Watershed Management Plan

Webster-Highland Lakes Watershed Partnership

Prepared for **City of Franklin,**
Municipal Services Department
43 West Bow Street
City of Franklin, NH 03255

Prepared by **Vanasse Hangen Brustlin, Inc.**
Six Bedford Farms Drive
Suite 607
Bedford, NH 03110-6532

Assisted By:
Hutchins Consulting Services
P.O. Box 130
Salisbury, NH 03268

and
naturesource communications
P.O Box 3019
Boscawen, NH 03303

December 21, 2006

Final

Table of Contents

Note: This Project was funded through a grant provided by the New Hampshire Department of Environmental Services; Watershed Management Bureau.

Executive Summary

During the summer of 2003 and late-summer of 2004, significant outbreaks of nuisance blue-green algae, including cyanobacteria, were observed in Webster Lake, these outbreaks greatly diminished its use for recreational purposes and posed a human health threat. Subsequently, several meetings and workshops were held with New Hampshire Department of Environmental Services (DES) personnel, Webster Lake Association members and municipal officials to try to identify sources of the problem and appropriate corrective measures. In early 2006, DES included Webster Lake on the DRAFT 2006 303(d) list of impaired water bodies due to the reoccurrence of cyanobacteria. Ongoing water quality sampling, conducted by DES personnel and the DES Volunteer Lake Assessment Program (VLAP) monitors, has also revealed occasional elevated levels of turbidity, phosphorus and *E. coli* bacteria, which represent additional water quality concerns.

The document will serve as a planning tool for the members of the Webster-Highland Lakes Watershed Partnership and municipal officials for future planning, scheduling and in seeking additional funding to implement feasible measures that will improve water quality in both Highland and Webster Lake and maintain their primary use as valuable recreational resources for years to come. Although the primary focus of this project is on Webster Lake, as directed by the grant application process submitted by the City of Franklin, the water quality objectives, data analysis, and recommended measures contained in this report may be beneficial and could be applied in the Highland Lake watershed as well, which is located in the neighboring Town of Andover. Approximately 75 % of the Webster Lake watershed, which includes Highland Lake, is located in the Town of Andover.

Both Webster Lake and Highland Lake have been part of VLAP for nearly 20 years. The VLAP volunteers are trained by DES to collect basic limnological measurements and water quality samples on a monthly basis during the summer months. The primary measurements or parameters analyzed include Secchi disk transparency (i.e., water clarity), chlorophyll *a*, and total phosphorus at various depths. As discussed above, these parameters represent the primary limnological indicators for determining in trophic status and monitoring changes. Recently, on April 3, 2006, a surface water sample was collected in Webster Lake, immediately after ice-out, when lakes are typically in a well-mixed condition. The phosphorus concentration was reported to be 0.015 mg/l or 15 ppb, which suggests that the average in-lake phosphorus concentration during well-mixed conditions for the entire lake volume may be slightly above the average summer eplimnetic concentration.

In addition, application of a widely used land use export model (discussed in Section 4.0) suggests that phosphorus loading to Webster Lake could be higher than indicated by the Dufresne-Henry study under well-mixed conditions. These modeling results combined with measured in-lake phosphorus levels at ice-out lead us to conclude that the "true" or "well-mixed" in-lake phosphorus concentration in Webster Lake is more likely 15 ppb instead the 12 ppb that is typically reported by VLAP for the epilimnion or 13 ppb reported in Dufresne-Henry study using the Vollenweider model.

To improve water quality conditions in Webster Lake, a reasonable goal would be to reduce the existing in–lake phosphorus concentration by 2 to 3 parts per billion (ppb) and maintain an average in-lake phosphorus concentration closer to 11 or 12 ppb, rather than 13 to 15 ppb. This may seem like a minor change but lake water quality conditions, in terms of water clarity and algal productivity, can be substantially different with an average phosphorus concentration closer to 12 ppb as opposed to 15 ppb. The proposed reduction would also buffer against any short-term, episodic influxes similar to those that may have occurred in 2003 and 2004. It may also allow for some future residential growth that will likely occur within the watershed. The existing phosphorus load would need to be reduced by about 94.0 kilograms per year (kg/yr) to lower the in-lake concentration by about 2 ppb and by as much as 140 kg/yr to lower the concentration by 3 ppb. These load reductions represent about 18% and 26% of the estimated existing phosphorus load, respectively, contributed from tributaries and septic systems.

To achieve these phosphorus load reductions, several different phosphorus sources within the watershed and around the Lake would need to be addressed. There is no one particular source where the entire recommended load reduction can be achieved with a simple fix. The existing phosphorus load is generated from many different sources within the watershed including residential development, timber harvesting, roadway runoff, manure spread on hayfields as fertilizer as well as that deposited in pasture areas, stables and pens by livestock. Other sources include shoreline septic systems, pet wastes, storm water runoff, use of detergents, sediment erosion caused by excessive runoff flow, construction activity and wave action, or other sediment disturbances caused by boating activity and internal loading from bottom sediments, to name a few. None of these sources or activities, by themselves, contributes more than 30% of the total phosphorus load entering Webster Lake. For most of these sources, their percentage of the total contribution is estimated to be less than 10 percent, which reinforces the need to initiate a multi-faceted approach to watershed management.

Based on pollutant modeling and previous sampling results, the largest phosphorus load reductions could be achieved through a combination of additional manure management measures and septic system upgrades for shoreline lots around Webster Lake. Manure management measures may include additional fencing in pasture areas to keep cows out of drainage ways that convey storm water runoff and by working with farmers to perhaps modify the timing of manure spreading on hayfields and avoid applications on frozen ground or saturated soils. Although there has been a great deal of improvement in this area over the years, there is still room for improvement. In addition, addressing some of the smaller livestock pens and horse stables or so-called "hobby" farms that exist in residential areas through local ordinances and drainage modifications would also be crucial step in the process.

