or processing; manufacture, compounding, or processing of chemicals; manufacture of charcoal; manufacture or compounding of solvent, water or oil based paints, varnishes or coatings; petroleum or tar refining or processing; recycling of metals, organic, or inorganic chemicals; smelting or melting of metals and ores; synthesis or blending of artificial or natural fertilizers; and stockyards and feed lots. No waste may be stored which may cause the leaching of chemicals or other pollutants into the surrounding water table or surface runoff, or the emission of toxic or harmful gases within these areas. Fluid discharges from the plants must be adequately treated so as not to pollute the surrounding water table or surface runoff.

Wetlands: Structures and fill activities are prohibited in wetland areas. No septic tanks or leach fields are to be located within 75' of a wetland boundary. No residential, commercial, or industrial use will be allowed that requires the filling of wetlands.

Water Supply Conservation District: The only uses permitted in this zone are single family dwellings, forestry, and wildlife refuge. No septic tank or leach fields are allowed within 150' of a wetland or other standing water.

Aquifer Protection Zone: This is an overlay intended to protect, preserve, and maintain existing and potential ground water supply and ground water recharge areas. Prohibited uses include the handling, treatment, storage, and disposal of hazardous wastes; subsurface storage of petroleum; disposal of solid waste or liquid or leachate wastes; storage of road salts; dumping of snow; commercial animal feedlots; excavation of sand or gravel; auto repair shops or junk yards.

6.0 Existing Protection Measures

Merrimack

Merrimack divides its land into 12 zones: Residential District, Limited Commercial District, General Commercial District, Industrial District (3 types), Wetland Conservation District, Flood Hazard Conservation District, Elderly Zoning District, Planned Residential District, Aquifer Conservation District, and the Shoreland Protection District.

Within the Pennichuck watershed, Merrimack is divided into Commercial, Residential, and Industrial Districts.

Subdivision Regulations

- A Site Plan Review is required for all developments other than a single residential dwelling.
- Cluster Residential Developments are used to promote the conservation of the natural environment, and to promote uses in harmony with the natural features of the lands. Wetland and flood plain areas are not to be included as buildable acreage within this district. Public water and sewer must serve all dwellings within this zone. Provisions are included that require the protection of the environment from factors such as pollution, noise, and odor.
- Mobile home parks are allowed in any residentially zoned district.
- Elderly housing must be located within 1 mile from the intersection of Daniel Webster Highway and Baboosic Lake Road, or within a 2-mile radius of the intersection of Daniel Webster Highway and Baboosic Lake Road east of the turnpike. Public water and sewer must serve dwelling units.
- Planned Residential Developments are intended to allow higher density housing in areas where public water and sewer are available. Provisions are included for environmental factors such as pollution, noise, odor and the protection of natural land features. No septic systems are allowed in these districts.
- Underground storage tanks are prohibited in all areas unless suitable secondary barriers and automatic alarm systems are provided.
- Excavation is permitted pursuant to Chapter 155-E Sections 1-11 inclusive of the NH Revised Statutes Annotated.
- Proposed individual septic systems require approval from the NH Water Supply and Pollution Control Commission. Septic systems must be located more than 20' from the property line and placed on the least severe soil on the lot.
- Closed storm drainage systems with an outfall into a wetland or water body are required to flow along a grassed swale prior to outfall.

Merrimack requires stormwater from closed pipe structures to flow along a grassed swale before discharging to a wetland or water body.

6.0 Existing Protection Measures

Zoning Bylaws / Protection Districts

Shoreland Protection District This district includes all land located within 250' of the reference line of surface waters including but not limited to Bowers Pond, Holts Pond, Harris Pond, Pennichuck Brook, and Pennichuck Pond. Prohibited uses include salt storage sheds, junk yards, solid or hazardous waste facilities; the use of fertilizer; bulk storage of chemicals; sand and gravel excavations; and snow dumps.

In Merrimack, the developer is responsible for paying for all downstream drainage improvements necessary for handling the additional flow of the drainage from a subdivision.

Where existing, natural woodland buffers must remain within 150' of the reference line (high water mark). The leaching portions of septic systems should be set back from the reference line at least 75'-125' depending on the soils of the area, whether or not there is a natural woodland buffer. Erosion and Sedimentation Control is required in the district; disturbance of a contiguous area greater than 50,000 square feet requires a permit from the NH DES. New lots with on-site water or sewage must have a minimum frontage of 150' from the shoreline whether or not there is a woodland buffer. No building shall be located within 50' of the shoreline. Impervious areas cannot exceed 20%. Agriculture uses are permitted provided best management practices are conformed to.

Aquifer Conservation District: The purpose of this district is to protect and preserve the existing groundwater supply and recharge areas of the town. Industrial and commercial uses are allowed provided no on-site discharge occurs. Prohibited uses include the disposal of solid, liquid and leachable wastes; USTs within 1000' of an existing municipal well; outside storage of road salt; snow dumps; commercial animal feed lots; mining of land; on-site despoil or processing of hazardous waste; auto repair shops or junk yards; underground brush or stump dumps; trucking and bus terminals; airports; and car washes. All subdivision proposals and site plan reviews must be reviewed by the planning board to assure that the proposed use is consistent with the need to protect the groundwater and the sewer systems are designed to minimize or eliminate leakage or discharges from the system. The Conservation Commission is also required to review developments within the Aquifer Conservation District.

This District was recently modified in terms of area covered and restrictions. New regulations are currently in process.

Junkyards: New junkyards are prohibited unless provision is made for monitoring wells of surface and subsurface groundwater for hazardous waste and/or toxic substances.

Wetland Conservation District: No construction is allowed within the district. Permitted uses include

6.0 Existing Protection Measures

forestry; agriculture; water impoundments; drainage ways; conservation areas; parks; wildlife refuges; open space; streets and utility rights of ways if necessary.

Flood Hazard Conservation District: Restrictions in Zone A flood area include prohibiting construction and the use of fill that would cause any increase in the base flood level. The removal of soils is prohibited. All industrial chemicals or hazardous materials located in the A zone shall be stored in flood proof containers or stored at elevations higher than the 100 year flood. Those located in the B zone should be stored at elevations higher than the 500 year flood elevation.

Open Space: No more than 50% of the land reserved as open space shall be wetlands or swamp areas. There is also a section within the ordinance that encourages the preservation of existing features.

Milford

Milford is divided into 7 districts with 3 overlay districts. The seven districts include Residence A, Residence B, Residence R, Commercial, Industrial, Limited Commercial, Integrated Commercial/Industrial District. The overlay districts include the Aquifer Protection District, the Wetland Protection District, and the Floodplain Management District. Land within the watershed in Milford is Zoned as Residence A, and Residence R.

Subdivision Regulations

- All subdivision proposals will undergo a planning board review and require an environmental impact statement.
- A soil erosion and sedimentation control plan is required for all site plans and subdivisions.
- Any proposed septic system requires approval from the NH Water Supply and Pollution Control Commission. Adequate information must be provided to ensure that soils are suitable to handle a septic system.
- In developments where septic systems are proposed, a soil scientist is required to determine the suitability of the soils. A 4000 square foot designated leachfield area or an area two times the required size must be reserved on each lot. Leachfields must be set back 100' from any water body.
- The alteration of any natural or man made water course requires approval from the NH Special Board or Zoning Board of Adjustment.
- The board may require a park (open space) before approval of a plan if it deems it necessary.
- High Intensity Soil Maps are required to be provided for wetland, septic, or drainage reasons.
- A permit is required for the removal of earth on any lot.
- Mobile home parks are allowed where adequate water and sewer facilities exist.

6.0 Existing Protection Measures

Zoning Bylaws / Protection Districts

Special Flood Hazard Areas: All development proposals will be reviewed to determine whether such proposals will be reasonably safe from flooding.

Residentially Zoned (A&B) - Uses specifically prohibited in the residentially zoned areas include manufactured housing, solid waste disposal sites, junk yards, and communication towers. Lots not serviced by both municipal sewer and water must have a minimum area of 40,000 square feet or larger depending on soil and slope conditions.

Milford requires that in the Aquifer Protection District, the onsite discharge of stormwater be maximized through leaching catching basins, piping and detention ponds.

Open Space - Open space is required except for in single family and two family dwellings. At least 30% of a lot area must be deemed open space.

Residential R - Uses excluded in this section are the processing of natural resources and junk yards. The purpose of this zone is to provide for scattered, low-density development, primarily residential and/or agricultural.

Cluster Open Space Developments - The intent of these developments is to promote the conservation of the natural environment and the development of community uses in harmony with the natural features of the land. These are permitted in residentially zoned areas of the town. Cluster developments must be constructed on land at least 5 acres in size if both municipal water and sewer are available and on at least 20 acres of land if both municipal water and sewer are not provided. In no case is the minimum lot size required less than that necessary to ensure adequate sewage disposal and water supply according to natural site conditions of soil type and slope of land. At least 50% of the total tract area must be reserved as common open space.

Aquifer Protection District - This district is provided to protect, preserve and maintain the existing and potential groundwater supply and groundwater recharge areas within the town; to conserve the natural resources of the town; and to prevent pollution of the environment. Many uses are prohibited in this district such as: disposal of solid waste; disposal of liquid or leachable waste, discharge of contact type process waters on-site; outside unenclosed storage of road salt; dumping of snow containing deicing chemicals; commercial animal feedlots; on-site disposal or processing for recycling of hazardous or toxic materials or liquids; junk yards; filling stations; and tank farms storing petroleum and/or toxic materials.
All subdivision and site plan approvals are contingent upon consistency in protecting the groundwater of the town and adjacent communities; sanitary sewers are designed to minimize or eliminate leakage or discharges from the system; on-site waste disposal

6.0 Existing Protection Measures

systems are located so as to avoid groundwater and environmental contamination; streets, roads, etc are constructed so that only minimum direct application of road salt is required for winter safety and so that runoff is channeled to minimize groundwater contamination; floor drains must be connected to the sanitary sewer system; outside storage of hazardous material shall not be directly exposed to the elements and shall be approved by the fire and building departments. An environmental impact statement may be required and a fire department approved, hazardous material contingency plan dealing with the storage and handling of toxic materials must also be developed.

Wetlands Conservation District - The purpose of this district is to protect the wetlands and their buffer zones; to reduce sedimentation of wetlands and bodies of water; to aid in control of non-point pollution; to provide a vegetative cover for the filtration of runoff; to protect fish and wildlife; and to control the development of land, structures and land uses that contribute to the pollution of surface and groundwater. No construction is allowed within 25' of the edge of wetlands. No construction within 50' of ponds and watercourses.

Permitted uses include: conservation areas, nature trails and wildlife refuges; parks and recreational areas; open space; forestry and tree farming; agriculture; and monitoring wells for observation purposes. Uses permitted in buffer areas only include: seasonal docks, buildings and structures not to exceed 120 square feet and without plumbing and electricity; and potable water supply wells. Many other uses are permitted with a Conservation Commission Review, such as bridge crossings and filling or dredging of swamps and wet meadows.

Floodplain Management District - This district is provided to minimize losses due to flood conditions. All proposed developments in this district require a special permit. Sanitary sewer systems must be designed to minimize or eliminate infiltration of flood waters into the systems and discharges from the system into floodwaters. On-site waste disposal systems will be located to avoid impairment to them or contamination from them during periods of flooding. Prior to the relocation or alteration of a watercourse the applicant must notify the Wetlands Board of the NH DES and the flood carrying capacity of the altered course must remain equal to the existing course. No new construction, substantial improvements or fill is allowed on designated regulatory floodways.

Milford requires an erosion and sedimentation control plan for all subdivisions.

Prior to development, applications will be considered for technical evaluations and standards including danger to life and erosion damage; importance of services provided to the community by the development; necessity of a waterfront location; availability of alternate locations; and safety of access in times of flood. No variance will be issued if there is an

increase in flood elevation due to the development.

Nashua

Nashua is also divided into many districts, districts including Rural Residence, A Suburban Residence, B Suburban Residence, C Suburban Residence, A Urban Residence, B Urban Residence, C Urban Residence, Local Business, General Business, Central Business, Highway Business, Park Industrial, General Industrial, Airport Industrial, Historic Overlay, Planned Residential Development Overlay, and Mixed Use Overlay.

Nashua can require studies to determine the effect the proposed subdivision may have on the surrounding environment.

Districts included in the Pennichuck Watershed are Planned Residential Development, General Business, General Industrial, Airport Industrial, A Suburban Residential, B Suburban Residential, and C Urban Residence.

Subdivision Regulations

- The board may require studies to determine the effect the proposed subdivision may have on the surrounding environment.
- An approval letter from the NH Water Supply and Pollution Control is required to ensure that proper erosion and sedimentation control measures are adequate to prevent water pollution.
- The NH Wetlands Board must review and approve of plans under the Site Plan Review regulations.
- Open space may be required by the board in developments within the residentially zoned districts.
- Septic systems: individual lots must be 40,000 sq.ft. and at least 500' from an existing gravity flow public sewer. Engineering data on soils, slopes and depth to bedrock, and perc rates are required by the board of health to ensure that potential pollution effects will not negatively effect the public health.
- The board of health must approve any subdivision plans with regard to drainage, water supply and sewage prior to development.
- Excavation requires a special permit in residential and industrial areas and is prohibited elsewhere.

Zoning Bylaws / Protection Districts

Floodplain Development: Special exception permits are required for development in these areas. Proper design must be included to prevent flood damage to structures and minimize the impact on water level.

Wetlands: Protects the wetlands and habitats within. Many of the Pennichuck watershed areas are included as critical wetlands in this section. A fee of $400 is required to request a variance to fill wetlands and/or floodplains. Common land requirements have provisions to protect wetlands and other natural areas.

6.0 Existing Protection Measures

Mobile Homes: No disposal of sewage or other discharge of liquid waste is permitted unless piped directly to the city sewer line. No dry or chemical toilet is allowed unless it is sewer connected.

Junkyards: Junkyards are only allowed in industrial areas with a special permit.

6.3 Land Ownership

Owning land for the purpose of conservation of natural resources is important to the protection of a water supply because it prevents development that has the potential to decrease water quality. Section 7 contains a buildout scenario to show the effect complete development of the watershed will have on the quality of the water.

Pennichuck Water Works and the local conservation commissions both own land within the watershed. The Society for the Protection of NH Forests owns land in some southern NH towns, but not within the Pennichuck watershed.

6.4 Pennichuck Water Works

Pennichuck Water Works owns some land surrounding Supply Pond, Harris Pond, Bowers Pond, and Holts Pond. Past use of Pennichuck's land holdings has been for the purpose of water quality protection. The land has been maintained in its natural vegetated state. Figure 6-2 shows the amount of protected land in the watershed.

The buildout analysis in Section 8 shows four scenarios, two with conservation land maintained as forested or open land, and two with conservation land allowed to develop into its zoning designations. There is not a significant difference in the pollutant load from those with conservation and those without. This is because only the Pennichuck owned lands were maintained as conservation land in the buildout analysis, and the quantity of land is small in comparison to what can be built out. A more significant difference would be noted if the amount of conservation land owned by Pennichuck Water Works or others were larger. Although there is not a signficant difference in the phosphorus loadings from the buildouts with and without conservation, the existing Pennichuck owned lands should be conserved to minimize the impacts of urbanization and to provide an adequate buffer to the chain ponds and their tributaries.

Owning land for the purpose of conservation of natural resources is important to the protection of a water supply because it prevents development that has the potential to decrease water quality.

However, should Pennichuck have to develop their land, the order in which they should sell, by subwatershed is:

6.0 Existing Protection Measures

1. Muddy Brook,
2. Pennichuck Brook to Holt's Pond; Nashua, south of Rte 101A
3. Pennichuck Brook to Pennichuck Pond
4. Pennichuck Brook to Holt's Pond; Merrimack
5. Pennichuck Brook to Bowers Pond; Nashua, south of Rte 101A
6. Boire Field Brook
7. Pennichuck Brook to Bowers Pond; Merrimack
8. Pennichuck Brook to Supply Pond

There is a significant level of protection provided by both the Pennichuck owned lands and the town-owned lands that are located near the ponds.

Note, however, that there is an expected negative impact on water quality from this development of currently preserved lands.

6.5 Town Ownership

The conservation commissions in each town were contacted to determine if any additional land was owned within the watershed. As can be seen in Figure 6-2, a significant amount of land is owned adjacent to the chain ponds and their tributaries. Town owned protected land provides additional protection to the watershed.

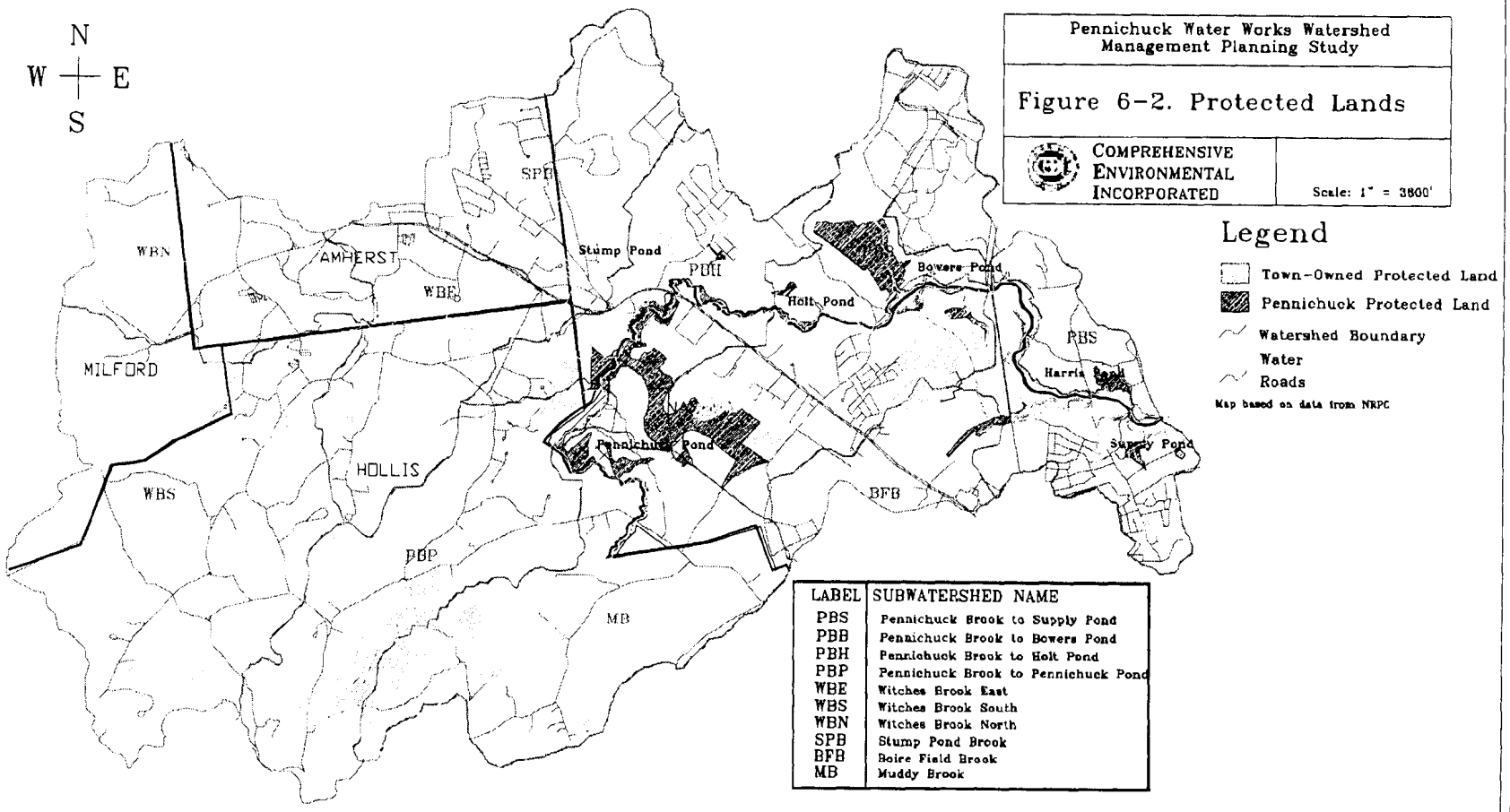
Amherst

The Town of Amherst Conservation Commission does own some land, however, it does not own any land within the Pennichuck Watershed.

Hollis

The Town of Hollis Conservation Commission owns approximately 340 acres within the watershed. All of these lots are kept as protected forested land. These lands are scattered throughout Hollis as shown on the Land Ownership Map (Figure 6-2). Below is a list of these lands.

- 2.96 acres on Laurel Hill Road
- 8.47 acres of cave land off Witches Spring Road
- 3.18 acres off Mooar Hill Road
- 5.12 acres off Witches Brook Area
- 2.43 acres off Sanderson Witches Brook
- 13.6 acres off Witches Spring Road
- 3.49 acres off Alsun Drive
- 32 acres, Pennichuck Land
- 7.6 acres owned by Jerry Collier, unbuildable lot, bog land
- 29 acres off Oakwood Drive
- 14.9 acres of Town forest off Silver Lake Road
- 2.23 acres of open land off Arbor Lane
- 4.0 acres off Mooar Road
- 1.0 acre off Mooar Road
- 1.16 acres off Pennichuck Drive
- 1.93 acres off Forrence Drive
- 1.3 acres off Farley Road
- 4.23 acres off Forest View Drive
- 2.43 acres off Federal Hill Road
- 3.64 acres off Silver Lake Road
- 114 acres; Spalding Park Town Forest off Farley Road
- 8.5 acres of Pennichuck land off Farley Road
- 10 acres off Hardy Lane - Windmill Lot
- 29.2 acres; Sterns lot / Parker Pond Brook



Pennichuck Water Works Watershed Management Planning Study

Figure 6-2. Protected Lands

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

Scale: 1" = 3600'

6.0 Existing Protection Measures

- 1.06 acres off Farley Road
- 8.63 acres surrounding Forest View Drive
- 4.5 acres between Forest View and Federal Hill Drive
- 11.7 acres North of Baxter Road
- 7.5 acres off Nartoff Road

These lands provide significant protection.

Merrimack

The Town of Merrimack owns many lots within the watershed. Two of these lots are protected lands. Both of these parcels are off Naticook Road. Locations of these can be found on the Land Ownership Map.

- 4.2 acres located at 2 Joey Road is currently being used as open space.
- 0.45 acres on the corner of Naticook Lane and Lorraine Road, is currently undeveloped land behind the fire station.

Milford

The Town of Milford does not own any land within Pennichuck Watershed.

Nashua

The City of Nashua currently has an Open Space Plan. Within the Pennichuck Watershed approximately 114,600 acres of land are owned as Open Space. Location of these areas can be seen on the Land Ownership Map. A general breakdown of these areas and who they are owned by is as follows:

- Homeowners Associations, 53,846 acres (47%)
- Private owners, 31,366 acres (27%)
- The City of Nashua, 19,655 acres (17%)
- Nashua Park Commission, 3,779 acres (3.2%)
- Audubon Society of NH, 3,398 acres (2.9%)
- Nashua Assembly of God Church, 2,038 acres (1.4%)
- The State of NH, 179 acres (less than 1%)
- The Nashua Airport Authority, 161 acres (less than 1%)

There is a significant level of protection provided by both the Pennichuck owned lands and the town-owned lands. Keeping these lands undeveloped will minimize the impacts of future development significantly as shown in Section 7.0. It is in the best interest of the water supply to keep these lands undeveloped. The purchase of additional lands will also increase the level of protection.

To minimize the pollutant loads, Pennichuck and the towns must conserve the existing lands.

6.6 Other Protective Measures

In addition to the many protective measures already occurring on a local and state level, watershed regulations exist for many water suppliers around the state. These are currently in the process of being updated. Current regulations for Pennichuck's water supply were written in 1934. There are many issues that need to be addressed in the updated regulations such as:

6.0 Existing Protection Measures

- Is a 250 foot buffer sufficient?
- Should there be a regulation on the amount of phosphorus loading due to development?
- Should policies on recreational uses of watershed land be more/less strict?
- Is a rule regarding the dumping or discharging of waste into tributary storm drains necessary?

Currently, the New Hampshire Department of Environmental watershed regulations (Env-WS 386.50) that deal with the protection of Pennichuck Pond, Pennichuck Brook Watershed, and Witches Spring Brook Watershed consist of 7 regulations:

1. No buildings where animals are kept can be built within 75 feet of these waters.
2. No wastewater, wash water, or sewage can be dumped into these bodies of water or within 75 feet of these bodies of water.
3. No dead animals or food scrapings can be thrown within 75 feet of these waters.
4. None of the above buildings or waste can be built beyond 75 feet of these waters if it is detrimental to said waters.
5. No sawdust or other waste from cutting timber can be thrown or allowed to fall into these waters.
6. No matter, waste, or materials mentioned above may be allowed to remain upon the ice of these waters.
7. No person shall bathe or swim in said ponds or brook.

Proposed updates of these regulations include:

- Increasing the 75 foot buffer to 250 feet in all sections.
- Prohibiting the dumping of hazardous waste and chemical waste.
- Prohibiting the application of fertilizers within 250 feet.
- Monitoring the application of pesticides.
- Prohibiting people from boating or other recreational activities on Pennichuck Brook below Holt dam, and disallowing boats or other recreational devices using motors powered by petroleum or other chemicals on Pennichuck Pond, Pennichuck Brook above Holt dam, or on Witches Spring Brook or its tributaries.
- Prohibit the use of aircraft on waters or ice.

Should these amendments be added to Pennichuck's Watershed Regulations, they will provide additional protection to the supplies. Further recommendations are discussed in Section 8.

7.0 Buffer Zones

Section Contents

7.1 What is a Buffer 7-1
7.2 Buffer Zones (Stages) 7-2
7.3 Buffer Widths..... 7-2
7.4 Ideal Buffers..... 7-3

As discussed in Section 5.0 nutrients, sediments and other pathogens contribute to general water quality degradation over time.

There are several BMPs that may be implemented to minimize the degradation impacts of these contaminants. Among the available BMPs is the use of buffer zones. Buffer zones are a critical component of any watershed protection program because of their implementability at any location, whereas several of the other available BMPs require specific site criteria in order to be used.

This section focuses on the use of buffer zones to reduce degradation impacts of water bodies.

7.1 What is a Buffer?

A buffer is a strip of land, surrounding a surface water body including tributaries, ponds, lakes and reservoirs. A buffer typically consists of land left in its natural state to provide protection from non-point source pollution including sediments, nutrients, heavy metals, toxics, pesticides, pathogens, salt and thermal pollution by providing a filter for these contaminants. They also provide a pervious area for recharge in otherwise impervious watersheds and help with bank stabilization and to protect riverfront habitat and the river ecosystem.

It is important to note, though, that buffer zones by themselves have had mixed success where used. In most cases, the buffer zone requirements were not defined, and the buffer was much less effective in practice than planned. For example, in a survey of 36 communities around the U.S. (Heraty, 1993) only half of the communities required that buffer boundaries be clearly shown on clearing/grading and sediment control plans.

In the suburban buffers, contractors often encroached or disturbed the buffer during construction and since the buffers were rarely placed on local maps, no management or inspection ever occurred. Few were maintained. The boundaries often became invisible to the property owner with the result that buffers often became part of the residential or commercial landscaping or lawn. Many were then used for non-beneficial activities unrelated to the original purpose of the buffer.

In many cases, buffer disturbances included tree removal, trampling and foot trails, filling, encroachment, dumping of yard wastes, erosion by stormwater runoff and conversion into lawns. Only five percent of the buffer zones established in 36 communities were maintained (Kirk, F.S., 1991).

The above referenced study emphasizes that to achieve the best results with a buffer zone, they need to be controlled and maintained.

In spite of these problems, buffer zones can be a good way to provide initial protection for the chain ponds, their tributaries and wetlands. The vegetation in the buffer zones can provide protection from nutrients due to plant uptake. Additionally, in agricultural areas, these buffer zones can help prevent agricultural uses directly adjacent to streams and wetlands by keeping animals away from the water (if fenced) in turn decreasing the amount of pathogens that are able to come in contact with water. The removal of contaminants

7.0 Buffer Zones

is dependent on how the buffer is setup, its vegetation, soils and slope.

Buffers are also helpful in alleviating pollution by providing an area for infiltration. Infiltration of drainage water through soil filters nutrients, pathogens and sediments.

7.2 Buffer Zones (Stages)

Effective buffers are usually divided into three zones; the streamside zone, the middle zone, and the outer zone. Each performs a different function,

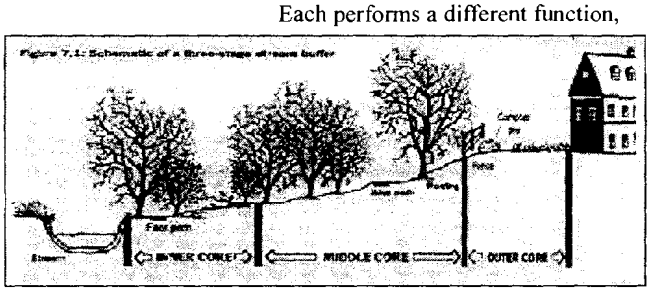


Figure 7-1. Three Zone Buffer, Schueler, 1994.

and has a different width and management scheme (Schueler, 1994).

1. The zone directly adjacent to the stream is called the streamside zone. Its purpose is to protect the physical and ecological integrity of the stream ecosystem by providing shade and leaf cover. The most effective streamside zones are those with mature, native trees.
2. A middle zone is a width of managed forest for control of pollutants in subsurface flow and surface runoff through biological and chemical transformations, storage in woody vegetation, infiltration, and sediment deposition.
3. An outer zone, sometimes considered the buffer's buffer, extends from the forested area to the nearest permanent structure or land use. In most cases this is a grassed or turf area, that acts as a level spreader to change concentrated flow into sheet flow and to help settle sediment and attached pollutants. This zone is particularly important to achieve optimal removal of pollutants through a buffer zone.

7.3 Buffer Widths

An extensive literature search found no consensus on the widths necessary to protect surface waters. Most studies have been site-specific and designed for a particular problem (sedimentation, nutrient removal). Widths used by various agencies and municipalities or recommended by various studies are compiled in Table 7-1. Buffer widths relative to nutrient and sediment removal range from 50 feet to 500 feet, depending on the sensitivity of the water resource and the land use associated with it.

There are many factors affecting the width of buffer strips. Silty loams and highly organic soils are highly erosive and may need larger buffer strips to provide adequate protection. Soils such as sand and gravel allow pollutants to percolate easily and quickly, reducing the amount of pollutants that enter the streams in stormwater, but potentially affecting groundwater baseflow in streams.

Another factor of concern is slope. The greater the slope the faster the water flows over the surface. Faster flow decreases the time for infiltration and causes more erosion. Studies show that slopes of 10% or less (Channing Kimball, 1993) work best

to minimize non-point source pollution. Other studies suggest that 1-2 feet of width should be added for every 1% increase in slope (Channing Kimball, 1993). Still others suggest that for steep slopes (5-25%), four additional feet of buffer width should be provided for every extra percent of slope over 5% (Schueler, 1995). The most effective buffers are flat. Use of topographic maps and site visits can confirm the slope of the land.

The best buffer width is thus dependent on a number of site specific factors. A summary of various filter strip studies is shown on Table 7-2. Summaries of the types of models that have been used to predict or calculate buffer strip widths are shown on Table 7-3. None of these are probably appropriate to the Pennichuck watersheds and are presented as reference because they are either focused on pollutants such as pesticides and/or were conducted in other areas of the country that are significantly different in topography, soils and vegetative characteristics.

Although it is difficult to identify a single "best" buffer width, a general guideline for sensitive water supply watersheds is a minimum of 400 feet, with a minimum of 200 feet from tributaries or wetlands that are directly connected to the water body. These widths are used in Massachusetts for all water supplies (See Cohen Bill, Appendix I).

In areas of steep slopes, the buffer may need to be larger while there may also be cases where it could be smaller, for example, where the developer can infiltrate most runoff and the site is flat.

In any buffer, it is critical that runoff not bypass, short-circuit or channelize, since this would reduce or eliminate its effectiveness. Protective measures are described below.

7.4 Buffer Criteria

As described previously, buffer zones have been used around the country for many years, but with mixed success. In many cases, the buffer zones have suffered encroachment that rendered them ineffective. Consequently, a good buffer zone would have more than just an adequate width for treatment of runoff. Some of the characteristics of properly functioning buffer zones are described below:

1. Dense Vegetation. The vegetative cover of the buffer zone is probably the most critical aspect of its proper operation and effective removal of pollutants, whether they are nutrients, pathogens or pesticides. Dense forested buffers that have remained undisturbed for at least the last ten years are generally recognized as the best vegetative cover. This is in part because forested areas provide streamside shade, wildlife habitat, a dense root system for bank stabilization and nutrient uptake in addition to the pollutant removal capabilities of other types of vegetative buffers.

Effective Buffer Zones
1. Dense Vegetation
2. Flow is not channeled
3. Infiltration is high
4. Protection from encroachment
5. Annual Inspections

The understory is also important, highlighting the importance of not mowing beneath the trees. A natural understory is typically

considered most desirable, but plantings could also be effective.

A mixture of shrubs, trees and other smaller vegetation could also provide an effective buffer. In many areas, grassed buffers have been used, with either infrequent or no mowing. A grassed buffer would provide some pollutant removal capacity and bank stabilization, however little shading would occur and the infiltration rates are not reported to be as high as for forested buffers.

The best infiltration and pollutant removal is found in soils with high organic content and a layer of forest duff on the surface.

2. Flow is not channelized. The second most important characteristic of a good buffer zone is that flow is not channelized within the buffer zone. If flow does channelize, then the buffer zone is effectively short-circuited, with little effectiveness at pollutant removal. Water should enter the buffer zone as sheet flow, and level spreaders may be required in some areas. If there is the potential for sheet flow to begin to channelize further into the buffer zone, check dams with level spreaders can be used to correct the problem. Maintaining sheet flow becomes more problematic as buffer zone slopes increase. In steeper slopes, it is likely that other infiltration measures will need to be added to the buffer zone for it to be effective. These must be developed on a site-specific basis.

3. Infiltration is high. Buffer zone soils are also critical to the equation. Although nearly any soil can provide a buffer zone, those soils with a high clay content or those that are mostly gravel may require increased buffer widths for effective performance at pollutant removals. The best infiltration and pollutant removal is found in soils with a high organic content and a layer of forest duff on the surface. Forest duff has been found to be one of the most significant factors in the effectiveness of forest buffers at pollutant removal. This suggests that more mature forests provide better pollutant removal capacities than do more recently disturbed forests.

The organic component of the soil is also important for two reasons. First, natural organic soil components such as leaf and other decomposed materials provide sites for absorption and adsorption of many pollutants. Second, a healthy soil with lots of wild microorganism activity provides many microorganisms that will prey on pathogenic organisms introduced by runoff. This may reduce the longevity of some of the pathogenic organisms that the buffer is designed to remove.

This type of soil also provides a good base for a healthy and dense vegetative cover, one that will take up many of the nutrients introduced by runoff. More gravelly and sandy soils can also provide a buffer zone, however, the width should be increased to account for the lower pollutant removal capabilities in spite of high infiltration capacity. In clay soils, the buffer zone width must also be increased and in some

7.0 Buffer Zones

cases these areas may not be suitable for buffer zones.

4. Protection from encroachment. In a study of buffer zones across the United States, Heraty, 1993, found that nearly all of the buffer zones studied in 36 communities had suffered from some encroachment. The encroachment ranged from clear cutting to lawn conversion to dumping and bike trails. In many cases, the encroachment encouraged channelized flows and rendered the buffers useless. Based on a review of this and other literature, the most important factors in preventing encroachment included:

   - Fencing. Although fencing can be expensive for large buffer zones, it is particularly important where livestock are an issue. The term "good fences make good neighbors" is very true for buffer zones.

     Fencing of buffer zones should be used wherever livestock can gain access to the buffer zone without it, and across areas where vehicle access may be problematic. If pedestrian access is to be allowed for local pathways, pathways must be constructed such that they do not create channelized flow. Fencing should also accommodate the pedestrians while blocking access to vehicles. If cattle or other livestock must cross a stream, fenced bridges should be provided that prevent the animals from entering the water and control drainage as much as possible, providing infiltration for drainage from the crossings.

   - Signage. Signage should be provided at the buffer zone fence line to inform nearby landowners and others of the buffer zone's status and restrictions. Any passive recreational trails should also be signed to indicate their appropriate usage. Signage should also include telephone numbers so that people may call in the case of encroachment or questions.

   - Buffer Mapping. Another important aspect of a good buffer is that it is protected by being shown on local and regional maps of the area. This should include efforts to have local Planning Boards and Conservation Commissions show the buffer zones on their maps. This should help prevent future encroachment from projects and provide awareness of the buffer's existence and importance to other agencies.

Factors in Preventing Encroachment
1. Fencing
2. Signage
3. Buffer Mapping
4. Public Education

BUFFER ZONE
DO NOT DISTURB
This is a protection zone that buffers the Pennichuck Water Works Water Supply from water quality threats. It should not be mowed, harvested or otherwise disturbed by human or livestock activity. Please contact Pennichuck Water Works at *(882-5191)* if you see human or livestock activity in this buffer.

7.0 Buffer Zones

- Public Education. Whether Pennichuck Water Works owns the buffer zone, or has a conservation easement of some form, information should be provided to the adjacent landowners. This information should include the restrictions on the buffer zone as well as the importance of maintaining it as is.

5. Annual Inspections. The final component of a good buffer is periodic inspections. The encroachment discussed above is particularly problematic, and should be inspected on an annual basis.

Table 7-1. Comparison of Required Setbacks

Author	Article	Related Activity	Recommended Buffer Width (feet)
Town of Scituate, MA	Code of Bylaws, Zoning	Any activity which causes land movement, construction, or any type of discharge is prohibited	150
State of NH	NH Rivers Management and Protection 483:9	Land application of solid waste is prohibited	250
Pennichuck Water Works	Existing Watershed Regulations	No fertilizers, compost, or other organic debris allowed within the buffer	250
Town of Amherst, NH	Zoning Ordinance	Any activity which would result in the deterioration of water quality is prohibited	100
Town of Hollis, NH	Zoning Ordinance	Septic tanks or leach fields prohibited	150
Commonwealth of MA	350 CMR 11.00	Pollutants (manure, fertilizers, pesticides and herbicides included) are prohibited	400 to reservoir, 200 to tributaries
Town of Southborough, MA	Zoning By-Laws	Sewage disposal is prohibited	500
State of RI	Coastal Buffer Implementation	Buffer recommended for 80% removal of pollutants	75
State of RI	Coastal Buffer Implementation	Buffer recommended for 90% removal of pollutants	200
Kimball, Joan Channing	Riverways Community Guide	Land must remain in its natural state within these buffers	sediment-160; nutrient 300; pesticide- 80 to 300; pathogens-2700
Schueler, Thomas	Controlling Urban Runoff	Land must remain in its natural state within these buffers	100-300
Schueler, Thomas	The Architecture of Urban Stream Buffers	Land must remain in its natural state within these buffers	minimum 100
NC Cooperative Extension	Senate Bill 1217	Recommended setback is for fields receiving swine manure	50
NC Farm A Syst	Protecting Water Supply Fact Sheet	Recommended setback is for animal waste	100 (increased if the water supply is downgradient of waste
NC Cooperative Extension Service	Protecting Water Supply Springs	Recommended setback is for animals	100
Wright, Peter	Prevention, Collection and Treatment of Concentrated Pollution Sources on Farms	Filter area required to treat barnyard runoff on a slope of 6%	165-230
Commonwealth of MA	MGL c 92S 107A(b) Surface Water Protection	Alterations to land or buildings	400 of water body 200 of tributary

Note: Not all municipalities in Massachusetts and New Hampshire were reviewed.

Table 7-2. Summary of Various Filter Strip Studies

Reference	Region / State	Study	Vegetated Area	Type of Vegetation	Soil Type	Slope	Results
Chaubey, 1994	Arkansas	Land area treated by swine manure	1.5 m x 24 m	fescue grass seeded at 500 kg/ha	silt loam	3%	Up to 96% reduction in nitrate, 88% reduction in phosphorus and 80% reduction in sediment, 0% reduction in bacteria.
Coyne, 1995	Kentucky	Poultry litter tested for fecal coliform	4.6m x 9m	planted tall fescue and bluegrass	Maury silt loam	9%	Area not sufficient for bacterial removal.
Doyle, 1977	Maryland	Dairy manure applied at 90 mT/ha with buffer strips up to 4 m wide on the downslope edge	7m x 4.9 m	tall fescue	Chester silt loam	10%	1.5 m was the minimum width required for nitrate removal, 4.0 meters was the minimum required for sufficient ammonia, sulfate, and potassium removal. Fecal was only reduced by up to 18% in these studies.
Edwards, 1983	Ohio	A paved feedlot with two consecutive strips and settling basin 1/6 the size of the feedlot	4.5 x 30 m	fescue grass	~	2%	Total system removed 81-89% of pollutants.
Schellinger, 1992	Vermont	Bacterial reduction	7.6 x 22.9 m	red fescue, tall fescue, bluegrass, ryegrass	Massena silt loam	2%	Fecal was reduced by approximately 30%.
Arora, 1995	Iowa	For herbicide reduction and sediment reduction	1.5 x 20.12 m	native grasses mostly bromegrass, bluegrass, and fescue	Canisteo silty clay loam	3%	Retention ranged from 8-100% for herbicides and 40-100% for sediment.
Aull, 1980	Michigan	Cropland runoff treated with swine manure applied at a rate of 45,000 l/ha/yr, filter strip elongated bowl shape	0.2 ha	not identified	sandy loam	1.80%	Study demonstrated that filter strips are effective in more than just strips.
Iowa State Agroforestry Research Team, 1994	Iowa	Pasture lands and cornfields	7.5 m wide strip	native trees and switchgrass	~	~	Cost was rougly $65/ha and reduced all levels of pollutants below those in the control area.
Magette, 1986	Maryland	Application of liquid N at 112 kgN/ha and application of poultry litter at 8.9 m-T/ha	5.5m x 22m	fescue grass	sandy loam	3-5%	Effectiveness was highly dependent on the condition of the filter itself with the most removal occurring at the interface of the source area and the filter. Efficiency of strips decreased over time.
Magette, 1989	Maryland	Repeated study above	5.5m x 22m	fescue grass	sandy loam	3-5%	A 9.2 m strip was more effective than a 4.6 m strip. Reductions were less than 50% for nutrients.
Robinson, 1996	Iowa	Sediment reduction	31m x 36.6m; 18.2 m acted as filter strip	bromegrass, alfalfa, orchardgrass	Fayette silt loam	7%, 12%	Sediment retention of 70% within the first 3m, reduction past 9m very small.
Dillaha, 1986	Virginia	33 farms in VA were studied	varied	94% dominated by fescue grass	varied	varied	Researchers concluded that standardizing site requirements and careful monitoring of installation and use would increase the successful application of filter strips.

Table 7-2. Summary of Various Filter Strip Studies

Reference	Region / State	Study	Vegetated Area	Type of Vegetation	Soil Type	Slope	Results
Pritchard, 1993	Indiana	A comparison of the physical and economic impacts of filter strips and microtargeting (setting aside highly erodible land)	~	native trees	silt loam	0-6%	Micro-targeting reduced sediment by 31% at $80 per ton; filter strips reduced sediment by 26% at $91 per ton, however, adding administrative and implementation costs led filter strips to be more cost effective. Farmers are also more willing to give up land at the edge of a field than the middle, as is sometimes required in the micro-targeting program.
Bingham, 1980	North Carolina	Determine the effect of lengths of filter strips in improving water quality	12m x 13m	reed canary grass, redtop, and tall fescue	Cecil clay loam	6-8%	Background runoff concentrations can be achieved with a buffer area to waste area ratio of 1:1.
Chaubey, 1993	Arkansas	Poultry litter applied at a rate of 5 kg/ha	1.5m x 24.4m	fescue grass	Captina silt loam	3%	Concentrations of nitrate and sediment did not decrease significantly past 3.1m, for TKN 9.2m, and for phosphorus 6.7m.
Dickey, 1981	Illinois	Determine if filter strips were a feasible alternative treatment technique for feedlots. Runoff from a settling basin	12m x 91m	reed canary grass, bromegrass, orchardgrass	~	0.50%	Filter strips reduced sediment, nutrients, and oxygen demanding materials from runoff by 80%
Dillaha, 1985	Virginia	Determine effectiveness of filters in feedlots	filter strip lengths of 0, 4.6, and 9.1 m	orchardgrass	Groseclose silt loam	5%	9.1 m plots were more effective than 4.6m plots.
Paterson, 1977	Illinois	Determine the pollution potential from a milkhouse and feedlot operation and evaluate filter strip system	9.1m x 27.4m and 9.1m x 36.6m	fescue with invading annuaals of crabgrass and barnyard grass	Hosmer silt loam	~	114 l/cow/day of wastewater was produced, an area of 82 square meters of filter strip was required for each cow. A downslope length of 19.2m was required to effectively retain pollutants.
Schwer, 1989	Vermont	Effect of filter strip on commercial dairy	10.6m x 26m	red fescue, tall fescue, and rygrass	Massena silt loam	2%	Reduction in sediment concentrations were 45%, phosphorus 78%, TKN 76%, and ammonia 2%
Young, 1980	Minnesota	Determine the ability of land and cropping practices as filter strips to absorb pollutants from feedlots	4.1m x 27.4m	corn, orchardgrass and sorghum/sudangrass	Barnes loam soil	4%	Buffering capacity of corn plots and native plots were effective when used together. Corn reduced nutrients up to 98%, orchardgrass up to 77% and sorgham/sudangrass up to 82%. A 36m filter strip was recommended for all vegetative types for this 310 head feedlot.
Daniels, 1996	North Carolina	Determine removal efficiencies of grass filters; runoff from corn field	6m, 13m, and 18m wide strips	fescue grass	Cecil sandy loam to clay loam	2-5%	Overall reduction were: TSS (30-60%); TKN (35-60%); ammonia (20-50%); nitrate (50-90%); phosphorus (60%) and phosphate (50%). Most removal occurred within 7 m.
Parsons, 1990	North Carolina	Compare effectiveness of field edge grass filter strips and riparian zones	4m x 37m x (4.3 and 8.5m in length)	fescue, weed, and crabgrass	sandy clay soil/ sandy loam	4-6% / 1%	The 4.3m strip had 75% reduction, while the 8.5m strip had 85% reduction. It was also concluded that long term effectiveness is subject to precipitation patterns.
Mickelson, 1993	Iowa	Effectiveness of filter strips on herbicides	1.5m x 4.6m and 1.5m x 9.1m	native grasses including bromegrass, bluegrass, and fescue)	Canisteo silty clay loam	3-6%	On no tillage plots, reduction averaged 35-60%, conventional tillage had 28-72% reduction.

Table 7-3. Buffer Zone Calculation Methods

Model	Abbreviation	Components	Application
Chemicals, Runoff, and Erosion from Agricultural Management Systems	CREAMS	Hydrology, erosion, nutrient and management	Outdated, GLEAMS is a more advanced version of CREAMS.
Groundwater Loading Effects of Agricultural Management Systems	GLEAMS	Hydrology, erosion, nutrient and management	To determine nutrient and pesticide levels on various farms and the amount of each leaving the farm.
Erosion/Productivity Impact Calculator	EPIC	Weather, hydrology, erosion, nutrient cycling, pesticide fate, soil temperature, tillage, crop growth, management and economics	To determine the impacts that soil erosion on croplands has on water quality, and the adequacy of different management practices.
Water Erosion Prediction Project	WEPP	Climate, infiltration, runoff, soil erosion, soil moisture and temperature, crop growth, plant residue and tillage	Determination of the effectiveness of buffer and filter strips and other agricultural BMPs.
(Revised) Universal Soil Loss Equation	USLE / RUSLE	Rainfall, runoff, soil erodibility, slope length, steepness, and cover management	Designed to estimate erosional load from hilltops.
Simulator for Water Resources in Rural Basins	SWRRB	Climate, infiltration, runoff, soil erosion, soil moisture and temperature, crop growth, plant residue and tillage	To determine hydrologic, sedimentation, and nutrient and pesticide transport in large watersheds.
Simulation of Production and Utilization of Rangelands	SPUR	Sediment yield, plant growth, animal and economics	Rangeland management (will be of little use to MDC).
Areal Nonpoint Source Watershed Environment Response Simulation	ANSWERS	Weather, flow erosion	Erosion and sediment control and water quality analysis associated with erosion.
Agricultural Nonpoint Source Pollution Model	AGNPS	Topography, hydrology, erosion and sediment transport, chemical transport	Analysis of nonpoint source pollution from agriculture.
Sedimentology by Distributed Model Treatment	SEDIMOT II	Hydrology, sedimentation	Design of sediment control structures on surface mined land (will be of no use to MDC).
Nitrate Leaching and Economic Analysis Package	NLEAP	On-farm management, soil,climate, aquifer data, economic informatin	Used for groundwater quality (will be of little use to MDC).
Support Technology of Environmental, Water and Agricultural Resource Decisions	STEWART	Hydrology, pollutant loads	The selection, evaluation, siting, and design of nonpoint source control systems.