One of the critical needs will be to continue working with shoreline homeowners to identify and upgrade the few poorly functioning shoreline septic systems that are likely to exist around Webster Lake. Although many shoreline homeowners have upgraded and improved their septic systems over the last 20 years or so, there could be as much as 10 to 15% of shoreline systems that are poorly functioning or failing. Previous estimates indicate that a large majority of the phosphorus attributed to shoreline septic systems is coming from poorly functioning or failing septic systems. Even though shoreline septic systems are estimated to contribute only 15 to 20% of the overall total phosphorus load to Webster Lake, eliminating or upgrading the remaining poorly functioning or failing septic systems could result in a significant reduction in the phosphorus load. A reduction of 5 to 10 % of the overall phosphorus load through septic system improvements could achieve at least half and perhaps more of the 18 to 26 % reduction goal, discussed above, to improve water quality in the lake.

More information is needed to identify exactly where these potentially failing systems are located. The remainder of the load reductions would perhaps come from treatment of road runoff in specific areas, additional maintenance of the existing storm drain system, additional zoning regulation updates to address certain activities such as future residential development, sediment disturbances resulting from timber harvesting and construction activities as well as through a coordinated education and outreach effort that would be updated each year to educate homeowners, lake users and other stakeholders on how their activities may affect lake water quality and promote good land stewardship within the watershed.

1

Introduction

Project Overview

This project was funded by a grant provided by NH Department of Environmental Services (DES) through the Watershed Assistance Grant Program. The Grant application was submitted by the City of Franklin Municipal Services Director, Mr. Brian Sullivan and the Planning/Zoning Administrator, Mr. Richard Lewis in November 2004. The grant award was approved and awarded to the City of Franklin in May 2005.
This project has four major components:

- Establish a Watershed Organization/ Partnership Group
- Conduct Additional Water Quality Monitoring
- Develop a Watershed Management Plan
- Prepare a Public Outreach and Education Plan

This document will serve to guide the Partnership in planning, scheduling and in seeking additional funding to implement feasible measures that will improve water quality in Webster Lake and maintain its primary use as a valuable recreational resource for years to come. The data analysis and recommended measures included in this document may also be directly or indirectly beneficial to protecting and improving water quality in Highland Lake as well. To insure eligibility for additional funding assistance through the EPA Sec 319 grant program for implementation of remedial measures, this Plan include the minimum nine elements for Watershed Management Plans, as required by EPA, (presented in greater detail on page 3).

Webster Lake is located in the City of Franklin, and is extensively used for recreational activities including swimming, boating and fishing by residents in the area. The Lake is approximately 610 acres in size with a maximum depth of about 39.0 feet (11.9 meters) and an average depth of 17 feet (5.2 meters). Nearly 75% of its watershed is located in the Town of Andover. The Lake's primary water inflow is provided by Sucker Brook, which originates approximately 12 miles upstream at the outlet of Highland Lake located in the Town of Andover. Both lakes were expanded around the turn of the 19th century to store water during spring runoff and then supplement flow to power the Franklin Mills during the drier times of the year. Highland Lake is the smaller of the two, at approximately 212 acres in size, and is slightly shallower with an average depth of 16 feet (5.0 meters).

During the August of 2003 and September of 2004, significant outbreaks of nuisance blue-green algae, including cyanobacteria, were observed in Webster Lake, which greatly diminished its use for recreational purposes and posed a human health threat. These outbreaks prompted several meetings and workshops with DES personnel, Webster Lake Association members and municipal officials to try identify sources of problem and appropriate corrective measures. Recently, DES included Webster Lake on the 2006 303(d) list of impaired water bodies due to the reoccurrence of cyanobacteria. Ongoing water quality sampling conducted by DES personnel and the Volunteer Lake Monitoring Program (VLAP) monitors, has also revealed occasional elevated levels of turbidity, phosphorus and *E. coli* bacteria, which represent additional water quality concerns. DES has also responded to findings of elevated *E. coli* bacteria levels that have been recently detected in various tributaries discharging to the Lake and particularly Sucker Brook. DES has, as a result, conducted additional water quality sampling in the Sucker Brook watershed over the last three (3) years in an attempt to identify *E. coli* bacteria sources. This information is summarized in this report.

The Webster-Highland Lakes Watershed Partnership was established in late summer-early fall of 2005 to help guide the development of this Watershed Management Plan and prioritize the issues and concerns related to water quality between the various stakeholders within the Webster-Highland Lakes watershed area. The Partnership consisted of municipal officials from both Franklin and Andover, lake association members, DES personnel and other at large community members. With Highland Lake being in the Webster Lake watershed, it was recognized early on in the process that community members of Andover and the Highland Lake Association should be included in the Plan development process. Potential measures that could improve water quality in Webster Lake could also benefit or be directly applicable to the Highland Lake watershed. The members and activities of this Partnership are discussed in greater detail in Section 2.0 of this Report.

In developing a Watershed Management Plan, the Partnership retained the services of a multi-disciplinary, consultant team consisting of Vanasse Hangen Brustlin, Inc (VHB) of Bedford, NH, Hutchins Consulting Services (HCS) of Salisbury, NH and naturesource communications of Boscawen, NH through a competitive bid proposal process. VHB was the lead consultant for this project and was assisted by HCS in evaluating the lake water quality data, pollutant source identification and BMP recommendations for the Watershed Management Plan. naturesource communications assisted in facilitating public meetings and in preparing the educational and outreach component of this Plan. The primary goal of this Watershed Management Plan was to identify measures, based on existing water quality data and other relevant studies that will improve the water quality conditions in Webster Lake and provide an implementation plan to help guide the Partnership in implementing these measures. These measures may consist of storm water treatment measures, additional controls on land use development or activities, in-lake treatments and other management alternatives.

Section 3.0 of this Plan describes the historical and current lake water quality conditions based primarily on a set of indicator limnological parameters measured by volunteer monitors as part of the DES Volunteer Lake Assessment Program (VLAP). Both Webster and Highland Lakes have been monitored for over 20 years. In general, conditions have remained fairly consistent with a few exceptions and some more recent signs of decline in Webster Lake.

Section 4.0 provides an assessment of the various possible sources and contributions of phosphorus in the Webster Lake watershed based on existing data. It is important to point out that the development of this Plan and associated recommendations are based primarily on the findings of previous water quality studies and investigations. More recent additional sampling conducted by DES in the Sucker Brook watershed and/or Webster Lake is also included to supplement the data interpretation.

Section 5.0 lists various action goals and recommendations to be considered for water quality improvements. Section 6.0 provides an implementation plan to assist the Partnership in implementing the various options for watershed management and on lake or shoreline activities. Section 7.0 presents an Education and Outreach Plan to outline activities.

To be eligible to receive Section 319 Grants for future implementation of the measures, this Plan was developed to be consistent with EPA's 319 elements listed below:

Nine Minimum Elements to be Included in a Watershed Plan for Impaired Waters Funded Using Incremental Section 319 Funds.

To improve eligibility to receive subsequent EPA or DES Restoration/ Implementation grants, this Watershed Management Plan contains the "Nine Minimum Elements to be Included in a Watershed Plan for Impaired Waters Required for Funded Using Incremental Section 319 Funds." The following lists the Nine Minimum Elements:

1. Identify the causes and/or pollutant sources that need to be controlled,
2. An estimate of the load reductions expected from management measures,
3. A description of nonpoint source management measures that will need to be implemented to achieve the load reductions,
4. An estimate of the amount of technical and financial assistance needed and the potential sources and agencies that may provide this assistance,
5. An information and education component that will enhance public understanding of the project and encourage early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented,
6. Schedule for implementing the nonpoint source management identified in this plan that is reasonably expeditious,
7. A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented,
8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards,
9. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item 8 immediately above.

2

The Webster - Highland Lakes Watershed Partnership

In 2005, members of the Webster Lake and Highland Lake Associations, and staff and citizens of the City of Franklin and the Town of Andover, and the NH Department of Environmental Services initiated a collaborate effort to investigate and address water quality concerns within the lakes' watersheds. This project builds on these efforts and strengthens the Partnership between the area stakeholders by forming the Webster-Highland Lakes Watershed Partnership. It is the continued collaboration of this Partnership that will be key to successful implementation of the water quality protection measures identified in this Plan.

Residents and stakeholders of both communities will need to commit to a unified effort in adopting or implementing the corrective measures identified as part of this project as well as any other future efforts to be successful. For certain measures, adoption or implementation could benefit both communities as they relate to Highland Lake or Webster Lake. Even the measures that may be focused on activities or sources that are physically located downstream of Highland Lake, could be beneficial to Andover residents just in terms of proper environmental stewardship of the land. Partners include:

Laurence Boyett, City of Franklin Planning Board
Don Gould, Town of Andover Planning Board
Sandra Graves, Town of Andover Conservation Commission
Mark Henderson, Webster Lake Association
Helen Johnson, Webster Lake Association
Ron Klemarczyk, FORECO (City of Franklin Forester)
Dick Lewis, City of Franklin
Glenn Morrill City of Franklin Conservation Commission
Brian Sullivan, City of Franklin
Jim Tullis, City of Franklin Planning Board
Bob Welch, Highland Lake Protective Association
Peter Zak, Town of Andover Conservation Commission

The project team met with the Partnership on March 9 and June 13, 2006 as well during the public listening sessions discussed below. During these meetings, Partners discussed water quality data and other information. They identified areas in which further information was required and collaborated to initiate additional water quality monitoring activities including ice-out sampling, conducting storm event monitoring, and producing an algal observation form for lake residents and visitors.

To raise awareness of the Partnership, encourage participation, and to hear stakeholders' concerns, three listening sessions were also conducted; one in Franklin on June 27th and two in Andover on July 11th and August 31, 2006. An Executive Summary of the Draft Watershed Management Plan was handed out and discussed at the latter session. During these listening sessions, nearly 50 participants shared their views, concerns, and suggestions about the most important aspects and pollutant sources that exist within the watershed. These include:

- One of the Plan outcomes should be that the City of Franklin connects Webster Lake waterfront and area residences to the sewer system or the report should evaluate the potential benefits of a possible sewer extension to the Webster Lake waterfront area.
- There could be unintended consequences of higher density development if a sewer extension is proposed for the Webster Lake waterfront area. The Partnership might be more effective if it works directly with owners of failing or failed septic systems vs. connecting them with a new City sewer.
- The newer septic system technologies allow for smaller leach fields, which means they will be closer to the water.
- The issue of a possible sewer line extension could become a political one with neighbors pitted against each other.
- Is it worth it to connect to the sewer if it will address 11% or less of the phosphorus loading into Webster Lake?
- Should there be a survey to determine residents' willingness and ability to pay the capital and ongoing costs to build and maintain a sewer line?
- The plan should focus on the phosphorus loading from Sucker Brook.
- Logging, road, and other runoff are adversely affecting Sucker Brook and its tributaries.
- Winter salt and sand applications on Webster Lake Avenue running into Webster Lake.
- Catch basins are never or not regularly cleaned: water is not running into them and they are not working (some residents are cleaning them themselves).
- A lot of sand and sediment runoff in the catch basins is coming from un-vegetated soils on private property and becomes part of the public (City) liability: Best Management Practices and other systems are needed on private property.
- A windshield survey found 72 locations where runoff directly entered Webster Lake.
- The plan should contain a graphic representation of the correlation between flow and runoff leading to phosphorous loading: this output could be GIS-based and on the Partnership website.
- Should VLAP and other monitoring be changed or increased to gain better data?
- Fireworks on Webster Lake are contributing to phosphorous loading.
- Do dishwasher detergent, dish soap, and laundry detergents adversely affect Webster Lake? Are there phosphorus-free alternatives?
- Will there be a study of current and potential development in the Plan? Will there be a build-out analysis?
- A sandbar has been forming and growing near the Sucker Brook outlet into Webster Lake and could be hindering flushing.
- Do tannins affect water clarity?
- Speed boating and the wakes that result seem to stir up turbidity.
- Should bacteria testing be part of the watershed evaluation?

- There are septic systems that are too close to the shore—how can the NH Department of Environmental Services allow this?
- There are new private septic system technologies that allow units to be installed even closer to the shore.
- Septic systems are causing phosphorus loading.
- Aren't there technologies to separate grey from black water and enable landowners to have holding tanks vs. septic systems?
- Higher and fluctuating water levels are eroding the shore—there is discussion about lowering the lake level.
- The Town beach area is a lot shallower than it used to be.
- The water is 8" lower than normal.
- Is the Maple Street dam size adequate to maintain the desired water level (is its size appropriate with increasing levels of development)?
- The effects if downstream surging from the Maple Street dam should be analyzed.
- Management of dams in needs to be more carefully monitored and coordinated between the two lakes because of the effect of flows and releases on Chance Pond Brook.
- There should be more analysis and management of Mill Pond.
- There should be a statistical analysis of precipitation patterns for the spring vs. summer in comparison to changes in water quality.
- The geomorphology of watershed tributaries should be analyzed—some have changed course or are eroding because of fluctuating flows.
- There has been a great deal of vegetation removal along Tilton Brook near the power lines.
- The Partnership should explore ordinances to require storm water detention and/or retention on sites vs. culverts and other direct flow to water bodies.
- Currently culverted water needs to be slowed down.
- Riparian protection zones should be considered in local ordinances.
- Steeps slopes should be taken into consideration to gauge the appropriateness of logging and development operations.
- Recent Maple Street logging activities have caused silt to deposit into the lake and woody debris to be discharged into the tributaries and the lake; a delta has formed at the mouth of the affected tributary.
- Blue-green algae do not currently seem to be a major issue but some anticipate that they could become a concern.
- Is there a relationship between increasing water temperatures coupled with additional nutrient loading—could this trigger blue-green algal growth?
- Oxygen levels have decreased.
- There is more in-lake native vegetation.
- The lakes should consider working with the Lake Host Program.
- Increasing boat traffic seems to increase shorefront erosion—can no wake zones or reduced speed limits be applied?
- Some would like to maintain the summer lake level year-round.
- Fireworks discharge has increased on the lake and goes on for many days—does this impact water quality?
- Grass clippings are flowing into water bodies.
- Unsecured docks are on the move in the lake(s).
- Traffic from launching and retrieving bob houses has caused erosion on the shore.
- The number of bob houses has increased.

Stakeholder input garnered during these listening sessions provided the Partnership with valuable local knowledge and serves as a record of observations and concerns in the Webster-Highland Lakes watershed and further informed discussions and decisions on water quality issues and management recommendations.

3

Existing Lake Water Quality Conditions and Possible Goals for Improvement

Lake Water Quality and the Eutrophication Process

Lake water quality conditions are often described in terms of trophic status and are typically categorized as either in an oligotrohic, mesotrophic or eutrophic state; terms that are used to describe the lake biological productivity. Lakes categorized as oligotrophic have low algal productivity and usually limited rooted aquatic plant growth, low phosphorus levels, clear water and adequate dissolved oxygen throughout the water column. Oligotrophic lakes are generally viewed as ideal for recreational purposes and aesthetic values. In New Hampshire, they are often larger and deeper than most lakes and may have limited development in the watershed on a relative basis. Eutrophic lakes are generally smaller and shallower with mucky, organic bottoms, extensive rooted plant growth, algae blooms that cause reduced water clarity and have depleted dissolved oxygen with increasing depth in the water column. These lakes are not well suited for recreational uses. Mesotrophic lakes generally exhibit water quality characteristics that are in between the range of oligotrophic and eutrophic conditions.

Eutrophication is caused by increased nutrient inputs, particularly phosphorus in most freshwater lakes. Nutrient enrichment can occur naturally through the natural erosion of sediments and through atmospheric deposition. It can also result from human activity within the watershed or around the lake. Human-induced eutrophication is often referred to as “cultural eutrophication” and associated nutrient enrichment can often stimulate or increase the level of lake biological productivity. Land use activities can significantly alter the amount of nutrients entering a lake. Studies have shown that the nutrient export from agricultural land and residential development, especially that of phosphorus, can be more than 5 and 10 times greater than that from forested lands, respectively (DES 1996; MeDEP 1992). Other activities that contribute to eutrophication include the use of fertilizers, faulty or inadequate septic systems, the discharge of detergent-laden water, erosion caused by excessive runoff flow or wave action, fecal matter from pets, livestock or waterfowl, dumping of organic matter (i.e. lawn clippings, leaves, etc.) and the disturbance of bottom sediments, to name a few.