Section 8.0 Buildout Analysis

Section Contents

8.1 Buildout Analysis -------- 8-1

A detailed analysis of the phosphorus levels in each subwatershed and in the chain ponds during buildout conditions was conducted to determine the potential water quality impacts from future land uses in the watershed. The purpose of doing a buildout is to identify the increase in pollutant loadings to the chain ponds under future conditions so the appropriate planning may be done to minimize these impacts as growth occurs in the watershed.

The Nashua Regional Planning Commission (NRPC) zoning data (Figure 6-1) was used to determine the different within the watershed during buildout conditions. This type of buildout analysis does not provide a detailed review but represents a worst case under existing zoning. Based on these land areas, the same model and methodologies used for the nutrient analysis were applied to obtain phosphorus loadings from each subwatershed under future conditions. Four buildout scenarios were identified and analyzed based on zoning and protected lands data.

The zoning map shows the worst case future buildout for the area. However, some areas of the watershed (in the Town of Hollis) are zoned as either residential or agricultural so that either of these land uses may be developed. Thus, both residential and agricultural scenarios were developed and modeled based on the zoning map, resulting in the first two scenarios.

However, the zoning map does not account for any privately owned conservation lands. Since much of this conservation land is under the ownership of Pennichuck Water Works, a buildout analysis with Pennichuck Water Works conservation lands was developed and modeled to compare the zoning scenarios. The comparison was used to determine the impacts on the water supply if Pennichuck were to sell these lands and allow total urbanization of the watershed. This was conducted by overlaying the zoning map with the mapped privately owned lands (Figure 8-1).

The four buildout scenarios are outlined below:

1. Scenario 1. Residential without Conservation - Buildout based on zoning map with residential development in Hollis (assumes development of Pennichuck-owned lands occurs).
2. Scenario 2. Agricultural without Conservation - Buildout based on zoning map with agricultural development in Hollis (assumes development of Pennichuck-owned land occurs).
3. Scenario 3. Residential with Conservation of Pennichuck Lands - Buildout based on zoning / conservation map overlay with residential development in Hollis.
4. Scenario 4. Agricultural with Conservation of Pennichuck Lands - Buildout based on zoning/conservation map overlay with agricultural development in Hollis.

A buildout analysis identifies the increase in pollutant loadings to the chain ponds under future conditions.

Section 8.0 Buildout Analysis

The percent contribution of phosphorus loadings by subwatershed for each of the four scenarios is shown on Table 8-1. Subwatersheds PBS and MB1 are the greatest contributors of phosphorus under an agricultural buildout scenario, both with and without the conservation land. The residential buildout reveals PBS, PBB and PBH to be the largest contributors of phosphorus. A detailed breakdown of the phosphorus laodings by subwatershed and land use for each buildiout scenarios can be found in Appendix G. A summary of the total phosphorus loadings for each scenario is provided on Table 8-2.

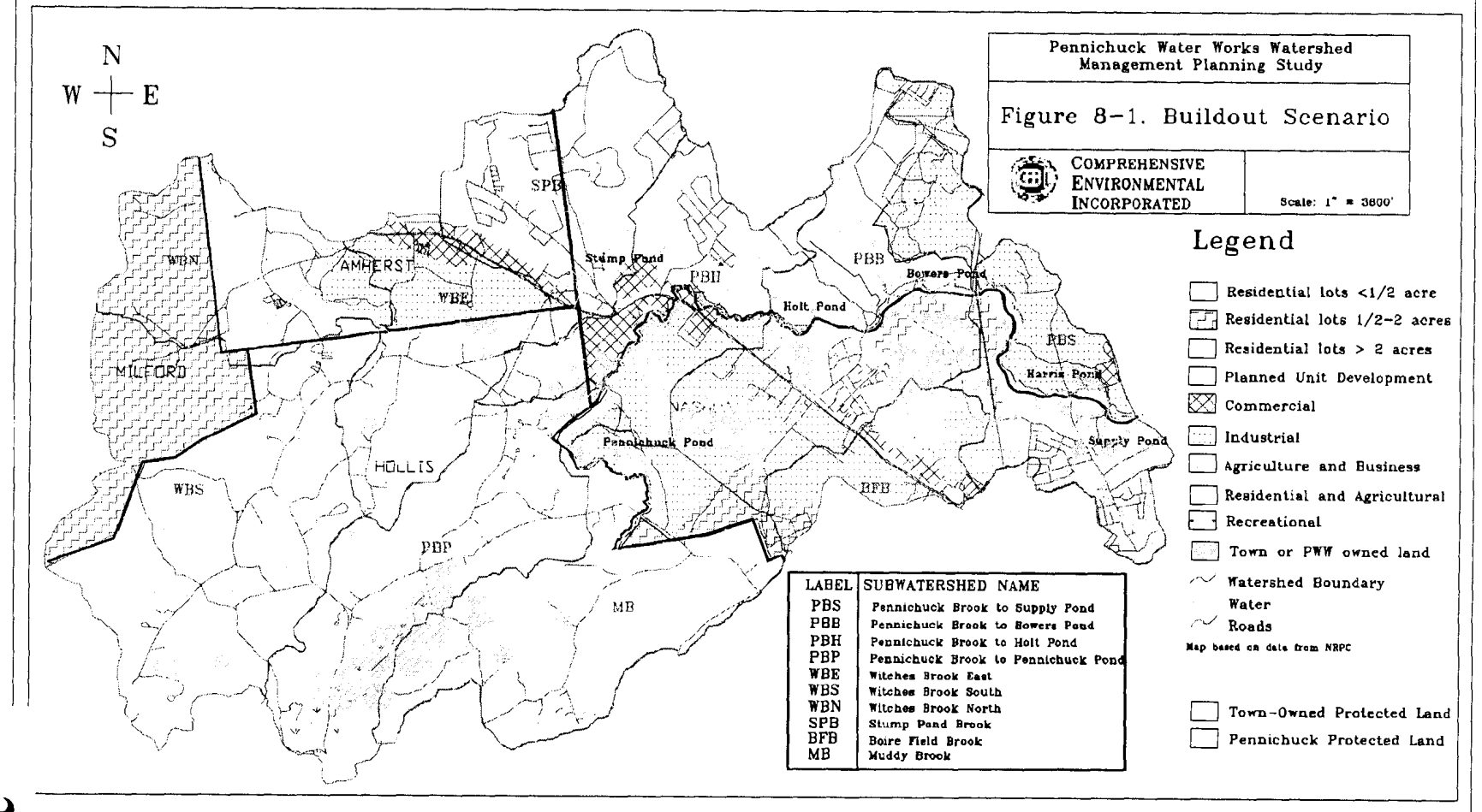
As shown on Table 8-2, a buildout scenario using agricultural development without the conservation lands, represents the worst case buildout scenario with about 19,500 pounds of phosphorus per year being contributed tot he chain ponds. This is about a 180% increase in loadings from the existing conditions. However, it is not likely that these areas will be developed strictly as agricultural, and it is expected that residential lots will be developed. In

Table 8-1. Percent Phosphorus Contribution by Subwatershed for Buildout Conditions

Subwatershed Name and Designation	Scenario 1. Residential without Conservation	Scenario 2. Agricultural without Conservation	Scenario 3. Residential with Conservation	Scenario 4. Agricultural with Conservation
PBS. Pennichuck Brook to Supply Pond	19%	16%	19%	16%
PBB. Pennichuck Brook to Bowers Pond	14%	11%	12%	10%
PBH. Pennichuck Brook to Holt's Pond	14%	11%	12%	10%
PBP. Pennichuck Brook to Pennichuck Pond	8%	7%	8%	7%
WBE. Witches Brook East	11%	8%	12%	8%
WBS. Witches Brook South	8%	10%	9%	11%
WBN. Witches Brook North	4%	4%	5%	4%
SPB. Stump Pond Brook	6%	5%	6%	5%
BFB. Boire Field Brook	8%	6%	7%	6%
MB1. Muddy Brook	9%	22%	10%	22%

Table 8-2. Total Phosphorus Loadings from Buildout Scenarios

Buildout Scenario	Total Phosphorus Loadings (lbs/yr)
Scenario 1. Residential without Conservation	16,465
Scenario 2. Agricultural without Conservation	19,487
Scenario 3. Residential with Conservation	15,258
Scenario 4. Agricultural with Conservation	18,121


Pennichuck Water Works Watershed
Management Planning Study
Figure 8-1. Buildout Scenario
COMPREHENSIVE
ENVIRONMENTAL
INCORPORATED
Scale: 1" = 3600'
N
W
E
S
AMHERST
MILFORD
HOLLIS
WBN
WBE
WBS
SPB
PBH
PBB
PBS
PBP
BFB
MB
Stump Pond
Holt Pond
Bowers Pond
Harris Pond
Supply Pond
Pennichuck Pond
LABEL | SUBWATERSHED NAME
PBS | Pennichuck Brook to Supply Pond
PBB | Pennichuck Brook to Bowers Pond
PBH | Pennichuck Brook to Holt Pond
PBP | Pennichuck Brook to Pennichuck Pond
WBE | Witches Brook East
WBS | Witches Brook South
WBN | Witches Brook North
SPB | Stump Pond Brook
BFB | Boire Field Brook
MB | Muddy Brook
Legend
Residential lots <1/2 acre
Residential lots 1/2-2 acres
Residential lots > 2 acres
Planned Unit Development
Commercial
Industrial
Agriculture and Business
Residential and Agricultural
Recreational
Town or PWW owned land
Watershed Boundary
Water
Roads
Map based on data from NRPC
Town-Owned Protected Land
Pennichuck Protected Land

Section 8.0 Buildout Analysis

this case, the phosphorus loadings to the pond increase by about 140%. This assumes that all privately owned conservation lands will be urbanized in the future.

If the conservation lands within the watershed are not sold for future development, the watershed will see an increase in phosphorus loadings of about 120%. Although this is still a significant increase, the impacts are lower than if all of the private owned conservation lands were developed and the results emphasize the importance of maintaining undeveloped lands within the watershed. This is confirmed below with an analysis or the in-pond concentrations under the four buildout scenarios.

As with the nutrient analysis presented in Section 4.0, in-pond concentrations were calculated for each buildout scenario for each of the chain ponds. Table 8-3 provides a summary of the estimated future in-pond concentrations for each buildout scenario. As expected, the agricultural buildout, assuming the private owned conservation lands are developed, results in the highest in-pond concentrations, with a concentration of 0.059 mg/l in Harris Pond. This is more than twice the in-pond goal of 0.025 mg/l. Other ponds in the watershed, such as Holts Pond, may reach levels of 0.112 mg/l under this scenario, which is about four and one half times higher than an in-pond goal of 0.025 mg/l.

Under the conservation scenarios, the worst case in-pond concentration for Harris Pond is expected to decrease from 0.059 mg/l as identified above to 0.056 mg/l, which is about twice the in-pond goal. Nevertheless, the other ponds in the watershed will still have substantially higher phosphorus levels ranging from 0.065 to 0.113 mg/l.

Table 8-3. In-pond Concentrations for Buildout Scenarios

Subwatershed	Scenario 1. Residential without Conservation (mg/l)	Scenario 2. Agricultural without Conservation (mg/l)	Scenario 3. Residential with Conservation (mg/l)	Scenario 4. Agricultural with Conservation (mg/l)
Pond				
Stump Pond	0.065	0.066	0.065	0.066
Pennichuck Pond	0.069	0.113	0.067	0.109
Holts Pond	0.101	0.112	0.096	0.107
Bowers Pond	0.067	0.072	0.063	0.068
Harris Pond	0.057	0.059	0.054	0.056
Supply Pond	0.054	0.055	0.052	0.053

From a more realistic point of view, it is unlikely that a large portion of the watershed will be developed as agricultural land and more likely that residential land will be developed. Under the residential scenarios, the in-pond concentrations are still expected to increase significantly from existing conditions, but the overall impacts in each of the ponds is lower than that seen for agricultural development.

All four scenarios show high levels of phosphorus in the ponds at buildout. Protective measures are needed.

The above analysis does not show a significant difference between the buildout scenarios with and without conservation lands. This is because the conservation lands in the watershed are small in proportion to the areas that may be developed. If larger quantities of conservation land were owned and maintained, there would be a significant difference between the scenarios with and without conservation lands. Although there isn't much of an increase between these scenarios, it is important to keep as much undeveloped land within the watershed to help minimize the

impacts of urbanization and to provide adequate buffers for each of the ponds and their tributaries. As outlined above, impacts could be significantly reduced if Pennichuck or the existing communities were to obtain additional private undeveloped lands in the future.

Although each of these future scenarios show a worst-case development to the fullest, any increases will decrease water quality. The analysis suggests that minimizing development pressures by rezoning or increasing the level of infiltration required at developments will help the situation. The phosphorus loading calculations are based on "typical" real-life land uses (forested, suburban, commercial, etc.) If the methods of developing these land uses can be improved to reduce the runoff coefficients and overall imperviousness, then future development impacts can be minimized. These steps, however, must be taken at all new developments and when commercial/industrial sites come up for approval for substantial modification.

Section 9.0 Recommendations

Section Contents

9.1 Findings ---------- 9-1
9.2 Recommended Actions ---------- 9-7

Based on the water quality evaluation described in earlier sections, ten major problem areas were identified in the Pennichuck Watershed as summarized on Table 9-1. Each of these problems is described in more detail below, followed by recommended actions to alleviate the problem or to minimize the problem in the future.

9.1 Findings

Problem 1: Loss of Baseflow/Increased Runoff/Stream Channel Modifications

As urbanization encroaches in all parts of the watershed, stormwater runoff is increased. Because the stormwater picks up many pollutants as it passes over impervious surfaces, a higher proportion of stormwater flow in the watershed is not beneficial to water quality. At the same time that stormwater flows increase, infiltration and recharge of groundwater decrease. Although it may take a long time to affect regional groundwater levels, it is likely to be the eventual result. As groundwater levels decrease, groundwater discharge to streams during low flow conditions also decreases. This has already been seen in the Pennichuck watershed.

Baseflow provides a typically very clean source of water to ponds and streams, so its loss is detrimental to the health of the watershed. Fish and wildlife, wetlands, and water supply resources are all affected by this problem. The decline of water quality and quantity for water supply are particularly important.

The most easily measured factor in evaluating the extent of the problem is the measurement of total imperviousness or the percentage of area that is not "green" (Schueler, Fall 1994). Schueler defines imperviousness as the sum of roads, parking lots, sidewalks, rooftops and other impermeable surfaces of the urban landscape. There are two primary components of imperviousness: 1) rooftops; and 2) transportation system. The rooftop component is somewhat fixed, while the transportation component is highly varied based on the layout of streets and parking.

Table 9-1 Top 10 Problems in Pennichuck Watershed
1. Loss of baseflow, increased stormwater runoff and stream channel erosion result in declining water quality.
2. Future development is likely to increase these problems.
3. The Pennichuck ponds appear to be filling in rapidly, which will further exacerbate water quality and quantity problems.
4. Transportation facilities in the watershed are widespread and have major impacts on water quality.
5. Agricultural activities that result in livestock using tributary streams for watering may result in the introduction of waterborne pathogens and high nutrient loads.
6. Multiple "hot spots" in the watershed pose chemical risks to the water supply and may threaten biological activity that normally cleanses water quality.
7. There is a general lack of understanding of watershed protection principles among the regulatory, planning, public works and engineering communities.
8. There is a general lack of understanding of watershed protection principles among the watershed businesses and residents.
9. Pennichuck Water Works Corporation lacks up to date regulatory authority within the water supply.
10. The available database is lacking.

As imperviousness increases, stream channels respond to the more severe and more frequent flooding by increasing their cross-sectional area to accommodate the higher flows. A loss

of stable streamside vegetation may result. This results in channel instability, which tends to trigger a cycle of stream bank erosion and loss of stable aquatic habitat. This loss of stability may increase both the rate of filling in of ponds on the system, and water quality in terms of turbidity and the pollutants that are carried with the increased sediment load.

Table 9-2. Pennichuck Watershed Imperviousness

Subwatershed	Imperviousness	Subwatershed Drainage Area (in acres)
PBS	14%	1,285
PBB	29%	2,390
PBH	15%	1,508
PBP	5%	1,978
WBE	23%	1,365
WBS	5%	3,193
WBN	19%	1,425
SPB	17%	1,516
BFB	36%	1,006
MB1	6%	2,317
Total Acreage		17,983

Total Imperviousness =2728/17983=0.152=15.2%

The increasing imperviousness can also increase phosphorus loads, and result in overenrichment of the receiving waters, in this case the Pennichuck ponds.

Impervious surfaces also increase local air and ground temperatures by as much as 10-12° (Schueler, 1994). This is the result of the impervious surfaces absorption and reflection of heat. Stream temperatures may ultimately be affected with increased stormwater and decreased cool baseflow discharges. The stream warming is detrimental to both aquatic life and water supplies, resulting in the loss of aquatic fish and other species as well as potential increases in nuisance species and aquatic vegetation.

Imperviousness also increases annual water level fluctuations in fresh water wetlands. Studies by Taylor, 1993, showed that the richness of both wetland plant and amphibian community dropped sharply as stream watersheds increased in imperviousness. As stream habitat becomes more degraded, both aquatic vegetation and animals are negatively affected. Diversity tends to be reduced, with native species being replaced by invasive plants. Most aquatic life, other than the nuisance invasive aquatic weed species and nuisance species of invertebrates such as blood worms (pollution-tolerant *Chironomidae*) are the survivors. This change is detrimental to both recreational users of the watershed and to the water supply.

Table 9-2 shows the percent imperviousness by subwatershed of the Pennichuck watershed. Total watershed imperviousness is estimated at 15%. Schueler (1994) suggests that the cycle of stream and water quality degradation begins at approximately 10% imperviousness. He also suggests that once background loads exceed 20-25%, it may be difficult or impossible to fully restore water quality.

Problem 2: Impacts of Future Development on Water Quality Expected

Not only has water quality deteriorated over time, but it is likely that it will deteriorate further as future development and urbanization of the watershed occurs. The buildout analysis described in Section 7.0

suggests that nutrient loads will increase significantly. This increase in nutrient loading will result in more pronounced taste and odor problems during the summer when algal blooms are common, higher turbidity during parts of the year, and increased stream channel erosion. Fish kills are likely, along with increases in the frequency and intensity of storm flows. Base flow may be further decreased, and eventually may result in the primary stream drying up during droughts. This could have a serious effect on aquatic habitat and wetlands in the watershed, further decreasing their ability to filter pollutants during storm flows.

As time goes on, if imperviousness increases to the extent that it is physically possible, Pennichuck will likely have to rely more on other sources of supply and decrease its use of the Pennichuck ponds. Since this is likely to occur at the maximum demand time of dry summertime, it could eventually result in difficulties in meeting maximum day demands for the system. If adequate water is available for use, it may require additional treatment. Chemical use for settling and filtration expenses are also likely to increase as water quality deteriorates.

Since EPA is expected to increase the requirements for systems with poor quality sources, Pennichuck may be subject to these additional treatment requirements as water quality deteriorates. EPA is likely to require that this additional treatment is at the front of the treatment train, for example, pre-sedimentation facilities. This provides very strong economic incentive to improve the raw water quality of the Pennichuck pond system.

Problem 3: Chain Ponds are Filling In

Limited sampling conducted for this study suggests that the chain ponds are quickly filling in with sediment from the watershed. In some cases, the ponds may already be largely filled with loose sediment, and washing over sediment during large storm flows. Should this happen, water quality could deteriorate much more rapidly than it has in the past. This is because the chain pond system has acted as a presedimentation system for the water supply.

As turbid, polluted storm flows enter the chain pond system, they are retained in the ponds, providing a trapping effect for many pollutants.

As turbid, polluted storm flows enter the system, they are retained in the ponds, providing a trapping effect for many pollutants. Most of the significant pollutants, including phosphorus and many bacteria, are "particulate" or tend to be associated with particles of soil. Thus they are transported most effectively with soil particles. These same particles tend to settle out in slow areas and in ponds, and if the ponds are deep enough, the sediments are retained.

In natural systems, sediments slowly build up over millions of years until ponds eventually become wetlands and finally land. In a natural system without urban development, this could take millions of years. In the Pennichuck watershed, this same filling in process could occur in a matter of decades or even years as urbanization and its resultant

imperviousness increases uncontrolled.

Even if the sediments are not spilling over, they may be exerting a water quality impact through their oxygen demand. As ponds develop a large sediment layer, the decomposition of this material typically creates an oxygen demand. As the sediments decompose and degrade, oxygen is pulled out of the water, often creating an oxygen deficient layer at the bottom of ponds and lakes. As oxygen is lost from this lower layer, chemical changes begin to occur that result in the release of some of the trapped pollutants from the sediments back into the water column. This can occur to the extent that some ponds actually produce a phosphorus load internally, hastening the eutrophication process exponentially. This can result in water quality that is actually worse than the level of watershed development would suggest.

Roadway drainage may result in the direct transport of hazardous pollutants to the water supply.

Problem 4: Transportation Impacts

Because the Pennichuck watershed has developed at a rapid pace and because it contains many large and small roadways, transportation impacts are particularly problematic. Cars, so critical to life in Southern New Hampshire, are a major source of a number of types of watershed pollutants. This includes copper from brake pad wear, zinc from wear and tear of automobile tires, atmospheric deposition of lead from the exhaust of diesel-fueled vehicles, solvents, oils and other automotive fluids from automotive leakage and repairs, and other pollutants from exhaust. The result of all this is that roadways are loaded with pollutants which wash into nearby watercourses during every rainstorm.

Although some advances have been made in controlling this pollutant load in newer roads, controls on major roadways are typically inadequate even now, and particularly on older roadways where the typical goal was to get the water to the nearest stream as quickly as possible through piping. This rapid transport increases pollutant loads and exacerbates the problem of imperviousness and increased stormwater runoff. Additionally, roadways, airports, and parking lots provide mostly uncontained areas for spills of hazardous materials and other undesirable fluids. These may result from accidents, since the typical response to these accidents is to wash spills off the road and into the nearest waterway. Because roadway drainage is typically uncontrolled in the watershed, this may result in the direct transport of hazardous pollutants to the water supply.

Aquatic habitat in the watershed is also likely to be damaged, with kills of many of the organisms that normally act to remove pollutants from the water column. Since a diversity of organisms helps to control water quality impacts by decomposition, the loss of these organisms is a detriment to both water supply and recreational uses of the watershed such as fishing and aesthetic enjoyment.

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Problem 5: Agricultural Impacts

In some limited parts of the upper watershed, particularly in Hollis, there remain large tracts of agricultural lands. These lands generally provide a benefit to water quality in the watershed by retaining pervious surfaces. However, where cattle and horses are pastured with use of tributary streams for their drinking water source, they may present a hazard related to pathogenic organisms. A number of pathogenic organisms are produced by humans and animals, and if feces enter streams untreated, the pathogens must be removed before the water can be distributed. Unfortunately, some of the most recently discovered organisms, particularly *Cryptosporidium,* have escaped conventional treatment systems and disinfection to cause waterborne disease outbreaks. Since this particular organism is often associated with cattle, particularly calves, there is the potential for significant water quality impacts.

This organism, which sickened 400,000 people in Milwaukee and killed 100, is commonly found in large numbers in poor quality sources of water. It is highly resistant to disinfection, and has escaped conventional treatment systems when they have become overloaded due to the large number of organisms and operational practice such as recycled backwash. Even with every precaution taken at the treatment end, it is still critical to limit the number of these organisms entering raw water sources.

Problem 6: Hot Spots

As described in Section 6.0, on pollution sources, the watershed contains a number of point sources or hot spots. These include known hazardous waste sites, permitted hazardous waste generators where spills of significant hazardous chemicals could occur, and smaller potential sources of pollutants such as car dealerships, gas stations, and auto repair shops. From these locations, a variety of hazardous chemicals, oils, and nutrient loads from car washing activities may emanate. These areas may be a significant source of pollution if not adequately controlled with Best Management Practices. There are dozens of each of these locations within the watershed, particularly the most urbanized portion of the watershed along Route 101A.

Problem 7: Lack of Community Understanding

The problems identified above are well known to watershed engineers and scientists, however, they are not typically recognized as issues by most regulatory, planning, public works staff or the engineering community in general. This is largely because many of the concepts are relatively new (within the last ten years) but are increasingly being applied around the United States. In general there has been resistance to change among the engineering community, largely

Many fishermen lament the loss of favorite trout streams – now gone because trout can not tolerate the higher stream temperatures and pollutant loads.

because standardization of the methods has not yet been done. This has also resulted in a reluctance by some planning boards and regulatory authorities to address these problems, in part because many of the solutions are relatively new. In many cases, regulatory, planning, and engineering communities are just not aware of the issues yet.

Problem 8: Lack of Understanding Among General Public

Many federal and state "watershed initiatives" developed so far by EPA and DES have focused on the larger watersheds of rivers such as the Merrimack. While these initiatives are beginning to get the word out, most residents in watershed towns and in general are probably not familiar with many of the concepts discussed in this report. However, it is likely that they are familiar with the degradation of the water resources around them. For example, many fishermen often lament the loss of their favorite trout fishing streams. This is usually due to the fact that trout can not survive in the higher temperatures that result from increased stormwater flows off heated impervious areas and the loss of shaded stream channels that results from eroded stream banks. Many people have also become aware of drinking water quality problems based on press accounts of waterborne disease outbreaks such as the one that occurred in Milwaukee.

Most people in the watershed are probably not aware of the fact that their everyday actions can have a significant impact on the environment and water quality.

Still, most people in the watershed are probably not aware of the fact that their everyday actions and their own property have a significant impact on water quality. Similarly, they are probably also unaware of the things that they can do as individuals to reduce the impacts.

This information is also not taught in the schools. For the most part, teachers are unaware of the problems, and this subject is not included in most curriculums. Science teachers may touch on the subject, but a focused program as related to the Pennichuck watershed is not known to be taught.

Problem 9: Lack of Regulatory Control/Authority

Pennichuck Water Works Corporation does not have any authority within the watershed. There is certainly influence based on the fact that many of the Towns are supplied water by Pennichuck, but in some cases there is little incentive for Towns to cooperate other than the fact that neighbors helping neighbors is the right thing to do. Watershed regulations do exist, authorized by the State Legislature in 1934. However, these regulations are outdated and do not provide the kind of controls that would assist Pennichuck Water Works Corporation in reducing water quality impacts within the watershed. Without more specific regulations, Pennichuck must rely on the goodwill of watershed communities in protecting its water supply. While most communities have been generally cooperative in the past, it is unknown how they will

react when asked to address the impacts from their communities.

Problem 10: Water Quality Database is Insufficient

While limited sampling was done for this study, and previous analysis information was incorporated into the report where possible, a solid database of raw water quality information within the watershed does not exist. This is not uncommon, since most water systems have relied on finished water quality and many water systems still rarely collect watershed information or data. However, this results in a lack of understanding of specific problem areas that could be corrected, and a lack of statistical significance in database trends. Other things, such as sediment depths in the ponds, are unknown. Stormwater quality, which is a serious threat to water quality, has not been compared between subwatersheds or sights. Stream channel impacts in different portions of the watershed due to urbanization is also unknown. This lack of a database makes comparison to water quality goals in the future difficult.

9.2 Recommended Actions

Based on the top ten problems identified above, recommended actions have been developed to address each problem. For ease of understanding, these are divided into three categories: 1) prevention; 2) remedial measures; and 3) monitoring.

Table 9-3 Methods to Reduce Future Imperviousness of the Pennichuck Watershed

Require that post-development runoff equals predevelopment runoff	Subdivisions and commercial/industrial developments should be required to match post-development conditions to pre-development conditions for runoff up to the ten-year storm. All water from a two-year storm should be infiltrated. Peaks should be attenuated and stored for slow release in larger than ten-year storms (up to 100-year).
Minimization of Parking Lot Impacts	• Use angled parking and smaller spaces on one-way streets and parking lots • Reduce parking ratios required where possible • Use vertical parking structures in urban areas where possible • Use permeable spillover parking where appropriate • Modify landscaping of parking lots to use permeable dividers and street side buffer strips (See Figure 9-1)
Reduce Transportation Impacts of Subdivisions	• Encourage cluster development wherever possible • Use skinny streets to reduce roadway impacts • Use grass swales instead of curbs and gutters • Use one-sided sidewalks or paths • Reduce cul-de-sac radii or use central cul-de-sac permeable doughnuts (Figure 9-2)
Use Onsite Infiltration Wherever Possible	• Roof leaders and sump pumps should be recharged onsite instead of conducted to the storm drain or sewage system • Leave native vegetation between residential lots for privacy and recharge • Leave stream buffers between residential developments and streams • When rezoning, use lowest density residential zoning possible
Clearing/Grading Plans	• Develop clearing and grading construction guidelines that minimize site disturbance and vegetation loss • Require grading and erosion control plans, and inspect same during progress of construction
Landscaping	• Encourage the use of native species for landscaping wherever possible • Leave native vegetation in place as a buffer • Use mulched areas for part of lawn • Minimize lawn size and increase native landscaped area
Other Onsite Recharge Methods	• Connect roof leaders and sump pumps to recharge gravel • Recharge all onsite runoff wherever possible

Source: Adapted from Schueler, Fall 1994, Watershed Protection Techniques, V1, N3. "The Importance of Imperviousness"

Prevention Measures

Prevention Method 1: Reduce future imperviousness

As discussed in findings above, the Pennichuck watershed is currently at a hefty 15% imperviousness overall. This is in spite of the fact that some portions of the watershed, largely in

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Hollis, are mostly undeveloped. Some subwatersheds, as was shown on Table 9-2, have extremely high imperviousness levels (up to 36%). The related water quality that is produced from these impervious subwatersheds is poor.

Table 9-4. Buffer Zone Requirements	
Planning Stage	1. Require buffer limits on all clearing/grading and erosion control plans. 2. Record all buffer boundaries on official maps. 3. Clearly establish acceptable and unacceptable uses 4. Establish clear vegetation targets and rules for different zones of the buffer. 5. Provide incentives for owners to protect buffers through perpetual conservation easements rather than deed restrictions. 6. Use level spreaders or other techniques as needed to prevent channelized flow through the buffer.
Construction Stage	1. Pre-construction stakeout of buffers to define the limits of disturbance. 2. Set limits of disturbance based on drip-line of the forested buffer. 3. Conduct pre-construction meeting to familiarize contractors and supervisors with limits of disturbance. 4. Mark limits of disturbance with a silt fence barrier, signs or other methods to exclude construction equipment. 5. Inspect the buffer during construction to assure that channelization is not occurring through the buffer.
Post-Development Stage	1. Mark buffer boundaries with permanent signs or fences describing allowable uses. 2. Educate property owners or homeowner associations on the purpose, limits and allowable uses of the buffer. 3. Conduct periodic walkthroughs to inspect the condition of the buffer network. 4. Reforest grass or lawn buffers.
Source: Adapted from Schueler, Technical Note 7, Watershed Protection Techniques, VIN1, Feb. 1994.	

To reduce future imperviousness, prevention measures are needed. Pennichuck Water Works Corporation currently tries to work with Planning Boards and Conservation Commissions in the watershed Towns to encourage Best Management Practices. However, a more concerted effort needs to be made in this area. Table 9-3 outlines some of the most important actions that can be taken by watershed Planning Boards and Conservation Commissions to reduce imperviousness.

The most important method to reduce imperviousness is to require developers to control runoff from new subdivisions and to incorporate remedial stormwater measures into existing facilities when they come up for substantial modification.

This can be done (and has been elsewhere) by requiring that post-development conditions not exceed pre-development conditions for stormwater. During very large storms (greater than ten-year storms) this is sometimes not practical but peaks can be captured and stored for slow release back to the system. In storms of two year frequency or less, CEI recommends that all runoff be infiltrated instead of leaving the site. Model bylaws geared towards water supply protection are included in Appendix H.

Prevention Method 2: Buffer Zones

In addition to providing pervious areas for recharge, buffer zones can filter poor water quality from highly urbanized sites such as commercial developments, subdivisions, and industrial land uses.

Although the distance of a buffer for pollutant removal varies considerably from site to site based on site-specific conditions, as outlined in Section 7.0, a general guideline would be to use a minimum 400' buffer around the chain ponds and a 200' buffer from the Ordinary High Water (OHW) mark from all tributaries and wetlands that are directly tributary to the chain ponds. This is consistent with the Cohen Bill that was recently passed in

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Massachusetts for the protection of water resources. This bill prohibits alternations to land or building within 200 feet of a tributary or other waterbody or within 400 feet of a reservoir. A summary of the Cohen Bill is included in Appendix I.

It should be understood however, that a different buffer may be appropriate depending on the site-specific conditions. For example, on steep slopes a larger buffer may be needed while in some areas where extensive infiltration is used and mature native forest is left in place, a lesser buffer may be appropriate. In any case, the buffer must not become channelized and provisions must be taken before the development occurs to protect it from short-circuiting.

In order to preserve the integrity of buffer zones created for the protection of water quality, the steps identified in Table 9-4 should be incorporated into the buffer zone requirements.

Additionally, a "demonstration buffer zone" should be developed by Pennichuck Water Works to provide an example for developers, Planning Boards, and Conservation Commissions. This could be done in conjunction with Pennichuck's review of a commercial or residential development where the developer wishes to perform a community service and stand as an example of environmentally friendly practices while incurring little or no increased cost.

Prevention Method 3: Minimize Transportation Impacts

As noted previously, transportation impacts are significant because of the number and size of the roadway network within the watershed. As development occurs in the future, additional impacts are likely to occur. To minimize these impacts, the following steps are recommended:

- Work with Public Works Departments and the State Department of Transportation to avoid direct piping of runoff to streams and instead use infiltration technologies. Grassed swales are already used in many areas, and can provide a very effective water quality improvement if stormwater is allowed to infiltrate. These groups should also be encouraged to use leaching catch basins where possible in their own construction efforts. These have been used in many areas, including along Route 101A, with a high level of success and good results.

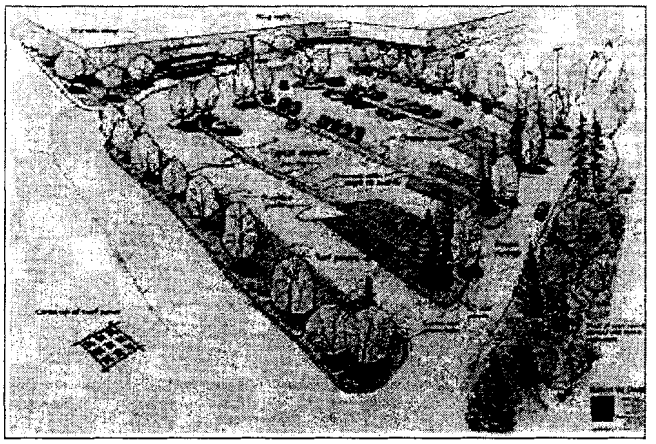

Figure 9-1. Commercial Parking Lot Using Infiltration Methods. Adapted from Schuler, 1994.

- Work with watershed Fire Departments to address spill

issues and to make them aware of spill potential and critical watershed areas. Fire Departments should be equipped with catch basin covers, pads for solvents, caustics and acids, and booms and pads for petroleum products. Additionally, the Fire Departments should all have maps that show the locations of critical catch basins, or ideally, the most important catch basins should be marked because of the problems with keeping track of maps during emergency conditions.

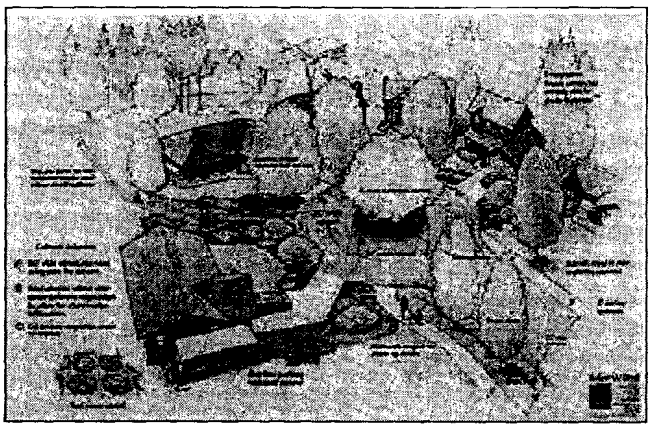

Figure 9-2. Cluster Housing Adapted to Promote Infiltration. Adapted from Schuler, 1994.

- Develop a monitored "demonstration roadway" for comparison to an existing similar but old style roadway. In conjunction with the demonstration buffer zone, Pennichuck should also develop a demonstration roadway that can be monitored as part of the monitoring program discussed in Section 9.3. The roadway should contain items such as a grassed swale mowed to a longer grass length or planted with low maintenance, low profile vegetation. If in a wet area, the swale might be replaced with a small wet pond. The purpose of the demonstration project would be to show developers, their engineers, and Planning Boards and Conservation Commissions how roadways can be developed in a more environmentally friendly method. It could also be used as a tool to work with Public Works Departments in the use of alternate technologies and narrower road widths than are typically allowed by Public Works Departments.

Prevention Method 4: Education

There are a number of education issues that need to be addressed:

- Education of general watershed residents on how their actions affect the watershed and how they can help.
- Education of school age children as tomorrow's customers.
- Education of planning boards, conservation commissions, public works departments, developers and site engineers.

In order to address these three broad classes of people, a multipart program is recommended, consisting of the following elements.

1. **Initial educational questionnaire** sent to all watershed residents regarding the current status of their knowledge and asking questions that will impart information even if the survey questionnaire is never returned.

2. The development of **a school age public education program** with materials made specifically for the watershed and taught in gradewide presentations by a part-time professional teacher or waterworks staff, or incorporated into the school curriculum.
3. Hold a **technical transfer workshop** for Conservation Commissioners, Planning Board members and staff, Public Works directors and staff, developers and site engineers. Many of the techniques and principles may be unfamiliar, so it is important to provide educational opportunities and to obtain input from affected parties such as developers. The workshop would also allow an opportunity to discuss cost implications with developers, which are typically minimal or non-existent. In fact, many of the infiltration technologies and methods described above are lower cost than conventional methods used today. If the workshop is successful, Pennichuck could consider making it an annual event for as long as important information needs to be transmitted to developers. It could also be an opportunity to do onsite visits and reviews of Pennichuck's demonstration projects.
4. Conduct a **follow-up questionnaire survey** to gauge the effectiveness of the program and develop an understanding of how attitudes have changed or increased in knowledge.

Prevention Method 5: Modify Watershed Regulations

The existing watershed regulations have few controls that are currently beneficial to protecting the watershed. Pennichuck should begin the process of reviewing and revising these regulations to incorporate a level of protection should it be needed in the watershed. While most watershed Towns have shown a high level of cooperation, the watershed regulations could be used as a backup if practices that are detrimental to Pennichuck's water quality can not be modified through discussions and technology transfer. In most cases, however, the use of watershed regulations for enforcement of requirements should be avoided. Wherever possible, cooperative agreements should be used instead.

Remedial Actions

The remedial actions recommended below address the most highly contaminated areas of the watershed. In these areas, less expensive/intensive prevention measures are ineffective or inapplicable. These remedial measures have been developed based on specific problem areas identified in Section 9.1 Findings.

Remedial Measure 1: Dredging of the Ponds

It is strongly suspected that the Pennichuck ponds have begun to fill with sediment due to the high level of stormwater entering the watershed. Stormwater is typically laden with sediments, and these are settled out in the ponds, which are believed to provide a major improvement to the water quality that eventually reaches the treatment plant and Pennichuck's customers. Some of the ponds show particular evidence of filling with sediments, and may even be acting as sources of additional nutrients

because of anaerobic conditions and the re-release of nutrients and other pollutants from the sediments that occurs under anaerobic (without oxygen) conditions. Because this could drastically accelerate water quality deterioration in the watershed, maintenance dredging of the ponds is probably going to be likely. However the first step in determining where and how much dredging is required is to evaluate sediment depths and characteristics. The following steps are recommended.

1. Map and probe sediments in each of the ponds for depth and extent. Take sediment samples for analysis, and measure water quality at the time of depth probes to determine whether bottom conditions are anaerobic.
2. Calculate total sediment depth and cubic yardage for potential removal.
3. Identify method of dredging and methods for dewatering dredged spoil materials or re-routing water during dry excavation.
4. Obtain approvals for dredging, which may be difficult in some instances. Show Conservation Commissions evidence of extreme need for dredging, if sediment depth probes show that it is necessary.
5. Continue to monitor ponds on a yearly basis, monitoring sediment depths at a specific location near the outlet of each pond. Use this to determine when maintenance dredging is required.

Remedial Measure 2: Infiltration Controls at Specific Sites

The most developed portions of the site are the Boire Field Brook subwatershed at 36% impervious, the Pennichuck Brook to Bowers Pond subwatershed (PBB) at 29% impervious, and the Witches Brook East (WBE) subwatershed at 23% impervious. Note the major difference in imperviousness between these subwatersheds and those with the least imperviousness, which include Witches Brook South (WBS) at 5% impervious and the Muddy Brook subwatershed (MB-1) at 6% impervious.

Although prevention methods are recommended for watershed-wide application, in many of the subwatersheds that are more developed there is little new development that can occur. It is thus likely that the prevention methods described above will have the most impact in maintaining water quality in those less developed watersheds, where they will have a lesser impact in the developed watersheds. The more developed watersheds, or those with higher imperviousness, are more likely to be affected by remedial measures. Therefore, it is these subwatersheds that are most appropriate for the use of structural Best Management Practices (BMPs).

These technologies are appropriate for projects that come back to the Planning Board for substantial modification of existing facilities, or expansion of those same facilities, or as stand alone units such as the one developed by Pennichuck for New Hampshire Technical College.

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An additional structural BMP was created for the Pennichuck Square area. Both of these BMPs are located within the most impervious subwatershed of Boire Field Brook. An additional structural BMP within this area that should be considered is one to control runoff from the airport. Airports are well known for their contribution of spills of aviation fuel, oil and deicing chemicals to waterways. Additionally, they commonly produce a heavy nutrient load and heavy metal load from the same sources as found on other types of roadways. This type of land use essentially presents itself as a huge parking lot, and the impacts on local waterways can be significant. We recommend that Pennichuck work with the Boire Field authorities to develop a BMP that will assist in reducing the impacts of this airstrip on Pennichuck's water supply. Once all the BMPs are completed in the most highly impervious subwatershed, the next most highly impervious subwatershed (PBB-Pennichuck Brook to Bowers Pond) should be addressed.

By addressing the most impervious watersheds with remedial measures, steps can be taken each year to reduce the impact of these most impervious areas on water quality. A ranking of the areas in terms of appropriateness for remedial measures is given on Table 9-4.

Remedial Measure 3: Hazardous Waste Sites

There are a number of hazardous waste sites in the watershed, some more benign than others. These sites are in various stages of remedial action being required by DES, but these processes can often be expedited if water supplies are at risk. We recommend that Pennichuck request a status report on each of the sites. Their status at the time of this report is recorded in that information, however, at least an annual discussion with each of the project managers at DES on each of the sites should be conducted to make sure that DES is aware of Pennichuck's Watershed Protection Program and that Pennichuck is aware of DES' most recent actions on the site.

Remedial Measure 4: Hot Spots

Hot spots are defined in this report as service stations, car dealerships and automotive repair shops. Because of the potential of these particular types of businesses to create major water quality impacts on the system as a whole, special educational efforts are warranted. Service stations can generate significant hydrocarbons, metals, and other pollutants from car washing, engine steam cleaning, spills of oil and gas, parts cleaning, leakage from wrecked vehicles and exposure of automotive products and waste to stormwater. Since most floor drains can no longer be connected to the

Table 9-4
Remedial Measures Priority Subwatersheds

Rank	Designation	Name	Location	Impervious
1	BFB	Boire Field Brook	Nashua	36%
2	PBB	Pennichuck Brook to Bowers Pond	Merrimack & Nashua	29%
3	WBE	Witches Brook East	Amherst/ Hollis	23%
4	WBN	Witches Brook North	Amherst/ Milford	19%
5	SPB	Stump Pond Brook	Amherst/ Merrimack	17%

sanitary sewer, many gas stations discharge these materials either directly to storm drains or recharge onsite. Neither of these is acceptable and in fact are illegal in areas defined as "underground sources of drinking water". Some of the recommended pollution prevention practices identified by the Santa Clara Valley Non-Point Source Control Program are listed in Table 9-5.

Table 9-5 Recommended Practices to Prevent Stormwater Pollution from Service Stations/Auto Repair Areas	
1	Prevent discharges when changing automotive fluids
2	Use drip pans when working on engines
3	Use special care to prevent leaks from wrecked vehicles
4	Quickly cleanup spills of all sizes
5	Keep wastes from entering floor drains and storm drains
6	Use concrete surfaces and roofing over fueling areas to prevent spilled fuel from contact with stormwater
7	Properly store and recycle used batteries
8	Clean parts without using liquid solvents (or use solvent recyclers)
9	Capture all metal particles during grinding and finishing operations
10	Properly store and recycle waste oil, antifreeze and other automotive fluids
11	Select "environmentally friendly" products and control inventory to reduce wastes
12	Keep all working areas inside and away from stormwater
13	Treat all liquid streams from car washing and engine cleaning
14	Train employees on pollution prevention activities for the shop
15	Educate customers on proper recycling and/or disposal of automotive products

Monitoring

Monitoring Technique 1: Measure Stream Channels and Imperviousness Annually

The imperviousness estimates made for this project, which was shown on Table 9-2, should be updated on an annual basis based on the amount of imperviousness added in each subwatershed. There are several methods to estimate this, which could include additional land use mapping or aerial photography, or the development of town by town "imperviousness" budgets that could be calculated by Planning Boards after each calendar year. Several locations along the main stream channel should also be selected to survey in channel characteristics. This could then be measured on an annual basis, or alternatively, aerial photographs could be used to calculate annual changes in key subwatersheds.

Monitoring Technique 2: Periodic Sediment Depth Mapping

As described in Remedial Measure 1, sediment depth mapping of the ponds is needed to evaluate their current status. This should also be continued on an annual or bi-annual basis to determine the rate of accumulation.

Monitoring Technique 3: Stormwater Monitoring of Demonstration Projects

The demonstration projects already undertaken by Pennichuck should be monitored upstream and downstream for at least three storms per year to evaluate the effectiveness of the measures. This should also be done at the demonstration buffer project and the demonstration roadway projects when completed. This pre- and post-monitoring of control areas and up and downstream areas of the demonstration projects will allow for corrections to be made if necessary and will demonstrate the effectiveness of the methods.

Section 9.0 Recommendations

Monitoring Technique 4: Intensive One Year Monitoring Program

Because there is little water quality baseline for the watershed, a baseline-monitoring program should be developed over a one-year period.

Dry Weather Monitoring

The purpose of a monitoring program is to provide critical long-term trending information for the chain ponds and their tributaries. The data obtained from the monitoring plan will identify the current in-pond water quality and assist in evaluating the impacts of the surrounding watershed on the chain pond system.

Since there is very limited data on watershed water quality, it is recommended that a monitoring program be implemented with monthly monitoring including depth sampling in each of the ponds and tributary sampling in each subwatershed. It is recommended that three samples be taken at each pond to establish whether in-pond sediments may be providing a source of phosphorus and other chemical loadings to the ponds and to provide more information on possible corrective methods. Only ponds that show stratification should be sampled in this way. Shallow ponds (typically less than 10 feet deep) that don't stratify should be sampled at top and bottom only, in the deepest section of the pond. The first should be taken at the water surface in the epilimnion layer. The second should be taken in the metalimnion layer, and the third should be taken a few inches from the bottom of the reservoir in the hypolimnion layer. The parameters recommended for analysis are provided below:

- Ammonia nitrogen - This is the nitrogen form most readily used by aquatic plants. Nitrogen may contribute to excess vegetative growth in a water system. High levels of ammonia nitrogen may indicate a nearby source of waste discharge or fertilizer storage. A method detection limit of 0.05 mg/l may be used for ammonia nitrogen analysis.
- Chloride - Chlorides may be introduced to runoff after salts are applied to remove ice and snow from roads, parking lots and sidewalks. At high levels, chlorides can be toxic to fresh water organisms. A field probe may be used for measurement.
- Dissolved oxygen* - Dissolved oxygen levels will indicate if bottom sediments have an oxygen demand. A field instrument should be used and calibrated before the readings are taken. High dissolved oxygen levels may cause algal blooms, which can lead to fish kills, and other undesirable water quality effects.
- Fecal coliform* - Indicator of disease causing pathogenic organisms. The laboratory should use the membrane filter method. The presence of fecal coliform is typically an indication of nearby feces from animals or humans.
- Nitrate - A method detection limit of 0.05 mg/l may be used for nitrate nitrogen. High nitrate levels may indicate contamination from fertilizer, municipal wastewaters, feedlots, or septic systems.
- pH* - A field probe may be used for measurement. Over-

productive reservoirs or ponds may see fluctuations in pH as vegetation photosynthesize and respire.

- Specific conductivity - Specific conductivity is a field measurement of the amount of particulate within a sample. A field probe may be used for measurement. Conductivity is also a measure of total dissolved solids, which are carriers for contaminant sources in water.
- Temperature* - Temperature can be used to identify the epilimnion, metalimnion and hypolimnion layers in the reservoir depth samples. A field probe may be used for measurement. Variations in temperature may be an indication of wastewater discharges.
- Total dissolved solids (TDS) - TDS are also carriers for phosphorus and other contaminant sources. A field probe may be used for measurement.
- Total Kjeldahl nitrogen (TKN) - A method detection limit of 0.20 mg/l may be used for TKN analysis. High TKN values may indicate the presence of a nitrogen source such as a feedlot or wastewater discharge.
- Total phosphorus* - This is the limiting nutrient in a fresh water system and may result in excess algal growth if present in sufficient quantities. A method detection limit of 0.01 mg/l should be used for total phosphorus analysis. The laboratory should be contacted before sample collection to see if they can analyze to this detection limit. They may require a larger sampling container for the lower detection limit.
- Total suspended solids (TSS)* - TSS are carriers for phosphorus and other contaminant sources. A field probe may be used for measurement.
- Turbidity* - Elevated turbidity levels can interfere with disinfection by sheltering microbes and reducing their exposure to chlorination, potentially allowing disease causing pathogenic organisms to enter the distribution system. A field probe may be used for measurement.

**Analyzing the chain ponds at these depths for the parameters indicated above with an asterik (*), will help establish whether there is a phosphorus loading from the sediments of the ponds.*

In addition to the pond depth sampling, it is recommended that quarterly sampling be conducted at seven tributaries to assist in determining the impacts the surrounding watershed has on the chain pond system.

It is recommended that each of these samples be analyzed for the parameters indicated in the list above. Additionally, flow rates should be taken from all streams monitored. Review of the long-term monitoring data over a few sampling runs may allow for the reduction of some parameters such as nitrate-nitrogen.

Stormwater Monitoring

To evaluate the degree of pollution associated with stormwater in this watershed, a wet weather sampling program using a "cluster" design was

developed. Sampling locations were chosen to collect stormwater runoff from various types of land uses within the watershed including residential, industrial and commercial. Both stormwater drainage maps and land use maps were used in choosing the locations. Sampling locations in each land use were chosen based on the stormdrain pipes that drained the largest area to ensure enough flow for the analysis. Sampling locations are identified in the appendix.

The equipment needed to complete the sampling will include plastic gloves (no zinc), acid washed sampling bottles, acid washed pail, stop watch, watch (with minute hand) and rain coats, which are discussed in more detail under the sampling procedure. All samples should be analyzed for:

- ■ Total Phosphorus
- ■ Nitrogen (TKN)
- ■ Heavy metals including lead, copper, zinc, chromium and cadmium
- ❑ Chloride
- ❑ Total Suspended Solids
- ❑ Volatile Suspended Solids
- ❑ Oil and grease
- ❑ Conductivity
- ❑ pH
- ❑ Total Coliform
- ❑ Fecal Coliform

The procedure for collecting stormwater samples should be as follows:

1. Teams of two people will be on site at least 30 minutes before rain starts. All team members should wear zinc free gloves to prevent sample contamination.
2. Sampling will begin when the flow of water starts (approximately one to two inches of water in pipe).
3. An acid washed bucket will be used to collect the sample from the drainpipe. Buckets will be rinsed three times between samples. Samples will be gathered in an acid washed bucket and distributed in appropriately labeled containers.
4. The following field parameters should be taken at each sample:
   - Time
   - Flow rate
   - Depth of water in pipe
   - Diameter of pipe
5. Samples will be taken every 30 minutes for two hours. A total of four samples per site should be taken.

It is important to have reasonable weather data to properly plan for stormwater sampling. Storm notification can be obtained from the Channel 9 Manchester Weather Station WMUR at (603) 669-9999, or from National Weather Service in Gray, Maine (One Weather Lane, PO Box 1208, Gray, ME 04039-1208) with real time radar at (207) 688-3216 from 7:00 am to 5:00 pm. The National Weather Service in Gray, Maine is the most accurate and can usually predict a storm one to two hours before rain starts.

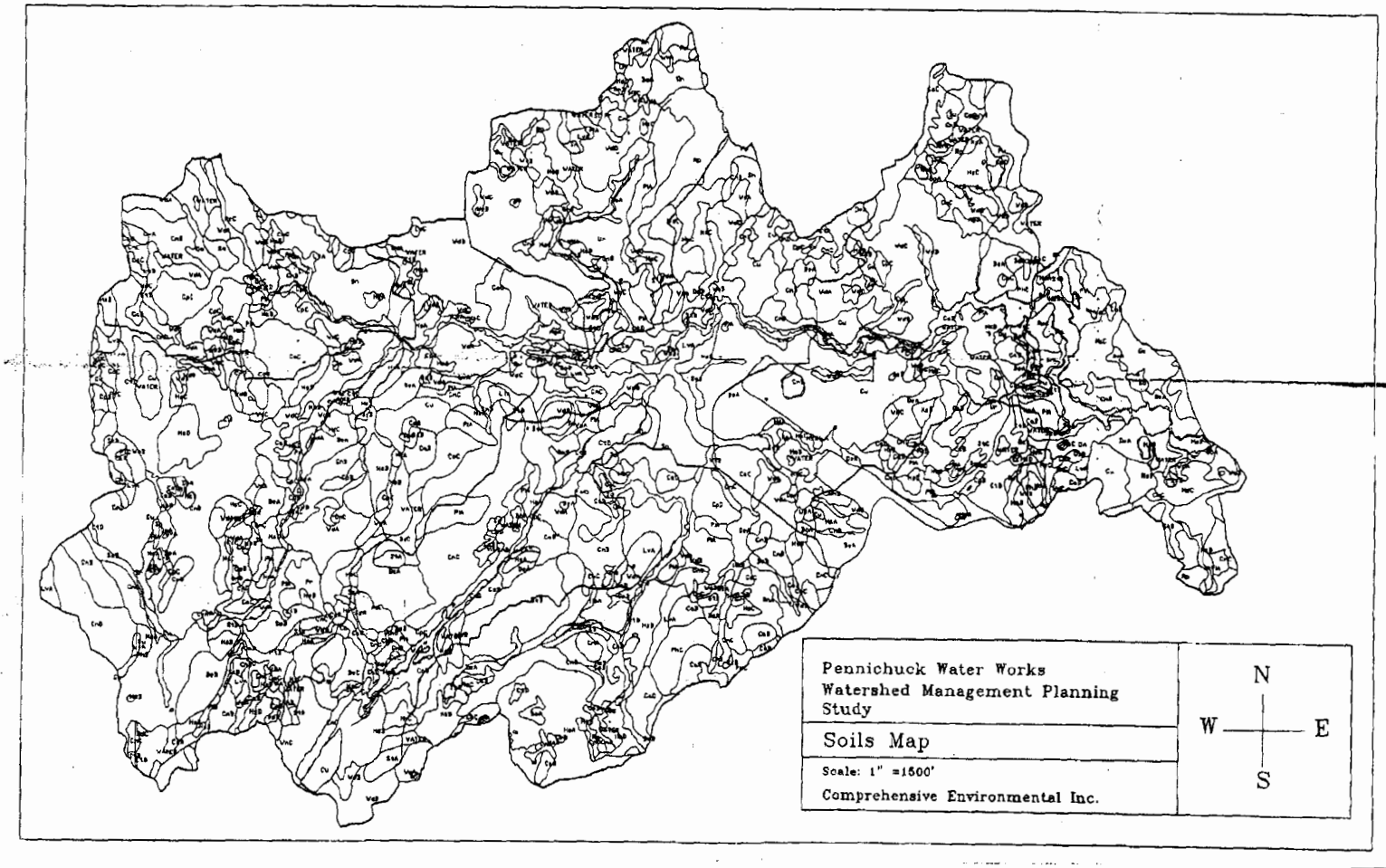
Late summer (July/August) sampling is recommended to provide a worst case event, preferably after a week long dry period so contaminants are built up on surfaces.

An alternative to this type of labor-intensive sampling would be to install a datalogger at specific locations, potentially with a sampler. However, not all parameters can be measured with this method.

Monitoring Technique 5: Follow-up Monitoring

Once the one year intensive baseline of dry weather and stormwater monitoring has been completed, trend graphs can be developed and evaluated. Some parameters may be dropped, others could potentially be added. The monitoring in the same locations should then continue for the long-term, using a quarterly baseflow monitoring, and periodic stormwater monitoring of demonstration projects and key areas identified during the baseline program. This program would then continue indefinitely, updated annually to determine the effects of the Watershed Management Program on water quality. It can also be used to monitor the progress in meeting the overall goals and objectives of the project.

Appendix A
Soil Map and Legend


Pennichuck Water Works
Watershed Management Planning
Study
Soils Map
Scale: 1" =1500'
Comprehensive Environmental Inc.
N
W
E
S

Legend

CnC – Canton very stony fine sandy loam, 8–15% slopes
CnD – Canton very stony fine sandy loam, 15–35% slopes
CoC – Canton–Urban Land complex, 3–15% slopes
CpB – Chatfield–Hollis–Canton complex, 3–8% slopes
CpC – Chatfield–Hollis–Canton complex, 8–15% slopes
CpD – Chatfield–Hollis–Canton complex, 15–25% slopes
CsB – Chatfield–Hollis complex, 3–8% slopes
CsC – Chatfield–Hollis complex, 8–15% slopes
CtD – Chatfield–Hollis–Rock Outcrop complex, 15–35% slopes
Cu – Chocorua mucky peat
DeA – Deerfield loamy fine sand, 0–3% slopes
DeB – Deerfield loamy fine sand, 3–8% slopes
Dp – Dumps
Gw – Greenwood mucky peat
HaA – Hinckley loamy sand, 0–3% slopes
HaB – Hinckley loamy sand, 3–8% slopes
HaC – Hinckley loamy sand, 8–15% slopes
HaD – Hinckley loamy sand, 15–35% slopes
LeA – Leicester Variant loam, 0–3% slopes
LsA – Leicester Variant stony loam, 0–3%
LtA – Leicester–Walpole complex, 0–3% slopes
LtB – Leicester–Walpole complex, 3–8% slopes
LvA – Leicester–Walpole complex stony, 0–3% slopes
LvB – Leicester–Walpole complex stony, 3–8% slopes
MeB – Montauk fine sandy loam, 3–8% slopes
MeC – Montauk fine sandy loam, 8–15% slopes
MeD – Montauk fine sandy loam, 15–25% slopes
MtB – Montauk stony fine sandy loam, 3–8% slopes
MtC – Montauk stony fine sandy loam, 8–15% slopes
MtD – Montauk stony fine sandy loam, 15–25% slopes
NnA – Ninigret very fine sandy loam, 0–3% slopes
NnB – Ninigret very fine sandy loam, 3–8% slopes
Oc – Occum fine sandy loam
Om – Occum fine sandy loam, high bottom
PbB – Paxton fine sandy loam , 3–8% slopes
PbC – Paxton fine sandy loam, 8–15% slopes
PbD – Paxton fine sandy loam, 15–25% slopes
PfB – Paxton stony fine sandy loam, 3–8% slopes
PfC – Paxton fine sandy loam, 8–15% slopes
PfD – Paxton stony fine sandy loam, 15–25% slopes
PfE – Paxton stony fine sandy loam, 25–35% slopes
PhB – Pennichuck channery fine sandy loam, 3–8% slopes
PhC – Pennichuck channery fine sandy loam, 8–15% slopes
PhD – Pennichuck channery fine sandy loam, 15–25% slopes
PiA – Pipestone loamy sand, 0–3% slopes

AgA – Agawam fine sandy loam, 0–3% slopes
AgB – Agawam fine sandy loam, 3–8% slopes
BaA – Belgrade silt loam, 0–3% slopes
BaB – Belgrade silt loam, 3–8% slopes
BdA – Bernardston Variant very fine sandy loam, 0–3% slopes
BdB – Bernardston Variant very fine sandy loam, 3–8% slopes
BdC – Bernardston Variant very fine sandy loam, 8–15% slopes
BsC – Bernardston Variant stony very fine sandy loam, 8–15% slopes
BsD – Bernardston Variant stony very fine sandy loam, 15–35% slopes
Bg – Binghamville silt loam
Bea – Borohemists, nearly level
BpA – Borohemists, ponded
CaB – Canton fine sandy loam, 3–8% slopes
CaC – Canton fine sandy loam, 8–15% slopes
CaD – Canton fine sandy loam, 15–25% slopes
CmB – Canton stony fine sandy loam, 3–8% slopes
CmC – Canton stony fine sandy loam, 8–15% slopes
CmD – Canton stony fine sandy loam, 15–25% slopes
CmE – Canton stony fine sandy loam, 25–35% slopes
PlB – Pipestone loamy sand, 3–8% slopes
Pr – Pits, gravel
PtA – Pittstown Variant loam, 0–3% slopes
PtB – Pittstown Variant loam, 3–8% slopes
Pu – Pootatuck fine sandy loam
Qr – Quarries
RbA – Ridgebury loam, 0–3% slopes
RsA – Ridgebury stony loam, 0–3% slopes
RsB – Ridgebury stony loam, 3–8% slopes
Rp – Rippowam fine sandy loam
Sm – Saco Variant silt loam
Sn – Saugatuck loamy sand
So – Searboro mucky loamy sand
Sr – Searboro stony mucky loamy sand
SaA – Scituate fine sandy loam, 0–3% slopes
SaB – Scituate fine sandy loam, 3–8% slopes
SaC – Scituate fine sandy loam, 8–15% slopes
StA – Scituate stony fine sandy loam, 0–3% slopes
StB – Scituate stony fine sandy loam, 3–8% slopes
StC – Scituate stony fine sandy loam, 8–15% slopes
Su – Sunnook loamy fine sand
UdA – Udipsamments, nearly level
Ur – Urban land
WdA – Windsor loamy sand, 0–3% slopes
WdB – Windsor loamy sand, 3–8% slopes
WdC – Windsor loamy sand, 8–15% slopes
WdD – Windsor loamy sand, 15–35% slopes
WnC – Windsor–Urban land complex, 3–15% slopes
WoA – Woodbridge loam, 0–3% slopes
WoB – Woodbridge loam, 3–8% slopes
WvB – Woodbridge stony loam, 3–8% slopes
WvC – Woodbridge stony loam, 8–15% slopes

Appendix B
Historical Sampling Data and Location Map

Fecal Coliform Data 1991

	River	Harris Pond	Bowers Pond	Holt Pond	Amherst Street	Supply Pond	Muddy Brook	Witches Brook	Stump Pond	Nevins Road
17-Jan		0				7				
23-Jan		1				3				
30-Jan		0				2				
12-Feb		0				5				
12-Mar		1				1				
18-Mar		2				0				
26-Mar	tntc	0	1	3	0	3	6	5	1	6
9-Apr	97.00	0.00	0.00	33.00	20.00	0.00	4.00	29.00		4.00
16-Apr	tntc	0	5	24	22	2	15	17	2	6
25-Apr	tntc	4	5	33	17	2	6	21	tntc	2
1-May	tntc	1	4	tntc	tntc	1	157	tntc	46	49
8-May	260	4	4	60	60	3	<10	20	78	8
13-May	305	0	3	30	60	0	<10	40	60	8
20-May	400	0	0	0	40	0	8	100	22	14
25-Jun	600	12	2	14	38	3	92	98	2	18
2-Jul	530	89	5	179	517	53	tntc	207	40	tntc
9-Jul	70	2		17	100	34	20	120	7	30
16-Jul	110	2	tntc	tntc	300	tntc	100	100	tntc	30
18-Jul		<10				<10			8	
24-Jul	10	1	0	25	40	16	20	100	7	90
30-Jul	0	1	9	4	40	0	10	700	5	20
6-Aug	22	0	0	13	20	0	87	800	40	80
13-Aug	210	1	1	17	<10	8	40	210		140
21-Aug		25	43	>200	>200	82	160	200	10	113
28-Aug	760	1	6	30	20	0	26	40	<10	230
5-Sep	300	1	0	10	20	3	252	200	4	100
10-Sep	<100	<1	<1	6	28	<1	<100	100	8	100
24-Sep	<100	<1	9	20	36	14	<100	200	84	300
9-Oct	200	10	10	24	158	3	70	100	<1	<100
21-Oct	90	<1	1	26	<10	<1	<10	10		<10
29-Oct		<1				11			6	
4-Nov	14	1	<1	26	10	1	<10	22		2
13-Nov									4	
18-Nov		1	66	14	6	3	6	<1	<1	8
2-Dec		4	4	4	12	8	14	6		6
19-Dec		<1				1				
Average	**268.5**	4.9	27.1	69.7	87.8	22.2	70.3	**151.7**	57.7	75.8

Fecal Coliform Data 1992

	River	Harris Pond	Bowers Pond	Holt Pond	Amherst Street	Supply Pond	Muddy Brook	Witches Brook	Stump Pond	Nevins Road
7-Jan		1				<1				
14-Jan		1				<1				
22-Jan		<1				<1				
28-Jan		<1				<1				
5-Feb		<1				<1				
11-Feb		<1				<1				
19-Feb		<1				<1				
26-Feb		<1				<1				
3-Mar		<1				<1				
10-Mar						<1				
18-Mar		<1				<1				
25-Mar		<1				<1				
1-Apr		2				<1				
8-Apr		<1				<1				
15-Apr		<1				<1				
22-Apr		<1				<1				
29-Apr		<1				<1				
13-May		<1				<1				
27-May	2	3	6	8	12	2	88	2	10	14
2-Jun	3700	tntc	<1	<1	<1	tntc	<1	tntc	<1	<1
9-Jun	1700	13	48	104	88	9	100	72	48	4
16-Jun	<1	<1	4	tntc	tntc	24	76	156	20	16
23-Jun	100	26	4	24	24	2	120	176	4	12
30-Jun	<1	1	4	4	68	2	<1	108	4	12
7-Jul	80	<1	22	3	54	2	28	52	13	13
14-Jul	20	<1	5	1	24	1	20	64	7	54
21-Jul	820	11	1	tntc	tntc	tntc	tntc	64	81	48
28-Jul	<1	<1	10	4	10	<1	<1	76	<1	24
4-Aug	40	1	4	2	10	2	40	20	10	184
11-Aug		<1	4	2	tntc	5	40	76	20	10
18-Aug	60	5	32	30	320	13	280	910	4	40
25-Aug	800	<1	5	18	50	<1	<100	200	63	4
1-Sep	60	12	3	6	20	3	140	100	28	22
8-Sep	20	1	9	1	30	1	30	30	4	228
16-Sep		1	1			1			42	<1
22-Sep	20	<1	<1	14	20	2	34	30		
6-Oct	6	1	<1	3	4	<1	<1	6	23	<10
13-Oct	80	<1	3	18	30	3	24	82	11	6
Average	**417.1**	15.6	8.3	65.4	**119.2**	28.2	81	**143.4**	20.6	36.8

Fecal Coliform Data 1993

	River	Harris Pond	Bowers Pond	Holt Pond	Amherst Street	Supply Pond	Muddy Brook	Witches Brook	Stump Pond	Nevins Road
25-May	18	<1	<1	54	20	<1	80	18	28	30
2-Jun	52	1	0	53	34	8	111	6	67	17
8-Jun	11	<1	<1	<1	6	<1	5	3	<1	5
16-Jun	77		1	18	36	11	39	79	20	24
23-Jun	24	26	0	1	40	1	13	44	0	37
30-Jun	0	0	0	0	0	0	1	0	0	0
8-Jul	2	21	0	>200	>200	33	93	115	59	>200
15-Jul	0	0	0	0	0	0	0	0	0	0
21-Jul	15	64	35	64	182	1	>200	123	>200	>200
28-Jul	68/62	3	1	32	>200	3	>200	>200	>200	>200
29-Jul	200/500									
30-Jul	144/82									
3-Aug	500/180									
4-Aug	200/400	>200	>200	12	>200	>200	>200	>200	>200	>200
5-Aug	290/300									
6-Aug	120/100									
9-Aug	100									
10-Aug	20	30	10	10	<100	10	390	60	540	620
11-Aug	20									
12-Aug	30									
17-Aug	77/72	116	16	18	78		81	88	>200	>200
18-Aug	32/60					>200				
19-Aug	4600/1700									
Average	**226.7**	38.4	20.2	35.5	84.2	35.9	**108.7**	72.0	**116.5**	**133.3**

Fecal Coliform Data 1994

	River	Harris Pond	Bowers Pond	Holt Pond	Amherst Street	Supply Pond	Muddy Brook	Witches Brook	Stump Pond	Nevins Road
24-May	8	6	6	34	66	68	66	82	22	16
2-Jun	8	<1	24	28	18	22	10	26	10	82
9-Jun	30	>200	34	66	78	<1	150	36	106	156
15-Jun	72	2	8	52	140	94	66	28	16	>200
22-Jun	82	74	12	48	56	12	86	82	48	94
29-Jun	4	4	1	34	2	<1	4	16	32	4
8-Jul	80	8	2	78	>200	<1	56	96	100	50
12-Jul	152	14	6	14	>200	4	60	4	4	138
19-Jul	12	8	6	20	72	<1	44	98	6	48
26-Jul	10	>200	6	20	>200	8	>200	8	20	56
2-Aug	50	<1	<1	>200	>200	<1	42	>200	8	24
9-Aug	110	<1	9	40	20	9	40	140	>200	20
16-Aug	82	<1	6	30	>200	<1	50	8	4	18
23-Aug	1570/1350	<1	tntc	tntc	>200/100	tntc	tntc	30	20	1580
30-Aug	100/<100	<1	100	<100	10	20	<100	60	20	<100
7-Sep	40/90	<1	10	10		12	<10	<20	10	10
Average	**145.3**	32.3	45.6	79.6	**103.9**	46.8	92.6	58.3	39.1	**162.2**

Appendix C
1996 Sampling Data

Fecal Coliform Data 1996

	River	Harris Pond	Bowers Pond	Holt Pond	Behind NHVT	Amherst Street	Pennichuck Brook	Supply Pond	Springs	Muddy Brook	Witches Brook	Stump Pond
25-Apr		<1						<1				
1-May	60	1	2	20	20	30	6	1	1	12	30	10
15-May	75	31	42	2	10	0	10	10	0	0	0	10
30-May	0	0	0	250	400	100	160	20			300	40
13-Jun	0	0	0	100	0	100	100	0		200	200	100
26-Jun	200	0	0	0	100	0	0	0		0	310	0
9-Jul	0	0	0	0	200	100	0	0		100	100	0
Average	55.83	4.57	7.33	62.00	**121.67**	55.00	46.00	4.43	0.50	60.00	**156.67**	26.67

Phosphorus Data 1996

	River	Harris Pond	Bowers Pond	Holt Pond	Behind NHVT	Amherst Street	Pennichuck Brook	Supply Pond	Muddy Brook	Witches Brook	Stump Pond
14-Nov	0.06	0.02	.02/.01	0.01	0.01	0.02	0.16				
15-Nov	0.08	<.01	.02/<.01	0.01		<.01	0.01				
17-Apr		0.02		0.025			0.02	0.04			
1-May	0.04	0.03	0.18	0.01	0.02	.02/.05					
2-May	0.11	0.06	0.55		0.07		0.05				
15-May	.02/.05	.01/.04		0.04	.01/.03	.01/.04		.01/.03			
30-May	.02/.06	<.01/.01	<.01/.02	.02/.05	0.02	.01/.01	.01/.02	.01/.04	<.01	<.01	0.01
13-Jun	0.10	0.05		0.09	0.07	0.04	0.04	0.03			
26-Jun	0.14	0.04	0.06	0.06	0.09	0.07					
9-Jul	0.23	0.06	0.01	0.21	0.12	0.09	0.09				
Average	**0.09**	**0.04**	**0.12**	**0.05**	**0.05**	**0.04**	**0.06**	**0.03**	**<.01**	**<.01**	**0.01**

Summary of 1996 Sampling Parameters																		
	ph			Conductivity			Turbidity			DO (% saturation)			Temperature			Flow		
Date	7/17/1996	8/28/1996	12/5/1996	7/17/1996	8/28/1996	12/5/1996	7/17/1996	8/28/1996	12/5/1996	7/17/1996	8/28/1996	12/5/1996	7/17/1996	8/28/1996	12/5/1996	7/17/1996	8/28/1996	12/5/1996
SW-1	7.87	7.49	4.62	165	607	216	8	NA	0	7.6	9	6.8	23.3	22	7.6	dam	dam	dam
SW-2	7.77	10.4	4.6	132	567	132	7	NA	28	7.34	11.9	6.3	23.1	22.5	2.5	dam	dam	dam
SW-3	7.4	8.02	4.42	276	617	285	16	NA	0.5	7.66	7.68	4.8	22	19.2	3.7	0.35	nfd	0.181
SW-4	7.66	8.63	4.45	119	186	112	8	NA	15.1	7.04	10.8	7.2	24.1	22.2	2.4	dam	dam	dam
SW-5	7.48	8.69	4.27	115	161	112	10	NA	8.4	7.48	10	4.4	23.5	22.1	3.2	nfd	visible	visible
SW-6	7.2	9.09	4.09	100	233	88	7	NA	6.7	7.71	6.09	4.4	22.8	20.7	2.9	dam	dam	dam
SW-7	6.97	8.95	4.38	105	209	112	10	NA	2.2	7.85	7.15	4	22.5	20.4	3	nfd	nfd	nfd
SW-8	7.61	10.8	4.11	106	215	93	9	NA	5.6	7.02	9.52	2.9	27.8	23.3	3.6	visible high flow	visible high flow	visible high flow
SW-9	6.92	9.57	4.08	93	161	84	23	NA	0.8	6.69	10.6	2.8	27.8	23.5	1.9	visible high flow	visible high flow	visible high flow
SW-10	7.01	8.59	4.34	141	231	152	11	NA	4.9	7.56	3.26	3.1	24.2	20	3.7	0.12	nfd	0.194
SW-11	7.27	8.79	4.28	96	155	67	11	NA	6.5	8.41	9.03	3.3	21.6	19.9	3.3	0.13	nfd	0.152
SW-12	7.05	10.1	4.3	91	108	75	11	NA	11.7	8.27	9.93	4.4	24.4	19.2	3.5	visible	nfd	visible
SW-13	7.26	9.78	4.28	87	140	53	9	NA	2.8	9.13	9.7	3.7	20.6	18.6	3.4	0.17	0.008	0.173

Summary of 1996 Water Quality Data
Laboratory Analysis

	Fecal Coliform (# per 100 ml)			Ammonia (mg/l)			TKN (mg/l)			Total Phosphorus (mg/l)			Nitrate (mg/l)		
Date	7/17/1996	8/28/1996	12/5/1996	7/17/1996	8/28/1996	12/5/1996	7/17/1996	8/28/1996	12/5/1996	7/17/1996	8/28/1996	12/5/1996	7/17/1996	8/28/1996	12/5/1996
SW-1 Supply Pond Dam	<100	3.1	6	<0.50	<0.50	<0.1	<1.0	<1.0	0.39	0.003	0.19	0.44	<0.50	<0.50	0.52
SW-2 Harris Pond Dam	<100	2	11	<0.50	<0.50	<0.1	<1.0	<1.0	0.3	0.046	0.12	0.28	<0.50	<0.50	0.43
SW-3 Boire Field Brook	310	144.5	105	<0.50	<0.50	<0.1	<1.0	<1.0	0.59	0.125	1.35	0.31	0.53	<0.50	0.74
SW-4 Bowers Pond Dam	<100	3.1	13	<0.50	<0.50	<0.1	<1.0	<1.0	0.3	0.016	0.29	0.33	<0.50	<0.50	0.42
SW-5 Bowers Pond Mid	<100	13.7	37	<0.50	<0.50	<0.1	<1.0	<1.0	0.3	0.026	4.53	0.48	<0.50	<0.50	0.42
SW-6 Holts Pond Dam	100	13.7	12	<0.50	<0.50	<0.1	<1.0	<1.0	0.3	0.049	0.13	0.47	<0.50	<0.50	0.39
SW-7 Pennichuck Brook	100	78.2	13	<0.50	<0.50	<0.1	<1.0	<1.0	0.3	0.18	0.04	0.14	<0.50	<0.50	0.39
SW-8 Pennichuck Pond Mouth	<20	1	5	<0.50	<0.50	<0.1	<1.0	<1.0	0.3	0.023	0.06	0.23	<0.50	<0.50	0.39
SW-9 Muddy Brook	40	2	18	<0.50	<0.50	<0.1	<1.0	<1.0	0.3	0.082	0.01	0.32	<0.50	<0.50	0.42
SW-10 Stump Brook	300	>200.5	39	<0.50	<0.50	<0.1	<1.0	<1.0	0.44	0.043	1.05	0.09	<0.50	<0.50	0.55
SW-11 Witches Brook	300	109.1	6	<0.50	<0.50	<0.1	<1.0	<1.0	0.3	0.03	<0.01	0.45	<0.50	<0.50	0.5
SW-12 Witches Brook	200	>200.5	31	<0.50	<0.50	<0.1	<1.0	<1.0	0.3	0.013	0.4	0.99	<0.50	<0.50	0.51
SW-13 Witches Brook	<100	34.4	29	<0.50	<0.50	0.5	<1.0	<1.0	0.65	0.009	1.19	0.09	<0.50	<0.50	0.5

Appendix D
Hydrologic Analysis

HYDROLOGY

Runoff Calculations

The estimated runoff from the total watershed for a series of varied conditions was determined by analyzing available precipitation and runoff records for the local. Precipitation records for Nashua were used, covering the period 1922-1995, a 74-year continuous period of monthly rainfall. These were analyzed for the total period and for two distinct periods, 1922-1965 (44 years) and 1966-1995 (30 years), as discussed below. The runoff estimates for the area were based on analysis of several gaging station records as obtained by the U.S. Geological Survey as discussed below.

Although long term precipitation records are most useful in watershed studies, the long term record must be broken into several periods of 30 to 40-year duration so that trends of wet or dry periods can be examined. The U.S. Weather Bureau bases its precipitation averages for a given location on 30 consecutive years of record, usually through the most recent decade ending in zero; this means current averages by the U.S. Weather Bureau are based on the period, 1961-1990. Since monthly precipitation values are available through 1995, this study considers the 30-year period, 1966-1995, so that the most recent records are included. The average, maximum and minimum precipitation values for each month of the year are given for three distinct periods (44-year, 30-year and 74-year period) in Table 1-1.

Examination of this table reveals that the 44-year period from 1922-1965 was somewhat drier than the 30-year period from 1966-1995. This is evidenced by the fact that the average monthly precipitation was greater during the latter period for 11 of the12 months (only January was greater in the 1922-1965 period). The average precipitation was more than 8% higher for the most recent 30-year period versus the 44-year period.

Further analysis of the 30-year period from 1966-1995 revealed that the wettest year occurred in 1983 with a total precipitation of 59.72 inches, while the driest year occurred in 1966 with a total precipitation of 33.23 inches. Table 1-2 shows the average monthly precipitation values for the 30-year period, and the monthly precipitation values for the wet and dry year within the 30-year period.

Analysis of the entire 74-years of precipitation records shows that 1983 was the wettest year in the 74 years of record. However, the dry year for this period occurred in 1941 when only 27.33 inches of precipitation were recorded. The driest three consecutive years occurred in the mid-1960's drought with the following annual precipitation values:

■ 1964	31.13 inches
■ 1965	27.56 inches
■ 1966	33.23 inches
Three-year total	91.92 inches

Table 1-1. Precipitation Analysis for the Nashua Area

Month	44-year Period 1922-1965				30-year Period 1966-1995				74-year Period 1922-1995			
	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum	Total	Average	Maximum	Minimum
Jan	151.52	3.44	7.54	0.74	92.64	3.09	10.50	0.60	244.16	3.30	10.50	0.60
Feb	125.95	2.86	5.93	1.05	95.02	3.17	8.07	0.07	220.97	2.99	8.07	0.07
Mar	153.81	3.50	9.64	1.38	112.32	3.74	9.81	0.56	266.13	3.60	9.81	0.56
Apr	153.54	3.49	6.26	0.48	108.92	3.63	9.51	0.93	262.46	3.55	9.51	0.48
May	139.34	3.17	9.34	1.07	106.34	3.54	7.20	0.92	245.68	3.32	9.34	0.92
June	151.48	3.44	8.66	0.86	112.65	3.76	9.00	0.90	264.13	3.57	9.00	0.86
July	144.08	3.27	9.21	0.75	104.32	3.48	6.27	0.45	248.40	3.36	9.21	0.45
August	145.04	3.30	8.21	0.98	111.45	3.72	9.46	0.70	256.49	3.47	9.46	0.70
Sept	147.81	3.36	11.53	0.11	104.60	3.49	7.42	0.70	252.41	3.41	11.53	0.11
Oct	138.04	3.14	10.21	0.50	106.71	3.56	7.28	1.04	244.75	3.31	10.21	0.50
Nov	174.26	3.96	8.33	0.63	132.15	4.41	8.82	1.28	306.41	4.14	8.82	0.63
Dec	145.03	3.30	7.26	0.75	122.00	4.07	8.84	0.91	267.03	3.61	8.84	0.75
Totals	1769.90	40.23			1309.12	43.66			3079.02	41.61		

NOTE: All values given in inches

Table 1-2 - Annual and Monthly Precipitation for the Nashua Area (Based on 30-year Record at Nashua for Period 1966-1995)

Month	Average Precipitation	Maximum Year in 30 = 1983	Minimum Year in 30 = 1966
	(inches)	(inches)	(inches)
January	3.09	5.71	3.79
February	3.17	4.64	3.02
March	3.74	9.81	1.98
April	3.63	7.06	0.93
May	3.54	4.74	2.84
June	3.76	3.22	1.33
July	3.48	2.39	2.64
August	3.72	2.75	1.12
September	3.49	1.05	5.44
October	3.56	3.57	3.53
November	4.41	8.92	3.87
December	4.07	5.96	2.74
Total	43.66	59.72	33.23

The average precipitation during this three-year period was 30.64 inches.

The runoff values used for the Pennichuck watershed were derived from a study of records compiled by the U.S. Geological Survey from certain continuous record streamflow monitoring stations. U.S.G.S. operated a gaging station on the Souhegan River at Merrimack, N.H. from 1909 to 1976, at which time the station was discontinued. Subsequently, a gaging station was established on Beaver Brook at North Pelham on the Pelham-Windham town line that has provided a continuous flow record since 1986 to the present day. Although this suggests a ten-year gap in recorded flow data, the period of record for the Souhegan was sufficient to derive relationships between flow data recorded and monthly and annual precipitation. These relationships were correlated with the ten years of data collected since 1986 on Beaver Brook to provide reliable monthly rainfall-runoff relationships. Since the Souhegan River had a drainage area of 171 square miles at its gaging station as compared to Beaver Brook with a drainage area of 47.8 square miles at its gaging station, comparisons of flow records were made on a unit discharge basis. This provides flow rates per square mile of drainage area.

Precipitation-Runoff Analysis

A study of annual precipitation at Nashua and flow data at the Souhegan River at Merrimack for the 54-year period (1923-1976), shows a very distinct relationship between precipitation and flow contribution as depicted in Figure 1-1. All but five of the 54 data points from the 54-year period of record fall within the 90% probability range noted on the figure. This figure can be used to estimate the annual runoff from the watershed given a value for precipitation. For example, the average annual precipitation of 43.66 inches for the 30-year period (1966-1995) would be expected to yield an average runoff value of 25.65 inches with a 90% probability that the annual rainfall producing this contribution would fall within the range of 37.8 to 49.5 inches. A frequency analysis for this 54-year period of rainfall shows the results of Table 1-3.

The rainfall-runoff relationship for the Nashua area was determined by comparing the average and ranges of precipitation and flow for the Beaver Brook period of record (1987-1995) with the Souhegan River period of record (1923-1976). This comparison shows that for the period 1987-1995 the average annual precipitation for the Nashua area was 42.36 inches, which is 1.30 inches (3.0%) less than the 30-year average (1966-1995). The average runoff for the same 1987-1995 period based on Beaver Brook records was 21.12 inches, or about 17% less than the runoff developed for the 54-year period (1923-1976) using the Souhegan River records. Comparison of the two runoff records showed that the Beaver Brook record fell within the 90% probability range developed from the Souhegan River records for all annual precipitation values less than 50 inches. This agreement suggests that monthly precipitation-runoff values could likely be developed from the Beaver Brook data available for the past decade.

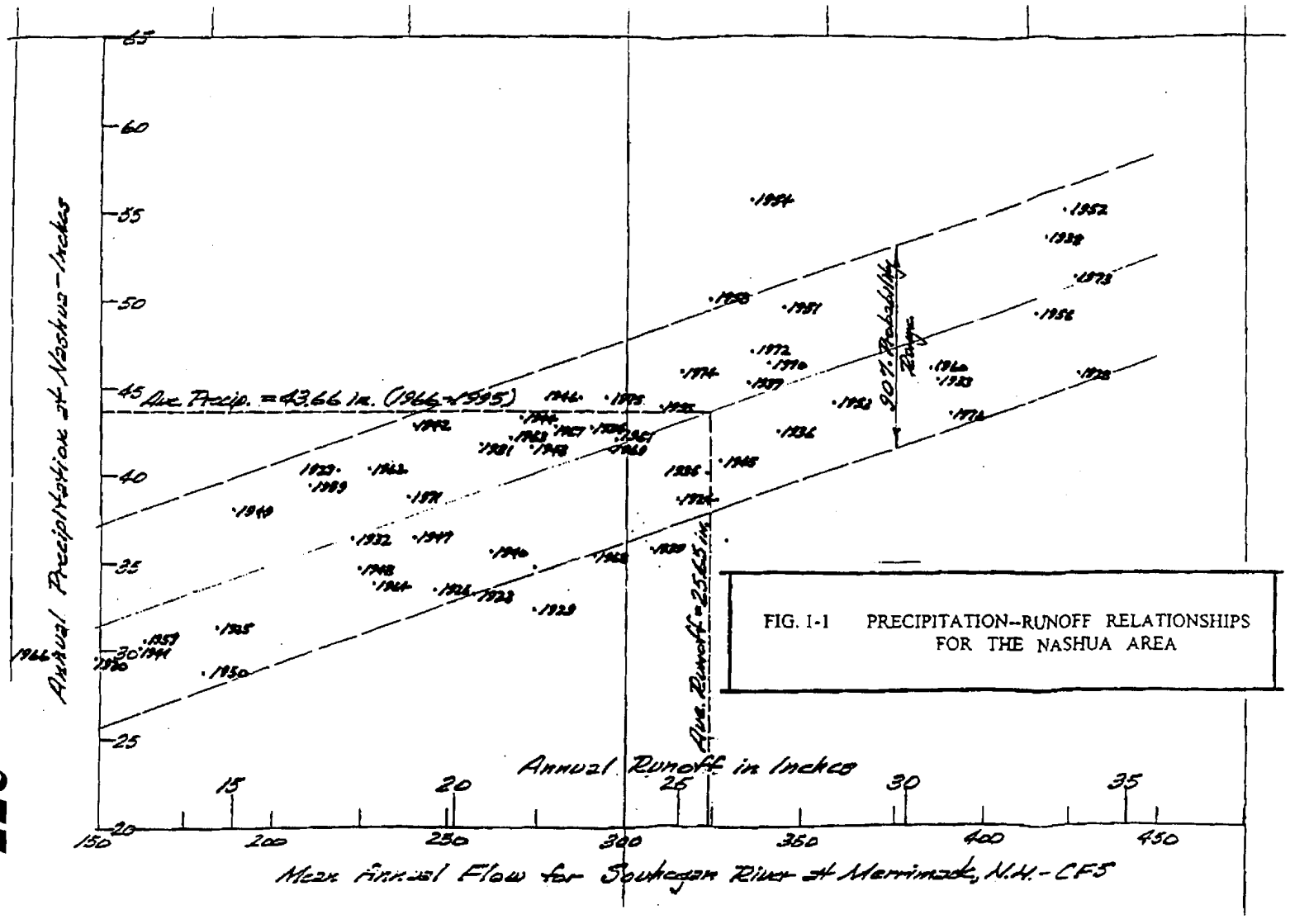


FIG. I-1 PRECIPITATION--RUNOFF RELATIONSHIPS FOR THE NASHUA AREA

Table 1-3. Frequency Analysis of 54-year Period of Precipitation	
Percent of Time Annual Precipitation is Less Than Stated	**Amount of Precipitation (inches)**
1%	27.5
2%	28.8
5%	30.9
10%	32.9
20%	35.4
30%	37.2
70%	44.5
80%	47.2
90%	50.5
95%	54.0
98%	57.8
99%	60.2

The monthly precipitation-runoff values developed from the Beaver Brook flow data and Nashua precipitation data resulted in discharge coefficients for each month that reflect seasonal and climatic affects on the relationships. For example, during the months of March and April, when runoff from rainfall and snowmelt can often exceed the precipitation for a given period, the monthly coefficient would range from 88% to 104% of rainfall in an average year. Similar rainfalls of 3.5 to 3.7 inches occurring in July through September would only average from 10% to 25% of rainfall appearing as runoff. Expected monthly runoff values, based on the long-term monthly average precipitation, are shown on Table 1-4. Discharge coefficients and runoff values, based on a wet (1983) and dry (1966) year are also shown on this table. The coefficients result in a calculated runoff value of 28.87 inches for 1983 (48.3% of rainfall) and a calculated runoff value of 15.39 inches for 1966 (46.3% of rainfall). Even in the wettest and driest year for the 30-years, the runoff ratio as a percentage is close to the 30-year average of 45.9%.

Table 1-4. Rainfall - Runoff Relationships for the Nashua Area

	Average Year			Maximum Year = 1983			Minimum Year = 1966		
Month	Precipitation (inches)	Discharge Coefficient	Runoff (inches)	Precipitation (inches)	Discharge Coefficient	Runoff (inches)	Precipitation (inches)	Discharge Coefficient	Runoff (inches)
Jan	3.09	0.63	1.95	5.71	0.26	1.48	3.79	0.46	1.74
Feb	3.17	0.56	1.78	4.64	0.42	1.95	3.02	0.58	1.75
Mar	3.74	0.88	3.29	9.81	0.62	6.08	1.98	1.60	3.17
Apr	3.63	1.04	3.78	7.06	1.00	7.06	0.93	1.50	1.40
May	3.54	0.52	1.84	4.74	0.52	2.46	2.84	0.58	1.65
June	3.76	0.20	0.75	3.22	0.20	0.64	1.33	0.56	0.74
July	3.48	0.11	0.38	2.39	0.13	0.31	2.64	0.13	0.34
Aug	3.72	0.16	0.60	2.75	0.09	0.25	1.12	0.06	0.07
Sept	3.49	0.10	0.35	1.05	0.40	0.42	5.44	0.08	0.44
Oct	3.56	0.27	0.96	3.57	0.27	0.96	3.53	0.27	0.95
Nov	4.41	0.43	1.90	8.82	0.35	3.09	3.87	0.45	1.74
Dec	4.07	0.60	2.44	5.96	0.70	4.17	2.74	0.51	1.40
Total	43.66			59.72			33.23		
Annual Average			20.02			28.87			15.39
Percentage			45.90%			48.30%			46.30%

Appendix E
Specific Factors Applied for Phosphorus Loading

Universal Soil Loss Equation (USLE) Parameters							
	Rainfall Erosivity (RE) (MJ-mm/ha-h)	Soil Erodibility (K)	Slope %	Length (ft)	Topographic Factor (LS)	Cropping Factor	Erosion-Control Practice Factor (P)
PBS							
Forest	125	0.15	5.5	200	0.855	0.011	1
Orchard	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cropland	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pasture	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PBB							
Forest	125	0.17	5	200	0.758	0.011	1
Orchard	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cropland	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pasture	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PBH							
Forest	125	0.16	3	200	0.354	0.011	1
Orchard	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cropland	125	0.18	605	150	0.917	0.003	1
Pasture	125	0.18	605	150	0.917	0.011	1
PBP							
Forest	125	0.18	6.1	200	0.974	0.011	1
Orchard	125	0.19	7.4	150	1.09	0.087	1
Cropland	125	0.19	6.2	150	0.861	0.003	1
Pasture	125	0.19	6.2	150	0.861	0.011	1
WBE							
Forest	125	0.18	6.4	200	1.04	0.011	1
Orchard	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cropland	125	0.17	2.1	150	0.237	0.003	1
Pasture	125	0.17	2.1	150	0.237	0.011	1
WBS							
Forest	125	0.19	10.9	200	2.201	0.011	1
Orchard	125	0.19	9.3	150	1.512	0.087	1
Cropland	125	0.21	10	150	1.68	0.003	1
Pasture	125	0.21	10	150	1.68	0.011	1
WBN							
Forest	125	0.19	9	200	1.66	0.011	1
Orchard	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cropland	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pasture	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SPB							
Forest	125	0.28	12.2	200	2.62	0.011	1
Orchard	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cropland	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pasture	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BFB							
Forest	125	0.18	8	200	1.41	0.011	1
Orchard	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cropland	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pasture	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MB							
Forest	125	0.195	9.3	200	1.744	0.011	1
Orchard	125	0.22	11.5	150	2.07	0.087	1
Cropland	125	0.2	7.7	150	1.15	0.003	1
Pasture	125	0.2	7.7	150	1.15	0.011	1

N/A - Not Applicable (This type of land use is not within this subwatershed)

K - Based on soil types within the watershed

Slope - Based on soil types within the watershed

Length - Based on recommendations of local Soil Conservation Service

C - Based on ground cover

P - Based on recommendations of local Soil Conservation Service

Septic System Evaluation Parameters				
	No. of Septic Systems	**No. Capita-Yrs.**	**Loading (kg/capita-yr)**	**Retention**
PBS	0	0.0	0.65	N/A
PBB	26	91.0	0.65	0.35
PBH	0	0.0	0.65	N/A
PBP	6	21.0	0.65	0.4
WBE	11	38.5	0.65	0.3
WBS	0	0.0	0.65	N/A
WBN	0	0.0	0.65	N/A
SPB	61	213.5	0.65	0.3
BFB	0	0.0	0.65	N/A
MB	0	0.0	0.65	N/A

No. of Septic Systems - Based on a count of houses within 200 meters of a pond known not to be on the town sewer system

No. Capita-Yrs. - Assumes 3.5 people per household

Retention - Literature coefficient based on soil type

Runoff Coefficients for Specific Land Uses in Each Subwatershed											
	Residential (>1 acre)	Residential (1/2-1 acre)	Residential (<1/2 acre)	Multi-Family/Condo.	Parks and Town Owned	Commercial	Industrial	Forest	Orchard	Crop	Pasture
% Impervious Area	16	22	31	65	N/A	85	72	N/A	N/A	N/A	N/A
PBS	N/A	0.248	0.329	0.635	N/A	0.815	0.698	0.08	N/A	N/A	N/A
PBB	N/A	0.248	0.329	N/A	0.15	N/A	0.698	0.15	N/A	N/A	N/A
PBH	0.194	0.248	0.329	N/A	0.15	0.815	0.698	0.15	N/A	0.15	0.15
PBP	0.194	N/A	N/A	0.635	0.3	0.815	N/A	0.15	0.25	0.25	0.25
WBE	0.194	0.248	N/A	N/A	0.25	0.815	0.698	0.15	N/A	0.15	0.15
WBS	0.194	N/A	N/A	N/A	0.25	N/A	N/A	0.15	0.25	0.25	0.25
WBN	0.194	N/A	N/A	N/A	N/A	N/A	0.698	0.15	N/A	N/A	N/A
SPB	0.194	0.248	N/A	N/A	0.15	0.815	N/A	0.15	N/A	N/A	N/A
BFB	N/A	0.248	0.329	N/A	N/A	0.815	0.698	0.08	N/A	N/A	N/A
MB	0.194	N/A	N/A	N/A	0.35	N/A	N/A	0.08	0.15	0.15	0.15

Runoff coefficients for developed areas are based upon the percent imperviousness of the specified land use, using the equation: $Rv = 0.05 + 0.009(I)$, where I is the percent imperviousness. For undeveloped areas it is estimated using literature coefficients based upon the soil type.

N/A - Not Applicable

The residential runoff coefficients for land in Hollis, Amherst and Milford located in subwatersheds PB-3, PB-4, WB-1, WB-2, WB-3, MB-1 and SB-1 have been weighted based on the amount of impervious and pervious area and the overall trapping efficiency calculated for each particular subwatershed. This was done to take into consideration that there are no storm drains in Hollis, Amherst and Milford to carry the residential runoff directly to a tributary. Thus, these weighted coefficients are provided in the table below, whereas the coefficients in the above table were used for all other areas of the watershed not located within these towns.