As mentioned earlier, lake water quality conditions generally decline as algal production increases. The decline in water quality relates to reduced water clarity and often an increased abundance of floating algae and/or rooted plants. These changes initially represent more of nuisance and detract from the aesthetic appeal for recreational uses. Eventually, however, if conditions worsen, toxic forms of blue-green algae (cyanobacteria) may become abundant, which can be toxic to pets and humans if sufficient quantities are ingested. Additionally, where there are increased nutrient inputs, especially if they relate to manure spreading or generated by faulty septic systems, pet or waterfowl wastes, there may be an increased presence of harmful pathogens, such as *E. coli* bacteria, and increased human health risk.

Table 3.1 presents DES' Lake Classification Scheme to Determine the Tropic Status (i.e. level of biological productivity) for a given lake.

Table 3.1
NH DES Lake Classification Scheme to Determine Trophic Status

Category	Total Phosphorus Concentration (mg/l)	Secchi disk Transparency (meters)	Chlorophyll (ug/l)	Dissolved Oxygen (mg/l)	Rooted Plant Abundance
Oligotrophic	< 0.010	≥ 4.0	≤ 4	> 1 throughout water column	Sparse to scattered
Mesotrophic	0.010 -0.020	2.0 – 4.0	4- 15	< 1 in less than ½ of hypolimnion volume	Along most of shoreline
Eutrophic	≥ 0.020	≤ 2.0	≥ 15	< 1 in more than ½ of hypolimnion volume	> 1/3 of lake surface area
NH Median Value	0.011	3.3	4.4	na	na

Source: DES's Layman's Guide for Measuring a Lake's Trophic Status

These limnological parameters are all interrelated but are primarily driven by the in-lake phosphorus concentration. As in-lake phosphorus concentrations increase, then algal productivity will also increase resulting in higher chlorophyll *a* concentrations and lower transparency readings (as measured by a lower Secchi disk depth). Each 1.0 ug/l increase in chlorophyll *a* concentrations, generally results in a 1.0 to 1.5 foot decrease in transparency reading due to increased abundance of algae. As the algal biomass dies and sinks to the bottom, this causes greater oxygen demand due to decomposition. As the oxygen demand increases, a greater portion of the hypolimnion will become anoxic (i.e., without oxygen).

The eutrophication process is typically a slow, gradual process that may require thousands of years to produce measurable or distinct changes in limnological conditions. On the other hand, lake productivity can sometimes sharply increase on a temporary basis in response to some distinct periodic event associated with some major runoff event, erosion issue or some infrequent major discharge of phosphorus. The lake algae growth may increase dramatically for a relatively short period of time and then return back to more mestrophic or oligotrophic conditions. Thus, it is extremely important to maintain a long-term record of limnological conditions to be able to distinguish these short-term episodic events from long term water quality conditions.

It is much easier to prevent the eutrophication from advancing further through proper management controls than it is to try to reverse the progression once conditions have become apparent.

Often times, a lake may become more vulnerable to periodic nuisance algal bloom as its trophic state moves from oligotrophic levels toward eutrophic levels. Eventually, a relatively small increase in phosphorus can sometimes be enough to push a lake into an apparent higher productivity level, in a relatively short time frame even though the actual average trophic condition has not changed significantly. The old adage, "An Ounce of Prevention is Worth a Pound of Medicine" definitely applies to Watershed Management as well. It is much easier to prevent advancing trophic conditions through proper management controls than it is to try to reverse the advancement, once trophic conditions have become apparent. It also is generally much more expensive to reverse the trend that it does to try to prevent it.

Historical Limnological Data Since 1986

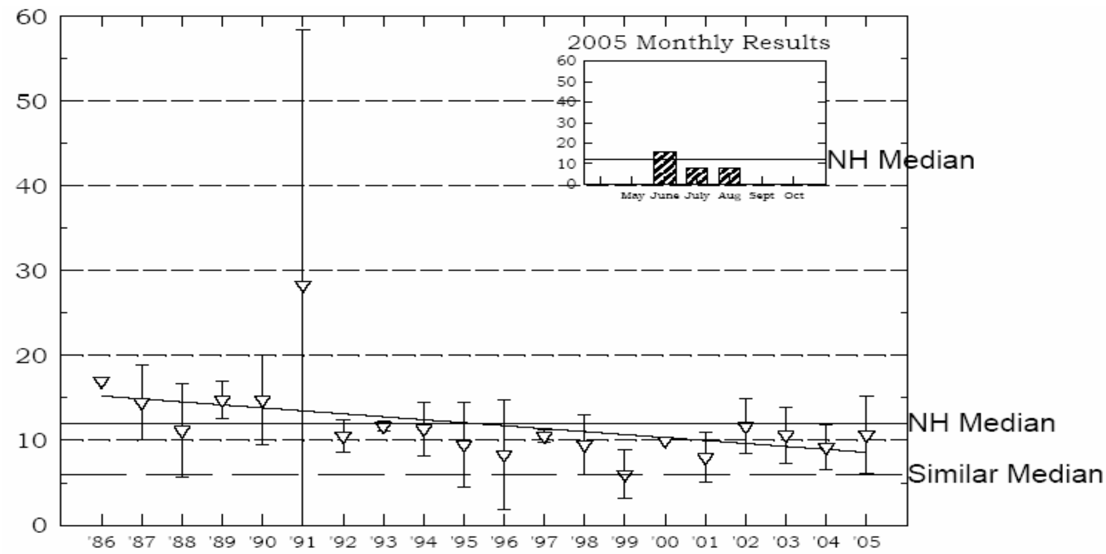
Both Webster and Highland Lake have been part of the DES Volunteer Lake Assessment Program (VLAP) for approximately 20 years. The VLAP volunteers are trained by DES to collect basic limnological measurements and water quality samples on a monthly basis during the summer months. The primary measurements or parameters analyzed include Secchi disk transparency (i.e., water clarity), chlorophyll *a*, and total phosphorus at various depths. As discussed above, these parameters represent the primary limnological indicators for determining in trophic status and monitoring changes. The following provides an overall assessment and discussion of trends for the 20 years of data collected in Webster Lake:

- ### Phosphorus Concentrations in Webster Lake

Total Phosphorus Concentrations in the Epilimnion

Figure 3-1 presents the maximum, minimum and average total phosphorus concentrations observed for each summer season in the epilimnion (upper water layer) of Webster Lake since 1986. Since 1992, the summer epilimnetic total phosphorus concentrations have averaged between 6 and 12 parts per billion (ppb). The maximum concentration during that time period was no greater than 15 ppb. Prior to 1992, the average concentrations were generally higher and closer to 15 ppb or slightly higher in one year. The maximum concentrations during the pre-1992 period were generally in the 18-20 ppb range and in one year, 1991, the maximum concentration was 59 ppb. This high level is an anomaly and was likely either due to a contaminated or unrepresentative sample or a reporting error. The trend line in Figure 3.1-1 indicates a declining trend in epilimnetic total phosphorus levels which suggests that nutrient loading may also be gradually declining. The 2005 Annual VLAP Report has reported that this declining trend is statistically significant. The historical average concentration is estimated to be 11.9 ppb based on the mean of the seasonal average concentrations for all 20 years and this would be very close to the median epilimnetic concentration of 12 ppb for all NH lakes in the VLAP system. However, in lakes with similar volumes and mean depth, the median epilimnetic phosphorus concentration is estimated to be 6.0 ppb which is significantly lower than that calculated for Webster Lake. Based on DES guidelines for lake trophic status classification, the seasonal average phosphorus concentrations would place Webster Lake in the low to mid "mesotrophic" category.

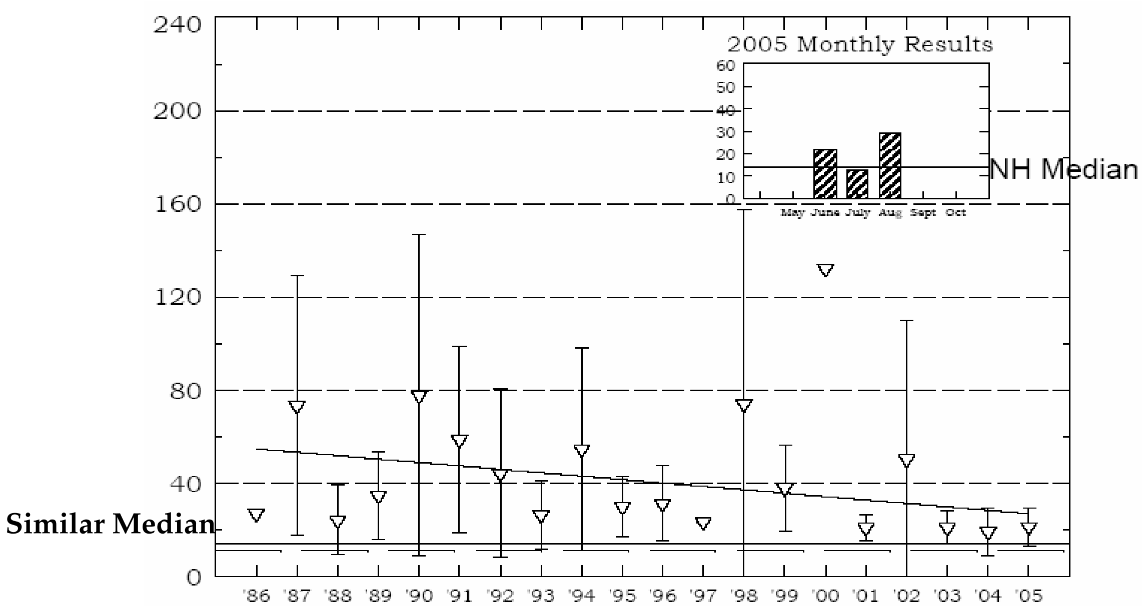
Figure 3.1-1
Historical Total Phosphorus Concentrations (ug/l) in the Epilimnion of Webster Lake



The historical total phosphorus levels in the hypolimnion (deep water layer) have generally been much higher and consistently above the median level observed in other NH Lakes for the entire period of record. Average concentrations (taken at mid-depth of the hypolimnion) ranged from low of around 20 ppb in 2001, 2003, 2004 and 2005 to highs of 80 and 130 ppb in 1990 and 2000, respectively. Maximum concentrations have exceeded 100 ppb in 7 out of the 20 years in the database. The higher phosphorus levels in the hypolimnion are due in large part to the anoxic conditions that are prevalent in deeper waters. Phosphorus tends to be released from bottom sediments and organic matter in low oxygen environments. As stated earlier, as algae dies and sinks to the bottom, the decomposition of this material consumes oxygen and can contribute to anoxic conditions. Organic loading from other sources such as decaying aquatic plants tributary sources may also create an oxygen demand in deeper lake waters.