Runoff Coefficients for Specific Land Uses in Each Subwatershed											
	Residential (>1 acre)	Residential (1/2-1 acre)	Residential (<1/2 acre)	Multi-Family/Condo.	Parks and Town Owned	Commercial	Industrial	Forest	Orchard	Crop	Pasture
% Impervious Area	16	22	31	65	N/A	85	72	N/A	N/A	N/A	N/A
PBH	0.122	N/A	N/A	N/A	N/A	N/A	N/A	0.15	N/A	0.15	0.15
PBP	0.113	N/A	N/A	0.152	0.3	N/A	N/A	0.15	0.25	0.25	0.25
WBE	0.124	0.134	N/A	N/A	0.25	0.232	0.212	0.15	N/A	0.15	0.15
WBS	0.113	N/A	N/A	N/A	0.25	N/A	N/A	0.15	0.25	0.25	0.25
WBN	0.119	N/A	N/A	N/A	N/A	N/A	0.184	0.15	N/A	N/A	N/A
SPB	0.117	0.123	N/A	N/A	0.15	0.191	N/A	0.15	N/A	N/A	N/A
MB	0.114	N/A	N/A	N/A	0.35	N/A	N/A	0.08	0.15	0.15	0.15

Phosphorus Loading Concentrations			
	Dissolved	Sediment Attached	Total
Residential (>1 acre)	N/A	N/A	0.38
Residential(1/2-1 acre)	N/A	N/A	0.38
Residential (<1/2 acre)	N/A	N/A	0.38
Condominium	N/A	N/A	0.38
Parks & Town Owned	N/A	N/A	0.12
Commercial	N/A	N/A	0.20
Industrial	N/A	N/A	0.20
Forest	0.006	638	N/A
Orchard	0.10	638	N/A
Crop	0.26	638	N/A
Pasture	0.25	638	N/A

All values are based on literature coefficients.

N/A - Not Applicable

Trapping Efficiencies											
	Residential (>1 acre)	Residential (1/2-1 acre)	Residential (<1/2 acre)	Multi-Family/Condo.	Parks and Town Owned	Commercial	Industrial	Forest	Orchard	Crop	Pasture
PBS	N/A	0	0	0	0.95	0	0	0.85	N/A	N/A	N/A
PBB	N/A	0	0	N/A	0.9	N/A	0.7	0.9	N/A	N/A	N/A
PBH	0	0	0	N/A	0.5	0	0	0.9	N/A	0.59	0.59
PBP	0	N/A	0	0	0.8	0	N/A	0.8	0.66	0.66	0.66
WBE	0	0	N/A	N/A	0.05	0	0	0.9	N/A	0.51	0.51
WBS	0	N/A	N/A	N/A	0.05	N/A	N/A	0.9	0.68	0.6	0.6
WBN	0	N/A	N/A	N/A	N/A	N/A	0	0.85	N/A	N/A	N/A
SPB	0	0	N/A	N/A	0.05	0	N/A	0.98	N/A	N/A	N/A
BFB	N/A	0	0	N/A	N/A	0	0	0.9	N/A	N/A	N/A
MB	0	N/A	N/A	N/A	0.6	N/A	N/A	0.85	0.73	0.73	0.73

Trapping efficiencies are scaled zero to one, where zero indicates that none of the sediment/pollutants are trapped and one means that all sediments will be trapped.

A trapping efficiency of one was chosen for all developed areas since they are usually piped through storm drains directly to a tributary. Since Hollis, Amherst and Milford do not have a storm drain collection system, a weighted coefficient was used to account for the amount of runoff that will not make it a tributary or to a pond.

Agriculture trapping efficiencies were based on the distance away from the downgradient tributary receiving runoff. All other trapping efficiencies (for forested or park areas) were estimated based on the slope and location of the land area.

Appendix F
Database Search and File Review Sites

Database Search and File Review Sites

Type	Pollutant	NH ID	Site Name	Site Address	Town	Status	Permit No.
UIC	@ 500 drums were buried, also a discharge of a cement like material	840010	ABC MACHINE CO.	8 MANHATTAN DRIVE	AMHERST	backlog	N/A
UIC	Benign wastewater	840015	RESIN SYSTEMS CORPORATION	60 ROUTE 101A (NASHUA R	AMHERST	backlog	N/A
LUST	Petroleum	870558	TIFFANY SQUARE	ROUTE 101A	AMHERST	backlog	N/A
HAZWASTE	Volatile Organic Compounds	890106	CLARK BROTHERS/MERGANSER CORPORATION	15 COLUMBIA DRIVE	AMHERST	backlog	N/A
UIC	Permit required for drains	890106	CLARK BROTHERS/MERGANSER CORPORATION	15 COLUMBIA DRIVE	AMHERST	backlog	N/A
LUST	Petroleum	890354	JASPER FARM	124 ROUTE 101-A	AMHERST	GW Permit	GWP-890354-/
UIC	Benign wastewater	900301	HITCHNER MANUFACTURING	7 NORTHERN BLVD	AMHERST	backlog	N/A
UIC	Benign wastewater	900302	NORTHERN ANALYTICAL LABORATORIES	3 NORTHERN BLVD	AMHERST	backlog	N/A
SEPTIC	Wastewater disposal system receiving >20,000 per day	900513	SOUHEGAN VALLEY COOPERATIVE HIGH SCHOOL	BOSTON POST ROAD	AMHERST	closed	GWP-900513-/
SEPTIC	Wastewater disposal system receiving >20,000 per day	900513	SOUHEGAN VALLEY COOPERATIVE HIGH SCHOOL	BOSTON POST ROAD	AMHERST	closed	GWP-900513-/
SEPTIC	Wastewater disposal system receiving >20,000 per day	900513	SOUHEGAN VALLEY COOPERATIVE HIGH SCHOOL	BOSTON POST ROAD	AMHERST	registration	GWP-900513-/
UIC	Benign wastewater	900916	COUNTRY CLUB KENNEL	RTE 122	AMHERST	backlog	N/A

Database Search and File Review Sites

Type	Pollutant	NH ID	Site Name	Site Address	Town	Status	Permit No.
UIC	Permit required for roof and parking lot drains	901034	KOLLSMAN	10 COLUMBIA DRIVE	AMHERST	backlog	N/A
AST	Heating oil	910623	BELLEMORE HEATING OIL CO. AMHERST TEMINA	21 OLD NASHUA ROAD	AMHERST	Willis - ongoing	N/A
FUEL	Fuel oil	910623	BELLEMORE HEATING OIL CO. AMHERST TEMINA	21 OLD NASHUA ROAD	AMHERST	backlog	N/A
LUST	~300 gallons of gasoline	910702	QUINN BROTHERS CORPORATION	5 CALDWELL DRIVE	AMHERST	closed	N/A
HOLDTANK	Holding tank registration, gasoline	930607	MOBIL OIL GAS STATION	75 RTE 101A	AMHERST	backlog	N/A
UIC	Discharge of benign wastewater	931015	GRANITE STATE DOG CENTER	90 RTE 101A (COBBLESTON	AMHERST	backlog	N/A
HAZWASTE UIC		840011 840011	H & M METALS	COLUMBIA DRIVE	AMHERST	backlog	N/A
HAZWASTE LUST	Solvents, gasoline, VOCs	840013 840013	MOORE PROPERTY	117 RT 101A	AMHERST	permits - management	N/A
HAZWASTE UIC		890923 890923	CUES	14 CALDWELL DRIVE	AMHERST	backlog	N/A
UIC	Permit required for water from cooling loop discharged to roof drain	901033	PLASTI-CLIP CORP.	11 COLUMBIA DRIVE	AMHERST	backlog	N/A
UIC	Permit required for non-sanitary wastewater from wave soldering process to on-site leachfield	901038	ITRONICS	11 COLUMBIA DRIVE	AMHERST	backlog	N/A

Database Search and File Review Sites

Type	Pollutant	NH ID	Site Name	Site Address	Town	Status	Permit No.
UIC / LUST	Petroleum	901101 901101	CLARK BROTHERS EQUIPMENT STORAGE	5 MANHATTEN DRIVE	AMHERST	backlog / closed	N/A
UIC	Benign wastewater	881208	WOODMONT ORCHARDS	SOUTH MERRIMACK ROAD	HOLLIS	backlog	N/A
OPUF	Heating oil, residential	940915	DAVID ROTH RESIDENCE	180 WHEELER RD.	HOLLIS	backlog	N/A
HAZWASTE	Chlorinated VOCs	840382	MERRIMACK METALS	RT 101A	MERRIMACK	permits / managemen t	N/A
HAZWASTE	Chlorinated VOCs	861101	MERRIMACK WELL #6 (VILLAGE H2O DISTRICT)	OFF MILFORD RD	MERRIMACK	Wickson	N/A
UIC	Benign wastewater	920907	LOCKHEED SANDERS MER 12 FACILITY	130 DANIEL WEBSTER HY	MERRIMACK	registration	N/A
SITEEVAL	Site evaluation, not an indication of pollution	921001	MCDONALDS	RT 101A/NATICOOK RD-0 N	MERRIMACK	backlog	N/A
OPUF	Heating oil, residential	930822	MAHON RESIDENCE	31 NATICOOK RD	MERRIMACK	closed	N/A
HAZWASTE	tetrachloroethene	940966	POST ROAD PLAZA SITE	ROUTE 101A	MERRIMACK	Wickson	N/A
LUST	Petroleum	941134	CONNELL SHOPPING PLAZA	RTE 3	MERRIMACK	Berry	N/A
SPILL/RLS	oil spill	900726	RODERICK RESIDENCE	49 OVERLOOK WAY, LEISU	MILFORD	closed	N/A
UIC	Benign wastewater	840408	PENNICHUCK WATER WORKS	MANCHESTER STREET	NASHUA	backlog	N/A
LUST	Petroleum	870268	DEMERS TRUCK CENTER	635 AMHERST STREET	NASHUA	closed	N/A
AST	Petroleum	880316	COCA-COLA	600 AMHERST STREET	NASHUA	Willis	N/A
LUST	Petroleum	880316	COCA-COLA	600 AMHERST STREET	NASHUA	closed	N/A

Database Search and File Review Sites

Type	Pollutant	NH ID	Site Name	Site Address	Town	Status	Permit No.
UIC	Benign wastewater	880920	SULLIVAN TIRE (ADJACENT TO 7-11)	369 AMHERST STREET	NASHUA	permits-management	N/A
LUST	Petroleum (TPA)	881101	OWENS-BROCKWAY PLASTICS	OFF CELLU DRIVE	NASHUA	closed	N/A
LUST	Petroleum	890930	PSNH FACILITY - NASHUA	370 AMHERST STREET	NASHUA	backlog	N/A
LUST	gasoline	910341	QUIK MART (#30290)	496 AMHERST STREET	NASHUA	permits-management	GWP-910341-N
UIC	Permit for stormwater discharge to a retention pond	910817	CONTAINER RECOVERY CORP	12 CELINA AVENUE	NASHUA	backlog	N/A
HAZWASTE	bromodichloromethane, chloroform	930507	ASA INTERNATIONAL COMPANY	615 AMHERST ST	NASHUA	closed	N/A
LUST	Petroleum	940213	STABILE/22 COTTON RD	22 COTTON RD	NASHUA	backlog	GWP-940213-N
LUST	Petroleum	890601	SOUTHLAND CORPORATION	361 AMHERST STREET	NASHUA	backlog	N/A
LUST/ LUST	Petroleum	880920/ 890601	SULLIVAN TIRE (ADJACENT TO 7-11)	369 AMHERST STREET	NASHUA	permits-management/ backlog	GWP-880920-N GWP-880920-N

New Hampshire RCRA List

Facility ID Number	Name / Address
NHD088584214	NH Vocational Technical College 505 Amherst Street Nashua
NHD986487205	Nicks Exxon Service Station 219 South Daniel Webster Highway Nashua
NHD0010082304	Nim Cor Inc. 575 Amherst Street Nashua
NHD069906352	Norge Village Amherst Street Nashua
NHD986469237	Micro Vesicular Systems Inc. 22 Cotton Road Nashua
NHD986472447	Micro Vesicular Systems Inc 20 Cotton Road Nashua
NHD981891062	Midas Muffler 518 Amherst Street Nashua
NHD982763690	Kawasak East 421 Amherst Street Nashua
NHD000791178	Kollsman 3 Capitol Street Nashua
NHD000791731	Kollsman 8 Capitol Street Nashua
NHD980523682	Kollsman MC DTV 460 Amherst Street Nashua
NHD980668859	Lockheed Sanders Inc 460 Amherst Street Nashua
NHD986466290	M TEK Inc 22 Tanguay Ave Nashua
NHD040231367	Itek Composition Systems Division 34 Cellu Drive Nashua
NHD981065915	Gyrex Corp 472 Amherst Street Nashua
NHD986471217	Hall J Lawrence Co Inc 10 Cotton Road Nashua

NHD982746901	GIS Graphics of Nashua 472 Amherst Street Nashua
NHD146673785	Gate City Collision Center 561 Amherst Street Nashua
NHD982746661	Getty Petroleum Corp 483 Amherst Street Nashua
NHD982202749	Greased Lightning Inc 504 Amherst Street Nashua
NHD050397959	Field Precast Corp Tanguay Ave Nashua
NHD986466647	Digital Equipment Corp Cotton Road Nashua
NHD066754151	Coca Cola USA 600 Amherst Street Nashua
NHD189567761	Builders Square 420 Amherst Street Nashua
NHD001084979	Beazer East Inc 2 Hills Ferry Road Nashua
NHD986471266	Alden & Brodan Corp 472 Amherst Street Unit 22 Nashua
NHD500014501	Anderson Sonny Automotive 537 R Amherst Street Nashua
NHD986466639	Anheuser Busch Recycling Corporation 12 Celina Drive Nashua
NHD986469260	Antons Cleaners 379 Amherst Street Nashua
NHD986473544	ATC Power Systems Inc 472 Amherst Street Unit 12 Nashua
NHD500011390	VIP Discount Auto Center 714 Milford Road Merrimack
NHD045052206	Robinson Laboratories Rte 101A Jenney BLDG Amherst
NHD980731319	Specialty Coating Systems Inc 13 Columbia Drive Bay 3 Amherst
NHD986466431	Route 101A Auto Body 110 Route 101A Amherst

NHD981072762	Surewood Excavation 99 Milford Road Amherst
NHD103707782	Teksource Inc 105 Milford Road Amherst
NHD073968778	Towne Lyne Foreign Motors Rte 101A Amherst
NHD092061910	Vibrac Corp 16 Columbia Drive Amherst
NHD980734000	Waveonics Rte 101A Amherst
NHD058540519	Wilderness Outfitters & Marine Rte 101A Amherst
NHD982201048	Robinson Laboratories 1 Tanguay Street Nashua
NH5986485381	Saturn of Nashua 635 Amherst Street Nashua
NHD986483063	Stabile HJ & Son Inc 22 Cotton Road Unit 1 Nashua
NHD980670301	Sunnyside Acura 482 Amherst Street Nashua
NHD982750762	TST Equipment Co 18 Tanguay Avenue Nashua
NHD98215455	Tiffany Cleaners Inc 650 Amherst St Nashua

Appendix G
Buildout Phosphorus Loadings

In-pond Concentrations and Parameters for Agricultural Buildout with Conservation

	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	1.22	1.83	4.08	3.60
Watershed area (km2)	6.14	17.38	57.35	64.57	71.17	72.78
Precipitation volume (10^6 m3)	0.09	0.25	0.10	0.41	0.35	0.07
Evaporation volume (10^6 m3)	0.05	0.13	0.05	0.21	0.18	0.04
Precipitation loading (kg/yr)	9	26	10	41	35	7
Land use phosphorus loadings (kg/yr)	420	2409	3099	634	1175	356
Land & precipitation phosphorus loadings (kg/yr)	430	2435	3109	676	1210	363
Phosphorus loadings from Merrimack River (kg/yr)	0	0	0	177	0	0
Phosphorus loadings from preceding pond(s) (kg/yr)	0	0	1224	3124	2413	1169
Total phosphorus loadings (kg/yr)	430	2435	4333	3977	3623	1533
Stream runoff (m/yr)	0.509	0.509	0.509	0.543	0.540	0.293
Lake volume (10^6 m3)	0.13	0.35	0.11	0.68	1.29	0.23
Detention time (years)	0.04	0.04	0.00	0.02	0.03	0.01
Volumetric waterload (10^6 m3/yr)	3	9	29	36	39	21
Total P-in (mg/l)	0.132	0.264	0.148	0.111	0.093	0.072
In-pond Phosphorus (mg/l)	**0.066**	**0.109**	**0.107**	**0.068**	**0.056**	**0.053**
P leaving pond (kg/yr)	214	1010	3124	2413	1169	N/A

Phosphorus Loadings for Residential Buildout											
	PBS	PBB	PBH	PBP	WBE	WBS	WBN	SPB	BFB	MB	Total
	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
Land Use											
Residential (>1 acre)	0	450	550	1151	617	982	306	613	0	795	5463
Residential (1/2 - 1 acre)	143	229	0	0	0	359	264	0	68	216	1279
Residential (<1/2 acre)	1198	430	0	0	0	0	0	0	162	0	1790
Parks and Town Owned	0	0	0	11	0	0	0	0	0	6	16
Commercial	20	42	487	6	285	52	0	46	112	0	1050
Industrial	1621	919	1186	104	898	0	118	0	902	486	6234
Forest	0	0	0	0	0	0	0	0	0	0	0
Orchard	0	0	0	0	0	0	0	0	0	0	0
Crop	0	0	0	0	0	0	0	0	0	0	0
Pasture	0	0	0	0	0	0	0	0	0	0	0
Septic	0	85	0	18	0	0	0	253	0	0	356
Precipitation	121	81	0	56	0	0	0	21	0	0	278
	3102	2236	2223	1346	1800	1392	688	932	1244	1502	16465
Percent Phosphorus Contribution	19%	14%	14%	8%	11%	8%	4%	6%	8%	9%	

In-pond Concentrations and Parameters for Residential Buildout

	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	1.22	1.83	4.08	3.60
Watershed area (km2)	6.14	17.38	57.35	64.57	71.17	72.78
Precipitation volume (10^6 m3)	0.09	0.25	0.10	0.41	0.35	0.07
Evaporation volume (10^6 m3)	0.05	0.13	0.05	0.21	0.18	0.04
Precipitation loading (kg/yr)	9	26	10	41	35	7
Land use phosphorus loadings (kg/yr)	413	1266	3211	778	1296	376
Land & precipitation phosphorus loadings (kg/yr)	423	1292	3222	819	1331	383
Phosphorus loadings from Merrimack River (kg/yr)	0	0	0	177	0	0
Phosphorus loadings from preceding pond(s) (kg/yr)	0	0	849	2960	2404	1198
Total phosphorus loadings (kg/yr)	423	1292	4071	3957	3735	1581
Stream runoff (m/yr)	0.509	0.509	0.509	0.543	0.540	0.293
Lake volume (10^6 m3)	0.13	0.35	0.11	0.68	1.29	0.23
Detention time (years)	0.04	0.04	0.00	0.02	0.03	0.01
Volumetric waterload (10^6 m3/yr)	3	9	29	36	39	21
Total P-in (mg/l)	0.129	0.140	0.139	0.111	0.096	0.074
In-pond Phosphorus (mg/l)	**0.065**	**0.069**	**0.101**	**0.067**	**0.057**	**0.054**
P leaving pond (kg/yr)	211	638	2960	2404	1198	N/A

Phosphorus Loadings for Agricultural Buildout											
	PBS	PBB	PBH	PBP	WBE	WBS	WBN	SPB	BFB	MB	Total
	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
Land Use											
Residential (>1 acre)	0	450	385	0	20	607	287	609	0	0	2357
Residential (1/2 - 1 acre)	143	229	0	0	0	359	264	0	68	216	1278
Residential (<1/2 acre)	1198	430	0	0	0	0	0	0	162	0	1790
Parks and Town Owned	0	0	0	11	0	0	0	0	0	6	16
Commercial	20	42	487	6	285	52	0	46	112	0	1050
Industrial	1621	919	1186	104	898	0	118	0	902	486	6234
Forest	0	0	0	0	0	0	0	0	0	0	0
Orchard	0	0	0	1173	0	955	0	20	0	3555	5702
Crop	0	0	92	0	321	0	14	0	0	0	427
Pasture	0	0	0	0	0	0	0	0	0	0	0
Septic	0	85	0	18	0	0	0	253	0	0	356
Precipitation	121	81	0	56	0	0	0	21	0	0	278
	3102	2236	2150	1368	1523	1973	682	948	1244	4262	19487
Percent Phosphorus Contribution	16%	11%	11%	7%	8%	10%	4%	5%	6%	22%	

Phosphorus Loadings from Residential with Conservation											
	PBS	PBB	PBH	PBP	WBE	WBS	WBN	SPB	BFB	MB	Total
	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
Land Use											
Residential (>1 acre)	0	358	510	1096	604	967	306	613	0	748	5201
Residential (1/2 - 1 acre)	115	125	0	0	0	359	264	0	68	216	1147
Residential (<1/2 acre)	1080	418	0	0	0	0	0	0	126	0	1623
Parks and Town Owned	0	0	0	7	0	0	0	0	0	6	13
Commercial	20	42	423	6	285	52	0	46	112	0	987
Industrial	1569	774	881	104	898	0	118	0	798	486	5628
Forest	2	7	4	6	2	1	0	0	1	3	25
Orchard	0	0	0	0	0	0	0	0	0	0	0
Crop	0	0	0	0	0	0	0	0	0	0	0
Pasture	0	0	0	0	0	0	0	0	0	0	0
Septic	0	85	0	18	0	0	0	253	0	0	356
Precipitation	121	81	0	56	0	0	0	21	0	0	278
	2906	1889	1819	1293	1789	1379	688	932	1106	1458	15258
Percent Phosphorus Contribution	19%	12%	12%	8%	12%	9%	5%	6%	7%	10%	

In-pond Concentrations and Parameters for Residential Buildout with Conservation

	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	1.22	1.83	4.08	3.60
Watershed area (km2)	6.14	17.38	57.35	64.57	71.17	72.78
Precipitation volume (10^6 m3)	0.09	0.25	0.10	0.41	0.35	0.07
Evaporation volume (10^6 m3)	0.05	0.13	0.05	0.21	0.18	0.04
Precipitation loading (kg/yr)	9	26	10	41	35	7
Land use phosphorus loadings (kg/yr)	413	1222	2994	634	1175	356
Land & precipitation phosphorus loadings (kg/yr)	423	1248	3004	676	1210	363
Phosphorus loadings from Merrimack River (kg/yr)	0	0	0	177	0	0
Phosphorus loadings from preceding pond(s) (kg/yr)	0	0	833	2813	2260	1129
Total phosphorus loadings (kg/yr)	423	1248	3837	3666	3470	1493
Stream runoff (m/yr)	0.509	0.509	0.509	0.543	0.540	0.293
Lake volume (10^6 m3)	0.13	0.35	0.11	0.68	1.29	0.23
Detention time (years)	0.04	0.04	0.00	0.02	0.03	0.01
Volumetric waterload (10^6 m3/yr)	3	9	29	36	39	21
Total P-in (mg/l)	0.129	0.135	0.131	0.103	0.089	0.070
In-pond Phosphorus (mg/l)	**0.065**	**0.067**	**0.096**	**0.063**	**0.054**	**0.052**
P leaving pond (kg/yr)	211	621	2813	2260	1129	N/A

Phosphorus Loadings from Agricultural Buildout with Conservation											
	PBS	PBB	PBH	PBP	WBE	WBS	WBN	SPB	BFB	MB	Total
	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
Land Use											
Residential (>1 acre)	0	358	369	0	20	601	287	609	0	0	2242
Residential (1/2 - 1 acre)	115	125	0	0	0	359	264	0	68	216	1147
Residential (<1/2 acre)	1080	418	0	0	0	0	0	0	126	0	1623
Parks and Town Owned	0	0	0	7	0	0	0	0	0	6	13
Commercial	20	42	423	7	285	52	0	46	112	0	987
Industrial	1569	774	881	104	898	0	118	0	798	486	5628
Forest	2	7	2	6	1	1	0	0	1	3	22
Orchard	0	0	0	1118	0	939	0	20	0	3342	5418
Crop	0	0	79	0	314	0	14	0	0	0	407
Pasture	0	0	0	0	0	0	0	0	0	0	0
Septic	0	85	0	18	0	0	0	253	0	0	356
Precipitation	121	81	0	56	0	0	0	21	0	0	278
	2906	1889	1755	1315	1517	1951	683	948	1106	4052	18121
Percent Phosphorus Contribution	16%	10%	10%	7%	8%	11%	4%	5%	6%	22%	

Appendix H
Model Bylaws

APPENDIX D

EXAMPLE MODEL BYLAWS/ORDINANCES AND REGULATIONS

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MODEL OPEN SPACE COMMUNITY ZONING BYLAW

(Source: Growth Management Workbook. EOCD, 1988)
(Based on a bylaw adopted by the Town of Granby, Massachusetts and Town of Whately, Massachusetts)

OPEN SPACE COMMUNITIES

1.00 Open Space Communities shall be permitted in the ___ districts only upon issuance of a Special Permit with Site Plan Approval from the Planning Board, as specified in Sections ___ and ___ of this bylaw, and in accordance with the additional requirements specified herein.

1.01 General Description
An "Open Space Community" shall mean a single family residential development in which the houses are clustered together into one or more groups on the lot and separated from each other and adjacent properties by permanently protected open space.

1.02 Purposes
The purposes of open space community developments are to:

a. allow for greater flexibility and creativity in the design of residential subdivisions, provided that the overall density of the development is no greater than what is normally allowed in the district;

b. encourage the permanent preservation of open space, agricultural lands, and other natural resources;

c. maintain the traditional New England rural character and land use pattern in which small villages contrast with open space and farmlands;

d. facilitate the construction and maintenance of streets, utilities and public services in a more economical and efficient manner;

e. encourage a less sprawling form of development that consumes less open land.

1.03 Additional General Requirements
The following standard shall be used as additional requirements in the special permit/site plan approval process for all open space communities:

a. The development shall include single family dwellings only.

b. The minimum land required for open space community development shall be five (5) acres and the parcels shall be held in single ownership or control at the time of application.

c. Each lot shall have adequate access on a public or private way.

d. Each lot shall be of a size and shape to provide a building site which shall be in harmony with the natural terrain and other features of the land.

e. There shall be an adequate, safe, and convenient arrangement of pedestrian circulation, facilities, roadways, driveways, and parking.

f. The site plan shall identify the location and extent of all wetlands on the site as determined by the Conservation Commission under the Massachusetts Wetlands Protection Act, M.G.L. Chapter 131, Section 40.

1.04 Additional Utility Requirements

1.041 All structures which require plumbing shall be connected to a public sanitary sewer, if available, or to a community septic system at no expense to the municipality.

1.042 For dwellings to be served by on-site waste disposal systems, the applicant shall submit a septic system design prepared by a certified engineer and approved by the Board of Health and a plan illustrating the location of water supply wells with the special permit applications. No community septic system serving the development shall exceed sewage flow of 2,000 gallons per day. Septic systems shall be placed in the development to maximize the distance between systems and shall be placed within common areas rather than on individual lots. Maintenance of community septic

systems shall be the responsibility of the community association specified in Section 1.08.

1.043 No open space community development served by on-site waste disposal systems shall be approved unless the applicant can demonstrate to the satisfaction of the Planning Board that the potential for groundwater pollution is no greater from the proposed open space community development than would be expected from a conventional subdivision with single family houses on lots meeting the normal lot size requirements located on the same parcel. Where necessary, the Planning Board may hire a Professional Engineer to analyze and certify groundwater quality impacts, and may charge the applicant for the cost of such analysis.

1.05 Dimensional and Density Requirements

1.051 A one-family detached dwelling, or lawful accessory building may be constructed on a lot within an Open Space Community development although such lot has less area and frontage than normally required, as herein specified.

1.052 The maximum number of dwelling units permitted in an open space community shall be calculated based upon (the minimum lot size normally required in the district, i.e., one unit per acre) for the net developable acreage remaining once the area of all wetlands and all areas unsuitable for on-site sewage disposal have been subtracted from the total acreage of the property.

1.053 Under the supervision of the Conservation Commission and in accordance with the provisions of the Wetlands Protection Act. M.G.L. Ch. 131, Sec. 40, all wetlands shall be identified, and their area subtracted from the net developable acreage of the total parcel.

1.054 Under the supervision of the Board of Health and in conformance with Title V, percolation tests shall be conducted for all lots in the total acreage of the property which would be developed in a standard subdivision layout. The area of those lots which is determined to be not suitable for on-site sewage disposal shall be subtracted from net developable acreage of the total parcel.

1.055 Lot sizes in a cluster development shall not be less than one-half (50%) of the minimum lot size normally required in the district, i.e., twenty thousand (20,000) square feet per lot.

1.056 In no instance shall a designated lot have less than 100 feet of frontage on a public or private way.

1.057 Minimum front, rear, and side yard setbacks shall be the same as normally required in the district.

1.058 All residential structures and accessory uses with the development shall be set back from the boundaries of the development by a buffer strip of at least fifty (50) feet in width which shall include trees and shall be kept in a natural landscaped condition.

1.06 Common Open Space Requirements

1.061 All land not devoted to dwellings, accessory uses, roads, or other development shall be set aside as common land for recreation, conservation, or agricultural uses which preserve the land in essentially its natural condition.

1.062 The total area of common open space shall equal or exceed the area by which all single-family dwelling lots are reduced below the basic minimum lot area normally required in the zoning district.

1.063 The following lands shall not be used to meet the common open space requirements:

a. Lands within the floodplain district;

b. Lands identified as wetlands in accordance with the Massachusetts Wetlands Protection Act;

c. Lands with slopes greater than twenty-five percent (25%).

1.064 Further subdivision of common open land or its use for other than recreation, conservation, or agriculture, except for easements for underground utilities and septic systems, shall be prohibited. Structures or buildings accessory to recreation, conservation, or agricultural uses may be erected but shall not exceed 5% coverage of such common open land.

1.07 Common Open Space Ownership

1.071 All common open land shall be either:

a. conveyed to a community association owned or to be owned by the owners of lots within the development. If such a community association is utilized, ownership thereof shall pass with conveyance of the lots in perpetuity;

b. conveyed to a non-profit organization, the principal purpose of which is the conservation or preservation of open space;

c. conveyed to the Town, at no cost, and be accepted by it for a park or open space use. Such conveyance shall be at the option of the Town and shall require the approval of the voters at a Town Meeting; and

d. if the parcel is located in an agricultural district, farmland owners are not required to sell the part of their property which is to become permanent agricultural open space, provided that they convey the development rights of that open space in a conservation easement prohibiting future development of the property in accordance with Section 1.071 (a-c).

1.072 In any case where such land is not conveyed to the Town, a restriction enforceable by the Town shall be recorded to ensure that such land shall be kept in an open or natural state and not be built for residential use or developed for accessory uses such as parking or roadways. Such restrictions shall further provide for maintenance for the common land in a manner which will ensure its suitability for its function, appearance, cleanliness, and proper maintenance of drainage, utilities and the like.

1.08 Community Association

1.081 A non-profit, incorporated community association shall be established, requiring membership of each lot owner in the open space community. The community association shall be responsible for the permanent maintenance of all communal water and septic systems, common open space, recreational and thoroughfare facilities. A community association agreement of covenant shall be submitted with the special permit/site plan approval application guaranteeing continuing maintenance of such common utilities, land and facilities, and assessing each lot a share of maintenance expenses. Such agreement shall be subject to the review and approval of Town Counsel and the Planning Board.

1.082 Such agreements or covenants shall provide that in the event that the association fails to maintain the common open land in reasonable order and condition in accordance with the agreement, the Town may, after notice to the association and public hearing, enter upon such land and maintain it in order to preserve the taxable values of the properties within the development and to prevent the common land from becoming a public nuisance. The covenants shall also provide that the cost of such maintenance by the Town shall be assessed ratably against the properties within the development.

1.09 Procedures and Pre-Application Review

1.091 Applicants for Open Space Communities shall follow the Special Permit procedures specified in Section ___ and the Site Plan Approval procedures specified in ___.

1.092 To promote better communication and to avoid misunderstanding, applicants are encouraged to submit a Preliminary Plan for review by the Planning Board prior to the application for a special permit. Such Preliminary Plans shall comply with the Town's Subdivision Control Regulations.

1.093 The Planning Board approval of a special permit hereunder shall not substitute for compliance with the Subdivision Control Act, nor oblige the Planning Board to approve a related Definitive Plan for subdivision, nor reduce any time periods for Board consideration under the law. However, in order to facilitate processing, the Planning Board shall, insofar as practical under law, adopt regulations establishing procedures for submission of a combined Special Permit application/Subdivision Plan which shall satisfy the Board's regulations under the Subdivision Control Act.

1.094 A Site/Plan Development Plan shall be submitted to the Planning Board with the application for a special permit. Following approval of the special permit, a Definitive Plan shall be submitted to the Planning Board consistent with their Subdivision Regulations and in substantial conformity with the approved Site Plan/Development Plan, except where the Cluster Development does not constitute a subdivision under the Subdivision Control Law.

MODEL AGRICULTURAL PRESERVATION ZONING BYLAW

(Source: Growth Management Workbook. EOCD, 1988)
(Based upon a bylaw adopted by the Town of Granby, Massachusetts)

AGRICULTURAL PRESERVATION DISTRICT

1.00 Purpose
The purposes of the Agricultural Preservation District are to:

a. Protect prime agricultural lands for future food production;

b. Maintain an adequate agricultural land base in _(town)_ to ensure continued economic viability for local agriculture and the availability of agricultural support service;

c. Promote adequate and efficient provision of public service by preventing unplanned urban growth in areas more appropriate for agriculture;

d. Preserve scenic, historic and other farming-related values which help define the character of _(town)_ culture and landscape;

e. Allow landowners a reasonable return on the value of their holdings while protecting the majority of existing farmland for use by future generations;

f. Promote and protect the practice of farming in _(town)_.

1.01 District Delineation
The Agricultural Preservation District is defined as all lands designated on the map entitled "Agricultural Preservation District, Town of _(town)_", on file with the Town Clerk.

1.02 Permitted Uses

a. Agricultural production, including raising of crops, livestock, poultry, nurseries, orchards, hay;

b. Normal agricultural practices, including but not limited to manure storage, farm machine operation, and fertilizer and pesticide use as regulated by state and federal law;

c. Uses accessory to farm operations, including greenhouses, farm animal veterinary facilities, agricultural processing, and storage facilities;

d. Farm-related dwelling units owned and occupied by persons actively engaged in farming;

e. Single family homes on frontage lots not requiring approval under the Massachusetts Subdivision Control Law, M.G.L., Ch. 41, which comply with the Site Design standards in Section 1.06 and other dimensional requirements of this bylaw.

1.03 Uses Permitted with Site Plan Approval
All residential subdivisions in the Agricultural Preservation District which require approval under M.G.L., Ch. 41 shall be laid out in accordance with the Cluster Development Standards in Section 1.07 and the Site Design Standards in Section 1.06 of this bylaw, and shall require Site Plan Approval from the Planning Board. All applicants for Site Plan Approval shall comply with Section ___ of this bylaw.

1.04 Additional Requirements for Site Plan Approval
The applicant shall comply with the minimum requirements for site plan contents in Section ___ of this bylaw, and shall also submit to the Planning Board the following information:

a. Description or illustration of the physical characteristics within and adjacent to this site, including: prime agricultural soils, soils of state and local importance, other soils and soil characteristics, areas used for crop or other agricultural production.

b. Description of compliance with Cluster Development Standards in Section 1.07 and Site Design Standards in Section 1.06.

1.05 Criteria for Review

In addition to the Site Plan Approval criterion contained in Section ___ the Planning Board shall also consider the following criteria:

a. is in compliance with Cluster Development Standards in Section 1.07;

b. will not interfere with farming operations on adjacent lands;

c. is situated on the portion of the site with soils least suitable for the production of crops or livestock; and

d. is integrated into the existing landscape through features such as vegetative buffers, and through retention of open agricultural land.

1.06 Site Design Standards

These standards shall apply to subdivisions requiring approval under Chapter 41 and to lots or subdivisions not requiring approval under Chapter 41:

a. All buildings, homes and structures shall be located a minimum of 100 feet from agricultural land and shall be separated by a 50-foot wide buffer strip of trees and fencing sufficient to minimize conflicts between farming operations and residences.

b. Each structure shall be integrated into the existing landscape on the property so as to minimize its visual impact and maintain visibility of adjacent agricultural lands from public ways through use of vegetative and structural screening, landscaping, grading, and placement on or into the surface of the lot.

1.07 Cluster Development Standards

Residential subdivision developments in the Agricultural Preservation District shall be laid out according to the cluster development standards contained herein. Single-family detached dwellings, or lawful accessory buildings, in a cluster development may be constructed on lots which have less area or frontage than normally required in the underlaying district, as herein specified.

1.071 All buildings and roads shall be located away from soils which are most suitable for agriculture (based on U.S. Soil Conversation Service classifications for prime farmland soils and soils of state and local importance) to the maximum practical extent. This provision does not apply to the location of on-site septic disposal facilities which must be placed in soils meeting the Massachusetts Environment Code.

1.072 All roads, drainage systems and utilities shall be laid out in a manner so as to have the least possible impact on agricultural lands and uses.

1.073 The minimum lot size for any cluster development lot shall be 20,000 square feet. The minimum frontage for such lots shall be 100 feet. All other dimensional requirements shall be the same as normally required in the district.

1.074 The maximum number of dwelling units permitted in a residential cluster development shall be calculated according to the following procedures:

a. The maximum number of dwelling units permitted on a parcel of land shall be determined based upon unit per acre for the net developable acreage remaining once the area of all wetlands and all areas unsuitable for on-site sewage disposal have been subtracted from the total acreage of the property, if appropriate.

b. Under the supervision of the Conservation Commission and in accordance with the provisions of the Wetlands Protection Act, M.G.L. Ch. 131, Sec. 40, all wetlands shall be identified, and their area subtracted from the net developable acreage of the total parcel.

c. Under the supervision of the Board of Health, and in conformance with Title 5 percolation tests shall be conducted for all lots in the total acreage of the property which would be developed in a standard subdivision layout. The area of these lots which is determined to be not suitable for on-site sewage disposal shall be subtracted for the net developable acreage of the total parcel.

1.075 The required open land within a cluster shall be determined as follows:

a. At least fifty (50) percent of the net acreage remaining after the area of all wetlands have been subtracted shall be retained as open agricultural land. Remaining open agricultural land shall have appropriate acreage, configuration and access to enable continued farming operations.

1.076 All buildings, homes, and structures shall be located a minimum of 75 feet from agricultural land and shall be separated from agricultural uses by a 50-foot wide buffer strip of trees and fencing sufficient to minimize conflicts between farming operations and residences.

1.077 The following standards shall apply to development requiring on-site sewage disposal.

a. The applicant shall submit a septic system design prepared by a certified engineer and approved by the Board of Health and a plan illustrating the location of water supply wells with the special permit application. No community septic system serving the development shall exceed sewage flow of 2,000 gallons per day. Septic systems shall be placed in the development to maximize the distance between systems and may be placed within common areas or in individual lots. Maintenance of community septic systems shall be the responsibility of the home-owners' association specified in Section 1.09.

b. No cluster development shall be approved unless the applicant can demonstrate to the satisfaction of the Planning Board that the potential for ground-water pollution is no greater from the proposed cluster development than would be expected from a conventional subdivision with single-family houses on lots meeting the normal lot size requirements located on the same parcel. Where necessary, the Planning Board may hire a Professional Engineer (P.E.) to analyze and certify groundwater quality impacts and may charge the applicant for the cost of such analysis.

1.08 Protection of Open Agricultural Land

The following standards shall apply to open agricultural land to be protected as part of the development of residential cluster developments:

1.081 Farmland owners are not required to sell the part of their property which is to become permanent agricultural open space, provided that they do convey the development rights of that open space in a conservation easement prohibiting future development of this property to any of the official bodies named in Section 1.082 below.

1.082 All remaining open agricultural land shall be permanently protected by either:

a. A permanent conservation easement or deed restriction conveyed to the Town of _(town)_ with Town approval or to a non-profit farmland trust or conservation organization whose principal purpose is to conserve farmland and open space. At a minimum, such an easement or restriction shall entail the use of management practices that ensure existing fields or pastures will be plowed or mowed at least once every year.

b. Ownership in fee simple conveyed to the Town of _(town)_ with Town approval or to a non-profit farm trust, open space or conservation organization as a gift or for consideration.

1.09 Community Association

1.091 A non-profit, incorporated community association shall be established, requiring membership of each lot owner in the open space community. The community association shall be responsible for the permanent maintenance of all community water and septic systems, common open space, recreation and thoroughfare facilities. A community association agreement of covenant shall be submitted with the special permit application guaranteeing continuing maintenance of such common utilities, land and facilities, and assessing each lot a share of maintenance expenses. Such agreement shall be subject to the review and approval of Town Counsel and the Planning Board.

1.092 Such agreements or covenants shall provide that in the event that the association fails to maintain the common open land in reasonable order and condition in accordance with the agreement, the Town may, after notice to the association and public hearing, enter upon such land and maintain it in order to preserve the taxable values of the properties within the development and to prevent the common land from becoming a public nuisance. The covenants shall also provide that the cost of such maintenance by the Town shall be assessed ratably against the record owners of the properties within the development, their successors or assigns.

1.10 Relationship to Agricultural Incentive Area

All land which is enrolled in the Agricultural Preservation Zoning district shall become eligible for enrollment in the _(town)_ Agricultural Incentive Area and, once enrolled in the Incentive Area, shall receive any and all benefits and incentives included therein.

Note: The adoption of this bylaw will also require the following addition to the zoning bylaw's Table of Dimensional Regulations.

District	Minimum Lot Size	Minimum Frontage	Minimum Side Yard	Minimum Rear Yard	Maximum Height	Max. Lot Coverage
Agricultural						
Preservation	80,000	200	50	50	50	25%

Note: Communities should consider a parallel amendment to the Town's subdivision regulations to ascertain and promote consistency with this zoning bylaw.

MODEL SITE PLAN APPROVAL BYLAW

(Source: Growth Management Workbook, EOCD, 1988)
(Based upon a zoning bylaw adopted by the Town of Granby, Massachusetts)

SITE PLAN APPROVAL

10.00 Projects Requiring Site Plan Approval

10.001 No special permit or building permit shall be issued for any of the following uses:

a. the construction or exterior alteration of a commercial structure;

b. the construction or exterior alteration of an industrial structure;

c. residential developments requiring approval under the Subdivision Control Law (M.G.L., Ch. 41);

d. any other use specified in the Schedule of Use Regulations, which indicates Site Plan Approval is required.

Unless a site plan has been endorsed by the Planning Board, after consultation with other boards, including but not limited to the following: Building Inspector, Board of Health, Board of Selectmen, Conservation Commission, Highway Department, Fire Department, and Police Department. The Planning Board may waive any or all requirements of site plan review for external enlargements of less than 25% of the existing floor area.

10.01 Purpose

The purpose of site plan approval is to further the purposes of this bylaw and to ensure that new development is designed in a manner which reasonably protects visual and environmental qualities and property values of the Town, and to assure adequate drainage of surface water and safe vehicular access.

10.02 Application

10.021 Each application for Site Plan Approval shall be submitted to the Planning Board by the current owner of record, accompanied by eight (8) copies of the site plan. The Planning Board shall, within five (5) days transmit one copy each to the Building Inspector, Board of Health, Conservation Commission, Board of Selectmen, Highway Department, Fire Department, and Police Department.

10.022 The Planning Board shall obtain with each submission, a deposit sufficient to cover any expenses connected with a public hearing and review of plans, including the costs of any engineering or planning consultant services necessary for review purposes.

10.03 Required Site Plan Contents

10.031 All site plans shall be prepared by a registered architect, landscape architect, or professional engineer unless this requirement is waived by the Planning Board because of unusually simple circumstances. All site plans shall be on standard 24" x 36" sheets and shall be prepared at a sufficient scale to show:

a. The location and boundaries of the lot, adjacent streets or ways, and the location and the owner's names of all adjacent properties.

b. Existing and proposed topography, including contours, the location of wetlands, streams waterbodies, drainage swales, areas subject to flooding, and unique natural land features.

c. Existing and proposed structures, including dimensions and elevations.

d. The location of parking and loading areas, driveways, walkways, access and egress points.

e. The location and description of all proposed septic systems, water supply, storm drainage systems, utilities, and refuse and other waste disposal methods.

f. Proposed landscape features including the location and a description of screening, fencing, and plantings.

g. The location, dimensions, height, and characteristics of proposed signs.

h. The location and a description of proposed open space or recreation areas.

10.032 The Planning Board may waive any information requirement it judges to be unnecessary to the review of a particular plan.

10.04 Procedures for Site Plan Review

10.041 The Planning Board shall refer copies of the application within 15 days to the Conservation Commission, Board of Health, and Building Inspector, who shall review the application and submit their recommendations and comments to the Planning Board. Failure of the Boards to make recommendations within 35 days of the referral of the application shall be deemed to be lack of opposition.

10.042 The Planning Board shall hold a public hearing within sixty-five (65) days of the receipt of an application and after due consideration of the recommendations of the Board shall take final action within 90 days from the time of hearing.

10.043 The period of review for a special permit requiring site plan approval shall be the same as any other special permit and shall conform to the requirements of Chapter 40A, Sec. 9, "Special Permits." Specifically, a joint public hearing to address the Special Permit application and Site Plan Approval application shall be held within sixty-five (65) days of the filing of a special permit application with the Planning Board or Board of Appeals. The Planning Board shall then have 90 days following the public hearing in which to act.

10.05 Site Plan Review Criteria

10.051 The following criteria shall be considered by the aforementioned Boards in the review and evaluation of a site plan, consistent with a reasonable use of the site for the purposes permitted or permissible by the regulations of the district in which it is located:

a. If the proposal requires a special permit, it must conform to the special permit requirements as listed in Section ___ of this bylaw..

b. The development shall be integrated into the existing terrain and surrounding landscape, and shall be designed to protect abutting properties and community amenities. Building sites shall, to the extent feasible: a) minimize use of wetlands, steep slopes, floodplains, hilltops; b) minimize obstruction of scenic views from publicly accessible locations; c) preserve unique natural or historical features; d) minimize tree, vegetation and soil removal and grade changes, e) maximize open space retention; and f) screen objectionable features from neighboring properties and roadways.

c. Architectural style to be in harmony with the prevailing character and scale of buildings in the neighborhood and the Town through the use of appropriate building materials, screening, breaks in roof and wall lines and other architectural techniques. Variation in detail, form and siting shall be used to provide visual interest and avoid monotony. Proposed buildings shall relate harmoniously to each other with adequate light, air, circulation and separation between buildings.

d. The development shall be served with adequate water supply and waste disposal systems. For structures to be served by on-site waste disposal systems, the applicant shall submit a septic system design prepared by a Certified Engineer and approved by the Board of Health.

e. The plan shall maximize the convenience and safety of vehicular and pedestrian movement within the site and in relation to adjacent ways. The plan shall describe estimated average daily and peak hour vehicle trips to be generated by the site and traffic flow patterns for vehicles and pedestrians showing adequate access to and from the site and adequate circulation within the site.

f. The site plan shall show adequate measures to prevent pollution of surface or groundwater, to minimize erosion and sedimentation, and to prevent changes in groundwater levels, increased run-off and potential for flooding. Drainage shall be designed so that run-off shall not be increased, groundwater recharge is maximized, and neighboring properties will not

be adversely affected.

g. The development will not place excessive demands on Town services and infrastructure.

h. Electric, telephone, cable TV, and other such utilities shall be underground where physically and environmentally feasible.

i. Exposed storage areas, machinery, service areas, truck loading areas, utility buildings and structures and other unsightly uses shall be set back or screened to protect the neighbors from objectionable features.

j. The site plan shall comply with all zoning requirements for parking, loading dimensions, environmental performance standards, and all other provisions of this bylaw.

10.052 Before approval of a site plan, the reviewing board may request the applicant to make modifications in the proposed design of the project to ensure that the above criteria are met.

10.06 Final Action

10.061 The Planning Board's final action shall consist of either:

a. A determination that the proposed project will constitute a suitable development and is in compliance with the criteria set forth in this bylaw;

b. A written denial of the application stating the reasons for such denial; or

c. Approval subject to any conditions, modifications, and restrictions as the Planning Board may deem necessary.

10.07 Enforcement

10.071 The Planning Board may require the posting of a bond to assure compliance with the plan and conditions and may suspend any permit or license when work is not performed as required.

10.072 Any special permit with site plan approval issued under this section shall lapse within one (1) year if a substantial use thereof has not commenced sooner except for good cause.

10.73 The Planning Board may periodically amend or add rules and regulations relating to the procedures and administration of this section.

MODEL WATER SUPPLY PROTECTION ZONING BYLAW

(Prepared by Pioneer Valley Planning Commission, Amended 12/31/91)

Note: This bylaw has been designed to meet the requirements of the Massachusetts Department of Environmental Protection Wellhead Protection "Source Approval" Regulations 310 CMR 22.21 within designated Zone II areas. Please refer to 310 CMR 22 if your community is in the source approval process. This model provides, in some areas, more stringent protection that the DEP regulations.

WATER SUPPLY PROTECTION DISTRICT

1.0 Purpose of District

To promote the health, safety and welfare of the community by protecting and preserving the surface and groundwater resources of the Town and the region from any use of land or buildings which may reduce the quality and quantity of its water resources.

1.1 Definitions

1.11 Groundwater: All water found beneath the surface of the ground.

1.12 Watershed: Lands lying adjacent to water courses and surface water bodies which create the catchment or drainage areas of such water courses and bodies.

1.13 Impervious Surfaces: Materials or structures on or above the ground that do not allow precipitation to infiltrate the underlying soil.

1.14 Trucking Terminal: Business which services or repairs commercial trucks which are not owned by the business.

1.15 Hazardous Waste: A waste which is hazardous to human health or the environment. Hazardous wastes have been designated by the Regulations of the Massachusetts Hazardous Waste Management Act, Massachusetts General Laws, Chapter 21C.

1.16 Aquifer: Geologic formation composed of rock or sand and gravel that contains significant amounts of potentially recoverable potable water.

1.17 Primary Aquifer Recharge Area: Areas which are underlain by surficial geologic deposits including glaciofluvial or lacustrine stratified drift deposits or alluvium or swamp deposits, and in which the prevailing directions of groundwater flow is toward the area of influence of water supply wells.

1.18 Secondary Aquifer Recharge Area: Areas which are underlain by surficial geologic deposits including till or bedrock, and in which the prevailing direction of surface waterflow is toward public water supply wells or potential sites for such wells.

1.19 "Hazardous material": Material including but not limited to, any material, in whatever form, which, because of its quantity, concentration, chemical, corrosive, flammable, reactive, toxic, infectious or radioactive characteristics, either separately or in combination with any substance or substances, constitutes a present or potential threat to human health, safety, welfare, or to the environment, when improperly stored, treated, transported, disposed of, used, or otherwise managed. The term shall not include oil.

1.195 "Zone II": means that area of an aquifer which contributes water to a well under the most severe pumping and recharge conditions that can be realistically anticipated (180 days of pumping at safe yield, with no recharge from precipitation). It is bounded by the groundwater divides which result from pumping the well and by the contact of the aquifer with less permeable materials such as till or bedrock. In some cases, streams or lakes may act as recharge boundaries. In all cases, Zone II shall extend up gradient to its point of intersection with prevailing hydrogeologic boundaries (a groundwater flow divide, a contact with till or bedrock, or a recharge boundary).

1.2 Scope of Authority

The Water Supply Protection District is an overlay district and shall be superimposed on the other districts established by this bylaw. All regulations of the Town of ____ Zoning By-law applicable to such underlying districts shall remain in effect, except that where the Water Supply Protection District imposes additional regulations, such regulations shall prevail.

Note: For systems in DEP's Source Approval process, the Water Supply Protection District must include, at a minimum, the DEP-approved Zone II. DEP also encourages, but does not require, protection of the Zone III area. 310 CMR 22.21 provides that, under certain circumstances, DEP may waive Zone II delineation requirements, if Zone III is adequately protected.

1.3 District Delineation

1.31 The Water Supply Protection District is herein established to include all lands within the Town of _____, lying within the primary and secondary recharge areas of groundwater aquifers and watershed areas of reservoirs which now or may in the future provide public water supply. The map entitled "Water Supply Protection District", Town of _____, on file with the Town Clerk, delineates the boundaries of the district.

1.32 Where the bounds delineated are in doubt or in dispute, the burden of proof shall be upon the owner(s) of the land in question to show where they should properly be located. At the request of the owner(s) the Town may engage a professional hydrogeologist to determine more accurately the location and extent of an aquifer or primary recharge area, and may charge the owner(s) for all or part of the cost of the investigation.

1.4 Permitted Uses

The following uses are permitted within the Water Supply Protection District, provided that they comply with all applicable restrictions in this bylaw, including but not limited to Section 1.5-1.8:

1.41 Single family residences;

1.42 Residential accessory uses, including garages, driveways, private roads, utility rights of way, and on-site wastewater disposal systems;

1.43 Agricultural uses such as farming, grazing and horticulture;

1.44 Forestry and nursery uses;

1.45 Outdoor recreational uses, including fishing, boating, and play areas;

1.46 Conservation of water, plants, and wildlife; wildlife management areas;

1.47 Excavation for earth removal, provided that the requirements of Section 1.6 are met, and an earth removal permit is granted by the Board of Selectmen.

1.5 Prohibited Uses

The following uses are prohibited within the Water Supply Protection District:

1.51 Business and industrial uses, not agricultural, which generate use, treat, process, store or dispose of hazardous wastes, including but not limited to metal plating, chemical manufacturing, wood preserving, furniture stripping, dry cleaning, and auto body repair, except for the following:

a) very small quantity generators of hazardous waste, as defined by 310 CMR 30.00 which generate less than 20 kilograms or 6 gallons of hazardous waste per month may be allowed by Special Permit in accordance with Section 1.9 of this bylaw;

b) household hazardous waste collection centers or events operated pursuant to 310 CMR 30.390;

c) waste oil retention facilities required by M.G.L. C.21, s.52A, and;

d) treatment works approved by Mass. Department of Environmental Protection and designed in accordance with 314 CMR 5.00 for the treatment of contaminated ground or surface waters;

Note: The above section of the model bylaw recommends a more restrictive minimum threshold level for businesses which generate hazardous waste than does 310 CMR 22 which allows very small quantity generators which generate less than 100 kilograms (220 pounds) per month. Also, 310 CMR 22 does not specify particular industries which are prohibited, but rather relies on a broader definition of business that "generate, treat, store or dispose of hazardous waste".

1.52 Business or industrial uses, not agricultural, which dispose of process wastewaters on-site.

Note: The above clause is not required in DEP's source approval regulations.

1.53 Trucking terminals, bus terminals, car washes, motor vehicle gasoline sales, automotive service and repair shops, commercial fuel oil storage and sales;

Note: The above clause is not required in DEP's source approval regulations.

1.54 Solid waste landfills, dumps, auto recycling, auto graveyards, junk and salvage yards, landfilling or storage of sludge and septage, with the exception of the disposal of brush or stumps;

1.55 Storage of liquid petroleum products of any kind, except for the following:

(a) Storage which is incidental to:

(1) normal household use and outdoor maintenance or the heating of a structure;

(2) emergency generators required by statute, rule or regulation, or;

(3) waste oil retention facilities required by Mass. General Laws C.21, s.52A;

(4) treatment works approved by the Mass. Department of Environmental Protection designed in accordance with 314 CMR 5.00 for the treatment of contaminated ground or surface waters;

provided that such storage shall be in a free standing, above ground container within a structure or within the basement of a structure, within a diked impermeable area sufficient to contain the volume of the tank plus 10% to prevent spills or leaks from reaching groundwater, and provided that the storage tank and piping must comply with all applicable provisions of 527 CMR 9.00 Massachusetts Board of Fire Prevention regulations.

Note: This model bylaw is more restrictive than DEP's source approval regulations which allow outside, unprotected storage tanks for liquid petroleum products other than gasoline, provided they have a direct secondary spill containment area.

(b) Replacement of storage tanks or systems for the keeping, dispensing or storing of gasoline, which existed at the time of adoption of this bylaw, provided that:

(1) all such replacement storage tanks or systems shall be located underground as required by Mass. Board of Fire Prevention regulation 527 CMR 14;

(2) all such storage systems shall be protected by one of the secondary containment systems specified in Mass. Board of Fire Prevention regulation 527 CMR 9.08(3);

(3) the head of the Fire Department may deny an application for tank replacement, or approve it subject to conditions if he or she determines that it constitutes a danger to public or private water supplies, in accordance with 527 CMR 9.26(4)(d).

Replacement of all other storage tanks for liquid petroleum products other than gasoline must be above ground, in accordance with Section 1.55 above.

Note: The model bylaw provides specific standards for replacement of existing (grandfathered) gasoline storage systems. The DEP source approval regulations do not address this issue.

1.56 Outdoor storage of salt, de-icing materials, pesticides or herbicides;

1.57 Dumping or disposal on the ground, in water bodies, or in residential septic systems of any toxic chemical, including but not limited to septic system cleaners which contain toxic chemicals such as methylene chloride and 1-1-1 trichlorethane, or other household hazardous wastes. (See list of prohibited chemicals at Board of Health or Town Clerk's office);

Note: DEP's source approval regulations do not require the above clause.

1.58 Stockpiling and disposal of snow or ice removed from highways and streets located outside of the Water Supply Protection District that contains sodium chloride, calcium chloride, chemically treated abrasives or other chemicals used for snow and ice removal;

Note: The DEP source approval regulations restrict stockpiling in Zone II, of snow or ice removed from outside of Zone II. This model bylaw, is consequently, somewhat more restrictive than DEP's regulations. The principal reason for this approach is that most communities do not have approved Zone II areas.

1.59 Individual sewage disposal systems that are designed to receive more than 110 gallons of sewage per quarter acre per day or 440 gallons of sewage per acre per day, whichever is greater, provided that:

(a) the replacement or repair or an existing system, which will not result in an increase in design capacity above the original design, shall be exempted;

(b) in calculating maximum sewage disposal system density, it shall be assumed that each residential bedroom will generate 110 gallons of sewage;

(c) maximum sewage disposal system density may be calculated either:

(1) on an individual per lot basis (i.e., a 3-bedroom home generates 330 gallons of sewage per day requiring a 3/4 acre minimum lot area, or;

(2) on a net density basis for an entire development, which includes individual lots and common open space of varying size (i.e., a cluster development of eight 3-bedroom homes generates 2,640 gallons of sewage per day requiring a minimum total parcel area of 6 acres including lots and common open space).

(d) In addition to meeting the standards above, all lots shall conform to any applicable minimum lot size requirements contained in this Zoning Bylaw.

Note: This section is required by DEP regulations and is essentially the equivalent of a 3/4 acre minimum lot size for a typical 3-bedroom home.

1.585 Wastewater treatment works subject to 314 CMR 5.00 (those treatment works which discharge over 15,000 gallons per day to the ground), except the following:

a. the replacement or repair of an existing system(s) that will not result in a design capacity greater than the design capacity of the existing system(s);

b. the replacement of an existing subsurface sewage disposal system(s) with wastewater treatment works that will not result in a design capacity greater than the design capacity of the existing system(s), and;

c. treatment works designed for the treatment of contaminated ground or surface waters subject to 314 CMR 5.00.

1.6 <u>Restricted Uses</u>

The following are restricted in the Water Supply Protection District:

1.61 Excavation for removal of earth, loam, sand, gravel and other soils or mineral substances shall not extend closer than five (5) feet above the historical high groundwater table (as determined from on-site monitoring wells and historical water table fluctuation data compiled by the United States Geological survey, whichever is higher). A monitoring well shall be installed by the property owner to verify groundwater elevations. This section shall not apply to excavations incidental to permitted

uses, including but not limited to providing for the installation or maintenance of structural foundations, freshwater ponds, utility conduits or on-site sewage disposal.

Note: DEP's source approval regulations sets the limit for excavation at four feet. PVPC's model bylaw limit of five feet is based on the recommendation of hydrogeologic studies completed for area communities.

a. Access road(s) to extractive operation sites shall include a gate or other secure mechanism to restrict public access to the site.

b. Upon completion of earth removal operations, all altered areas shall be restored with topsoil and vegetative plantings suitable to control erosion on the site. All fine materials, such as clays and silts, removed as part of the earth removal operation and leftover as by-products, shall be disposed of off-site to prevent damage to aquifer recharge characteristics.

1.62 Sodium chloride for ice control shall be used at the minimum salt to sand ratio which is consistent with the public highway safety requirements, and its use shall be eliminated on roads which may be closed to the public in winter.

1.63 The storage of sodium chloride, calcium chloride, chemically treated abrasives or other chemicals used for the removal of ice and snow on roads shall be covered and located on a paved surface with berms, or within a structure designed to prevent the generation and escape of contaminated run-off.

1.64 Fertilizers, pesticides, herbicides, lawn care chemicals, or other leachable materials shall be used in accordance with the Lawn Care Regulations of the Massachusetts Pesticide Board, 333 CMR 10.03 (30, 31), as amended, with manufacturer's label instructions and all other necessary precautions to minimize adverse impacts on surface and groundwater.

1.65 In cases where soil percolation rates are faster than two minutes per inch, additional measures such as appropriate fill materials, may be imposed by the Board of Health to slow the percolation rate for on-site sewage disposal systems, (See Board of Health Regulations).

Note: Concurrent regulations should be adopted by the Board of Health.

1.66 The storage of commercial fertilizers and soil conditioners shall be within structures designed to prevent the generation and escape of contaminated run-off or leachate.

1.67 To the extent feasible, all new permanent animal manure storage areas shall be covered and/or contained to prevent the generation and escape of contaminated run-off or leachate.

1.68 All liquid hazardous materials, as defined in M.G.L. Chapter 21E, must be stored either in a free standing container within a building, or in a free standing container above ground level with protection to contain a spill the size of the container's total storage capacity.

1.7 Drainage

1.71 For commercial and industrial uses, to the extent feasible, run-off from impervious surfaces shall be recharged on the site by being diverted toward areas covered with vegetation for surface infiltration. Such run-off shall not be discharged directly to rivers, streams or other surface water bodies. Dry wells shall be used only where other methods are infeasible, and shall be preceded by oil, grease and sediment traps to facilitate removal of contamination. All recharge areas shall be permanently maintained in full working order by the owner(s).

1.8 Area Regulations

1.81 Within the primary aquifer recharge area the minimum allowable lot size shall be 40,000 square feet in areas not served by municipal sewerage systems.

Note: The above regulation is not required by DEP's source approval regulations. The establishment of a minimum lot size for water supply areas should be based upon careful consideration of soils and surficial geology in the district. See the "Planner's Handbook" for additional information on this subject.

1.9 Special Permit Uses

1.91 Uses Allowed by Special Permit

The following uses may be allowed by Special Permit obtained from the Planning Board:

a. Commercial, industrial, governmental or educational uses which are allowed in the underlying district, and which are not prohibited in Section 1.5;

b. Any enlargement, intensification, alteration, or change of use of an existing commercial or industrial use;

c. The rendering impervious of more than 15%, or 2,500 square feet of any lot, provided that a system for artificial recharge of precipitation to groundwater is developed, which shall not result in degradation of groundwater (see Section 1.71).

1.92 Requirements for Special Permit in the Water Supply Protection District

The applicant shall file six (6) copies of a site plan prepared by a qualified professional with the Special Permit Granting Authority. The site plan shall at a minimum include the following information where pertinent.

a. A complete list of chemicals, pesticides, fuels and other potentially hazardous materials to be used or stored on the premises in quantities greater than those associated with normal household use.

b. Those business using or storing such hazardous materials shall file a hazardous materials management plan with the Planning Board. Hazardous Materials Coordinator, Fire Chief, and Board of Health which shall include:

1. Provisions to protect against the discharge of hazardous materials or wastes to the environment due to spillage, accidental damage, corrosion, leakage or vandalism, including spill containment and clean-up procedures.

2. Provisions for indoor, secured storage of hazardous materials and wastes with impervious floor surfaces.

3. Evidence of compliance with the Regulations of Massachusetts Hazardous Waste Management Act 310 CMR 30, including obtaining an EPA identification number from the Mass. Department of Environmental Protection.

c. Drainage recharge features and provisions to prevent loss of recharge.

d. Provisions to control soil erosion and sedimentation, soil compaction, and to prevent seepage from sewer pipes.

1.93 Additional Procedures for Special Permit in the Water Supply Protection District:

a. The Special Permit Granting Authority shall follow all special permit procedures contained in Section ___ of this By-law. In addition the Special Permit Granting Authority shall distribute copies of all application materials to the Board of Health, the Conservation Commission, and the Water Commissioners, each of which shall review the application, and following a vote, shall submit recommendations and comments to the Special Permit Granting Authority. Failure of boards to make recommendations within 35 days of distribution of the applications shall be deemed to be lack of opposition. One copy of the application materials shall be transmitted to or retained by the Town Clerk for viewing by the public during office hours.

b. The Special Permit Granting Authority may grant the required special permit only upon finding that the proposed use meets the following standards and those specified in Section ____ of this bylaw. The proposed use must:

(1) in no way, during construction or thereafter, adversely affect the existing or potential quality or quantity of water that is available in the Water Supply Protection District, and;

(2) be designed to avoid substantial disturbance of the soils, topography, drainage, vegetation and other water-related natural characteristics of the site to be developed.

c. The Special Permit Granting Authority shall not grant a special permit under this section unless the petitioner's application materials include, in the Board's opinion, sufficiently detailed, definite and credible information to support positive findings in relation to the standards given in this section.

1.95 Non-conforming Use

Non-conforming uses which were lawfully existing, begun or in receipt of a building or special permit prior to the first publication of notice of public hearing for this bylaw may be continued. Such non-conforming uses may be extended or altered, as specified in M.G.L. Ch. 40a, Sec. 6, provided that there is a finding by the Planning Board that such change does not increase the danger of surface or groundwater pollution from such use.

Note: The provisions of Section 1.9, above, are not required in DEP's source approval regulations, except for Section 1.91(c) which is a DEP requirement.

MODEL BYLAW/ORDINANCE GROUNDWATER PROTECTION DISTRICT

(This bylaw has been designed to conform to the minimum local control standards specified by the Department of Environmental Protection in 310 CMR 22.21(2).)

Acknowledgements: This model bylaw/ordinance was prepared by an ad-hoc committee convened and directed by the Massachusetts Water Resources Authority. Members include Tara Gallagher from the Department of Environmental Protection, Martin Pillsbury from the Metropolitan Area Planning Council, Alexandra Dawson from the Water Supply Citizens Advisory Committee, Jonathan Yeo and Fred Brandon from the Massachusetts Water Resources Authority, and Philip Chernin of Camp Dresser & McKee Inc. Kim Smith, a MWRA intern, also assisted in the project. The committee's purpose in creating this document is to provide a generic example of bylaw/ordinance language which can be modified and adopted by Massachusetts communities an internal component of a local water supply protection program. The state Attorney General's office has reviewed this model bylaw and concluded that it does not appear to be inconsistent with state law. This Attorney General's office review does not mean that a community's bylaw that is based on this model will automatically be approved by the Attorney General's office.

1. PURPOSE OF DISTRICT

The purpose of this Groundwater Protection District is:

a. to promote the health, safety, and general welfare of the community by ensuring an adequate quality and quantity of drinking water for the residents, institutions, and businesses of the (Town)(City) of _____;

b. to preserve and protect existing and potential sources of drinking water supplies;

c. to conserve the natural resources of the (town)(city); and

d. to prevent temporary and permanent contamination of the environment.

2. SCOPE OF AUTHORITY

The Groundwater Protection District is an overlay district superimposed on the zoning districts. This overlay district shall apply to all new construction, reconstruction, or expansion of existing buildings and new or expanded uses. Applicable activities or uses which fall within the Groundwater Protection District must comply with the requirements of this district as well as with the underlying zoning. Uses that are prohibited in the underlying zoning districts shall not be permitted in the Groundwater Protection District.

3. DEFINITIONS

For the purposes of this section, the following words and phrases shall have the following meanings:

Aquifer:	Geologic formation composed of rock, sand, or gravel that contains significant amounts of potentially recoverable water.
Groundwater Protection District:[1]	The zoning district defined to overlay other zoning districts in the (Town)(City) of _____. The groundwater protection district may include specifically designated recharge areas.

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[1]. The Massachusetts Dept. of Environmental Protection (DEP) defines two specific types of recharge areas - Zone II and Zone III to which certain regulations may apply (See Section 6B). If these zones are a part of the District, and have been approved by DEP, the following definitions should be included:

Zone II: The area of an aquifer which contributes water to a well under the most severe pumping and recharge conditions that can be realistically anticipated (180 days of pumping at safe yield with no recharge from precipitation), as defined in 310 Code of Massachusetts Regulations (CMR) 22.00.

Zone III: The land area beyond the area of Zone II from which surface water and groundwater drain into Zone II, as defined in 310 CMR 22.00.

Impervious Surface:	Material or structure on, above, or below the ground that does not allow precipitation or surface water to penetrate directly into the soil.
Mining:	The removal or relocation of geologic materials such as topsoil, sand, gravel, metallic ores, or bedrock.
Recharge Areas:[1]	Areas that collect precipitation or surface water and carry it to aquifers. Recharge areas may include areas designated as Zone 1, Zone II, or Zone III.
Toxic or Hazardous Material:	Any substance or mixture of physical, chemical, or infectious characteristics posing a significant, actual or potential hazard to water supplies or other hazards to human health if such substance or mixture were discharge to land or water of the (Town)(City) of ____. Toxic or hazardous materials include, without limitation, synthetic organic chemicals, petroleum products, heavy metals, radioactive or infectious wastes, acids and alkalis, and all substances defined as Toxic or Hazardous under Massachusetts General Laws (M.G.L.) Chapter 21C and 21E and 310 CMR 30.00, and also include such products as solvents and thinners in quantities greater than normal household use.

4. ESTABLISHMENT AND DELINEATION OF GROUNDWATER PROTECTION DISTRICT

For the purposes of this district, there are hereby established within the (town)(city) certain groundwater protection areas, consisting of aquifers or recharge areas which are delineated on a map. This map is at a scale of 1 inch to ___ feet and is entitled "Groundwater Protection District, (Town)(City) of ___," dated ___. This map is hereby made a part of the (town)(city) zoning (bylaw) (ordinances) and is on file in the Office of the (Town)(City) Clerk.

5. DISTRICT BOUNDARY DISPUTES

If the location of the District boundary in relation to a particular parcel is in doubt, resolution of boundary disputes shall be through a Special Permit application to the Special Permit Granting Authority (SPGA). Any application for a special permit for this purpose shall be accompanied by adequate documentation.

The burden of proof shall be upon the owner(s) of the land in question to show where the bounds should properly be located. At the request of the owner(s), the (town)(city) may engage[2] a professional engineer (civil or sanitary), hydrologist, geologist, or soil scientist to determine more accurately the boundaries of the district[3] with respect to individual parcels of land, and may charge the owner(s) for all or part of the cost of the investigation.

6. USE REGULATION

In the Groundwater Protection District the following regulations shall apply:

A. Permitted Uses

The following uses are <u>permitted</u> within the Groundwater Protection District, provided that all necessary permits, orders, or approvals required by local, state, or federal law are also obtained:

i. conservation of soil, water, plants, and wildlife;

ii. outdoor recreation, nature study, boating, fishing, and hunting where otherwise legally permitted;

iii. foot, bicycle and/or horse paths, and bridges;

iv. normal operation and maintenance of existing water bodies and dams, splash boards, and other water control, supply and conservation devices;

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2. It may be desirable to specify the professional requirements for the people permitted to redefine districts boundaries under this paragraph. For example, a land surveyor, registered with the state of Massachusetts, may be acceptable for the definition of watershed it, but not recharge area boundaries.

3. For disputes which may arise related to Zone II areas, (if included in the District) the following provision would be appropriate: The determination of the location and extent of Zone II shall be in conformance with the criteria set forth in 310 CMR 22.00 and in the DEP's <u>Guidelines and Policies for Public Water Systems</u>.

v. maintenance, repair, and enlargement of any existing structure, subject to Section B (prohibited uses) and Section C (special permitted uses);

vi. residential development, subject to Section B (prohibited uses) and Section C (special permitted uses);

vii. farming, gardening, nursery, conservation, forestry, harvesting, and grazing, subject to Section B (prohibited uses) and Section C (special permitted uses);

viii. construction, maintenance, repair, and enlargement of drinking water supply related facilities such as, but not limited to, wells, pipelines, aqueducts, and tunnels. Underground storage tanks related to these activities are not categorically permitted.

B. Prohibited Uses

The following uses are prohibited.[4,5]

i.[6] landfills and open dumps as defined in 310 CMR 19.006;

ii.[7] storage of liquid petroleum products, except the following:

a. normal household use, outdoor maintenance, and heating of a structure;

b. waste oil retention facilities required by statute, rule, or regulation;

c. emergency generators required by statute, rule, or regulation;

d. treatment works approved under 314 CMR 5.00 for treatment of ground or surface waters;

provided that storage, listed in items a. through d. above, is in free-standing containers within buildings or above ground with secondary containment adequate to contain a spill the size of the container's total storage capacity.

iii.[7] landfilling or sludge or septage as defined in 310 CMR 32.05;

iv.[7] storage of sludge and septage, unless such storage is in compliance with 310 CMR 32.30 and 310 CMR 32.31;

v.[8,9] individual sewage disposal systems that are designed in accordance with 310 CMR 15.00 to receive more than 110 gallons of sewage per quarter acre under one ownership per day, or 440 gallons of sewage on any one acre under one ownership per day, whichever is greater,
except the replacement or repair of an existing system that will not result in an increase in design capacity above the original design;

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4. The boundary of the district to which these prohibitions apply should be specifically indicated. DEP requirements (310 CMR 22.21) apply to Zone II areas only.

5. Federal and State agencies, and counties are not subject to local zoning regulations. This is a long established principle, recently reinforced by decisions of the Mass. Supreme Judicial Court (SJC). In its zoning enabling act and amendments, the state has never delegated the power to regulate activities on state properties, or the properties of its political subdivisions.

6. It may be the preference of counsel to include an "as of effective date" clause in relation to all prohibitions which reference state or federal statutes.

7. This could be supplemented through a Board of Health Regulation or other non-zoning bylaw/ordinances.

8. This may be best prohibited through a Board of Health Regulation or other non-zoning bylaw/ordinance.

9. Another way to meet this DEP requirement and protect supply wells from excessive nitrogen concentrations is to conduct a nitrogen loading analysis within each Zone II. New development within Zone IIs will be allowed only if it will not cause the planning goal of 5 mg/l nitrate to be exceeded. DEP must approve the nitrogen loading methodology for wells subject to 310 CMR 22.21(2).

vi.[7,10] storage of deicing chemicals unless such storage, including loading areas, is within a structure designed to prevent the generation and escape of contaminated runoff or leachate;

vii. storage of animal manure unless covered or contained;

viii.[11] earth removal, consisting of the removal of soil, loam, sand, gravel, or any other earth material (including mining activities) to within 6 feet of historical high groundwater as determined from monitoring wells and historical water table fluctuation data compiled by the United States Geological Survey, except for excavations for building foundations, roads or utility works;

ix.[7,12] facilities that generate, treat, store, or dispose of hazardous waste subject to M.G.L. 21C and 310 CMR 30.00, except the following:

a. very small quantity generators as defined under 310 CMR 30.00;

b. household hazardous waste collection centers and events under 310 CMR 30.390;

c. waste oil retention facilities required by M.G.L. C21, s. 52A;

d. water remediation treatment works approved under 314 CMR 5.00;

x. automobile graveyards and junkyards, as defined in M.G.L. c. 140B, s.1;

xi. treatment works that are subject to 314 CMR 5.00 including privately owned sewage treatment facilities, except the following:

a. the replacement or repair of an existing treatment works that will not result in a design capacity greater than the design capacity of the existing treatment works;

b. the replacement of existing subsurface sewage disposal system(s) with wastewater treatment works that will not result in a design capacity greater than the design capacity of the existing system(s);

c. treatment works approved by the Massachusetts Department Environmental Protection designed for the treatment of contaminated groundwater;

xii. storage of liquid hazardous materials, as defined in M.G.L. c. 21E, unless in a free standing container within building or above ground with secondary containment adequate to contain a spill the size of the container's total storage capacity;

xiii.[7,13] industrial and commercial uses in which discharge process wastewater on-site;

xiv. stockpiling and disposal of snow and ice containing deicing chemicals if brought in from outside the district;

xv. storage of commercial fertilizers and soil conditions, as defined in M.G.L., c. 128, s. 64, unless such storage is within a structure designated to prevent the generation and escape of contaminated runoff or leachate;

xvi.[8,13] the use of septic system cleaners which contain toxic or hazardous chemicals.

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10. Uncovered storage of salt in water supply areas is forbidden by M.G.L. Ch. 85 S.7A.

11. All towns and cities should have earth removal regulations to restrict new and existing earth removal activities. The 6 foot buffer above the high groundwater is more restrictive than the 4 feet required by DEP for new source approval under 310 CMR 22.21.

12. Includes most vehicular maintenance facilities, dry cleaners, print and photo processing operations as well as many industrial uses.

See however M.G.L. Ch. 40A, Section 9 and Chapter 21D, S.21.

13. Provision not required for new source approval under 310 CMR 22.21.

C. Uses and Activities Requiring a Special Permit

The following uses and activities are permitted only upon the issuance of a Special Permit by the Special Permit Granting Authority[14] (SPGA) under such conditions as they may require:

i.[13,15] enlargement or alteration of existing uses that do not conform to the Groundwater Protection District;

ii.[13,16] the application of pesticides, including herbicide, insecticides, fungicides, and rodenticides, for non-domestic or non-agricultural uses in accordance with state and federal standards. The special permit shall be granted if such standards are met. If applicable, the applicant should provide documentation of compliance with a Yearly Operating Plan (YOP) for vegetation management operations under 333 CMR 11.00 or a Department of Food and Agriculture approved Pesticide Management Plan or Integrated Pest Management (IPM) program under 333 CMR 12.00;

iii.[13] the application of fertilizers for non-domestic or non-agricultural uses. Such applications shall be made in a manner so as to minimize adverse impacts on groundwater due to nutrient transport, deposition, and sedimentation;

iv.[13] those activities that involve the handling of toxic or hazardous materials in quantities greater than those associated with normal household use, permitted in the underlying zoning (except as prohibited under Section B). Such activities shall require a special permit to prevent contamination of groundwater;

v.[13] the construction of dams or other water control devices, ponds, pools or other changes in waterbodies or courses, created for swimming, fishing, or other recreational uses, agricultural uses, or drainage improvements. Such activities shall not adversely affect water quality or quantity;

vi. any use that will render impervious more than 15% or 2,500 square feet of any lot, whichever is greater. A system for groundwater recharge must be provided which does not degrade groundwater quality. For non-residential uses, recharge shall be by stormwater infiltration basins or similar system covered with natural vegetation, and dry wells shall be used only where other methods are infeasible. For all non-residential uses, all such basins and wells shall be preceded by oil, grease, and sediment traps to facilitate removal of contamination. Any and all recharge areas shall be permanently maintained in full working order by the owner.

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14. This model bylaw/ordinance identifies, in Section 6C, a series of standard governed uses/activities and conditions for a special permit. A town or city may want to identify additional or more specific governed uses/activities or conditions that are especially relevant to its own situation. None of the special permit requirements are mandated by 310 CMR 22.21 except C.vi.

15. Local conditions will affect how extensive this and similar provisions may become. If there are many industrial and commercial uses in Groundwater Protection District, and their expansion is probable, specific conditions should be included in the (bylaw) (ordinance).

16. The use of herbicides and pesticides is regulated by the Massachusetts Department of Food and Agriculture. Regulations (333 CMR 11.00 and 12.00) that became effective in January, 1992, impose strict requirements on the application of specific pesticides and herbicides in Zone II areas and will require the use of alternative forms of pest management.

7. PROCEDURES FOR ISSUANCE OF SPECIAL PERMIT

A. The Special Permit Granting Authority (SPGA)[17] under this bylaw shall be the ___. Such special permit shall be granted if the SPGA determines, in conjunction with the Board of Health, the Conservation Commission, (Town) (City) Engineer/Department of Public Works, and Planning Board that the intent of this bylaw, as well as its specific criteria, are met. The SPGA shall not grant a special permit under this section unless the petitioner's application materials include, in SPGA's opinion, sufficiently detailed, definite, and credible information to support positive findings in relation to the standards given in this section. The SPGA shall document the basis for any departures from the recommendation of the other (town)(city) boards or agencies in its decision.

B. Upon receipt of the special permit application, the SPGA shall transmit one copy to the Planning Board, Board of Health, the Conservation Commission, and (Town)(City) Engineer/Department of Public Works for their written recommendations.[17] Failure to respond in writing within 35 days of receipt by the Board shall indicate approval or no desire to comment by said agency. The necessary number of copies of the application shall be furnished by the applicant.

C. The SPGA may grant the required special permit only upon finding that the proposed use meets the following standards, those specified in Section 6 of this bylaw, and any regulations or guidelines adopted by the SPGA. The proposed use must:

1. in no way, during construction or thereafter, adversely affect the existing or potential quality or quantity of water that is available in the Groundwater Protection District, and

2. be designed to avoid substantial disturbance of the soils, topography, drainage, vegetation, and other water-related natural characteristics of the site to be developed.

D. The SPGA may adopt regulations to govern design features of projects. Such regulations shall be consistent with subdivision regulations adopted by the municipality.[18]

E. The applicant shall file ___ copies of a site plan and attachments. The site plan shall be drawn at proper scale as determined by the SPGA and be stamped by a professional engineer. All additional submittals shall be prepared by qualified professionals. The site plan and its attachments shall at a minimum include the following information where pertinent:

1. a complete list of chemicals, pesticides, herbicides, fertilizers, fuels, and other potentially hazardous materials to be used or stored on the premises in quantities greater than those associated with normal household use;

2. for those activities using or storing such hazardous materials, a hazardous materials management plan shall be prepared and filed with the Hazardous Materials Coordinator, Fire Chief, and Board of Health. The plan shall include:

a. provisions to protect against discharge of hazardous materials or wastes to the environment due to spillage, accidental damage, corrosion, leakage, or vandalism, including spill containment and clean-up procedures.

b. provisions for indoor, secured storage of hazardous materials and wastes with impervious floor surfaces;

c. evidence of compliance with the Regulations of the Massachusetts Hazardous Waste Management Act 310 CMR 30.00, including obtaining an EPA identification number from the Massachusetts Department of Environmental Protection.

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17. M.G.L. Ch. 40A, Section 9 specifies that the SPGA must be one of the following: Board of Selectmen; Board of Appeals; or Planning Board. Applications should be routed to and reviewed by all town or city boards, department and commissions having an interest in or responsibility for review and approval of actions taken by the applicant.

18. The SPGA is encouraged to adopt regulations to administer this (bylaw) (ordinance). The SPGA should consider including performance and/or design standards in such regulations. This may mean changing other regulations such as those for subdivisions.

3. proposed down-gradient location(s) for groundwater monitoring well(s) should the SPGA deem the activity a potential groundwater threat.

F. The SPGA shall hold a hearing in conformity with the provision of the M.G.L. ch. 40A, s.9, within 65 days after the filing of the application and after the review by the (Town)(City) Boards, Departments and Commissions.

Notice of the public hearing shall be given by publication and posting and by first-class mailings to "parties of interest" as defined in M.G.L. ch. 40A, s.11. The decision of the SPGA and any extension, modification, or renewal thereof shall be filed with the SPGA and (Town)(City) Clerk within 90 days following the closing of the public hearing. Failure of the SPGA to act within 90 days shall be deemed as a granting of the permit. However, no work shall commence until a certification is recorded as required by said s.11.

G. Written notice of any violations of this (Section)(Article)(Ordinance) shall be given by the (Code Enforcement Officer)(Building Inspector) to the responsible person as soon as possible after detection of a violation or a continuing violation. Notice to the assessed owner of the property shall be deemed notice to the responsible person. Such notice shall specify the requirement or restriction violated and the nature of the violation, and may also identify the actions necessary to remove or remedy the violations and preventive measures required for avoiding future violations and a schedule of compliance. A copy of such notice shall be submitted to the Building Inspector, the Board of Health, Conservation Commission, (Town)(City) Engineer/Department of Public Works, and Water Department. The cost of containment, clean-up, or other action of compliance shall be borne by the owner and operator of the premises.

For situations that require remedial action to prevent adverse impact to the water resources within the Groundwater Protection District, the (Town)(City) of _____, the Building Inspector, the Board of Health, or any of their agents may order the owner or operator of the premises to remedy the violation. If said owner and/or operator does not comply with said order, the (Town)(City) of _____, the Building Inspector, the Board of Health, or any of their agents, if authorized to enter upon such premises under the terms of the special permit or otherwise, may act to remedy the violation. The remediation costs shall be the responsibility of the owner and operator of the premises.

8. SEVERABILITY

A determination that any portion or provision of this overlay protection district is invalid shall not invalidate any other portion or provision thereof, nor shall it invalidate any special permit previously issued thereunder.

MODEL FLOODPLAIN MANAGEMENT ZONING BYLAW

(Source: Growth Management Workbook, EOCD, 1988)
(Based upon a zoning bylaw adopted by the Town of Granby, Massachusetts)

FLOODPLAIN DISTRICT

2.0 Purpose
The purpose of the Floodplain District are:

a. To provide that lands in the Town of _____ subject to seasonal or periodic flooding as described hereinafter shall not be used for residence or other purposes in such manner as to endanger the health or safety of the occupants thereof.

b. To protect, preserve, and maintain the water table and water recharge areas within the Town so as to preserve present and potential water supplies for the public health and safety of the Town of _____.

c. To assure the continuation of the natural flow pattern of the water course(s) within the Town of _____ in order to provide adequate and safe floodwater storage capacity to protect persons and property against the hazards of flood inundation.

2.01 Scope of Authority
The Floodplain District is an overlay district and shall be superimposed on the other districts established by this bylaw. All regulations on the ___(town)___ Zoning Bylaw applicable to such underlying districts shall remain in effect, except that where the Floodplain District imposes additional regulations, such regulations shall prevail.

2.02 District Delineation

a. The Floodplain District is defined as all lands designated as Zone A or Zones A 1-30 on the Town of _____ Flood Insurance Rate Maps (FIRM), panels ___(panel numbers)___, effective date ___(date)___.

b. The floodway boundaries are delineated on the ___(town)___ Flood Boundary and Floodway Map (FBFM) dated ___(town)___.

c. The FIRM and FBFM maps are incorporated herein by reference and are on file with the Town Clerk.

2.03 Permitted Uses
In the Floodplain District no new building shall be erected or constructed, and no existing structure shall be altered, enlarged or moved; no dumping, filling or earth transfer or relocation shall be permitted; nor shall any land, building or structure be used for any purposes except:

a. Outdoor recreation, including play areas, nature study, boating, fishing and hunting where otherwise legally permitted, but excluding buildings and structures.

b. Wildlife management or conservation areas, foot, bicycle, and/or horse paths and bridges, provided such uses do not affect the natural flow pattern on any water course.

c. Grazing and farming, including truck gardening and harvesting of crops.

d. Forestry and nurseries.

e. Dwellings lawfully existing prior to the enactment of this bylaw.

2.04 Uses by Special Permit

2.041 No structure or building shall be erected, constructed, substantially improved over 50 percent of assessed market value or otherwise created or moved; no earth or other materials dumped, filled, excavated, or transferred, unless a special permit is granted by the Zoning Board of Appeals.

2.042 The following uses may be allowed by Special Permit from the Zoning Board of Appeals in accordance with the Special Permit regulations of this bylaw, and additional restrictions and criteria contained herein:

a. Single family detached dwelling

b. Commercial golf course, recreation, or camp facility

c. Commercial landing strip or heliport

2.043 The following additional requirements apply in the Floodplain District:

a. Within Zone A or Zones A 30, where base flood elevation is not provided on the FIRM or FBFM, the applicant shall obtain any existing base flood elevation data. These data will be reviewed by the Building Inspector for their reasonable utilization toward meeting the elevation or floodproofing requirements, as appropriate, of the State Building Code.

2.044 The following provisions apply in the Floodplain designated on the FBFM:

a. Within the Floodway designated on the FBFM, no encroachments (including fill, new construction, substantial improvements to existing structures, or other development) shall be allowed unless it is demonstrated by the applicant that the proposed development, as a result of compensating actions, will not result in any increase in flood levels with the Town during the occurrence of a 100-year flood in accordance with the Federal Emergency Management Agency's regulations for the National Flood Insurance Program.

b. Any encroachment in the Floodway meeting the above standard must also comply with the floodplain requirements of the State Building Code.

2.05 Additional Special Permit Criteria

In addition to the Special Permit criteria specified in __(bylaw section)__, the Zoning Board of Appeals may grant a Special Permit if it finds:

a. The proposed use will not create increased flood hazards which shall be detrimental to the public health, safety and welfare.

b. The proposed use will comply in all respects to the provisions of the underlying District or Districts within which land is located.

c. The proposed is in compliance with all applicable state and federal laws, including the Massachusetts Building Code and the Massachusetts Wetlands Protection Act (M.G.L. Ch. 131, Sec. 40).

2.06 Prohibited Uses

The following uses are specifically prohibited and may not be allowed by special permit:

a. Solid waste landfills, junkyards, and dumps.

b. Business and industrial uses, not agricultural, which manufacture, use, process, store, or dispose of hazardous materials or wastes as a principal activity, including but not limited to metal plating, chemical manufacturing, wood preserving, furniture stripping, dry cleaning, and auto body repair.

c. The outdoor storage of salt, other de-icing chemicals, pesticides, or herbicides shall be prohibited without suitable overhead protection from weather and an impervious containment area to hold the volume of store chemicals.

d. Drainage, dredging, excavation, or disposal of soil or mineral substances, except as necessary for permitted uses or uses allowed by special permit, as specified in the Earth Removal Bylaw, __(bylaw section)__.

MODEL RIVER PROTECTION ZONING BYLAW

(Source: Growth Management Workbook. EOCD, 1988)
(Based upon a bylaw developed for Connecticut River communities by Pioneer Valley Planning Commission)

RIVER PROTECTION DISTRICT

3.00 Purposes

The purposes of the __(town)__ River Protection District are to:

a. Promote the preservation of the scenic qualities of the natural landscape along the River;

b. Prevent any disruptions to the natural flow of the river;

c. Protect fisheries and wildlife habitat within and along the river;

d. Control erosion and siltation;

e. Enhance and preserve existing agricultural lands, floodplains, and other environmentally sensitive areas along the shoreline;

f. Conserve shore cover and encourage well-designed developments.

3.01 Scope of Authority

The _____ River Protection District is an overlay district and shall be superimposed on the other districts established by this bylaw. All regulations of the __(town)__ Zoning Bylaw applicable to such underlying districts shall remain in effect, except that where the River Protection District imposes additional regulations, such regulations shall prevail.

3.02 District Delineation

The area affected by this Bylaw shall be the portion of the _____ River under the jurisdiction of this Town, its shores, and landward up to two hundred (200) feet from each bank (as defined by the M.G.L. Ch. 131, Sec. 40). All distances shall be measured in horizontal feet.

3.03 Permitted Uses

The following uses are permitted provided they are in conformance with the River Protection Standards in Section 3.09:

a. Agricultural production, including raising of crops, livestock, poultry, nurseries, orchards, hay;

b. Recreational uses, provided there is minimal disruption of wildlife habitat;

c. Maintenance and repair usual and necessary for continuance of an existing use;

d. Conservation of water, plants, and wildlife, including the raising and management of wildlife;

e. Emergency procedures necessary for safety or protection of property;

f. Single-family residences on frontage lots not requiring approval under the Massachusetts Subdivision Control Law, M.G.L. Chapter 41.

3.04 Prohibited Uses

3.041 No altering, dumping, filling, removal of riverine materials or dredging is permitted. Maintenance of the river may be done under requirements of M.G.L. Ch. 131, Sec. 40, and any other applicable laws, bylaws, and regulations.

3.042 No clear-cutting of existing vegetation and no more than minimal disruption of wildlife habitat is permitted except in those cases where the purposes of M.G.L. Ch. 131, Sec. 40, would be adversely affected, as determined by the Conservation Commission.

3.043 All other uses not specifically permitted or allowed by Special Permit within the overlay zone are

prohibited.

3.05 Uses By Special Permit

3.051 Construction of one dock providing access to the river per parcel or set of contiguous parcels in common ownership shall be allowed upon issuance of a Special Permit from the Planning Board, as specified in _____ of this bylaw.

3.06 Uses By Site Plan Approval

3.061 All residential subdivisions which require approval under M.G.L. Ch. 41 shall be laid out in accordance with the cluster development standards contained in Section 3.10, and shall require site plan approval from the Planning Board, as specified in _____ of this bylaw. Each building lot and residence within a residential subdivision shall comply with Section 3.09 of this bylaw.

3.07 Additional Site Plan Approval Criteria

3.071 In addition to the Site Plan Approval Criteria contained in Section ___, the Planning Board shall also consider whether uses proposed for Site Plan Approval in the River Protection District meet the following criteria:

a. Complies with River Protection Standards in Section 3.09 and Riverbank Cluster Development Standards in Section 3.10;

b. Is situated on a portion of the site that will most likely conserve shoreland vegetation and the integrity of the buffer strip;

c. Is integrated into the existing landscape through features such as vegetative buffers and through retention of the natural shoreline;

d. Will not result in erosion or sedimentation;

e. Will not result in water pollution.

3.08 Site Plan Approval Procedures for Cluster Developments

3.081 In addition to the Site Plan Approval procedures contained in Section ___ the following procedures shall be followed in the ___ River Protection District:

a. To promote better communication and to avoid misunderstanding, applicants are encouraged to submit a Preliminary Plan for review by the Planning Board prior to the application for a special permit. Such Preliminary Plans shall comply with the Town's Subdivision Control Regulation.

b. The Planning Board granting of site plan approval hereunder shall not substitute for compliance with the Subdivision Control Act nor oblige the Planning Board to approve a related Definitive Plan for subdivision, nor reduce any time periods for Board consideration under that law. However, in order to facilitate processing, the Planning Board shall, insofar as practical under law, adopt regulations establishing procedures for submission of a combined Site Plan Approval Application and Subdivision Review Application which shall satisfy this section and the board's regulations under the Subdivision Control Act.

c. A Site Plan Approval Application and Subdivision Review Application shall be submitted to the Planning Board. Following granting of Site Plan approval, a Definitive Plan shall be submitted to the Planning Board consistant with their Subdivision Regulations and in substantial conformity with the approved Special Permit Application and Subdivision Review Application, except where the Cluster Development does not constitute a subdivision under the Subdivision Control Law.

3.09 River Protection Standards

3.091 All land uses, including all residences developed either on frontage lots or within a cluster development, shall comply with the following standards:

a. A buffer strip extending at least one hundred (100) feet in depth, to be measured landward from each bank of the _____ River shall be required for all lots within the River Protection District. If any lot, existing at the time of adoption of this bylaw, does not contain sufficient depth, measured landward from the river bank, to provide a one hundred foot buffer strip, the buffer strip may be reduced to 50% of the available lot depth, measured landward from the river bank.

1. The buffer strip shall include trees and shall be kept in a natural or scenic condition.

2. No buildings nor structures shall be erected, enlarged, altered or moved within the buffer strip.

3. On-site disposal system shall be located as far from the ____ River as is feasible.

b. All new development shall be integrated into the existing landscape on the property so as to minimize its visual impact and maintain natural beauty and environmentally sensitive shoreline areas through use of vegetative and structural screening, landscaping, grading, and placement on or into the surface of the lot.

c. Run-off from new development shall be directed towards areas covered with vegetation for surface infiltration. Catch basins, and piped storm sewers shall be used only where other methods are infeasible.

3.10 Riverbank Cluster Development Standards

3.101 Residential subdivision developments in the ____ River Protection District shall be laid out according to the cluster development standards contained herein. Single-family detached dwellings, or lawful accessory buildings, may be constructed on lots in a cluster development, although such lots have less area on frontage than normally required in the underlying district, as herein specified.

a. The minimum lot size for any cluster development lot shall be 20,000 square feet. The minimum frontage for such lots shall be 100 feet. All other dimensional requirements shall be the same as in the regulations for the underlying district.

b. The maximum number of dwelling units permitted in a residential cluster development shall be calculated according to the following procedures:

1. The maximum number of dwelling units permitted on a parcel of land shall be determined based upon one unit per acre for the net developable acreage remaining once the area of all wetlands and all areas unsuitable for on-site sewage disposal have been subtracted from the total acreage of the property, if appropriate.

2. Under the supervision of the Conservation Commission and in accordance with the provisions of the Wetlands Protection Act, M.G.L. Ch. 131, Sec. 40, all wetlands shall be identified, and their area subtracted from the net developable acreage of the total parcel.

3. Under the protection of the Board of Health, and in conformance with Title V, percolation tests shall be conducted for all lots in the total acreage of the property which would be developed in a standard subdivision layout. The area of those lots which is determined to be not suitable for on-site sewage disposal shall be subtracted from net developable acreage of the total parcel.

c. All buildings, roads, drainage systems and utilities shall be laid out in a manner to have the least possible impact on the scenic qualities of the river, and on important natural resources including prime farmlands, wetlands, and tributary watercourses.

d. The required open land within a cluster shall be determined as follows:

1. At least fifty (50) percent of the net acreage remaining after the area of all wetlands have been subtracted shall be retained as open land.

2. Open land shall be configured in order to protect river areas, shorelines and other important natural resource areas such as prime farmlands to the extent feasible.