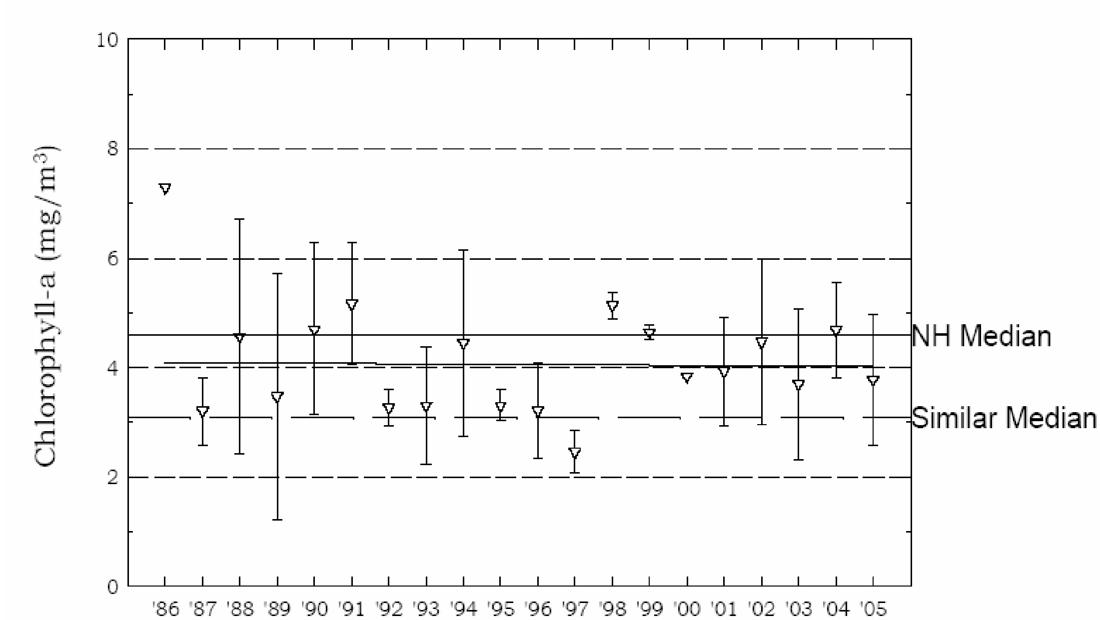
Similar to the epilimnetic phosphorus concentrations, the data show that phosphorus concentrations in the hypolimnion were considerably higher in the late 1980's and early 90's. Importantly, phosphorus levels in both the epilimnion and the hypolimnion show statistically significant declining trends. Interestingly enough, the phosphorus concentrations in both the epilimnion and hypolimnion were relatively low from a historical perspective in the summers of 2003 and 2004 when the nuisance algal blooms were observed. This may suggest that other factors or very localized conditions may have contributed to the algae blooms in Webster Lake may that may not be entirely reflected in the available phosphorus data measured in the middle of the Lake.

Figure 3-2
Historical Total Phosphorus Concentrations (ug/l) in the of Hypolimnion of Webster Lake



Chlorophyll *a* Concentrations

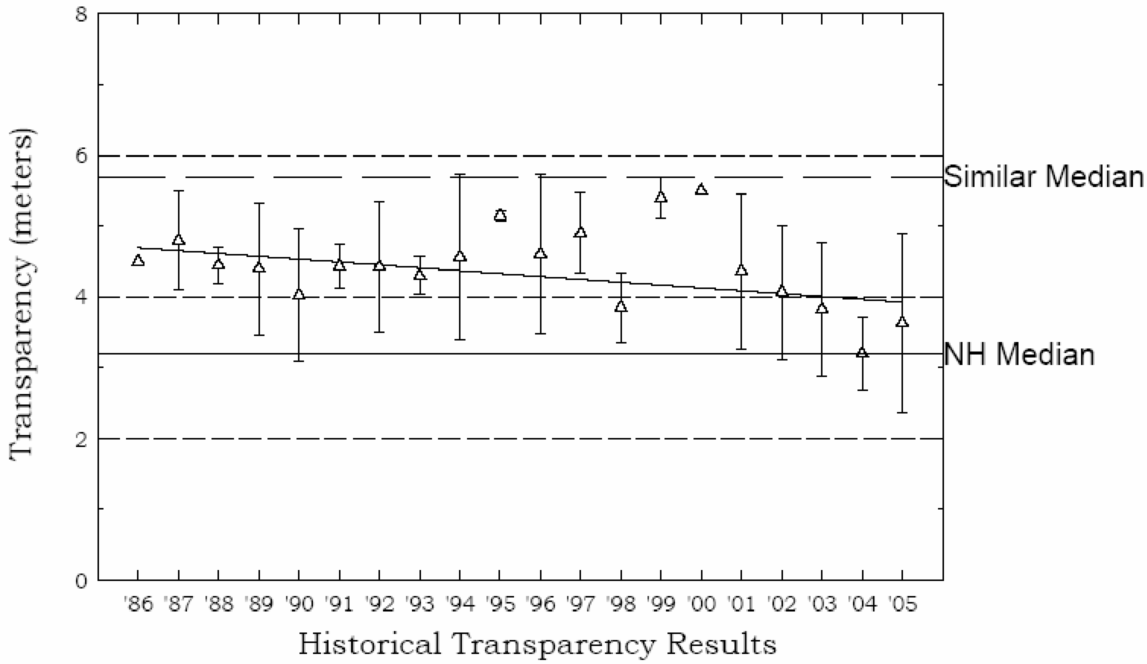
Chlorophyll *a* is a measure of the chlorophyll content of algae and is well correlated to water quality and trophic state. DES guidelines indicate chlorophyll *a* levels less than 4 ppb are indicative of oligotrophic or "good" conditions (0-5 ppb) while values in the 4-15 ppb range indicate mesotrophic conditions or "more than desired" levels. In Webster Lake, chlorophyll *a* concentrations have historically averaged between 3 and 5 ppb for the summer months, with recent maximum values almost always less 6 ppb. These average levels would result in a "good" classification, somewhat better than the NH median of 4.6 ppb. Even so, some of the maximum values exceed the "good" category, and while not at "nuisance" levels (>15 ppb), they would place occasional Webster Lake chlorophyll *a* values at "more than desired" levels. There is no statistically significant trend in the long-term chlorophyll *a* data which suggests that concentrations are neither increasing nor decreasing. Given the natural variability of phytoplankton activity, this is not unexpected.