3. All open land shall be permanently protected as provided for in Section 3.11.

e. All residential structures and accessory uses within the development shall be set back from the boundaries of the development by a buffer strip of at least fifty (50) feet in width which shall include trees and shall be kept in a natural or landscaped condition.

f. The following standards shall apply to developments requiring on-site sewage disposal:

1. The applicant shall submit a septic system design prepared by a certified engineer and approved by the Board of Health and a plan illustrating the location of water supply wells with the special permit applications. No community septic system serving the development shall exceed sewage flow of 2,000 gallons per day. Septic systems shall be placed in the development to maximize the distance between systems and shall be placed within common areas rather than on individual lots. Maintenance of community septic systems shall be the responsibility of the homeowners' association specified in Section 3.12.

2. No cluster development shall be approved unless the applicant can demonstrate to the satisfaction of the Planning Board that the potential for groundwater pollution is no greater from the proposed cluster development than would be expected from a conventional subdivision with single-family houses on lots meeting the normal lot size requirements located on the same parcel. Where necessary, the Planning Board may hire a Professional Engineer to analyze and certify groundwater quality impacts, and may charge the applicant for the cost of such analysis.

3.11 Common Space Ownership

3.111 All common open land shall be either:

a. Conveyed to a community association owned or to be owned by the owners of lots within the development. If such a community association is utilized, ownership thereof shall pass with conveyances of the lots in perpetuity.

b. Conveyed to a non-profit organization, the principal purpose of which is the conservation or preservation of open space;

c. Conveyed to the Town, at no costs, and be accepted by it for park or open space use. Such conveyance shall be at the option of the Town and shall require the approval of the voters at a Town Meeting.

3.112 In cases where such land is not conveyed to the Town, a restriction enforceable by the Town shall be recorded to ensure that such land shall be kept in an open or natural state and not be built for residential use nor developed for accessory uses such as parking or roadways. Such restrictions shall further provide for maintenance of the common land in a manner which will ensure its suitability for its function, appearance, cleanliness, and proper maintenance of drainage, utilities and the like.

3.12 Community Association

3.121 A non-profit, incorporated community association shall be established, requiring membership of each lot owner in the open space community. The community association shall be responsible for the permanent maintenance of all community water and septic systems, common open space, recreational and thoroughfare facilities. A community association agreement of covenant shall be submitted with the special permit application guaranteeing continuing maintenance of such common maintenance expenses. Such agreement shall be subject to the review and approval of Town Counsel and the Planning Board.

3.122 Such agreements or covenants shall provide that in the event that the association fails to maintain the common open land in reasonable order and condition in accordance with the agreement, the Town may, after notice to the association and public hearing, enter upon such land and maintain it in order to preserve the taxable values of the properties with the development and to prevent the common land from becoming a public nuisance. The covenants shall also provide that the cost of

such maintenance by the Town shall be assessed ratably against the record owners of the properties within the development, their successors or assigns.

3.13 Non-Conforming Uses

3.131 Any lawful use, building, structures, premises, land or parts thereof existing at the effective date of this bylaw or amendments thereof and not in conformance with the provisions of this bylaw shall be considered to be a non-conforming use.

3.132 Any existing use or structure may continue and may be maintained, repaired, and improved but in no event made larger.

3.133 Any non-conforming structure which is destroyed may be rebuilt on the same location but no larger than its overall original square footage.

3.14 Hardships

3.141 To avoid undue hardship, nothing in this bylaw shall be deemed to require a change in design, construction, or intended use of any structure for which a building permit was legally issued prior to the effective date of this bylaw. Such construction may be completed within two years from the effective date of this bylaw, or such construction shall be required to conform to this bylaw.

MODEL SCENIC UPLAND ZONING BYLAW

(Source: Growth Management Workbook. EOCD, 1988)
(Based upon a zoning bylaw adopted by the Town of Monson, Massachusetts and on the Berkshire Scenic Mountains Act, M.G.L. Chapter 131, Section 39a)

SCENIC UPLAND REVIEW

4.00 Purpose

The purposes of the Scenic Upland District are:

a. To preserve and enhance areas in the Town of _____ of natural scenic beauty including mountain, ridges, wooded canyons, exceptional vistas or viewsheds, and related natural resources;

b. To regulate new construction, vegetation removal, filling, or excavation of land which could adversely affect natural resources of scenic qualities;

c. To prevent erosion, sedimentation, water pollution, flooding and other adverse impacts of development in sensitive upland areas.

4.01 Scope of Authority

The Scenic Upland District is an overlay district and shall be superimposed on the other districts established by this bylaw. All regulations of the ____ Zoning Bylaw applicable to such underlying districts shall remain in effect, except that where the Scenic Upland District imposes additional regulations, such regulations shall prevail.

4.02 District Defineation

4.021 The Scenic Upland District Bylaw shall be applied to sensitive mountain or steep slope areas of scenic and natural resource value as designated on the overlay map entitled "Scenic Upland District, Town of _____", on file with the Town Clerk.

4.022 The Scenic Upland District is intended to include those mountain or upland areas which have one or more of the following characteristics:

a. Steep slopes greater than 15%.

b. Unique landforms, including bedrock outcrops, till-covered hills, geological rarities, cliffs, or other unusual topographic features;

c. Areas of high visual amenity including areas with scenic views, farmlands, streams, wetlands, waterways, and forested slopes.

4.03 Permitted Uses

a. Agricultural production, including raising of crops, livestock, poultry, nurseries, orchards, hay;

b. Recreational uses, provided there is minimal disruption of wildlife habitat;

c. Maintenance and repair usual and necessary for continuance of an existing use;

d. Conservation of water, plants and wildlife, including the raising and management of wildlife.

e. Uses permitted under M.G.L. Chapter 40a, Section 3 with the limitations imposed therein.

4.04 Prohibited Uses

All uses not permitted in Sections 4.03 or 4.05 shall be deemed prohibited.

4.05 Uses Permitted With Scenic Upland Review

The following uses shall be permitted subject to Scenic Upland Review of project site plans prior to the

issuance of a building permit or Special Permit or approval of a definitive plan under the Massachusetts Subdivision Control Law:

a. Any construction or significant alteration of any dwelling or other structure, if any such action affects the exterior appearance. A significant alteration is defined as any alteration exceeding __ percent of the existing square footage of the structure, or which adds to the height of a structure, or which substantially alters the visual profile of the property or structures thereon;

b. Any commercial or industrial use allowed by Special Permit in the underlying district;

c. Any subdivision which requires approval under the Massachusetts Subdivision Control Law, M.G.L., Ch. 40.

4.06 Scenic Upland Review Board

4.061 In accordance with the provisions of Chapter 40A of the Massachusetts General Laws, a Scenic Upland Review Board shall review applications and site plans for all actions that are subject to this bylaw, and shall make recommendations to the Building Inspector, Planning Board or Zoning Board of Appeals as described in Section 4.08 concerning the conformance of the proposed action to the design and development standards contained herein.

4.062 The Scenic Upland Review Board shall consist of five members, two of whom are registered architects, landscape architects, or persons with equivalent professional training, and one of whom owns property in the affected areas. Appointments to the Scenic Upland Review Board shall be made by the Board of Selectmen.

4.063 The terms of all members of the Scenic Upland Review Board shall be three years, except that when the Board is originally established, the Board of Selectmen shall make two of their appointments for a three-year term, two appointments for a two-year term, and the remaining appointment shall be for a one-year term.

4.07 Application Contents and Procedures

4.071 Applications for all actions subject to review by the Scenic Upland Review Board shall be made by completing an application form and site plan and submitting it to the Building Inspector. Application forms are available from the Office of the Building Inspector.

4.072 All applications to the Scenic Upland Review Board shall include all information required by the rules and regulations of the Scenic Upland Review Board, as applicable, in addition to any other information that is required under this bylaw as part of an application for a special permit variance or building permit.

4.073 To facilitate siting and design of buildings sensitively related to the natural setting, application for Scenic District Review of proposed development in the scenic district must be accompanied by a site plan which describes or illustrates:

a. The location and boundaries of the lot, adjacent streets or ways, and the location and owner's names of all adjacent properties;

b. Existing and proposed topography including contours, the location of wetlands, streams, waterbodies, drainage swales, areas subject to flooding and unique natural land features;

c. Placement, height and physical characteristics of all existing and proposed buildings and structures located on the development site;

d. Architectural rendering illustrating design of all proposed structures;

e. Proposed landscape features including the location and a description of screening, fencing, and planting;

f. View points - Photographs of the development site taken from points along the street, together with a map indicating the distance between these points and the site;

g. The location of parking and loading areas, driveways, walkways, access and egress points;

h. The location and a description of all proposed septic systems, water supply, storm drainage systems, utilities, and refuse, and other waste disposal methods;

i. The location and a description of proposed open space or recreation areas;

j. Measures to be undertaken during and after construction to prevent erosion, sedimentation, flooding, or water pollution.

4.08 Review Procedures

4.081 Upon receipt of an application for Scenic Upland Review, the Building Inspector shall immediately transmit the application to the Scenic Upland Review Board. The Scenic Upland Review shall review the application and return its recommendations in writing to the Building Inspector within thirty-five (35) days of the receipt of the application. If the application for Scenic Upland Review is associated with an application for a variance, special permit, or subdivision review, the Scenic Upland Review Board shall immediately transmit their recommendations to the Planning Board or Zoning Board of Appeals as appropriate.

4.082 If the Scenic Upland Review does not submit its recommendations to the Building Inspector within thirty-five (35) days, such failure to act shall constitute approval of the application.

4.083 The Scenic Upland Review Board's action shall be advisory and shall consist of either:

a. A determination that the proposed project will constitute a suitable development and is in compliance with the criteria set forth in this bylaw;

b. Approval subject to conditions, modifications, and restrictions as the Scenic Upland Review Board may deem necessary.

4.084 The applicant shall be given written notice of the public meeting at which their application will be reviewed, and shall be given an opportunity to be heard on the application.

4.085 The Building Inspector, Planning Board, and Zoning Board of Appeals shall, in making their permit granting decisions, give due consideration to the Scenic Upland Review Board's recommendations, and shall communicate all subsequent decisions to said Board.

4.09 Scenic District Review Criteria

4.091 Scenic District Review should ensure that when man-made structures are built in scenic areas, they are sensitively related to the natural setting and that special consideration has been given to their siting and design.

4.092 A Scenic District application may be approved where consistent with the following criteria:

a. Buildings, building materials, and landscaping are designed and located on the site to blend with the natural terrain and vegetation and preserve the scenic character of the site;

b. Where public views will unavoidably effected by the proposed use, architectural and landscaping measures have been employed so as to minimize significant degradation of the existing scenic or aesthetic qualities of the site;

c. Safeguards have been employed where needed to mitigate against environmental degradation from erosion, sedimentation, water pollution, or flooding.

4.10 Design and Development Standards

All applications for Scenic Upland Design Review shall comply with the following design and development standards:

4.101 Siting of Structures

a. The placement of buildings, structures, or signs shall not detract from the site's scenic qualities or obstruct significant views, and shall blend with the natural landscape.

b. Building sites shall be directed away from the crest of hills in order to preserve the visual integrity of the district.

c. Developments for more than one structure shall incorporate variable setback, multiple orientations, and other site-planning techniques to avoid the appearance of a solid line of development.

d. Foundations should be constructed to reflect the natural slope of the terrain. Excessive support members or mechanical systems should be covered or screened.

4.102 Building Materials, Colors, and Architectural Style

a. Natural building materials which blend with the natural landscape, such as brick, stone, masonry or wood should be emphasized in the design of the exterior.

b. Architectural style shall reflect the traditional New England character of community.

c. In selecting exterior colors for structures, reference shall be given to "earth" colors, such as olive, ochre, sienna, gray, gray green, gray blue, etc. Warm colors may be appropriate for small accessory uses or for design details.

d. Business or industrial uses other than restaurants, recreational uses or travel-related uses such as gasoline service stations and roadside stands are to be conducted entirely within enclosed buildings.

4.103 Landscaping and Site Preparation

a. In landscaping, preference shall be given to native trees and plants.

b. The removal of native vegetation or trees shall be minimized to the extent feasible in clearing sites for new structures or roads. Selective clearing of vegetation may be permitted where views may be presently obscured by such vegetation adjoining or within 200 feet of a public or private way, subject to approval of the Scenic Upland Review Board.

c. Retaining walls may be used to create usable yard space in the side and rear yard. Retaining walls in the exposed side and downhill portions of a lot shall be screened with appropriate landscaping materials.

d. Any grading or earth-moving operation in conjunction with a proposed development shall be planned and executed in such manner that final contours are consistent with the existing terrain both on and adjacent to the site.

4.104 Accessory Uses and Utilities

a. Utilities shall be constructed and routed underground except in those situations where natural features prevent the underground siting or where safety considerations necessitate above-ground construction and routing. Above-ground utilities shall be constructed and routed to minimize detrimental effects on the visual setting.

b. Potentially unsightly accessory uses such as parking lots, storage areas, equipment sheds, above-ground swimming pool, and communications towers shall be located in areas not visible from streets, or shall be screened by dense evergreen plantings or landscaped earthen berms.

c. Antennae shall not be silhouetted against the view, preferably not mounted on roof.

4.105 Signs

a. Signs shall be constructed and located on the site so as to, as nearly as possible, satisfy the standards in Section 4.101(a).

b. Signs shall be of the minimum size and height necessary for identification of the business, and shall be located on the building premises.

c. Signs shall not be internally illuminated. Signs shall be illuminated only with steady, stationary, shielded light sources directed solely onto the sign without causing glare.

4.106 Prevention of Water Pollution and Flooding

a. Storage and/or transmission of petroleum or other refined petroleum products is prohibited except within buildings which they will heat. Petroleum products stored within a building shall be placed on a diked, impermeable surface to prevent spills or leaks from reaching groundwater.

b. The amount of sanitary waste discharged to an on-site sewerage system shall not exceed 330 gallons per day per acre.

c. All run-off from impervious surfaces shall be recharged on the site by being diverted to stormwater infiltration basins covered with natural vegetation. Stormwater infiltration basins must be designed to handle a 25-year storm. Dry wells shall be used only where other methods are infeasible, and shall be preceded by oil, grease, and sediment traps to facilitate removal of contamination. Any and all recharge areas shall be permanently maintained in full working order by the owner.

4.107 Prevention of Erosion and Sedimentation

a. No area or areas totalling two (2) acres or more on any parcel or contiguous parcels in the same ownership shall have existing vegetation clear-stripped or be filled six (6) inches or more so as to destroy existing vegetation unless in conjunction with agricultural activity or unless necessarily incidental to construction on the premises under a currently valid building permit or unless within streets which are either public or designated on an approved subdivision plan or unless a special permit is approved by the Planning Board on the condition that run-off will be controlled, erosion avoided and either a constructed surface or cover vegetation will be provided not later than the first full spring season immediately following completion of the stripping operation. No stripped area or areas which are allowed by special permit shall remain through the winter without a temporary cover of winter rye or similar plant materials being provided for soil control, except in the case of agricultural activity where such temporary cover would be infeasible.

b. Sediment and erosion control measures shall be employed to minimize such impacts during and after construction, in accordance with guidelines established by the U.S. Soil Conservation Service "Guidelines for Soil and Water Conservation in Urbanizing Areas of Massachusetts."

MODEL WETLANDS PROTECTION BYLAW

(Source: Growth Management Workbook. EOCD, 1988)
(Based upon a bylaw adopted by the Town of Amherst, Massachusetts)

WETLAND PROTECTION BYLAW

5.00 Purpose

The purposes of this bylaw are to protect the wetlands, related water resources, and adjoining land areas in the Town of _____ by prior review and control of activities deemed by the Conservation Commission likely to have a significant or cumulative effect upon wetland values, including, but not limited to the following: public water supply, private water supply, groundwater, flood control, erosion and sedimentation control, storm damage prevention, prevention of water pollution, fisheries, wildlife, wildlife habitat, recreation, and aesthetic values; these values are to be known collectively as the "wetlands protected by this bylaw."

5.01 Jurisdiction

Except as permitted by the Conservation Commission or as provided in this bylaw, no person shall remove, fill, dredge, build upon, or alter the following resource areas:

a. Any freshwater wetland, riverine wetlands, marsh, wet meadow, bog or swamp, or within one hundred (100) feet of said areas:

b. Any bank or beach, or within one hundred (100) feet of said areas;

c. Any lake, river, pond, or stream, whether intermittent or continuous, natural or man-made;

d. Any land under aforesaid waters;

e. Any land subject to flooding or inundation by groundwater, surface water, storm flowage, or within one hundred (100) feet of said areas;

f. Isolated wetlands including kettle holes, or within one hundred (100) feet of said areas;

g. Seasonal wetlands, or within one hundred (100) feet of said areas.

5.02 Exceptions

The application and permit required by this bylaw shall not be required for maintaining, repairing, or replacing, but not substantially changing or enlarging (more than 50% of structure area), an existing or lawfully located structure or facility used in the service of the public to provide electric, gas, water, telephone, telegraph or other telecommunication services, sanitary sewers and storm sewers, provided that the structure or facility is not substantially changed or enlarged, provided that written notice has been given to the Commission at lease forty-eight (48) hours prior to commencement of work, and provided that the work conforms to performance standards in regulations adopted by the Commission.

The application and permit required by this bylaw shall not apply to emergency projects necessary for the protection of the health or safety of the public, provided that the work is to be performed by or has been ordered to be performed by an agency of the Commonwealth or a political subdivision thereof, provided that advance notice, oral or written, has been given to the Commission prior to commencement of work or within twenty-four (24) hours after commencement, provided that the Conservation Commission or its agent certifies the work as an emergency project, provided that the work is performed only for the time and place certified by the Conservation Commission for the limited purposes necessary to abate the emergency, and provided that within twenty-one (21) days of commencement of an emergency project a permit application shall be filed with the Commission for review as provided in this bylaw. Upon failure to meet these and other requirements of the Commission, the Commission may, after notice and public hearing, revoke or modify an emergency project approval and order restoration and mitigation measures.

The application and permit required by this bylaw shall not be required for work performed for the normal maintenance or improvement of lands in agricultural use.

The application and permit required by this bylaw shall not be required for work performed when covered by a proper notice of intent/forest cutting plan as filed under M.G.L. ch. 132, sect. 40-46. (Forest Cutting Practices Act).

5.03 Requests for Determinations and Applications for Permits

Any person desiring to know whether or not a proposed activity or an area is subject to this bylaw may request in writing a determination from the Commission. Such a request for determination shall contain data and plans specified by the regulations of the Commission.

The Commission in an appropriate case may accept as the request under this bylaw the Request for Determination of Applicability filed under the Wetlands Protection Act, G.L. Ch. 131, Sec. 40.

Written application shall be filed with the Commission to perform activities regulated by this bylaw affecting resource areas protected by this bylaw. The application shall include such information and plans as area deemed necessary by the Commission to describe proposed activities and their effects on the environment. No activities shall commence without receiving and complying with a permit issued pursuant to this bylaw.

The Commission in an appropriate case may accept as the application and plans under this bylaw the Notice of Intent and plans filed under the Wetlands Protection Act, G.L., Ch. 131, Sec. 40.

At the time of an application request, the applicant shall pay a filing fee specified in regulations of the Commission. This fee is in addition to that required by the Wetlands Protection Act, G.L., Ch. 131, Sec. 40. In addition, the Commission is authorized to require the applicant to pay the costs and expenses of any expert consultant deemed necessary by the Commission to review the application. The Commission may waive the filing fee and costs and expenses for an application or request filed by a government agency, and may waive the filing fee for a request for determination filed by a person having no financial connection with the property which is the subject of the request.

5.04 Public Notice and Hearings

An application or a request for determination shall be hand delivered or sent by certified mail to the Commission. The Commission shall notify all abutters according to the most recent records of the assessors, including those across a traveled way or body of water. The notice to abutters shall state where the request or application, including any accompanying documents, may be examined or obtained. When a person requesting a determination is other than the owner, the request, the notice of the hearing, and the determination itself shall be sent by the Commission to the owners as well as to the person making a request.

The Commission shall conduct a public hearing on any application or request for determination, with written notice given at the expense of the applicant, five (5) working days prior to the hearing, in a newspaper of general circulation in the Town of _____. The Commission in an appropriate case may combine its hearing under this bylaw with the hearing conducted under the Wetlands Protection Act, G.L., Ch. 131, Sec. 40.

The Commission shall commence the public hearing within twenty-one (21) days from receipt of a completed application or request for determination, unless the applicant extends the twenty-one (21) day time period by a signed written waiver.

The Commission shall have authority to continue the hearing to a certain date announced at the hearing or to an unspecified date, for reasons stated at the hearing, which may include the receipt of additional information offered by the applicant or others, information and plans required of the applicant, deemed necessary by the Commission in its discretion, or comments and recommendation of boards and officials listed in Section 6. If a date for continuation is not specified, the hearing shall reconvene within twenty-one (21) days after the submission of a specified piece of information or the occurrence of a specified action. The date, time and place of said continued hearing shall be published in a newspaper of general circulation in the Town of _____, five (5) working days prior to the continuation, at the expense of the applicant, and written notice shall be sent to any person who so requests in writing.

The Commission shall issue its permit or determination in writing within twenty-one (21) days of the close of the public hearing thereon.

5.05 Coordination with Other Boards

Any person filing a permit application or a request for determination with the Commission shall provide written notice thereof at the same time, by certified mail or hand delivery, to the Board of Selectmen, Planning Board, Zoning Board of Appeals, Board of Health, Town Engineer, and Building Commissioner. The Commission shall not take final action until such boards and officials have had fourteen (14) days from receipt of notice to file written comments and recommendations with the Commission, which the Commission shall take into account but which shall not be binding on the Commission. The applicant shall have the right to receive any such comments and recommendations, and to respond to them at a hearing of the Commission, prior to final action.

5.06 Determination, Permits and Conditions

The Commission shall have the authority, after a public hearing, to determine whether a specific parcel of land contains or does not contain resource areas protected under this bylaw. If the Commission finds that no such resource areas are present, it shall issue a negative determination.

If the Commission, after a public hearing on the permit application, determines that the activities which are the subject of the application are likely to have a significant or cumulative detrimental effect upon the wetland values protected by this bylaw, the Commission within twenty-one (21) days of the close of the hearing, shall issue or deny a permit for the activities requested. If it issues a permit, the Commission shall impose conditions which the Commission deems necessary or desirable to protect those values, and all activities shall be done in accordance with those conditions.

The Commission is empowered to deny a permit for failure to meet the requirements of this bylaw, for failure to submit necessary information and plans requested by the Commission; for failure to meet the design specification, performance standards, and other requirements in regulations of the commission; for failure to avoid or prevent significant or cumulative detrimental effects upon the wetland values protected by this bylaw; and where no conditions are adequate to protect those values.

A permit shall expire three years from the date of issuance. Notwithstanding the above, the Commission in its discretion may issue a permit expiring five years from the date of issuance for recurring or continuous maintenance work, provided that annual notification of time and location of work is given to the Commission. Any permit may be renewed once for an additional one year period.

For good cause the Commission may revoke or amend a permit issued under this bylaw after public notice and public hearing, and notice to the holder of the permit.

The Commission in an appropriate case may combine the permit or other action on an application issued under this bylaw with the Order of Conditions or other action issued or taken under the Wetlands Protection Act, G.L., Ch.131, Sec. 40.

5.07 Regulations

After public notice and public hearing the Commissions shall promulgate rules and regulations to accomplish the purposes of this bylaw. These regulations shall be consistent with the terms of this bylaw. The Commission may amend the rules and regulations after public notice and public hearing.

Failure by the Commission to promulgate such rules and regulations or a legal declaration of their invalidity by a court of law shall not act to suspend or invalidate the effect of this bylaw.

Unless otherwise stated in this bylaw or in the rules and regulations promulgated under this bylaw, the definitions, procedures, and performance standards of the Wetlands Protection Act. G.L. Ch. 131, Sec. 40 and associated Regulations, 310 CMR 10.00 as promulgated April 1983, shall apply.

5.08 Definitions

The following definitions shall apply in the interpretation and implementation of this bylaw:

The term "person" shall include any individual, group of individuals, association, partnership, corporation, company, business organization, trust, estate, the Commonwealth or political subdivision thereof to the extent subject to town bylaws, administrative agency, public or quasi-public corporation or body, this municipality, and any other legal entity, its legal representatives, agents, or assigns.

The term "alter" shall include, without limitation, the following activities when undertaken to, upon, within or effecting areas protected by this bylaw:

a. Removal, excavation or dredging of soil, sand, gravel, clay, minerals, or aggregate materials of any kind;

b. Changing or pre-existing drainage characteristics, flushing characteristics, salinity distribution, sedimentation patterns, flow patterns, or flood retention characteristics;

c. Drainage, or other disturbance of water level or water table;

d. Dumping, discharging, or filling with any material which may degrade water quality;

e. Placing of fill, or removal of material, which would alter elevation;

f. Driving of piles, erection or repair of buildings, or structures of any kind;

g. Placing of obstructions or objects in water;

h. Destruction of plant life including cutting of trees;

i. Changing water temperature, biochemical oxygen demand, or other physical, chemical, or biological characteristics of surface and groundwater;

j. Any activities, changes or work which may cause or tend to contribute to pollution of any body of water or groundwater.

5.09 Security

As part of a permit issued under this bylaw, in addition to any security required by any other municipal or state board, agency or official, the Commission may require that the performance and observance of the conditions imposed hereunder be secured wholly or in part by a proper bond or deposit of money or negotiable securities or other undertaking of financial responsibility sufficient in the opinion of the Commission.

In addition or in the alternative, the Commission may accept as security a conservation restriction, easement, or other covenant enforceable in a court of law, executed and duly recorded by the owner of record, running with the land to the benefit of this municipality and observed before any lot may be conveyed other than by mortgage deed.

5.10 Enforcement

The Commission, its agents, officers, and employees shall have the authority to enter upon privately owned land for the purpose of performing their duties under this bylaw and may make or cause to be made such examinations, surveys, or samplings as the Commission deems necessary.

The Commission shall have authority to enforce this bylaw, its regulations, and permits issued thereunder by violation notices, administrative orders, and civil and criminal court actions.

Upon request of the Commission, the Selectboard and the Town Counsel will take legal action for enforcement under civil law. Upon request of the Commission, the Chief of Police shall take legal action for enforcement under criminal law.

Any person who violates any provision of this bylaw, regulations thereunder, or permits issued thereunder, shall be punished by a fine of not more than three-hundred dollars ($300). Each day or portion thereof during which a violation continues shall constitute a separate offense, and each provision of the bylaw, regulations, or permit violated shall constitute a separate offense. This fine may be in addition to any levied under the Wetlands Protection Act, G.L., Ch. 131, Sec. 40.

In the alternative to criminal prosecution, the Commission may elect to utilize the non-criminal disposition procedures set forth in G.L., Ch. 40, Sec. 21D.

5.11 Burden of Proof

The applicant for a permit shall have the burden of proving by a preponderance of credible evidence that the work proposed in the application will not have any significant or cumulative detrimental effect upon the wetland values protected by this bylaw. Failure to provide adequate evidence to the Commission supporting this burden shall be sufficient cause for the Commission to deny a permit or grant a permit with conditions.

5.12 Relation to the Wetlands Protection Act

This bylaw is adopted under the Home Rule Amendment of the Massachusetts Constitution and the Home Rule statutes, independent of the Wetlands Protection Act, M.G.L., Ch. 131, Sec. 40, and the regulations thereunder.

5.13 Severability

This invalidity of any section or provision of this bylaw shall not invalidate any other section or provision thereof, nor shall it invalidate any permit or determination which previously has been used.

REGULATION PROVIDING FOR SEPTIC SYSTEM INSPECTION UPON SALE OF PROPERTY OR CHANGE IN USE

(Based on Health Regulations passed in Whatley, Sunderland and Gill, Massachusetts, effective Feb., 1991)

I. INSPECTION OF SEWAGE DISPOSAL SYSTEMS PRIOR TO TRANSFER OF REAL ESTATE OR CHANGE IN USE.

A. Purpose and Authority

1. Authority. These regulations shall be effective on and after (date) and so remain until modified or amended by the Board of Health. They are enacted by the board of health under authority which includes, but is not limited to one or more of the following: Massachusetts General Laws, Chapter 111, Sections 31, 122, 122A, 127, 143, 155, 187, 188, 310 CMR (Code of Massachusetts Regulations) 11.02. Board of health regulations are an exercise of the police power under which the various levels of government are responsible for protection of the public health, safety and welfare.

2. Purpose. This regulation of the board of health has been enacted for the purpose of protection of the public health, safety and welfare, by identifying failed, or otherwise inadequate subsurface sewage disposal systems, and correcting any deficiencies which may exist. It is also intended to ensure that systems are not used for purposes for which they were not designed.

B. Definitions

CHANGE OF USE - is when the use of the property is altered or extended in any way.

DEVELOPED PROPERTY - is any real estate with a human-made structure used or intended for human occupancy or use, or with an existing subsurface sewage disposal system located on the property, or both.

FAILED SYSTEM - is defined as a septic system in which there is evidence, based upon the inspection required by this regulation, of one or more of the following problems:

a. sewage flow to the surface or into any waters of the Commonwealth,

b. outlet tee or baffle is not in place or is damaged in the septic tank,

c. inlet tee or baffle is not in place or is damaged in the septic tank,

d. liquid level in tank is above the tank outlet,

e. after or during tank pumping, liquid is observed flowing from the outlet back into the tank,

f. leaching facility is not in place after the septic tank,

g. any other problem, as defined by the board of health, representing an actual threat to the public health.

INSPECTION - shall consist of the following:

a. visual inspection of the ground surface around the septic system to look for signs of sewage or high ground water,

b. review of all available records and inquiry to the owner, installer, and board of health, to identify, if possible, location and type of leaching facility and distribution box,

c. review of all available records and inquiry to the owner and licensed plumbers, to determine, if possible, how often the septic tank has been pumped during the two years preceding the inspection,

d. location of all domestic water supply wells, lakes, ponds, streams, and watercourses, within one hundred feet (100') of the leaching facility if its location can be determined, or, if the location of the leaching facility cannot be determined, within one hundred feet (100') of the septic tank,

e. opening the septic tank and pumping out its contents,

f. determine materials of tank construction,

g. fill the bathtub with water and releasing, checking for slow wastewater discharge to the system,

h. personal observation, by a registered professional engineer or registered sanitarian, of the pumping of the septic tank. A representative of the board of health must be present for the observation to be valid,

i. recording observations of the following:

(1) address and owner of tank,

(2) determine tank construction material,

(3) the amount of septage pumped from the tank,

(4) whether an outlet tee or baffle is in place and not damaged in the septic tank,

(5) whether an inlet tee or baffle is in place and not damaged in the septic tank,

(6) whether the liquid level in tank, prior to pumping, is above the tank outlet,

(7) whether liquid is observed flowing from the outlet back into the tank during or after pumping.

Nothing in the foregoing definition of INSPECTION is intended to require any registered professional engineer or registered sanitarian to excavate or directly certify the condition of any leaching facility, distribution box, or septic tank inlet/outlet lines. This definition adopts the approach that visual inspection of the property, inspection of any available records, and observation of pumping of the septic tank, together provide a reasonable indicator of the functioning of the septic system. Any opinion or certification provided by the registered professional engineer or registered sanitarian is based solely upon this limited inspection.

OWNER - means every person who alone or severally with others (a) has legal title to any developed property, or (b) has care, charge, or control of the developed property, in any capacity including but not limited to agent, executor/rix, administrator/rix, trustee, or guardian of the estate of the holder of legal title, or (c) mortgagee in possession, or (d) agent, trustee, or other person appointed by the courts, or (e) any officer or trustee of the association of unit owners of a condominium.

REAL ESTATE TRANSFER - is any sale or conveyance of real estate, except:

a. conveyance or devise of the property to a surviving spouse,

b. a sale under a power of sale contained in a bona fide recorded mortgage affecting the property,

c. in the case of joint ownership, if the property is conveyed to one of the original joint owners.

SEPTIC SYSTEM - is the septic tank, distribution box (if available), and surface land area of the lot on which the system is most likely located, unless exact location is known.

C. <u>Inspection of Existing Sewage Disposal Systems</u>

1. The inspection of existing commercial and residential sewage systems shall be the responsibility of the owner and real estate agent if applicable, prior to real estate transfers or change in use.

2. The owner of a developing property shall order and complete an inspection of the existing subsurface sewage system not more than one hundred eighty (180) days and not less than thirty (30) days prior to the time of transfer of the real estate, or of a change in use. The Board of Health may, at its discretion, grant a variance in these time limitations.

3. For the purpose of this regulation, reference is made to the standards and provisions of Title 5 of the State Environmental Code (310 CMR 15.00), and to any applicable regulations of the Board of Health for subsurface sewage disposal.

4. In the case of a change of use, the applicant shall have the responsibility of proving to the Board of Health that the septic system is adequate for safely handling the proposed change of use.

5. After an inspection by, a registered professional engineer or registered sanitarian, that engineer or sanitarian shall file an Inspection Form with the Board of Health, and shall provide copies to the owner or seller, seller's attorney, seller's real estate broker/salesperson, and buyer, stating whether the system is believed to be in operational, or failed condition, based upon the inspection required by this regulation, and whether the system is adequate for a proposed change in use. The filing with the Board of Health shall be accompanied by a filing fee, in an amount to be established by the Board of Health.

D. Exemptions

1. Any new or replacement Title 5 system having been installed and having received final inspection approval by the Board of Health within a period of five years preceding the transfer of the property, shall be exempt from this regulation, providing additional living space which exceeds the capacity has not been added, nor has anything been added to the house which is not in accordance with the original approved design of the system; such as a garbage grinder, addition, or roof drains. And further providing that there has been no change in intended use. A copy of the Disposal Works Construction Permit and Certificate of Compliance, as approved by the Board of Health must be submitted, together with the filing fee, in lieu of the Inspection Form not less than thirty days prior to each transfer.

2. Real estate transfers, which are otherwise subject to this regulation, and which take place within two (2) years following the date of an inspection under this regulation and found to be in operational working order, may be exempt from the inspection requirement, but not the pumping requirement as found in this regulation, upon review and approval by the Board of Health. A copy of the original Inspection Form must be submitted, together with a new filing fee, to the Board of Health for review thirty (30) days prior to the real estate transfer. Systems that were found to be in a failed condition are required to be repaired and to be inspected prior to a real estate transfer, unless meeting the requirements of paragraph three below. The Board of Health may, in its discretion, provide for review in a period less than thirty (30) days. There shall be a fee, in an amount to be established by the Board of Health, for any reinspection.

3. Sellers and Buyers who transfer an existing structure with the intent to replace the existing septic system with a system in compliance with Title 5 of the State Environmental Code and all applicable local bylaws and regulations, may submit, together with the filing fee, an application to the Board of Health for exemption from this regulation. The Seller and the Buyer together must apply in writing showing that both parties have agreed to the arrangement and accept joint responsibility for seeing that the new system is installed. The application for exemption must include a written statement from a registered professional engineer or registered sanitarian (a) that he/she has been placed under contract by the parties to design the replacement system and (b) that a replacement septic system in compliance with Title 5 of the State Environmental Code, and any applicable local regulations, can be installed on the property, and (c) that all work necessary for installation of the replacement septic system will be completed by a stated date, which must be within one year from the date of transfer. The repair/replacement work may not be done by the same professional engineer or professional sanitarian or associated firms as conducted the original inspection under this regulation. Applications under this paragraph may be granted or denied at the discretion of the Board of Health.

E. Enforcement

1. If it is determined by the Board of Health that the system constitutes a danger to the public health, the board shall order the owner to make repairs/replacement of the system, in accordance with all applicable laws and regulations, within a time limit to be determined by the Board of Health. If the work is not completed within the time designated by the Board of Health, the board may impose fines and may repair or replace the system at the cost of the owner. The repair/replacement work may not be done by the same professional engineer or professional sanitarian or associated firms as conducted the original inspection under this regulation.

2. If it is determined by the Board of Health that the system is inadequate for a proposed change in use, the board shall require the upgrading of the systems to meet the anticipated use, in accordance with all applicable laws and regulations, within a time limit to be determined by the Board of Health. If the work is not completed within the time designated by the Board of Health, the board may impose fines and may repair or replace the system at the cost of the owner. The upgrading work may not be done by the same professional engineer or professional sanitarian or associated firms as conducted the original inspection under this regulation.

3. In addition to any other remedy, the Board of Health may take any enforcement action deemed appropriate and lawful, including but not limited to criminal prosecution, to seek a fine in accordance with Chapter III, Section 31, or Civil Action for injunctive relief or money damages or both.

4. The Board of Health is authorized to issue notices of violation, cease and desist orders, or other administrative enforcement orders to compel compliance with these regulations.

5. After an inspection by a registered professional engineer or registered sanitarian, that engineer or sanitarian shall file an Inspection Form with the Board of Health, together with the required filing fee, and shall provide copies to the Board of Health, the seller, and buyer, stating whether the system is in operational condition or needs to be repaired. A representative of the Board of Health must be present during said inspection in order for it to be valid.

6. Each part of this regulation shall be construed as seperate to the end that if any paragraph, sentence, clause or phrase thereof shall be held invalid for any reason, the remainder of that regulation and all other regulations shall continue in full force.

F. Instructions for Inspections

NOTE: See the definition of INSPECTION in Section B of this regulation, as well as the definitions of FAILED SYSTEMS.

1. The inspection by the registered professional engineer or registered sanitarian shall take place no more than one hundred eighty (180) days nor less than thirty (30) days prior to the real estate transfer, or change in use. A representative of the Board of Health must be present at said inspection. The Board of Health must receive the inspection Form within seven (7) days of the inspection. In addition, the copies must be given to the owner and to the buyer at that time. Inspection Forms are provided by the Board of Health.

2. If the inspection finds evidence of a failed system, the Board of Health shall determine within fourteen (14) days after receiving the Inspection Form, whether the system constitutes a danger or potential danger to the public health and should be repaired or replaced. By the end of the fourteen day time period, the Board of Health must notify the owner by certified or registered mail, with return receipt requested, whether the system must be repaired or replaced, or that some other available alternative must be pursued. Follow-up inspection(s) may be required by the Board of Health. A representative of the Board of Health must be present at such an inspection. There shall be a fee for each follow-up inspection.

3. The time allowed for the repair or replacement will be determined by the Board of Health and will be contained in the letter of notification to the owner.

4. If repair or replacement is required, the owner must conduct the site inspection as provided by Title 5 of the State Environmental Code (310 CMR 15.00) and by local regulations of the Board of Health. Any such repair or replacement shall be done only in accordance with a disposal works construction permit obtained by the owner in accordance with said Title 5 and local regulations.

MODEL SOIL EROSION AND SEDIMENT CONTROL BYLAW

(Source: Middlesex and Essex Conservation Districts)[19]

MEMORANDUM ON MODEL SOIL EROSION AND SEDIMENT CONTROL BYLAW

The following bylaw has been published by the Middlesex and Essex Conservation Districts to assist those communities wishing to utilize Home Rule authority to enact local protection against unregulated land-disturbing activities, causing erosion and sedimentation of waterbodies and other natural resources and jeopardizing the public health, safety, welfare, and the environment. During 1988 we reviewed bylaws in various forms in place in Massachusetts and we researched what permit procedure would be simplest. We encourage cities and towns to use their powers to require basic soil erosion and sediment control wherever land-disturbing activities take place. The appropriate measures are relatively inexpensive to incorporate in development plans and they are a cheap form of insurance against very expensive environmental damage.

This draft, published in March 1989, has been reviewed by planners, scientists, local officials, and lawyers. Yet we want to caution that no model is perfect for every local situation. Any bylaw must be tailored to your community. Identify erosion problems in your city or town, reflect these problems in the purpose section of the bylaw, select the board to which you wish to give jurisdiction, set the thresholds for project review, describe the basic permit procedures, add any application and plan requirements, consider what performance standards to impose, and shape the monitoring and enforcement approach to adopt.

In other words, this model bylaw is a starting point for your deliberations and discussed, not an end. We commend it as a good foundation, a solid structure.

This bylaw would require extensive land-disturbing activities to obtain a full permit from the Conservation Commission, with detailed plans and specifications to avoid unacceptable erosion and sedimentation. Smaller projects are not subject to this full procedure, but are required to obtain limited permits.

Copies of the permit application are shared with other community boards and officials, and with the local conservation district, for review and comment. The Conservation Commission, though, is the agency with jurisdiction to promulgate regulations and grant permits.

The procedure is kept simple on purpose. Erosion control is something to be incorporated in development plans. The Commission will review erosion control measures needed, not the wisdom of the project or any other board issue. The Commission will render its decision within forty-five days. The permit is recorded in the Registry of Deeds. If desiring to change the project or its erosion control measure substantially, the applicant must notify the Commission, which may require an amended application.

The Commission is directed to adopt a fee schedule by regulation, adequate to reimburse its actual costs of project review and approval.

In addition, the Commission is authorized to require the applicant to pay the expense of an expert engineer or consultant to assist Commission review, up to a maximum of $2,500. Again, only the cost attributable to the project may be charged.

This bylaw adopts a state statute allowing the community to set up a special fund into which such fees and charges go, to be available to the Commission during the fiscal year without the need for appropriation. The bylaw provides for a refund of any unused fees or charges. This special account procedure was adapted from the Town Braintree Home Rule wetlands protection bylaw, approved by the Attorney General during 1988.

Massachusetts lacks an erosion control statute at the state level. Siltation of a body of water is defined as water pollution, but the Clean Water Act does not yet prevent dangerous erosion. Erosion can be reduced under the Wetlands Protection Act, but only relative to work which already is subject to that statute because it is in or near wetlands. State drinking water laws mandate that cities and towns protect water supplies, but leave to you the decision how best to do that. The Zoning Act empowers communities to adopt wetland, watershed, floodplain, and aquifer zoning, but operates largely through announcing what land uses are legal, where, without specifying erosion control measures to prevent problems. The Subdivision Control Act sets up planning boards to review subdivisions, but erosion control measures may be required only if the planning board adopts regulations on that subject, and they only apply to the subdivision of land.

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[19] Beth Handler, EIP Intern; Gregor I. McGregor, Esq., Legal Counsel; Rhett R. Grant, Supervisor MCD Technical Adviser; Fourth Revision, March 1989.

Consequently we strongly urge that cities and towns seriously consider adopting this model soil erosion and sediment control bylaw. Remember that it reflects the best wisdom as of this date. Be sure to contact either the Middlesex or Essex Conservation District for advice on experience with the bylaw in practice, and to obtain the most current version of this model.

SOIL EROSION AND SEDIMENT CONTROL BYLAW

I. TITLE

This bylaw shall be known as the Soil Erosion and Sediment Control Bylaw.

II. PURPOSE

The Purpose of this bylaw is to eliminate or reduce the harmful impacts of soil erosion and sedimentation on the public health, safety, and welfare, and the environment by prohibiting increase in sediment-laden runoff from land-disturbing activities and by prohibiting streambank erosion along bodies of water. This bylaw regulates activities with potential for such impacts by requiring permits and pre-activity review. For activities above the thresholds of jurisdiction under this bylaw, either a full or limited land disturbance permit is required, and compliance with permit conditions. By implementing the controls in permit conditions and in this bylaw, and in regulations promulgated pursuant to this bylaw, erosion and sediment shall be controlled so as to protect water quality, flood storage, stream flow, wildlife habitat, aquatic resources, and public safety.

III. JURISDICTION

No person shall clear, cut, grade, or perform any land-disturbing activity on an area of land 5000 square feet or greater without first applying for and receiving an approved full or limited land disturbance permit from the Conservation Commission in accordance with this bylaw. The Commission shall have authority to promulgate rules and regulations to implement this bylaw, to review permit applications, to perform monitoring and inspections, to grant or deny permits, and to enforce the provisions of this bylaw, and to take any other actions reasonable and appropriate to implement this bylaw. The Conservation District may provide technical services to the Commission in the review of plans or any other matter under this bylaw.

IV. APPLICATION PROCEDURES

Where a full or limited land disturbance permit is required, a written application shall be submitted to the Commission. The application shall be signed by the owner of the property on which the proposed activity is to be conducted. In addition, the applicant, if the applicant is not the owner, shall sign the application. If the owner or applicant is a business entity, the chief executive officer or other officer with authority shall sign the application. Any application or other submittal in support thereof shall be submitted to the Commission in duplicate by certified mail or hand delivery. Upon receipt, the application shall be marked with the date and time received and a file number shall be assigned.

V. COORDINATION WITH OTHER BOARDS

Any person filing a permit application with the Commission shall submit a copy thereof at the same time, by certified mail or hand delivery, to the City Council/Board of Selectmen, Planning Board, Board of Appeals, Board of Health, Building Inspector, and Conservation District. The person filing such application shall at the same time submit to the Commission a written notice that these copies have been submitted to these other agencies. The Commission shall not take final action on an application until such boards and officials have had twenty-one calendar days from their receipt to submit written comments, if any, to the Commission. The applicant shall have the right to receive such written comments, if any, and to respond to them, if desired, prior to final action.

VI. COMPLIANCE

No land-disturbing activity shall take place, unless exempt by the terms of this bylaw, without compliance with a land disturbance permit issued by the Commission, with the plans approved by that permit, and with any rules and regulations promulgated by the Commission. In addition, any land-disturbing activity shall comply with all federal, state and local statutes, regulations, and bylaws/ordinances and shall obtain and comply with any other necessary permits, licenses, or other approvals.

VII. MODIFICATION OF PLANS

Any change, in or alteration of, a land-disturbing activity approved in a permit, and any approved plans, shall be submitted to the Commission, prior to any further land-disturbing activities, for prior review and approval. If in the judgement of the Commission the change or alteration is substantial, the Commission may require that an amended application shall be submitted. If any change or alteration takes place during land-disturbing activities, the Commission may require the installation of interim erosion and sediment control measures before the change or alteration may be approved.

VIII. FEES

The Commission by regulation shall promulgate an application fee schedule for full and limited land-disturbance applications and compliance certificates. The fee specified in such a fee schedule shall be made payable to the Commission and shall accompany the permit application or request for certificate of compliance. The Commission may require a fee for review of any change in or alteration from an approved permit or plan.

Said fee shall be paid into a special account of the Commission set up by the Town/City Treasurer and may be expended by the Commission for the purpose allocated without further appropriation. Any balance in said account at the end of the fiscal year shall be deposited into the general treasury of the town/city. This town/city hereby accepts the provisions of General Laws, Chapter 44, Section 53E. The Commission may draw upon said special account for costs and expenses in processing applications, plans, changes or alterations, certificates of compliance, providing notices, conducting hearings, meetings field inspections and other reviews, performing services by Commission staff and other departments, agencies, boards, officers and employees of the town/city in reviewing matters pending, performing measurements, testing, monitoring, and other evaluations, and mileage, recording, and telephone costs. Provided, however, that only those costs and expenses reasonably attributable to review, approval, disapproval, or other actions on applications, plans, changes or alterations, or certificates of compliance may be so charged against said special account. This filing fee schedule has been determined by the town/city to be commensurate with the expense of providing these municipal services to applicants.

The application fee is non-refundable except as provided herein. Any unused portion of said fee shall be returned by the Commission to the applicant within forty-five calendar days or written request for same by the applicant, unless the Commission decides in a public meeting that other action is necessary. Said Treasurer shall return such portion, if any, as directed by the Commission. Any applicant aggrieved by the imposition of, or size of, the fee, or any act related thereto, may appeal according to the provisions of the Massachusetts General Laws.

In addition to the filing fee imposed by this bylaw and by regulations promulgated by the Commission hereunder, the Commission is authorized to require the applicant to pay the reasonable costs and expenses borne by the Commission for specific expert engineering and consulting service deemed necessary by the Commission to review an application, plan, change or alteration, or certificate of compliance, up to a maximum of $2,500. Said payment may be required by the Commission at any point in reviewing or deliberating prior to a final decision being rendered. Said services may include but are not necessarily limited to soil survey and delineation, hydrogeologic and drainage analysis, erosion and sedimentation potential, and environmental/land use law.

The Commission is hereby authorized to charge said fee for expert engineering and consulting services when an application proposes any of the following: 500 square feet or greater of alteration of a freshwater or costal wetland; 50 linear feet or greater of alteration of a bank or waterway; 500 square feet or greater of alteration of land within 100 feet of a body of water; alteration of greater than 500 square feet of land under a waterbody; discharge of any sediment or siltation into or contributing to surface or groundwater; or construction of a detention or retention basin or other drainage device.

Said fee for expert engineering and consulting services shall be paid into a special account of the Commission set up by the town/city treasurer and may be expended by the Commission for the purpose allocated without further appropriation. Any balance in said account at the end of the fiscal year shall be deposited into the general treasury of the town/city. This town/city hereby accepts the provisions of General Laws, Chapter 44, Section 53 E. The Commission may draw upon said special account for services approved by the Commission at a public meeting. Provided, however, that only those costs and expenses reasonably attributable to review, approval, disapproval, or other action on applications, plan, changes or alterations, or certificates of compliance may be so charged against said special account.

Fees are non-refundable except as provided herein. Any unused portion of said fee for expert engineering or consulting services shall be returned by the Commission to the applicant within forty-five calendar days of written request for same by the applicant, unless the Commission decides in a public meeting that other action is necessary. Said treasurer shall return such portion, if any, as directed by the Commission. Any applicant aggrieved by the imposition of, or size of, the fee or any act related thereto, may appeal according to the provisions of Massachusetts General Laws.

IX. BOND

The Commission may require that the applicant post a performance bond, as a condition of a permit, in form and content approved by the municipal attorney before construction may commence. This bond shall ensure that the installation and maintenance of soil erosion and sediment control procedures are completed as approved by the Commission, within a time specified in the permit.

If satisfactory to the Commission, the applicant may substitute a certificate of guarantee, irrevocable letter of credit, or cash bond in lieu of a performance bond. Any performance bond or letter of credit shall be executed and maintained by a financial institution, surety, or guaranty company qualified to do business in the Commonwealth.

X. CERTIFICATION

At the time of application, the applicant shall certify in writing the name of the person who is responsible for sediment control for the land-disturbing activity which is the subject of the application. Said person shall ensure that said activity takes place in accordance with the application, plan and permit conditions.

XI. REGISTRY OF DEEDS

Prior to commencement of any land-disturbing activity, the applicant shall record the permit with the registry of deeds for the county in which the activity is to take place, or the appropriate land court section of said registry, and shall submit to the Commission written proof of such recording.

XII. FULL LAND DISTURBANCE PERMIT

The following land-disturbing activities shall require a full land disturbance permit:

A. Clearing and grading activity disturbing an area of more than 20,000 square feet; OR

B. Volume of earth resulting in a total quantity of 500 cubic yards or more of earth; OR

C. Land-disturbing activities on two or more contiguous lots within a twelve month period.

The following information shall be submitted, at a minimum, with any full land disturbance application: a plan adequately describing the proposed activity; the items specified below; and any additional information specified in regulations promulgated by the Commission. The applicant shall submit any additional information requested by the Commission or the Conservation District during review of the application.

Detailed engineering plans for proper soil erosion and sediment control shall be submitted including the following, at a minimum:

1. A locus map, legend, and north arrow;
2. A scale showing one inch equals forty feet;
3. Title blocks identified by project name or parcel;
4. Delineation of the total land area to be disturbed;
5. Boundary lines of lots and delineation of land area where activity is to be performed;
6. Contours showing existing and proposed elevations and/or contours at two foot intervals;
7. Symbols for sediment and erosion control practices including detail and elevation;
8. Existing and proposed roadways;
9. Delineation of wetland areas;
10. Delineation of the 100 year floodplain;
11. Street profiles showing proposed grades and elevations;
12. Proposed storm drainage systems;
13. All bodies of water, including streams, rivers, lakes and ponds, within 100 feet of the proposed activity;
14. A description of construction activities, in sequence, which specifies the expected date of soil stabilization and completion;
15. Temporary and permanent soil erosion and sediment control measures;
16. Temporary and permanent seeding and other vegetative controls.

If any structural soil erosion and sediment control is deemed necessary in the judgement of the Commission, the detailed engineering plans shall include the following additional information:

1. Detailed location of any dam or basin;

2. Plan view of any dam or basin;

3. Spillway designs showing calculations and profiles;

4. Emergency spillway designs showing calculations, profiles, and cross-sections;

5. Runoff calculations for peak runoff during a 100 year storm;

6. Notes and construction specifications;

7. Type of sediment trap;

8. Drainage area to any sediment trap;

9. Volume of storage required;

10. Outlet length or pipe sizes;

11. Storage depth below outlet or cleanout elevation;

12. Embankment height and elevation;

13. A portable safety fence surrounding any basin or trap, not less than forty-two inches in height with openings not more than three inches in height, firmly anchored at spacing no greater than eight feet.

The Commission shall review and respond to any completed permit application with forty-five calendar days of receipt, or such additional time as is necessary to provide coordination with other local boards and officials in accordance with Section V above. If the application is denied by the Commission, the Commission shall specify its reasons in writing. The decision with permit or denial shall be mailed or hand delivered by the Commission to the applicant.

Any person aggrieved by the decision of the Commission may appeal in the nature of certiorari to the Superior Court.

XIII. LIMITED LAND DISTURBANCE PERMIT

Any land-disturbing activity not requiring a Full Land Disturbance Permit if it meets the limitations below, shall require a Limited Land Disturbance Permit application:

A. Activity disturbing an area of land no more than 20,000 square feet and no less than 5,000 square feet; AND

B. Volume of earth movement resulting in a total quantity of no more than 500 cubic yards of earth and no less than 100 cubic yards; AND

C. Activity involving a parcel of land having a final graded slope no steeper than three horizontal units to one vertical unit, equivalent to a slope of 33 percent; AND

D. Any area of soil cut or filled not exceeding four feet in vertical depth at its deepest point as measured from the natural ground level.

An application for a Limited Land Disturbance Permit shall, at a minimum, include a sketch of the parcel or parcels on which the activity is to take place, drawn so as to include soil erosion and sediment control practices, roadways, waterways, building or buildings to be constructed, topography, and a stabilized construction entrance.

The Commission shall review and respond to the permit application within forty-five calendar days of receipt, or such additional time as necessary to provide coordination with other boards as specified in Section V above. If the permit is denied, the Commission shall specify its reasons in writing. The decision with permit or denial shall be mailed or hand delivered by the Commission to the applicant.

Any person aggrieved has a right to appeal a decision of the Commission in the nature of certiorari to the appropriate Superior Court.

XIV. STABILIZATION

Vegetative stabilization measures shall be employed. All perimeter dikes and slopes, basin or trap embankments shall be stabilized with sod, seed, and anchored straw mulch within seven calendar days of disturbance. All other disturbed areas shall be stabilized with sod, seed, and anchored straw mulch within fourteen calendar days after disturbing activities have ceased.

Topsoil shall be stripped from disturbed areas and stockpiled in an approved area and stabilized with temporary vegetative cover if left for more than thirty calendar days. Perimeter sediment controls shall be installed around stockpiled topsoil.

During the months of October through March, when seeding and sodding may be impractical, an anchored mulch shall be applied as approved by the Commission.

XV. EXTENSION

A full or limited land-disturbance permit shall be valid for one year from the date the permit is issued. The Commission may grant one extension for an additional year, upon written request for renewal no later than 30 days prior to expiration. Thereafter, a new application shall be required.

XVI. INSPECTION

The Commission, in its discretion, may conduct an inspection at any stage of construction to ensure compliance with the terms of this bylaw and any permit. The Commission also may require the applicant to submit periodic oral or written reports at any stage of construction. The Commission shall be authorized to conduct announced or unannounced inspections at any reasonable time. In any event, upon completion of the land-disturbing activities approved by a permit, the applicant shall notify the Commission to request an inspection.

XVII. COMPLIANCE CERTIFICATE

Upon request of the Commission, the City Council/Board of Selectmen and the City Solicitor/Town Counsel shall take legal action for enforcement of this bylaw under civil law. Upon request of the Commission, the Chief of Police shall take legal action for enforcement under criminal law. Municipal boards and officers, including any police officer or other officer having police powers, shall have authority to assist the Commission in enforcement.

The Commission shall have the power and duty to enforce this bylaw, regulations thereunder, and permits, including but not limited to issuance of violation notices and enforcement orders. An enforcement order may require the halt to any illegal work, removal of equipment and site restoration.

XIX. VIOLATIONS/PENALTIES

Violations of this bylaw, any regulations hereunder, or any permit shall be punished by a fine of not more than $300 per day.

As an alternative to criminal prosecution in a specific case, the Commission may elect to utilize the non-criminal disposition procedure set forth in General Laws, Chapter 40, Section 21D [recite complete text of Section 21D here, in order for your Town to accept provisions of this state law].

XX. EDUCATION

The Commission, within its available resources, should provide education programs on soil erosion and sediment control to the general public and persons regulated by this bylaw. Workshops and seminars should provide guidelines and advice to ease the permit application process and foster acceptance of good erosion control practices.

XXI. DEFINITIONS

ANCHORED MULCH: Mulch consisting of straw, woodchips, emulsifier, and other appropriate materials, bound together by anchored pegs and twine.

APPLICANT: Any natural person, individual, partnership, corporation, trust, agency, department, political subdivision, or other legal entity requesting a soil erosion and sediment control permit for proposed land-disturbing activity.

CLEAR: The act of removing vegetative cover in a manner that does not disturb root mat or the existing soil surface.

CUT: The excavation of soil, sand, gravel, stones, or other earth material from the land.

CONSERVATION COMMISSION: The Conservation Commission of this municipality.

CONSERVATION DISTRICT: The Conservation District for the county in which this municipality lies.

ENGINEERING PLAN: A plan developed by a professional engineer, landscape architect, land surveyor, or person duly qualified, whose name appears on said plan.

EROSION: The process by which the ground surface is worn by natural forces such as wind, water, ice, gravity, glaciers or by artificial means.

FILL: Any act by which soil, earth, sand, gravel, rock, or any similar material is deposited, placed, pushed, pulled, or transported, and includes the conditions that result from that act.

GRADE: An act by which soil is cleared, stripped, stockpiled, or any combination thereof.

LAND-DISTURBING ACTIVITY: Any action that causes the alteration of earth, sand, rock, gravel, vegetation, or similar material on land.

ONE HUNDRED YEAR FLOODPLAIN: An area delineated under the Federal Emergency Management Act (FEMA) indicating the extent of flooding as a result of a 100 year storm.

PERIMETER CONTROL: A measure that prevents erosion and sedimentation through the use of earth and dikes at the outer extent of land-disturbing activities.

PERMIT: The full or limited land-disturbance permit issued by the Commission authorizing land-disturbing activity in accordance with the requirements of this bylaw.

SEDIMENT: Organic material or minerals transported or deposited by the movement of wind, water, ice, gravity, glaciers, or by artificial means.

SEDIMENT BASIN: A temporary barrier or dam constructed across a drainage way or at another suitable location to intercept and trap sediment.

SEDIMENT TRAP: A temporary sediment control measure formed by excavation or embankment to intercept and trap sediment.

SITE: Any lot or parcel of land or area of property where land-disturbing activities are, were, or will be performed.

SLOPE: The inclined surface of a fill, excavation, or natural terrain.

SOIL: Any earth, sand, rock, gravel, or similar material.

STRIP: Any activity which removes the vegetative surface cover including but not limited to tree removal, clearing, grubbing, and storage or removal of topsoil.

WETLAND: Any resource area which is subject to the Wetlands Protection Act, General Laws, Chapter 131, Section 40.

XXII. SEVERABILITY

If any provision of this bylaw is held to be invalid, such invalidity shall not affect any other provision of this bylaw.

XXIII. EFFECTIVE DATE

This bylaw shall take effect upon adoption by Town Meeting/City Council.

MODEL HAZARDOUS MATERIAL AND UNDERGROUND STORAGE TANK BYLAW

(Source: Growth Management Workbook. EOCD, 1988)
(Based upon a bylaw adopted in the City of Westfield, Massachusetts)

HAZARDOUS MATERIAL AND UNDERGROUND STORAGE TANK BYLAW

6.00 Authority

The Town of _____ adopts the following measures under its home rule powers, its police powers to protect the public health and welfare, and its authority under M.G.L., Ch. 40, Sec. 21.

6.01 Definitions

a. Discharge: the spilling, leaking, pumping, emitting, or dumping of toxic or hazardous materials upon or into any land or waters of the Town of _____.

b. Hazardous Material: any substance with such physical, chemical, or infectious characteristics as to pose a potential hazard to existing or potential water supplies or to human health. Hazardous materials include, but are not limited to, toxic chemicals, heavy metals, radioactive or infectious wastes, acids and alkalies, pesticides, petroleum products, herbicides, solvents, and thinners.

c. Underground Storage: storage below ground level but not including storage in a free-standing container within a building.

6.02 Prohibitions

6.021 All new underground storage tanks with volumes less than 1,100 gallons are prohibited from the Water Supply Protection District.

6.022 The discharge of hazardous materials within the Town of _____ is prohibited with the following exceptions:

a. Disposal of sanitary sewage to subsurface sewage disposal systems approved under Title 5 of the Massachusetts Environmental Code or to a wastewater treatment facility.

b. Application of fertilizers and pesticides in accordance with label recommendations and with regulations of the Massachusetts Pesticide Control Board.

c. Application of road salts or other de-icing chemicals provided that such use is minimized and consistent with public highway safety standards.

d. Proper disposal of acceptable materials at a facility or site which has received and maintained all legal approvals as specified in the Massachusetts Hazardous Waste Management Act, M.G.L., Ch. 21C, Sec. 7.

6.023 The use of septic system cleaners containing toxic or hazardous materials is prohibited.

6.03 Hazardous Material Registration and Controls

6.031 Every owner, or operator of a commercial, industrial or agricultural operation storing hazardous materials in quantities totaling more than 50 gallon liquid volume or 25 pounds dry weight shall register with the Fire Department a description of the types and quantities of hazardous materials stored, and the location and method of storage. Registration required by this subsection shall be submitted within sixty (60) days of the effective date of this bylaw and annually thereafter.

6.032 The Fire Department may require that an inventory of hazardous materials be maintained on the premises and be reconciled with purchase, use, sales and disposal records on a monthly basis.

6.033 Hazardous materials shall be stored in product-tight storage containers and shall be removed and disposed of in accordance with the Massachusetts Hazardous Waste Management Act, M.G.L., Ch. 21C.

6.034 The Fire Department shall require that containers of hazardous material be stored on an impervious,

chemical-resistant surface, that the storage area be enclosed with an impermeable dike or within an impermeable basement, and that the containers be protected from weather, vandalism, corrosion, and leakage.

6.04 Underground Storage Tanks of Volumes Greater Than 1,100 Gallons

Every owner of an underground storage container for hazardous materials including petroleum products of volumes greater than 1,100 gallons shall comply with all applicable state regulations for such storage.

6.05 Permits For Existing and New Underground Storage Tanks of Volumes Less Than 1,100 Gallons

6.051 Every owner of an underground storage container for hazardous materials including petroleum products affected by this bylaw shall apply to the Fire Department for a permit to maintain a storage facility. Application shall be made within sixty (60) days of the effective date of this ___ and shall contain the following information:

a. Name, address, and telephone numbers of the owner and operator;

b. The type of material stored;

c. Tank size and construction type for tank and piping;

d. Evidence of the date of installation warranty;

e. Plot plan of the site, including location of the tank, pumping components, and any wells or water bodies.

6.052 The head of the _____ Fire Department is required to send to the Board of Health, the Water Department and the Conservation Commission a copy of every permit application for a new storage facility, with a request for a recommendation of approval or disapproval within 30 days.

6.053 Subsequent to the effective date of this ordinance, no new underground storage containers shall be installed unless the owner shall have first obtained a permit from the Fire Department. If the Fire Department determines that the proposed storage container constitutes a danger to a water supply, water body, public health or safety, the Fire Department may deny the permit or may grant it subject to conditions which the Department determines are necessary.

6.054 These permits shall be in addition to any license or permit required by M.G.L., Ch. 148, as amended, or by any regulation issued thereunder. The fee for this permit, payable to the Town of _____ shall be _____ dollars.

6.055 If the ownership of any underground storage tank is transferred, the new owner shall notify the Fire Department within ten (10) working days.

6.06 Underground Storage Tank Installation and Construction Standards For Tanks of Volumes Under 1,100 Gallons

6.061 New underground storage containers shall be installed by a manufacturer's approved installation contractor in the presence of the head of the Fire Department or his agent. Newly installed underground storage containers shall be surrounded by at least twelve (12) inches of clean sand which shall also be placed between the tank and a firm base.

6.062 Every new or replacement tank and its piping shall be tested separately, at the owner's expense, prior to its being buried. The tank shall be tested by air pressure at not less than 3 and not more than 5 lbs. per square inch. The piping shall be tested hydrostatically to 150% of the maximum anticipated pressure of the system, or tested pneumatically, after all joints and connections have been coated with a soap solution, to 100% of the maximum anticipated pressure of the system but not less than 50 lbs. per square inch gauge at the highest point of the system. After the tank and piping have been fully buried, all subsequent testing of underground tanks shall be done by the precision test in accordance with the provisions of Pamphlet No. 329, Chapter 4-3-10, of the National Fire Protection Association, or other test of equivalent or superior accuracy. The owner shall furnish the head of the Fire Department with a certified copy of the results of all testing required by this Section which the head of the Fire Department shall keep with the records of the storage facility.

6.063 Newly installed underground storage containers shall be protected from internal and external corrosion and shall be of a design approved by the Board of Health and the head of the Fire Department. The following container construction systems are considered to provide adequate corrosion protection:

a. UL-listed fiberglass reinforced plastic (FRP);

b. UL-listed steel tanks provided with cathodic protection;

c. UL-listed steel tanks with bonded fiberglass coating;

d. UL-listed double-walled steel tanks with cathodic protection or bonded fiberglass coating;

e. Other container construction providing equal or better protection against leakage than the above mentioned containers and approved by the head of the Fire Department.

6.064 All replacements of underground storage tanks must comply with aforementioned standards.

6.07 Testing of Underground Storage Tanks of Volumes Less Than 1,100 Gallons

6.071 The owner of every existing storage facility which does not satisfy the design requirements of Section 6.06 shall have each tank and its piping tested, at the owner's expense, during the 10th, 13th, 15th, 17th, and 19th year after installation, and annually thereafter.

6.072 The owner of every kind of new or existing tank which satisfies all the design requirements of Section 6.06 shall have the tank and its piping tested, at the owner's expense, during the 15th, and 20th years following the date of installation and at 2-year intervals thereafter.

6.073 If no satisfactory evidence of the installation date exists, annual testing shall begin upon order of the Fire Department.

6.074 It is strongly recommended that underground tanks be removed following expiration of manufacturer's warranty or 20 years after installation.

6.075 All testing of underground storage containers shall be administered by qualified persons approved by the Fire Department which shall be notified prior to administering a test. The owner of an underground storage container shall, within one week of their receipt, supply to the head of the Fire Department a certified copy of all test results. The head of the Fire Department shall keep this copy with the records of that storage facility.

6.076 Except for testing performed on a tank and its piping prior to their being covered, a tank shall be tested by any final or precision test not involving air pressure which can accurately detect a leak of 0.05 gallon per hours or less after adjustment for relevant variables such as temperature change and tank end deflection, and which has been approved by the Marshall. Piping deflection shall be tested hydrostatically to 150% of the maximum anticipated pressure of the system.

6.077 The head of the Fire Department may require the owner of any existing tank to have it and its piping tested, at the owner's expense, in any case in which the owner has failed to make a timely application for a permit as required under Section 6.05.

6.078 If any of the testing specified in this subsection discloses a leak, the owner of the storage container shall immediately comply with the requirements of Sections 6.07 and 6.08 of this bylaw. If any owner fails or refuses to complete a required test, the Fire Department may require repair or removal of the container.

6.08 Report of Leaks or Spills

Any person who is aware of any spill or loss of a toxic or hazardous material shall report such spill or loss immediately to the head of the Fire Department.

6.09 Removal or Repair of Underground Storage Tanks of Volumes Less Than 1,100 Gallons

6.091 All leaking storage containers affected by this bylaw must be emptied by the owner or operator within 24 hours of leak detection and removed or repaired by the owner or operator as specified by the head of the Fire Department in consultation with the Board of Health.

6.092 No underground storage container affected by this bylaw shall be removed, or repaired unless the Fire Department has issued written instruction to protect public health and safety during the removal or repair, or unless the head of the Fire Department or Board of Health determine that an emergency exists.

6.093 All underground storage containers affected by this bylaw which the owner has decided to take out of service for a period of less than six (6) months shall promptly notify the Fire Department of the decision and, subject to their direction, have all the product and vapors removed from the container. Before any such container may be restored to service, the owner shall notify the Fire Department which may require that the owner have the container tested, at the owner's expense. Any owner of a container affected by this bylaw which has been or will be out of service for a period of greater than six (6) months shall, subject to the directions of the head of the Fire Department, have the container removed or filled with inert material, and have the fill pipe removed or capped with concrete.

6.010 Enforcement

6.101 The Fire Department and its agents may enter upon privately-owned property for the purpose of performing their duties under this bylaw.

6.102 Any person who violates any provision of this bylaw shall be punished by a fine of not more than $300. Each day or portion thereof during which a violation continues shall constitute a separate offense. If more than one, each condition violated shall constitute a separate offense. Upon request of the Fire Department and Town Council shall take such legal action as may be necessary to enforce this ordinance.

6.011 Costs

In every case the owner shall assume responsibility for cost incurred necessary to comply with this ordinance. The owner shall be responsible for all costs of recovering and properly disposing of any product that has leaked and for all costs of restoring the environment, including groundwater and surface water to an acceptable condition. The Fire Department may charge the owner for expenses incurred in the enforcement of the bylaw.

6.12 Variances

6.121 The Fire Department may vary the application of a provision of this bylaw, unless otherwise required by law, in any case when, in its opinion, the applicant has demonstrated that an equivalent degree of environmental protection required under this bylaw will still be achieved.

6.122 In granting a variance, the Fire Department will take into consideration the direction of the groundwater flow, soil conditions, depth to groundwater, size, shape and slope of the lot, and existing and future water supplies.

6.123 Any denial of a variance shall be in writing and shall contain a brief statement of the reasons for the denial.

6.13 Severability

The invalidity of any provisions of this bylaw shall not affect the validity of the remainder.

MODEL UNDERGROUND STORAGE TANK ORDINANCE

(Based on a Barnstable, Massachusetts Model Ordinance)

FUEL, STORAGE TANK REGULATIONS

Whereas, leaking underground storage tanks pose an immediate and serious threat to Cape Cod's sole source aquifer, and Whereas the Town of ___ does not have records to locate all such tanks in the Town, Therefore under Chapter III, Section 31, of the Massachusetts General Laws, the _____ Board of Health hereby adopts the following (revised) regulation to protect the ground and surface waters from contamination with liquid toxic or hazardous materials.

DEFINITIONS

*Toxic or hazardous materials shall be defined as all liquid hydrocarbon products including, but not limited to, gasoline, fuel and diesel oil, and any other toxic or corrosive chemicals, radioactive materials or other substance controlled as being toxic or hazardous by the Division of Hazardous Waste of the Commonwealth of Massachusetts, under the provisions of Massachusetts General Laws, Chapter 21C, Section 1, et. seq.

The following regulations apply to all toxic or hazardous material storage systems:

1.0 Installation of Storage Tanks

1.1 Following the effective date of this regulation, the installation of all underground fuel, gasoline or other chemical storage tanks shall conform with the following criteria: In that the United States Environmental Protection Agency designated the Town of _____ as overlying a sole source aquifer, secondary containment of tank and piping and an approved in-tank or interstitial space monitoring system shall be required for new or replacement tanks.

1.2 Following the effective date of this regulation, all tanks installed aboveground outside shall be of material approved for outside use.

2.0 Tank Registration

The following regulations shall apply to all underground tanks containing toxic or hazardous materials, as defined above, which are not currently registered under 527 CMR 9.26 - Tanks and Containers (tanks storing fuel oil for consumptive use on the premises, and farm and residential tanks of 1,100 gallon capacity or less used for storing motor fuel for noncommercial purposes.)

2.1 Owners shall file with the Board of Health, on or before _____, the size, type, age and location of each tank, and the substance stored in them. Evidence of date of purchase and installation, including fire department permit, if any, shall be included along with a sketch map showing the location of such tanks on the property. Upon registering the tank with the Board of Health, the tank owner will receive a permanent metal or plastic tag, embossed with a registration number unique to that tank. This registration tag must be affixed to the fill pipe or in a location visible to a distributor filling the tank and to any inspector authorized by the Town.

2.2 Effective _____, every petroleum and other chemical distributor, when filling an underground storage tank, shall note on the invoice or bill, the registration number appearing on the tag affixed to the tank which was filled. Every petroleum and other chemical distributor shall notify the Board of Health of the existence and location of any unregistered or untagged tank which they are requested to fill. Such notifications must be completed within two (2) working days of the time the distributor discovers that the tank registration tag is not present.

2.3 Prior to the sale of a property containing an underground storage tank, the fire department must receive from the current owner a change of ownership form for the registration of the underground storage tank. Such form can be obtained from the fire department.

3.0 Testing

3.1 The tank owner shall have each tank and its piping tested for tightness fifteen (15) years after installation and annually after twenty (20) years. Tests shall be by any final or precision test, not involving air pressure, that can accurately detect a leak of 0.10 gal/hr, after adjustment for relevant variables, such as temperature change and tank end deflection, or by any other testing system approved by the Board of Health, as providing equivalent safety and effectiveness. Certification of the testing shall be submitted to the Board of Health by the owner, at the owner's expense.

Those tanks subject to the testing requirement of this regulation shall submit the certification of testing to the Board of Health by _____. Tanks which are currently tested under the provisions of 527 CMR 9.13 are exempt from this section.

4.0 Maintenance of Fuel Storage Systems

4.1 All underground fuel lines which do not have secondary containment shall be replaced with an approved double-containment system at which time any service to the system requiring a permit is performed.

4.2 All above-ground elements of a fuel storage system shall be maintained free of leaks and visible rust.

4.3 All in-tank or interstitial-space monitoring systems shall be checked on a monthly basis to verify system integrity. Records of these checks shall be sent to the Board of Health annually.

5.0 Report of Leaks or Spills

5.1 Any person who is aware of a spill, loss of product, or unaccounted for increase in consumption which may indicate a leak shall report such spill, loss or increase immediately to the head of the fire department and to the Board of Health.

6.0 Tank Removal

6.1 All underground fuel, gasoline or other chemical tanks not registered under 527 GMR 9.26 (farm or residential tanks of 1,100 gallons or less and underground tanks storing fuel for consumptive use at the property) in service on the effective date of this regulation, shall be removed thirty (30) years after the date of installation. If the date of installation is unknown, it shall be assumed to be ___ (20 years after effective date of regulation). All underground storage tanks currently subject to the removal regulation must be removed by _____.

6.2 Prior to the removal of an underground storage tank governed by this regulation, the owner shall first obtain a permit from the head of the fire department, pursuant to M.G.L., C. 148.

6.3 Any person granted a permit by the Marshal or head of a local fire department to remove a tank under the provisions of M.G.L., C. 148 or 527 CMR 9.00, shall, within 72 hours, provide the permit granting authority with a receipt for delivery of said tank to the site designated on the permit.

6.4 Before any person is granted a permit by the Marshal or the head of a local fire department to remove a tank, under the provisions of M.G.L., C. 148 or 527 CMR 9.00, and said tank is not being transported to an approved tank yard, the person requesting the permit shall provide the permit-granting authority with written approval from the owner/manager of the disposal site.

7.0 Costs

7.1 In every case, the owner shall assume the responsibility for costs incurred necessary to comply with this regulation.

8.0 Variances

8.1 Variances from this regulation may be granted by the Board of Health after a hearing at which the applicant establishes the following:

1. the enforcement thereof would do manifest injustice; and

2. installation or use of an underground storage tank will not adversely effect public or private water resources. In granting a variance, the Board will take into consideration the direction of the ground water flow, soil conditions, depth to ground water, size, shape and slope of the lot, and existing and known future water supplies.

9.0 Enforcement

9.1 Any owner or operator violating any provision of this regulation shall be subject to the penalties provided under M.G.L. Ch. 111 s. 31, as amended. Each day during which the violation occurs shall constitute a separate offense. Upon request of the head of the fire department or the Board of Health, the licensing authority and the town counsel shall take any legal action as may be necessary to enforce the provisions of this regulation.

10.0 Severability

10.1 Provisions of this regulation are severable and if any provision hereof shall be held invalid under any circumstances, such invalidity shall not affect any other provisions or circumstances.

TABLE D.1 - EXISTING MUNICIPAL BYLAWS

Table D.1 lists Massachusetts communities that have enacted various bylaws/ordinances and regulations to prevent or reduce nonpoint source pollution as of December 1991 (DWS, 1991). Contact the community for more information on specific bylaws that may be applicable to your community.

REFERENCES:

Primary reference: Ch. 40, and Ch. 40A Bylaw file at the office of the Attorney General, Commonwealth of Massachusetts.

Secondary reference: CONEG (Coalition of Northeast Governors), survey completed by DEP, 1987 and updated 1989.

OTHER SOURCES:

Regional Planning Agencies' Water Protection Matricies
as submitted with 1991 205(j) applications.

DWS/TS TAP files, legal files, and personnel.
Laidlaw's complied BoH Regulations.

Compiled by DWS/TS Analyst Ron Stelline, 1991. Please contact DWS at (617) 292-5859
with corrections, updated information, or comments.

KEY and FOOTNOTES to the Water Supply Protection Matrix for the Commonwealth of Massachusetts

KEY: EXAMPLE: Status (Authority) <Special Note>, Fine/Fee

TOWN FOOTNOTES:

P - The town/city uses only private water supplies.
S - EPA designated Sole Source Aquifer
(may only include portion of town/city)

Status:

Y - yes
N - no
? - unknown
N/A - Not Applicable

Authority:

The Massachusetts General Laws are cited by chapter:

G - denotes MGL 40, general bylaw
Z - denotes MGL 40A, zoning bylaw
H - denotes MGL 111, Board of Health regulation
C - denotes MGL 130, coastal wetlands conservation
I - denotes MGL 131, in-land wetlands conservation

Fee: f - denotes a fee for registration, etc.
Fine: F - denotes a fine associated with non-compliance

SPECIAL NOTES:

i - The town/city has filed a Vulnerability Assessment Questionnaire Emergency Plan (Form G) with the DWS.

Year/Pre - The Open Space Plan (OSP) is outdated; in some cases the date of the OSP in effect is cited (e.g. Y<'89>).

Well/Water Supply Regulations Special Notes:

W - Well Regulations
wp - Well Protection
nw - New Well Regulations
s - Water Supply Regulation
e - Groundwater Elevation Regulations

TOWN NAME	Groundwater Protection District	Watershed Protection District	Floodplain District Bylaw	Wetlands Protection District	Toxic & Hazardous Materials	Underground Storage Tanks	Earth Removal/Erosion Control	Env. Impact Analysis for Major Dev.	Spill Response Plan	Contingency Plan / Water Emergencies	Open Space Plan	Regional Protection Committee	Title 5 Revisions/ Amendment	Private Well/ Water Sup. Regulations	Other Regulations
Abington	Y	N	Y(Z)	Y(Z&I)	N	Y(G),f	Y(Z)	N	N	?	?	?	Y		Road Salt Res., Mand. Sewer H
Acton	Y(G,Z,H)	N/A	Y(Z)	Y(G)	Y(G),f	Y,fF	Y(G)	?	?	Y<i>	Y(G&Z)	?	Y	Y<e>	
Acushnet	N	N	?	N	?	N	Y	Y	?	?	Y<'88>	Y	?		
Adams	?	N	Y(Z)	N	N	N	Y(Z)	N	?	Y<i>	N	Y	N		
Agawam	N/A	?	N	N	?	?	N	?	?	?	?	?	Y		
Alford(P)	Y	N/A	?	?	?	?	?	?	?	?	?	?	Y	Y<w>	2 Acre Zoning
Amesbury	N	Y(G)	Y(Z)	Y(G)	N	Y(G)	Y(Z)F	N	N	Y	?	?	Y		Herbicide/Pesticide Ban (H
Amherst	Y(Z)	Y(Z)	Y(Z)	Y(Z)F	Y	Y(Z&H)F	Y(Z)	?	?	?	?	Y	Y		Herbicide Use Regulations (H
Andover	N/A	Y	Y(Z)	?	Y	Y	Y(Z)	Y	Y	?	?	Y	N	Y<w>	
Arlington	N/A	?	Y(Z)	Y(Z)	?	?	Y(Z)	?	?	?	?	?	?		
Ashburnham	N/A	Y(Z)	Y(Z)	Y(Z)	N	N	Y(G&Z)	N	N	Y<i>	?	N	Y	Y<w>	
Ashby	N	N/A	?	?	Y(G)	N	?	N	N	?	?	Y	?	Y<wp>	2 Acre Zoning
Ashfield	?	?	?	?	Y(G),fF	N	Y(Z)	Y	?	?	?	?	Y	Y<w>	
Ashland	?	N/A	Y(Z)	?	N	N	?	N	?	?	?	?	N	Y<s>	
Athol	N	?	Y(Z)	?	Y	Y	?	N	?	?	?	?	?	Y<w>	
Attleboro	Y(G)	N	Y	?	Y	Y	Y	?	?	Y<i>	N	N	?		
Auburn	Y(Z)	N	Y(Z)	Y(G&I)	Y(G)	Y(G),f	Y	Y	?	Y<i>	?	?	Y	Y<w>	
Avon	Y(Z)	N/A	Y(Z)	Y	N	Y(G),F	Y(Z)	N	N	?	N	N	Y		Salt Use Controls
Ayer	N	N/A	Y(Z)	?	N	Y	Y(G)	N	?	Y<i>	?	Y	?		
Barnstable	Y(G&Z)	Y(Z)	Y(Z)	Y(G&C)	Y(G&Z)	Y(Z&H)	Y(G)	?	?	Y<i>	Y(G)	Y	?	Y<w>	Herbicide Use Regulations (I
Barre	N	N	Y(Z)F	Y(G),fF	Y,fF	?	?	Y	?	Y<i>	?	?	Y		
Becket	?	N/A	?	?	?	?	?	Y	?	?	?	?	Y		
Bedford	?	?	Y(Z)	Y(G,Z,I)	Y(G),F	Y(G)F	Y(Z)	?	?	?	?	?	?	Y<w>	
Belchertown	Y(Z)	N/A	Y(Z)	Y(Z)	Y(G)	?	Y	?	?	Y<i>	?	Y	?		Road Salt Policy Statemen
Bellingham	Y(Z)	Y(Z)	Y(Z)	N	Y(Z)	N	Y(Z)	?	?	Y<i>	Y<Pre>	N	?		Water Resources District
Belmont	N/A	?	Y(Z)	?	?	Y(G)f	?	?	?	?	?	?	?		
Berkley(P)	N	N/A	?	N	Y	Y(G)F	Y(G)	?	?	?	N	N	?		
Berlin	N/A	N/A	Y(Z)	?	Y	?	Y	Y	?	?	?	?	Y	Y<w>	
Bernardston	Y	N/A	Y(Z)	?	?	?	Y	Y	Y	Y<i>	Y	?	?	Y<w>	
Beverly	N/A	?	?	?	?	?	?	?	?	?	?	?	?		
Billerica	N/A	N	Y(H&Z)	Y	N	Y	Y(Z)	N	N	N	Y<Pre>	N	?		
Blackstone	Y(Z)	N/A	Y(Z)	Y(G)	Y(Z)	?	Y(G)f	Y	?	?	?	?	Y		Watercourse Setbacks (H
Blandford	N/A	Y(Z)	N	?	Y(Z)	?	N	?	?	?	?	?	?		
Bolton(P)	Y(Z&G)	N/A	Y(Z&G)	?	?	Y(G&H)	?	?	?	?	?	?	Y	Y<e>	2 Acre Zoning
Boston	N/A	?	?	?	?	?	?	?	?	Y<i>	?	?	?		
Bourne(S)	Y(Z)	N/A	?	Y(GC&I)	Y(Z&H)	Y(G&H)	?	?	?	Y<i>	?	?	?	Y<e>	Wtrcrse, Stbck(Z), Herb/Pest R
Boxborough	Y(Z)	N/A	Y(Z)	Y(G&Z)	Y(Z)	Y(Z)	Y(G)	?	?	?	?	?	?	Y<w>	
Boxford	N	N/A	Y(Z)	Y(Z)	Y	Y(H)	Y	Y	N	N	Y<Pre>	N	?	Y<s>	2 Acre Zoning
Boylston	Y(Z)	N	Y(Z)	?	?	Y(G)	Y(G)	Y	?	Y<i>	?	?	Y		
Braintree	N/A	Y(Z)	Y(Z)	Y(Z)	Y(G),f	Y(Z)	?	N	Y(G)	?	Y(Z)	?	N	Y<s>	
Brewster(S)	Y(Z)	N/A	Y(Z)	Y(GZ&C)	N	Y(H)	N	Y	Y	Y<i>	Y	Y	Y	Y<w>	
Bridgewater	Y(Z)	N/A	Y(Z)	Y	N	N	N	N	N	?	Y	N	Y		Mandatory Sewer Hookup
Brimfield	?	N/A	Y	?	?	?	?	?	?	?	?	?	?		
Brockton	N	N	Y(Z)	Y(Z)	N	N	N	N	N	?	?	?	N		
Brookfield	N	N/A	Y(Z)	N	N	N	N	N	N	N	N	N	?		
Brookline	N/A	?	?	?	?	?	?	?	?	?	?	?	?		
Buckland(P)	?	N/A	Y(Z)	?	N	N	Y	?	Y	?	Y	Y	N		
Burlington	Y(G&Z)	Y(Z)	Y(H&Z)	Y(G,I,Z)F	Y(G&H)	Y(G)	Y(G)	?	?	?	?	?	?		Pesticide Use Regulations(I
Cambridge	N/A	?	?	?	?	?	?	?	?	?	?	?	?		
Canton	?	Y	?	Y(G)	Y(G),fF	Y(G)f	?	?	Y(G)	?	?	?	?	Y<s&wp>	
Carlisle(P)	?	N/A	Y(Z)	Y(Z)	?	?	Y(G)	?	?	?	?	?	Y		
Carver(S)	N	N/A	Y(Z)	Y(G&Z)	?	?	Y(Z)	?	?	Y<i>	Y<'86>	N	?	Y<w>	

TABLE D.1 - Water Supply Protection Matrix for the Commonwealth of Massachusetts (Updated to December 10, 1991)

TOWN NAME	Groundwater Protection District	Watershed Protection District	Floodplain District Bylaw	Wetlands Protection District	Toxic & Hazardous Materials	Underground Storage Tanks	Earth Removal/Erosion Control	Env. Impact Analysis for Major Dev.	Spill Response Plan	Contingency Plan / Water Emergencies	Open Space Plan	Regional Protection Committee	Title 5 Revisions/ Amendment	Private Well/ Water Sup. Regulations	Other Regulations
Charlemont	?	?	?	?	?	?	?	?	?	?	?	?	?		
Charlton	N	N/A	Y	Y	Y(G)	Y	Y(G)F	Y	?	Y<i>	?	?	Y		
Chatham(S)	N	N/A	Y(Z)	Y(Z,C,I)	Y	Y(H)	N	?	Y	N	Y	Y	?	Y<w>	Herbi/Pesticide Regulations(H)
Chelmsford	N	N/A	Y(Z)	Y(G)	Y(G)	Y(G)f	Y(G)	Y	N	Y<i>	Y<Pre>	N	?		
Chelsea	N/A	?	?	?	?	?	?	?	?	?	?	?	?		
Cheshire	?	N	Y(Z)	N	Y(Z)	?	Y	N	?	?	N	Y	?		
Chester	?	?	?	?	?	?	?	?	?	?	?	?	N		
Chesterfield(P)	Y	Y	Y	?	?	?	Y	?	?	?	?	?	?		Westfield River Prot. Dist. (Z)
Chicopee	N	N	Y	?	?	?	Y	?	?	?	?	?	N		
Chilmark(S)	N	N	N	Y(Z&C)f	N	Y	N	Y	Y	N	Y	N	?		Dist. of Critical Planning Concern (
Clarksburg	N	N/A	Y	N	N	N	Y	N	?	Y<i>	N	N	?		
Clinton	N/A	?	Y(Z)	?	Y	N	Y(Z)	N	?	?	?	?	?		
Cohasset	Y	Y(H&Z)	Y(H&Z)	Y(C)	?	Y(H)f	?	?	?	?	?	?	Y(H)		
Colrain	?	?	Y(Z)	?	?	?	Y(Z)	?	Y	?	Y	?	?		
Concord	Y(G&Z)	Y(G)	Y(Z)	Y(Z)	Y(H)F	?	Y(Z)	?	?	?	?	?	?		
Conway(P)	?	?	Y(Z)	?	?	?	?	?	?	?	?	?	Y		Road Salt Policy Statement
Cummington	Y	N/A	Y	?	Y	Y	N	?	?	?	?	?	?		
Dalton	N/A	N	Y(Z)	N	Y(G&Z)	?	Y(Z)	N	?	Y<i>	N	N	Y	Y<w>	
Danvers	?	Y(Z)	Y(Z)	Y(G),f	Y(G)	Y(G)f	?	?	?	?	?	?	?	Y<w>	
Dartmouth	Y(G&Z)	Y(Z&G)	Y(G&Z)	Y(G,Z,I)	Y	Y(Z)f	Y(G)	?	Y	?	N	N	?		
Dedham	Y(G)	Y(G)	Y(Z)	Y(G&I)	?	?	?	?	?	?	?	?	N		
Deerfield	?	Y(Z)	Y	Y	Y	?	?	?	Y	Y<i>	Y	?	Y		Herbi/Pesticide Regulations(H)
Dennis(S)	Y(Z&H)	N/A	N	Y(G&C)	Y(H)F	Y(H)	Y(G)F	Y	Y	N	Y	Y	?		
Dighton	N	N	Y(Z)	N	N	?	Y	?	?	Y<i>	N	N	N		Defoliants Regulation (H)
Douglas	Y(G)	N/A	Y(G)	Y(G)	?	?	Y(Z)	Y	?	?	?	?	Y	Y<s>	
Dover(S)	Y(Z)	N/A	?	Y(C)	N	Y(H)	?	?	?	Y<i>	Y<Pre>	Y	?	Y<w>	
Dracut	Y(Z)	N/A	Y(Z)	Y(Z)	?	N	Y(Z)	Y	N	N	N	N	?		Pub. Water Sup. Hookup Moratori
Dudley	N	N/A	Y(Z)	Y	?	?	?	?	Y	?	?	?	Y	Y<w>	
Dunstable	N	N/A	Y	Y(G)	Y	N	Y	N	N	N	Y	N	Y		
Duxbury	Y(G&Z)	N/A	?	Y(G&C)	?	?	Y(G)	?	?	?	?	Y	?		
East Bridgewater	Y(Z)	N/A	Y(Z)	Y(Z)	N	?	Y(G)	N	N	?	?	?	Y		
East Brookfield	N	N/A	Y(Z)	?	?	?	Y	?	?	?	?	?	?		
East Longmeadow	N/A	N	Y(Z)	N	Y	N	Y(Z)	?	?	Y<i>	?	?	?		Road Salt Limit Bylaw (G)
Easthampton	Y(Z)	N/A	Y(Z)	N	?	Y	?	?	?	Y<i>	?	Y	?		Herbi/Pesticide Regulations(H)
Eastham(P&S)	Y(G)	N/A	Y(Z)	Y(C&I)	Y(G&H)	Y(H)	Y	Y	Y	N	Y	Y	?	Y<w>	Road Salt Restrictions
Easton	Y(Z)	N/A	Y(Z)	Y(G)	Y	Y(Z)	N	Y	Y	?	?	Y	Y		Zoning for Crit. Plan. Concern
Edgartown(S)	Y(H)	Y(Z)	Y(Z)	Y(G&C)	Y(H)	Y(H)	N	Y	Y	N	N	N	?	Y<w&wp>	Stream & Pond Protection
Egremont	N/A	N	Y(Z)	N	N	N	Y	N	N	N	N	N	?	Y<w>	
Erving(P)	N	N/A	?	?	Y(G),IF	Y	?	?	?	?	?	Y	Y	Y<w>	
Essex	Y(Z)	N/A	Y(Z)	Y(C)	?	?	Y(G)	?	?	?	?	Y	Y		
Everett	N/A	?	?	?	?	?	?	?	?	?	?	?	N		Pesticide Regulations(H)
Fairhaven	Y	N/A	Y(Z)	Y(G)	Y	Y(G)f	Y(Z)	?	?	Y	Y<'89>	Y	?		
Fall River	N/A	Y	N	N	N	N	N	?	?	Y<i>	Y	N	?		Density Limit(Z), Areas of Env.
Falmouth(S)	Y(Z)	Y(Z)	Y(Z)	Y(G,Z,C),I	?	Y(Z&H)	?	?	?	?	?	?	Y		Concern
Fitchburg	N/A	Y(Z&H)	?	?	N	N	?	Y	Y	?	?	Y	?		
Florida(P)	N/A	?	?	?	?	?	?	Y	?	?	?	?	?		
Foxborough(S)	Y(Z)	N/A	Y(G)	Y(G&I)	Y(G)F	Y(G)F	Y(G&Z)F	?	?	Y<i>	?	Y	Y		Vinyl Chloride Storage Controls (
Framingham	?	?	Y(Z)	?	?	?	?	Y	Y	Y<i>	?	?	Y		
Franklin	Y(Z)	N/A	Y(Z)	?	Y(H&Z)	?	?	?	?	?	?	?	Y	Y<w>	
Freetown	N	Y(Z)	Y(Z)	Y(G)	Y	N	Y	?	?	?	N	N	?		
Gardner	N/A	?	?	?	N	N	?	Y	?	Y<i>	?	?	?		
Gay Head(P)	N	N	Y(Z)	Y(C)	N	N	Y	Y	Y	N	N	N	N		[illegible]

TOWN NAME	Groundwater Protection District	Watershed Protection District	Floodplain District Bylaw	Wetlands Protection District	Toxic & Hazardous Materials	Underground Storage Tanks	Earth Removal/Erosion Control	Env. Impact Analysis for Major Dev.	Spill Response Plan	Contingency Plan / Water Emergencies	Open Space Plan	Regional Protection Committee	Title 5 Revisions/ Amendment	Private Well/ Water Sup Regulations	Other Regulations
Gill	?	N/A	Y(Z)	?	Y	Y	?	?	Y	?	?	?	Y	Y<w>	
Gloucester	N/A	?	?	?	?	?	?	?	?	?	?	?	Y	Y<w>	Road Salt Policy Statement
Goshen(P)	N	N	N	N	N	N	?	?	?	?	?	?	?	Y<w>	
Gosnold	?	N/A	Y(Z)	?	?	?	?	?	?	?	?	?	N		
Grafton	Y(Z)	N/A	Y(Z)	N	Y	?	Y(G)	Y	?	?	?	?	Y	Y<w>	Road Salt Policy Statement
Granby	Y	N/A	Y(Z)	Y(Z)	?	?	Y(Z)	?	?	Y<i>	?	?	Y		
Granville	N	N	N	N	N	N	N	?	?	Y<i>	?	?	?	Y<s>	
Great Barrington	Y	N	Y(Z)	Y(Z)	?	N	Y	N	Y	Y	N	Y	Y		
Greenfield	Y(Z)	Y(Z)	Y(Z)	?	Y(H)F	Y(H)F	Y	?	Y	Y	Y	?	N		Herbicide Regulations(H)
Groton	Y(Z)	N/A	Y(Z)	Y(G)	Y(G&H)fF	Y(G,Z,H)f	?	Y	?	?	?	?	?	Y<w>	
Groveland	Y(Z)	N/A	Y(Z)	N	Y(H)	Y(H)	Y(G)	Y	N	N	Y<'74>	Y	?		
Hadley	Y(Z)	N	Y(Z)	?	?	Y(G)f	Y	?	?	Y<i>	?	?	?		Watershed Building Moratoriu
Halifax	N	N/A	Y(Z)	Y	N	?	N	N	N	?	?	?	Y		
Hamilton	Y(Z)	N/A	Y(G)	Y(G)	?	?	?	?	?	?	?	Y	?		
Hampden	N	N/A	Y(Z)	Y(Z)	N	N	Y(Z)	?	?	?	?	?	?		
Hancock	?	N/A	?	?	?	?	?	Y	Y	?	?	?	?		
Hanover	Y(G&Z)	N/A	Y(Z)	Y(G,Z,C)	?	Y(G,Z&H)	Y(G)	?	?	?	?	?	?	Y(Z)<wp>	Herbi/Pesticide Regulations(G
Hanson	Y(Z)	N/A	Y(Z)	Y	Y	?	Y	?	?	Y<i>	?	?	Y	Y(Z)<wp>	
Hardwick	N	N/A	Y(Z)	?	?	Y	?	?	?	Y<i>	?	?	?		
Harvard	Y(Z)	N/A	Y(Z)	Y(Z&I)	Y	Y(H),fF	?	N	?	Y<i>	?	?	?		Herbi/Pesticide Regulations(H
Harwich(S)	Y(Z)	N/A	N	Y(G&I),F	N	Y(H)	N	Y	Y	Y<i>	?	N	Y	Y<w>	
Hatfield	Y	Y(Z)	Y(Z)	N	Y	Y	N	?	?	?	?	Y	?		
Haverhill	N/A	?	Y(Z)	?	Y(G)	Y(G)	?	Y	N	Y<i>	?	?	N		
Hawley(P)	?	?	?	?	Y(Z)	?	?	?	?	?	?	?	?		
Heath(P)	?	?	?	Y	?	?	Y(Z)	?	?	?	?	?	?		
Hingham	Y(G)	Y(Z)	Y(Z)	Y(G&I)	?	?	Y(Z)	?	?	Y<i>	?	Y	Y		
Hinsdale	N/A	N	N	N	N	N	Y	N	?	Y	N	N	?		
Holbrook	N/A	N	Y(G)	?	Y(G)fF	Y(G)f	?	N	?	?	N	?	?	Y<w>	
Holden	Y(Z&G)	N	Y(Z)	Y	Y(G)fF	Y(G)fF	Y(G)	Y	?	?	?	?	Y		
Holland(P)	?	?	?	?	?	?	?	?	?	?	?	?	?		
Holliston	Y(G&Z)	N/A	Y(Z)	Y(G,Z,I),F	N	Y(Z)	Y(G)	?	?	?	Y<Pre>	N	?	Y<s>	
Holyoke	Y(Z)	Y(Z)	Y(Z)	N	?	?	Y	?	?	Y<i>	?	?	?		
Hopedale	N	N	Y(Z)	?	?	?	Y(G)	?	?	Y<i>	?	?	?		
Hopkinton	Y(Z)	N/A	Y(Z)	Y(Z)	?	?	Y(G)	?	?	Y<i>	?	?	Y	Y<nw>	
Hubbardston	Y	N/A	?	?	Y(G)	N	?	Y	?	?	?	?	Y		
Hudson	Y	Y(Z)	Y(Z)	Y(Z)	Y(G)	Y(G)	Y	?	?	?	?	Y	N		
Hull(P)	?	?	Y(Z)	?	?	?	?	?	?	?	?	?	?		Conservancy Buffer District
Huntington	Y	Y	Y	?	?	?	Y(Z)	?	?	?	?	?	?		
Ipswich	Y(Z)	Y(Z)	Y(Z)	Y(Z&C)	Y(G&Z)	Y(G)	Y(Z)	?	?	?	?	?	Y	Y<e>	Watershed Building Moratoriu
Kingston	Y(Z)	N/A	Y(Z)	Y(G&I)	N	?	Y	N	N	?	?	N	Y	Y<s>	
Lakeville	Y(Z)	N/A	Y(Z)	N	Y	Y	Y	?	?	Y<i>	N	N	?	Y<w>	River Protection Regulations I
Lancaster	Y(Z)	N/A	Y(Z)	?	?	?	?	N	?	Y<i>	?	?	?		
Lanesboro	?	N/A	Y(Z)	Y	Y(Z)	Y(H)fF	Y	N	?	Y<i>	N	?	?	Y<w>	
Lawrence	N/A	?	?	?	N	N	?	N	N	Y<i>	?	?	N/A		Stream & Pond Protection
Lee	N/A	N	Y(Z)	N	?	N	Y(Z)	N	?	Y<i>	N	N	Y	Y<w>	
Leicester	Y(Z)	Y(Z)	Y	Y(G&I)	?	?	?	?	?	Y<i>	?	?	Y		
Lenox	N/A	Y	Y(Z)	N	?	N	Y(G)	N	?	Y<i>	N	N	?		
Leominster	Y(Z&H)	Y(H)	?	?	Y	Y(Z)	?	Y	?	?	?	?	?	Y<w>	Stream & Lake Protection Distri
Leverett(P)	Y(Z)	Y	Y(Z)	?	Y	Y	Y(Z)	Y	Y	?	?	?	Y	Y<w>	Herbi/Pesticide Regulations(H
Lexington	N/A	?	Y(Z)	Y(G&Z)	?	?	Y(G)	?	?	?	?	?	?		
Leyden(P)	?	?	?	?	?	?	Y	Y	Y	?	Y	?	N		
Lincoln	Y(Z)	Y(Z)	Y(Z)	Y(G&Z)	?	Y(G)f	?	?	?	?	?	?	?		
Littleton	Y(Z)	N/A	Y(Z)	Y(Z)	Y(G)	Y(G,Z,H)	?	?	?	?	?	?	Y	Y<w>	

TABLE D.1 - Water Supply Protection Matrix for the Commonwealth of Massachusetts (Updated to December 10, 1991)

TOWN NAME	Groundwater Protection District	Watershed Protection District	Floodplain District Bylaw	Wetlands Protection District	Toxic & Hazardous Materials	Underground Storage Tanks	Earth Removal/Erosion Control	Env. Impact Analysis for Major Dev.	Spill Response Plan	Contingency Plan / Water Emergencies	Open Space Plan	Regional Protection Committee	Title 5 Revisions/ Amendment	Private Well/ Water Sup. Regulations	Other Regulations
Longmeadow	N/A	N	Y(Z)	Y(G)	?	?	Y(Z)	?	?	?	?	?	N		
Lowell	N/A	N	Y	Y(Z)	N	N<ii>	Y	N	N	Y<i>	Y<Pre>	N	N		Mandatory Sewer Hookup (H)
Ludlow	N/A	N	Y(Z)	N	N	Y(G)f	Y	?	?	?	?	?	?		2 Acre Zoning
Lunenburg	Y(Z)	N/A	Y(Z)	Y(G)	N	N	Y(G)	Y	?	Y<i>	?	?	Y	Y<w>	
Lynn	N/A	?	?	?	?	?	?	?	?	?	?	?	N		
Lynnfield	?	?	Y(Z)	?	?	Y(G)f	Y(Z)	?	?	Y<i>	?	?	?		
Malden	N/A	?	?	?	?	?	?	?	?	?	?	?	N		
Manchester	Y(Z)	Y(Z)	Y(Z)	?	Y(H)	Y(Z)	Y(G&Z)	?	?	?	?	Y	Y		Waterbody Setback
Mansfield	Y(Z)	Y(Z)	Y	Y(Z&I)	Y	Y(Z)	Y(Z)	?	?	Y<i>	Y	Y	?		
Marblehead	N/A	?	Y(Z)	?	?	?	Y(G)	?	?	?	?	?	N		
Marion	Y(Z)	N/A	Y(Z)	Y(C)	Y	Y	Y	?	?	Y<i>	Y<'88>	Y	?		
Marlboro	N/A	?	Y(Z)	Y(Z&I)	?	?	Y	?	?	Y<i>	?	?	?		
Marshfield	Y(Z)	N/A	Y(Z)	Y(G,Z,I)	?	Y(G)	Y(G)	?	?	?	?	Y	?	Y<w>	Herbi/Pesticide Regulations(H)
Mashpee(S)	Y(Z&H)	N/A	Y(Z)	Y(G&Z)	Y(H)	Y(H)	?	?	?	Y<i>	?	?	?	Y<e>	Building in Wetlands Regs. (H)
Mattapoisett	Y(Z)	N/A	Y(Z)	N	Y	Y(H)	Y(G)	?	?	?	Y<'88>	Y	?		
Maynard	?	?	?	?	Y(G),fF	Y(G),fF	?	?	?	?	?	?	?		
Medfield(S)	Y(Z)	N/A	Y(Z)	Y(G&I)	?	Y(G)	Y(Z)	?	?	?	?	?	?	Y<e>	
Medford	N/A	?	?	?	?	?	?	?	?	Y<i>	?	?	N		
Medway	N	N/A	Y(Z)	Y(Z)	N	Y(G)	?	?	?	Y<i>	N	N	?		
Melrose	N/A	?	?	?	?	?	?	?	?	?	?	?	N		
Mendon	?	N/A	Y(Z)	Y(G),f	?	?	Y(G)F	?	?	Y<i>	?	?	Y		
Merrimac	Y(Z)	N/A	Y	N	N	N	Y(Z)	?	N	N	N	N	?		
Methuen	N/A	Y	Y(Z)	?	?	Y	?	?	?	?	?	?	N		
Middleborough(S)	Y(Z)	N/A	Y(Z&H)	Y(Z&I)	N	Y(G)F	Y(G)	Y	?	Y<i>	N	N	?	Y<w>	
Middlefield(P)	N	Y	Y	?	?	?	Y	?	?	?	?	?	?		
Middleton	Y(Z)	N/A	Y(Z)	?	?	?	?	?	?	?	?	?	?	Y<s>	
Milford	N	N	Y(Z)	N	Y(H)	Y(G)F	?	?	?	?	Y<Pre>	U	?		Radioactive Wastes Reg (G)
Millbury	Y(Z)	N/A	Y	Y	?	Y(G)F	Y	Y	?	Y<i>	?	?	Y		
Millis	Y(Z)	Y(Z)	Y(Z)	Y(I)	Y(G&H)	Y(G)fF	Y(H)	?	?	?	Y<Pre>	Y	Y	Y<w&s>	
Millville(P)	N/A	N/A	Y	?	?	?	?	?	?	?	?	?	?		
Milton	N/A	?	Y(G)	Y(G)	?	?	?	?	?	Y<i>	?	?	N		
Monroe	N/A	?	?	?	?	?	?	?	?	?	?	?	N		
Monson	Y	N	Y(Z)	?	Y(Z)	?	Y	?	?	?	?	?	Y		Groundwater Regulations (H)
Montague	N	?	Y(Z)	?	N	N	Y(Z)	Y(Z)	?	Y<i>	?	Y	?	Y<w&e>	Stream & Pond Protection
Monterey	N	N	N	N	N	N	N	N	?	N	N	N	?	Y<w>	
Montgomery	N	N/A	N	N	N	N	N	?	?	?	?	?	?		
Mt.Washington(P)	?	?	?	?	?	?	?	?	?	?	?	?	?		
Nahant	N/A	?	Y(Z)	?	?	?	?	?	?	?	?	?	?		
Nantucket(S)	Y(Z)	N/A	Y(Z)	Y(Z&C)	?	Y(Z&H)	?	?	?	Y<i>	?	?	?		Water Conservation Bylaw
Natick	Y(Z)	N/A	Y(Z)	?	Y(H)	Y(G)	?	Y	?	?	?	Y	Y	Y<w>	
Needham	Y(Z&H)	Y(Z&H)	Y(Z)	Y(G&I)	Y	Y(G,Z&H)f	Y(A)	?	?	?	?	?	?		
New Ashford(P)	?	?	?	?	?	?	?	?	?	?	?	?	?		
New Bedford	N/A	N	N	N	N	N	N	?	?	?	Y<'88>	N	?		
New Braintree(P)	N/A	N/A	?	?	N	N	Y	?	?	?	?	?	?		
New Marlboro	N	N	N	N	N	N	N	N	?	N	N	N	?		
New Salem(P)	?	?	?	?	?	?	?	?	?	?	?	?	?	Y<w>	
Newbury	N	N	Y(Z)	Y(C)	N	Y	?	Y	N	N	N	N	?		
Newburyport	N	?	?	Y(C)	N	?	?	N	N	?	?	?	N		
Newton	N/A	Y(Z)	Y(Z)	Y(I)	?	?	?	?	?	?	?	?	?	Y<w>	
Norfolk	Y(H)	N/A	Y(Z)	Y(Z,G,I)	?	Y(G&H)	Y(G)	?	?	Y<i>	?	Y	Y	Y<w&e>	
North Adams	N/A	N	Y	N	N	N	Y	N	Y	Y	N	N	?	Y<w>	
North Andover	Y(Z)	Y(Z&H)	Y(Z)	Y(Z),f	Y(G)	Y(G)	Y(Z)	N	N	?	?	?	?		
North Attleboro	Y(Z)	N/A	Y	N	Y	N	Y(Z)	?	?	Y<i>	Y<'85>	N	?		

TOWN NAME	Groundwater Protection District	Watershed Protection District	Floodplain District Bylaw	Wetlands Protection District	Toxic & Hazardous Materials	Underground Storage Tanks	Earth Removal/Erosion Control	Env. Impact Analysis for Major Dev.	Spill Response Plan	Contingency Plan / Water Emergencies	Open Space Plan	Regional Protection Committee	Title 5 Revisions/ Amendment	Private Well/ Water Sup. Regulations	Other Regulations
North Brookfield	N/A	N	N	?	N	N	?	?	?	Y<I>'	?	?	Y		
North Reading	Y(Z)	N/A	Y(Z)	Y(Z&I)	Y(G)	Y(H)	Y(G)	?	?	Y<I>	?	?	?		Mineral Removal Controls
Northampton	Y(Z)	Y	Y(Z)	N	?	Y	Y	?	?	?	?	Y	?		
Northborough	Y	N	Y	Y(G&I)	?	?	Y(G)	?	?	Y<I>	?	?	Y		Herbi/Pesticide Regulations (I-
Northbridge	N	N/A	Y	Y(G)	?	?	?	?	?	?	?	?	Y		
Northfield	Y	?	Y(G)	?	Y	?	Y(G)	?	Y	Y<I>	?	Y	?		
Norton	Y(Z)	N/A	Y(Z)	Y(Z)	Y	Y(Z)	Y(Z)	?	?	?	N	Y	?	Y<w>	
Norwell	Y(Z)	N/A	Y(Z)	Y(G,Z,C)	?	Y	?	?	?	?	?	Y	Y		Salt Use Controls
Norwood(S)	Y(Z)	Y(Z)	Y(Z&H)	Y(G&I)	?	?	Y(Z)	?	?	?	?	?	Y	Y<w>	
Oak Bluffs(S)	Y	N/A	Y(Z)	Y(G&C)	Y	Y(G&Z)	N	Y	Y	?	N	N	?		Dist. of Critical Planning Concern
Oakham(P)	N/A	N/A	Y	?	?	?	Y	Y	?	?	?	?	N		
Orange	Y(G)	Y(G)	Y(Z)	?	Y(Z)	Y	Y(Z)	Y	Y	N	Y	?	Y	Y<w>	Herbicide Reg(H), Rest Grdwtr U
Orleans(S)	Y(Z)	N/A	Y(Z)	Y(I)	Y(G)	Y(Z&H)	N	N	N	N	Y	Y	Y		
Otis(P)	?	N/A	Y(Z)	?	?	?	?	?	?	?	?	?	?		
Oxford	N	N/A	Y(Z)	N	?	?	Y(G)	Y	?	?	?	?	?	Y<w>	
Palmer	Y(Z)	Y(Z)	Y(Z)	Y	?	?	?	?	?	?	?	Y	?		
Paxton	N/A	Y	N	?	?	?	Y	Y	?	Y<I>	?	?	Y		
Peabody	?	?	?	?	?	?	?	?	?	?	?	?	N		Road Salt Policy Statement
Pelham(P)	Y(Z)	Y(Z)	N	Y(G)	?	Y(Z)	Y(G)	?	?	?	?	Y	?	Y<w>	
Pembroke	Y(Z)	N/A	Y(Z)	Y(C)	N	Y(G)f	Y	N	N	?	?	Y	Y		
Pepperell	Y(Z)	N/A	Y(Z)	Y	N	Y	Y(Z)	N	N	N	Y	N	Y		
Peru(P)	N/A	?	?	?	?	?	?	?	?	?	?	?	Y		
Petersham	N	N/A	?	?	N	N	?	Y	?	Y<I>	?	?	?		
Phillipston(P)	N	?	?	?	N	N	Y(Z)	N	?	?	?	?	?		
Pittsfield	N/A	N	Y	N	N	N	Y	N	Y	Y	N	N	N		
Plainfield(P)	N	N/A	N	N	?	?	?	?	?	?	?	?	N		
Plainville	Y(Z&H)	Y(Z&H)	Y	Y(G,Z,C)	Y	Y(H)	Y	?	?	Y	Y	N	?	Y<w>	Watershed Building Moratoriu
Plymouth(S)	Y(Z)	N	Y	Y(G,Z,C)	N	Y(Z)f	Y	N	N	Y<I>	?	?	Y		Herbi/Pesticide Regulations(I-
Plympton(P&S)	Y(Z)	?	Y(Z)	?	N	N	N	N	N	?	?	N	Y	Y<w>	
Princeton	N/A	N/A	N	?	N	N	?	?	?	?	?	?	Y		Salt Use Controls
Provincetown(S)	?	N/A	?	Y(G&C)	Y(H)	Y(H)	?	?	?	Y<I>	?	?	Y		
Quincy	?	?	?	Y(C)	?	?	?	?	?	?	?	?	?		Herbi/Pesticide Regulations(I-
Randolf	N	Y(Z)	Y(Z)	Y(Z)	?	Y	?	N	?	?	N	?	?		
Raynham	Y	N/A	Y(Z)	Y(G&Z)	Y	Y(G)	Y(Z)	?	?	?	Y<'89>	N	Y		
Reading	Y(Z)	N/A	Y(Z)	Y(Z&I)	?	?	?	?	?	Y<I>	?	?	?	Y<w>	
Rehoboth(P)	Y	N/A	Y	N	N	N	Y	?	?	?	Y	N	?	Y<w&s>	
Revere	N/A	?	?	?	?	?	?	?	?	?	?	?	?		
Richmond	?	N/A	Y(Z)	Y(Z)	?	?	?	Y	?	?	?	?	Y		Stippican Riverfront Protection E
Rochester(P)	N	N/A	Y(Z)	N	N	N	Y(G)	?	?	?	Y<'88>	Y	?		
Rockland(P)	Y(Z)	Y(Z)	?	?	?	?	Y(Z)	?	?	Y<I>	?	?	?		
Rockport	Y(Z)	Y(Z)	Y(Z)	Y(Z)	?	?	Y(Z)	?	?	?	?	?	Y	Y<w>	
Rowe(P)	?	N/A	?	?	?	?	Y(G)	Y	?	?	?	?	?		
Rowley	Y(Z)	N/A	Y(Z)	Y(Z)	N	Y	Y(Z)	Y	N	N	Y<Pre>	N	?	Y<s>	
Royalston	N	N/A	Y(Z)	?	N	N	?	?	?	?	?	N	N		
Russell	?	?	N	N	?	?	Y	?	?	Y<I>	?	Y	N		
Rutland	N/A	Y(Z)	N	N	N	N	Y	?	?	?	?	?	Y		
Salem	N/A	?	?	?	?	?	?	?	?	?	?	?	?		
Salisbury	Y(Z)	N/A	Y(Z)	Y(C)	N	N	Y(G)	?	N	?	N	N	?		
Sandisfield	?	?	Y(Z)	?	?	?	?	?	?	?	?	?	Y		Herbi/Pesticide Regulations(I-
Sandwich(S)	Y(Z)	N/A	Y(Z)	Y(G)	Y(Z&H)	Y(Z&H)	Y(Z)	?	?	?	?	?	Y	Y<w&e>	
Saugus	N/A	?	Y(Z)	Y(G)	?	?	?	?	?	?	?	?	?		
Savoy(P)	?	?	?	?	?	?	?	Y	?	?	?	?	Y		Waterways Protection Bylaw
Scituate	Y(Z)	Y(Z)	Y(Z&H)	Y(G&H)	Y(H)	?	?	?	Y	Y<I>	?	?	Y	Y<e>	

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Wellfleet(S)	?	N/A	Y(Z)	Y(C)	Y	Y(Z&H)	?	?	?	?	?	?	Y		
Wendell(P)	Y	?	?	?	Y	?	?	Y	?	?	?	?	?		
Wenham	Y(G)	N/A	?	Y	?	?	?	?	?	Y<i>	?	Y	?	Y<s>	
West Boylston	Y(Z)	N	Y	?	?	?	Y	?	?	Y<i>	?	?	Y		
West Bridgewater	N	N/A	Y(Z)	Y	N	N	Y	N	N	?	?	N	Y		
West Brookfield	N	N/A	Y(Z)	Y	?	?	?	Y	?	Y	?	?	?		
West Newbury	N/A	N	Y(Z)	N	Y	N	Y	N	N	?	?	?	N		
West Springfield	N	Y	Y(Z)	N	?	?	?	?	?	?	?	?	?		
West Stockbridge	N	N	Y	Y	?	N	Y	N	?	N	N	N	Y	Y<s>	
WestTisbury(P&S)	N	N	Y(Z)	Y(C)	Y	Y(H)	Y	Y	Y	N	Y	N	?		
Westborough	Y(Z)	N	Y(G&H)	Y	Y	?	Y	Y	?	?	?	?	Y	Y<w>	
Westfield	Y(Z)	Y(Z)	Y	N	Y(G)	Y(G&H)	N	?	?	Y<i>	?	Y	?		Groundwater Monitoring (H)
Westford	Y(G)	N/A	Y(Z)	Y(Z)	Y	Y	Y(G)	N	N	N	Y	N	Y		
Westhampton	N/A	N	Y	N	Y(Z)	?	N	?	?	?	?	?	Y		
Westminster	N/A	?	Y(Z)	Y(Z)	N	N	?	?	?	?	?	N	?		
Weston	Y(Z)	?	Y(Z)	Y(Z)	?	?	?	?	?	?	?	Y	Y		Pesticide Regulations (H)
Westport	N	N/A	Y(Z)	Y(C)	N	N	Y	?	?	Y<i>	Y	N	?		
Westwood(S)	Y(Z)	N/A	?	Y(I)	Y(G)	?	?	?	?	?	?	?	?		
Weymouth	Y	Y	Y(Z)	Y(G)	?	Y(G)	?	?	?	?	?	Y	N		
Whately	Y(Z)	N/A	Y(Z)	?	Y(G),tF	Y	Y	Y	Y	?	?	Y	Y	Y<w>	
Whitman	N	Y(Z)	Y(Z)	Y	N	N	N	Y	N	?	?	N	Y		
Wilbraham	N/A	Y(Z)	Y(Z)	Y	?	Y(Z)	Y	?	?	?	?	?	N		
Williamsburg	Y(Z)	Y(Z)	Y(Z)	?	Y(Z)	?	Y	?	?	?	?	?	N		
Williamstown	Y(Z)	Y(Z)	Y(Z)	Y	Y(G)	Y	Y(Z)	Y	?	Y<i>	N	Y	?	Y(Z)<w>	
Wilmington	Y(Z)	N/A	Y(Z)	Y(G)	?	Y(G)	Y(G)	?	?	?	?	?	Y		
Winchendon	N	N	Y(Z)	N	N	N	Y	N	N	?	?	Y	?		
Winchester	N/A	?	Y(Z)	?	?	?	?	?	?	Y<i>	?	?	?		
Windsor(P)	N/A	?	?	?	?	?	?	?	?	?	?	?	Y		
Winthrop	N/A	?	Y	Y(Z)	Y(Z)	?	?	?	?	?	?	?	N		
Woburn	N/A	?	?	?	?	?	?	?	?	?	?	?	?		
Worcester	Y	N	Y	Y	?	?	Y	?	?	Y<i>	?	?	Y		
Worthington	Y	?	Y(Z)	?	?	?	?	?	?	?	?	?	?	Y<w>	
Wrentham	Y(Z)	N/A	Y(Z)	Y(G)	N	Y(Z)	Y(G)	?	?	Y<i>	Y<Pres>	?	Y	Y<s>	
Yarmouth(S)	Y(Z)	N/A	Y(Z)	Y(Z&C)	Y(G&H)	Y(G,Z,H)tF	N	?	Y	N	Y	Y	Y		

Appendix I
Cohen Bill

		PROTECTION DISTRICT	
I. AREAS TO WHICH THE LAW OR BYLAW APPLIES			
Definition of Protected areas	No alternations to land or building within 200 feet of a tributary or other waterbody or within 400 feet of a reservoir; Land use restrictions apply: Within the area between 200 feet and 400 feet of the bank of a tributary or other surface water; Within the 100 year flood plain of a tributary or other water; Within bordering vegetated wetlands that border on tributaries or surface waters, or reservoirs; Mapped aquifers with potential yield greater than 100 gallons per minute; Within land that overlays and aquifer with a potential well yield between one and 100 gallons per minute provided that the division and the DEP find that regulation of the aquifer is necessary of the protection of water quality.	Zone A: areas which fall within 400 feet of the 100-year flood plain elevation as delineated on the federal FEMA map, of all 314 CMR 4.00 defined Class A surface waters. An additional setback of a half mile or to the contributing surface watershed boundary will be applied for high-slope areas where the adjacent slope equals or exceeds 15%. Zone B: areas which are located one half mile upgradient of the Zone A boundary or the watershed boundary, whichever is less. Zone C: areas which encompass the remaining watershed not designated as either Zone A or B.	The Cohen bill applies to the area described in this section. The model bylaw applies generally to Zone A. In reviewing these prohibited uses you should decide if they should apply to Zone B and/ or C as well.

CATEGORIES	COHEN BILL	DRAFT MODEL BYLAW	COMMENTS
II. PROHIBITED USES AND ACTIVITIES			
Sewage treatment plants and sludge disposal	The disposal of pollutants from private or publicly owned sewage treatment facilities;	landfilling of sludge or septage as defined in 310 CMR 31.05; AND storage of sludge and septage, unless such storage is in compliance with 310 CMR 32.30 and 310 CMR 32.31;	
Sewage treatment plants		AND treatment works that are subject to 314 CMR 5 including privately owned sewage treatment facilities, except the following: a. the replacement or repair of an existing treatment works what will not result in increased capacity; b.the replacement of existing subsurface sewage disposal systems not greater than the existing system; c.treatment works approved by the DEP designed for the treatment of contaminated surface water;	What are the new requirements of title V? Were any specific requirements made for additional protection/restrictions to watersheds.
Subsurface sewage disposal systems	The placement of the leaching field of a subsurface wastewater disposal system less than four feet above the maximum water table level as measured at the time of annual high water;	individual sewage disposal systems that are designed and located in accordance with 310 CMR 15.00 to receive more than 110 gallons of sewage per quarter acre under one ownership per day, or 440 gallons of sewage on any one acre under one ownership per day, whichever is greater, except the replacement or repair of an existing system that will not result in any decrease in design capacity above the original design;	

petroleum products	The storage of liquid petroleum products of any kind; other than for normal residential use or with a containment system;	storage of liquid petroleum products, except the following: a. normal household use, outdoor maintenance, and heating of a structure; b.waste oil retention facilities required by statute, rule or regulation; c.emergency generators required by state, rule or regulation; d.treatment works approved under 314 CMR 5.00 for treatment of ground or surface waters; provided that storage, listed in items a. though d. above, is in free-standing containers within buildings or above ground with secondary containment adequate to contain a spill the size of the container's total storage capacity.	
Hazardous materials	The treatment, disposal, use, generation, or storage of hazardous material or waste, except a reasonable amount, incidental to normal residential use;	facilities that generate, treat, store, or dispose of hazardous waste subject to MGL 21C and 310 CMR 30.00 except the following: a. very small quantity generators as defined under 310 CMR 30.00; b.household hazardous waste collection centers and events under 310 CMR 30.390; c.waste oil retention facilities required by MGL c.21,s.52A; d.water remediation treatment works approved under 314 CMR 5.00; AND storage of liquid hazardous materials as defined in MGL c.21E, unless in a free standing container within a building or above ground with secondary containment adequate to contain a spill the size of the container's total storage capacity;	
Solid Waste	The storage and the disposal of solid waste other than a reasonable amount incidental to normal residential use;	landfills and open dumps as defined in 310 CMR 19.006	

III. SPECIAL PERMITTED USES

CATEGORIES	COHEN BILL	DRAFT MODEL BYLAW	COMMENTS
Existing Uses		Enlargement or alteration of nonconforming existing uses.	
Pesticide Use		Non-domestic and non-agricultrual use must be in accordance with state and federal standards. Documentation required.	
Fertilizer Use		Non-domestic and non-agricultural use.	
Hazardous Materials		Permitted activities involving handling of toxic or hazardous materials in quantities greater than for household use.	
Construction of Water Bodies		Construction of dams or other water control devices, ponds, or other changes in waterbodies or courses	
Impervious Surfaces	(See Prohibited Uses)	Any use that will render impervious more than ___% or ___sq. ft. of any lot, whichever is greater. A system for groundwater recharge must be provided which does not degrade ground or surface water quality.	
High Slope Construction		Residential construction upon a lot with an average slope exceeding 15%.	

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Earth removal	The excavation of gravel and sand to the depth greater than six feet above the maximum water table, except where incidental to the construction of permitted structures;	earth removal, consisting of the removal of soil, loam, sand gravel or any other earth material (including mining activities) to within 6 feet of historical high groundwater as determined from monitoring wells and historical water table fluctuation data compiled by the USGS, except for excavations for building foundations, roads, or utility works;	
Bordering vegetated wetlands	The altering of bordering vegetated wetlands;	The altering of bordering vegetated wetlands;	
Other activities	Any other activity which could degrade the quality of the water in the watersheds as determined by the division after consultation with DEP; provided, however, that de-icing may be performed on a roadway under procedures approved by the Secretary of Environmental Affairs.		
Density requirements	Additionally, section 107A (d) prohibits construction of dwellings exceeding a density of two bedrooms per acre or generation of more than 220 gallons per acre per day of sewage.		
Distance from bank of surface water	Alterations to land with 200 feet of a tributory or water body or within 400 feet of a reservoir	any structure within __ft of the banks of a surface water supply body or its tributaries;	
Horse paths		horse paths	
Process water		industrial and commercial uses which discharge process wastewater on-site;	
Septic system cleaners		the use of septic system cleaners which contain toxic or hazardous chemicals;	

CATEGORIES	COHEN BILL	DRAFT MODEL BYLAW	COMMENTS
Road salt and de-icing chemicals	The outdoor storage of road salt or other de-icing chemicals; except that this section shall not prohibit the outdoor storage of sand, gravel or materials used in road construction which are not hazardous materials or waste;	storage of deicing chemicals unless such storage, including loading areas, is within a structure designated to prevent the generation and escape of contaminated runoff or leachate; AND stockpiling and disposal of snow and ice containing deicing chemicals if brought in from outside the district; and any disposal of such material directly into a tributary to the water supply;	
Fertilizers, herbicides and pesticides	The outdoor storage of fertilizers, herbicides and pesticides;	storage of commercial fertilizers and soil conditioners, as defined in MGL c.128,s.64, unless such storage is within a structure designated to prevent the generation and escape of contaminated runoff or leachate;	
Pesticides	The use or storage of pesticides or herbicides which carry a mobility rating as provided for by the United States Environmental Protection Agency or which have been determined by the Commonwealth using EPA standards to pose a threat or potential threat to ground water;		
Manure piles	The outdoor uncovered storage of manure;	storage of animal manure unless covered or contained	
Vehicle service and repair facilities	The servicing, washing, or repairing of boats or motor vehicles other than for reasonably incidental to normal residential use;	commercial repair servicing, washing and rebuilding of vehicles, boats and other large motorized equipment other than for normal household activities;	
Junkyards	The operation of junk and salvage yards;	automobile graveyards and junkyards as defined in MGL c140B s.1.	
Impervious surfaces	The rendering impervious of more than ten percent of any lot or 2,500 square feet, whichever is greater;		

References

Boutiette, Laurence N. and Duerring, Christine L. 1993. *Massachusetts Nonpoint Source Management Manual "The Megamanual" A Guidance Document for Municipal Officials*. Massachusetts Department of Environmental Protection. Publication No. 17356-500-500-6/93-67.00. Boston, MA.

Hounslow, Arthur W., 1995. *Water Quality Data Analysis and Interpretation*. New York: Lewis Publishers

Kimball, Joan Channing. 1993. *Riverways Community Guide – Strategies for Drafting and Passing Local River Protection Bylaws*. Prepared for the Massachusetts Riverways Program Department of Fisheries, Wildlife & Environmental Law Enforcement.

Lindeburg, Michael R. 1989. *Civil Engineering Reference Manual Fifth Edition*. Belmont, CA. Professional Publication, Inc.

Morris, Jackie. 1996. *Source Protection: A Guidance Manual for Small Surface Water Supplies in New England*.

Novotny, Vladimir. 1994. *Water Quality Prevention, Identification, and Management of Diffuse Pollution*. New York. Van Nostrand Reinhold.

Ponce, Victor Miguel. 1989. *Engineering Hydrology Principles and Practices*. Englewood Cliffs, New Jersey: Prentice Hall.

Reckhow, Kenneth H. 1983. *Engineering Approaches for Lake Management, Volume 1: Data Analysis and Empirical Modeling*. Boston. Butterworth Publishers.

Reckhow, Kenneth H. 1990. *Eutromod Watershed and Lake Modeling Software*. 1990. Prep. for North American Lake Management Society.

Schueler, T.R. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Metropolitan Washington Council of Governments.

Schueler, T.R. 1994. *Performance of Stormwater Ponds and Wetlands in Winter*. Watershed Protection Techniques. Vol. 1 No. 2.

Schueler, T.R. 1994. *The Importance of Imperviousness*. Watershed Protection Techniques. Vol. 1 No. 3.

Schueler, T.R. 1995. *The Architecture of Urban Stream Buffers*. Watershed Protection Techniques. Vol. 1 No. 4.

Schueler, T.R. 1997. *Impact of Suspended and Deposited Sediments.* Watershed Protection Techniques. Vol 2. No. 3.

Schueler, T.R. 1997. *The Economics of Watershed Protection.* Watershed Protection Techniques. Vol. 2. No 4.

Stewart, B.S., D.A. Woolhiser, W.H. Wischmeier, J.H. Caro, and M.H. Frere. 1975. *Control of Water Pollution from Croplands, Volume I*, EPA-600/2-75-026, US EPA, Washington, D.C.

Tchobanoglous, George. 1987. *Water Quality*. Reading, Massachusetts. Addison-Wesley Publishing Company.

Urban Hydrology for Small Watersheds. 1986. USDA Soils Conservation Service Engineering Division. Technical Release 55.

Wedepohl, R.E., D.R. Knauer, G.B. Wolbert, H. Olem, P.J. Garrison, and K. Kepford. 1990. *Monitoring Lake and Reservoir Restoration*. EPA 440/4-900007. Prep. by N. Am. Lake Manage. Soc. for U.S. Environ. Prot. Agency, Washington, DC.

Wischmeier, W.H. and Smith, D.D. 1978. *Predicting Rainfall Erosion Losses – A Guide to Conservation Planning*. Agricultural Handbook 537, US Dept of Agriculture, Washington, D.C.

1988. *The Lake and Reservoir Restoration Guidance Manual First Edition*. EPA 440/5-88-002. Prepared by the North American Lake Management Society for U.S. Environmental Protection Agency. Washington, D.C.

Town of Milford NH Zoning Ordinance. March 12, 1996 Edition

Laws of the Town of Amherst NH 1995 Zoning Ordinance and 1996 Zoning Ordinance Revisions.

Town of Milford NH Subdivision Regulations, November 6, 1990 - Amended July 28, 1992.

Ordinances and Regulations, Town of Hollis, NH. May 1994.

Town of Merrimack Subdivision Regulations, February 1992.

Town of Merrimack Zoning Ordinance and Building Code, May 1996.

City of Nashua, NH Zoning and Subdivision Ordinances, Revised May 14, 1996.

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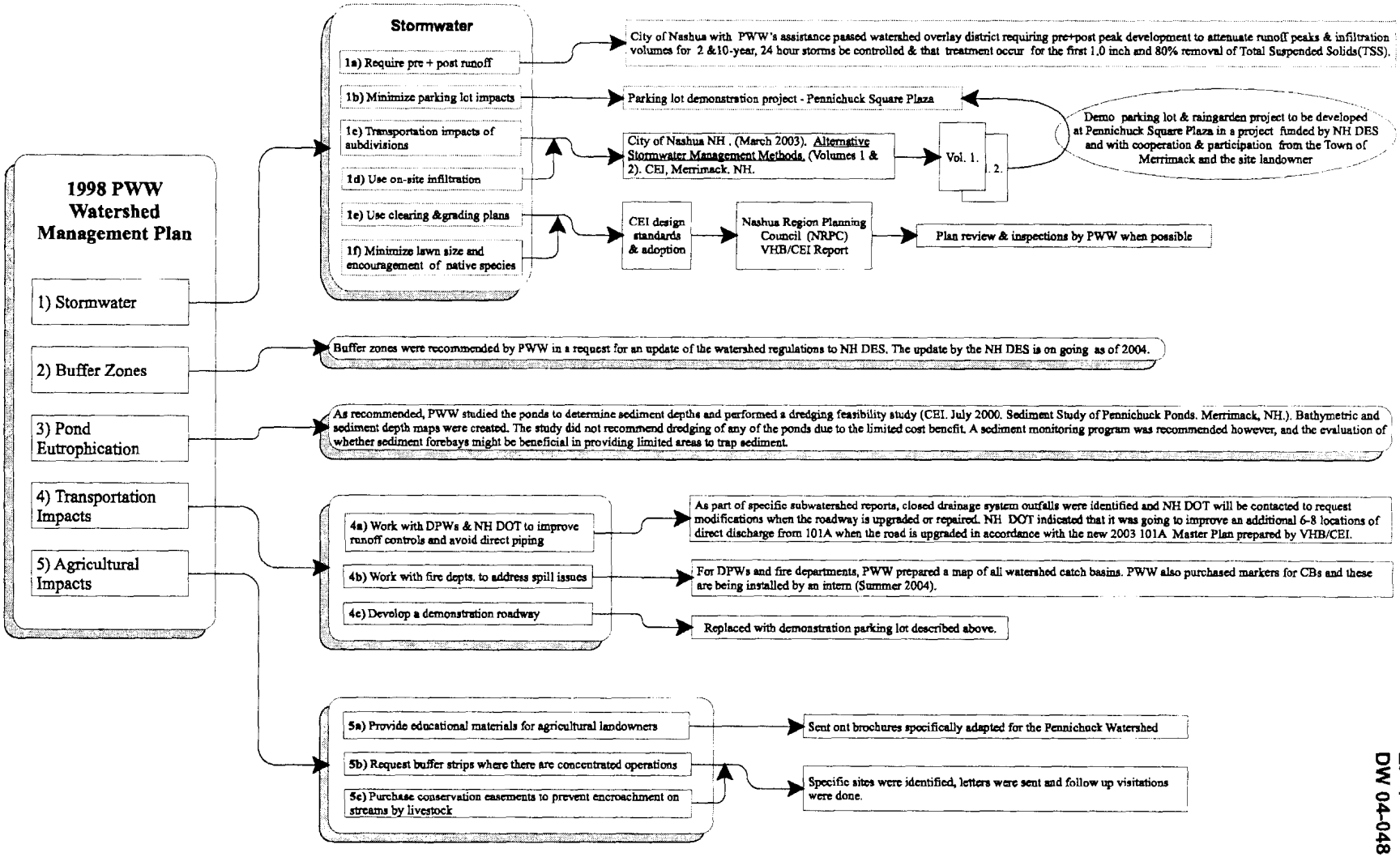
Figure 6-1 Watershed Recommendation Overview



Eileen Pannetier
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DW 04-048 - 6 Pages

Figure 6-1 Watershed Recommendation Overview

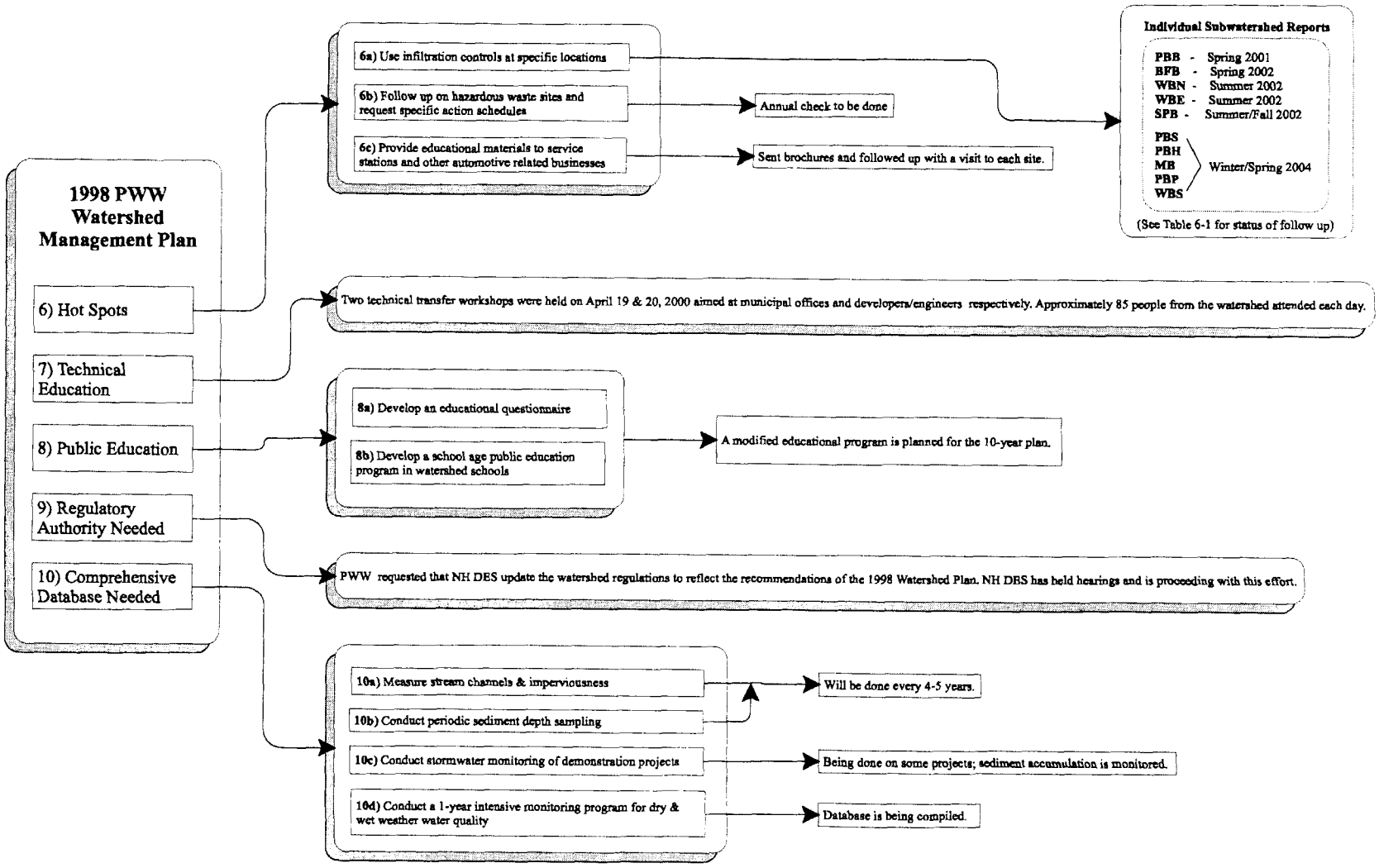

Table 6-1 Pennichuck Watershed 10 Year Action Plan Items To Be Completed

Report Reference	Description	Specifics and Schedule
1. A. Require pre and post development stormwater runoff controls[a]	Encourage watershed towns to adopt similar runoff controls to that adopted by Nashua (equal pre and post-development peaks and infiltration for 2 and 10-year, 24 hour storms.	Send letters to the remaining watershed towns encouraging them to use the Nashua model regulation or to adopt CEI's design standards for runoff controls. Emphasize that this could be part of the communities' Phase II Stormwater compliance.
1. B. Minimize parking lot impacts[a]	Construct a demonstration project in an existing parking lot in one of the watershed communities at the site of a cooperating landowner. Include raingarden as a demonstration if possible.	Construction to begin summer and fall of 2004, Pennichuck Square, Merrimack. Design by CEI is now ongoing and a kickoff needs to be scheduled to gain participation of the stakeholders (landowner, Town of Merrimack, tenants, Pennichuck).
1.D. Use onsite infiltration of roof leader and other recharge; 1.E. Use clearing and grading pans; 1.F. Minimize lawn sizes, encourage use of native plantings	Continue plan reviews for all watershed projects as they arise. Encourage adoption of CEI's design standards for stormwater controls by all communities in the watershed as these standards address these issues.	Set up a design review checklist and distribute to the watershed communities to encourage its use. Send to DPWs, Conservation Commissions and Planning Boards of all watershed communities.
3. Pond Eutrophication[b]	Monitor sediment depths over time and evaluate whether sediment forebays might benefit the ponds.	Replicating the original locations to the extent possible, sediment depth monitoring needs to be done every 4 or 5 years during the summer. Original depths acquired late summer 1999, so depths should be acquired in 2004.
5. Agricultural Impacts[c]	Farms and nurseries visited in 2001 and 2002 should be revisited in 2004 and every two years afterwards.	Use the checklist in the Hot Spot Visitations report during visits, distribute the brochures again. Check whether the Natural Resource Conservation Service (NRCS) has completed their work with watershed farms identified in the report.

[a] Pennichuck Water Works Watershed Management Plan, Recommendation #1 Stormwater, CEI, August, 1998.
[b] Sediment Study of Pennichuck Ponds. CEI, July 2000.
[c] Hot Spot Visitations Pennichuck Watershed. CEI, May 2002.

Table 6-1 Pennichuck Watershed 10 Year Action Plan Items To Be Completed

6.A. Use infiltration controls at specific locations	See followon recommendations from Subwatershed Reports at the end of this table on page 6-3.	- Inspect all constructed BMPs annually and send letters to applicable authorities if maintenance has not been completed
6.B. Follow up on hazardous waste sites	- Update the sites list generated in the 1998 Watershed Plan. - Contact NH DES and request information on specific action schedules for each site.	- Update the record search of sites done for the 1998 plan (Appendix F HAZWASTE sites) - Send a letter to John Regan at NH DES asking if he could give you an update on the status of these sites, listing those identified above
7. Technical Education	Apply for another grant for 2005/6 to repeat the highly successful 2000 workshops with updated information and model regulations.	Submit grant application November 2004.
8. Public Education	Provide a map of the demonstration sites and plan a tour to be combined with the 2005 workshops. Invite cable channels from each of the watershed towns to the tour. Invite public through press releases beforehand. Build on current Low Impact Development (LID) movement by including techniques that could be used in new development in ongoing construction sites.	Map should include selected existing BMPs that work well, the Pennichuck Square BMP, the Celina Avenue BMP and Cornerstone properties BMP. It should show watershed areas and provide plans and specifications. Add to above grant application.
10.A. Measure stream channels and imperviousness; 10B. Conduct periodic sediment depth sampling; 10.C. Conduct stormwater monitoring of demonstration projects.	A-B should be done on a 4-5 year basis. C. is being done by NRPC under grant to DES. D. is being completed 2004.	Analyze after completion of 8-10 years of data and update the watershed recommendations to reflect the results. Substitute sediment depth monitoring (for stormwater monitoring) for infiltration based demonstration projects to gauge effectiveness.

Table 6-1 Pennichuck Watershed 10 Year Action Plan Items To Be Completed

10.D. One year intensive monitoring program for dry and wet weather water quality.	(See above)	(See above)
Boire Field Brook Subwatershed	- O&M Plans. Encourage the use of O&M plans by watershed towns by sending them a "model" plan under a cover letter that highlights why it is important for their Phase II compliance and for water quality in Pennichuck Brook. - Request that EPA or NHDES Phase II program provide guidance on disposal of street sweepings. - Evaluate whether the Crowne Plaza waterfowl situation warrants further actions	- Other specific Phase II bylaws that must be adopted will also improve the maintenance situation on new BMPs. Provide model bylaws from NHDES if needed. - Hand out DES prepared guidance on street sweepings to the involved businesses and their contractors if this is noted as a problem. - Inspect sites specifically mentioned in the BFB report and send new letters if needed to encourage maintenance. Copy in Nashua DPW as the City is now responsible for making sure that maintenance is accomplished (Phase II regulations). - Take samples for E. coli upstream and downstream of the site and if significantly higher downstream in summer, take further actions.
Pennichuck Brook to Bowers Pond Subwatershed	- The Amherst Planning Board could request that the detention structures at Amherst Park be rebuilt if the site ever needs approval for expansion or substantial modification Send a letter to Nashua DPW, the Nashua Planning Board and the Nashua Conservation Commission, with copies to NH DOT regarding the Blackstone pond and its need for maintenance.	- If this site comes up for review by Amherst municipal agencies, Pennichuck should request that the drainage detention structures be modified to be more effective. - Remind Nashua agencies that the Blackstone detention pond needs cleaning out and request action. If this is not done before the 101A upgrades, request from NH DOT when they go to make the improvements on 101A near that site. - Reinspect these sites and send a letter to Nashua DPW with

Table 6-1 Pennichuck Watershed 10 Year Action Plan Items To Be Completed

Pennichuck Brook to Bowers Pond Subwatershed (continued)	- Similar to the above, request that Nashua require owners to maintain the sites listed in the report (pages 8-9)	copies of the notes above.
Witches Brook North Subwatershed	- Sponsor a Master Gardener from the local area who would then provide public education on how homeowners can reduce fertilizer and pesticide use in yards - Encourage watershed towns to include recharge requirements and steep slope controls in their Phase II regulatory updates. - Inspect other small sites identified in the WBN report to obtain a status and need for further actions	- Contact UNH Master Gardener program to see how they might be able to assist Pennichuck in this education effort - Send a letter to watershed Planning Boards encouraging them to consider steep slope and recharge requirements in their regulatory updates required under Phase II.
Witches Brook East Subwatershed	- Inspect drainage structures listed in the WBE report and update status. - Send letters to Amherst regarding these sites and maintenance actions needed or modifications requested when site changes are approved.	- These are all private developments with drainage issues. They may be contacted during the visits to see if they might want to participate in modifications such as are occurring at Pennichuck Square in 2004. Each site will need updating if further actions need to be taken so that the latest designs can be used.
Stump Pond Brook Subwatershed	- Submit sediment forebay (pg 4-1) to NH DOT for consideration in 101A upgrades in future. Alternatively, a grant application could be submitted for this BMP. - Submit other roadway BMPs to the town of Amherst for consideration and similarly possibly grant applications if involved parties agree to participate.	- These BMPs are in right-of-ways for the state and for Amherst. They will need to participate for any construction to occur. Some landowners are also peripherally involves as well.