- **Secchi Disk Transparency**

The historic summer Secchi disk readings have generally averaged around 4 to 5.5 meters (13 to 18 feet). According to the DES guidelines, these values are in the "good" to "exceptional" category, and considerably better than the NH Lake median value of 3.3 meters. However, lakes with similar mean depth and volume appear to have better transparency with a median Secchi depth reading of 5.8 meters. The 2005 Annual VLAP Report indicates that there is a statistically significant, declining trend in Secchi depth readings. This is especially true in the last 4 or 5 years which is not consistent with either the total phosphorus or chlorophyll *a* data. The worst year for transparency appears to be in 2004, with an average Secchi depth reading of 10 feet or 3.3 meters, which is the lowest in the 20 year history. This low transparency could be partially explained by chlorophyll *a* values for 2004, but total phosphorus data do not support either elevated levels of chlorophyll *a* or reduced Secchi depth. Conditions in 2005 appear to be slightly worse in terms of total phosphorus than in 2003 and yet there were no noticeable blooms of cyanobacteria in 2005. It is difficult to explain why cyanobacteria became so abundant in 2003 and 2004 but not in 2005. It is also unclear as to why transparency has diminished in recent years despite the improving or declining trend in phosphorus concentrations. If the reduction in transparency is due to increased turbidity from sediment erosion and related soil disturbances or storm events, then the summer of 2006 should have particularly poor transparency conditions given several extreme storm events that occurred in May and June.

Figure 3-4
Historical Average Secchi Depth Readings in Meters
(Water Transparency) for Webster Lake



Summary of VLAP Water Quality Data

The historical trend in the VLAP data suggests the total phosphorus and chlorophyll a concentrations are improving. However, even with these improvements, Webster Lake has experienced some recent occasional water quality problems with the nuisance algal blooms that occurred during the summer of 2003 and 2004. A notable algal bloom is usually linked to a recent influx of phosphorus in the water column either from "external" or "internal" sources. However, according to the VLAP data, the phosphorus concentrations during these two seasons were at historical low levels based on monthly sampling. Thus, it is unclear as to what caused these particular nuisance algal blooms. Phosphorus influxes could result from either "external" loading such as that from a major storm event, shoreline disturbances, construction activity, timber harvesting or a major septic system failure or from "internal" loading that could result from hypolimnetic or metalimnetic water being entrained in the upper surface waters.

With respect to possible "external" sources, if the possible cause for the previous blooms in 2003 and 2004 was related to major storm events and associated runoff, then similar blooms would have been expected in the summer of 2006 when several unusual intense storm events occurred in May and June of 2006. In May, the region had what was later determined to be a 100-year flood event with nearly 6.0 inches of rain in 24 hours and about 10.0 inches of rain over a 36–hour period. In June, there were at least two or three storms that had 2.5 to over 3.0 inches of rain in a matter of hours causing very high turbidity and sediment loads in the area streams. Based on the preliminary VLAP data collected in the summer of 2006, there were no unusually high phosphorus concentrations observed in the epilimnion and hypolimnion nor were there any unusual algal blooms reported. No other anecdotal evidence has been mentioned or discussed by local residents during the public hearings with respect to any unusual construction or other soil disturbance activities that may have occurred during the summers of 2003 and 2004.

With respect to the possibility of internal loading from the hypolimnion, typically over the course of the summer, the epilimnion volume increases or deepens as a result of entrainment of metalimnetic water into the epilimnion and hypolimnetic water into the metalimnion. Entrainment accelerates during the late summer and early fall with cooling temperature until complete top-to-bottom mixing is achieved. The potential influence of hypolimnetic entrainment on algae growth depends primarily on the magnitude of phosphorus concentrations in the hypolimnion and the relative difference in volumes between the epilimnion and hypolimnion. The potential change in the in-lake phosphorus concentration can be assessed by assuming complete mixing of the hypolimnion volume with the epilimnion volume with a predetermined phosphorus concentration, as discussed below.

The total volume of the lake it is estimated be approximately 452 million cubic feet. In review of Webster Lake's bathymetric data, about 80 % of this lake volume is contained in the upper 10 feet of water. Review of the historical dissolved oxygen/temperature profiles suggests that the hypolimnion during the summer stratification period consists of the volume of water below approximately 20 feet in depth. Although 20 feet is more than 50% of Webster Lake's maximum depth, this amount of water below 20 feet represents only 5% of the total Webster Lake volume (about 27 million cubic feet). Thus, if all the hypolimnetic water were to completely mix with the epilimnetic water and the typical phosphorus concentrations in the hypolimnion were around 20 to 30 ppb, the resulting increase in the epiliminion would, at most, be only 1.0 to 1.5 ppb. Since this type of complete mixing only occurs during the early to mid-fall when water temperatures have cooled, the potential increase in the phosphorus concentration resulting from localized mixing or partial entrainment of the hypolimnion due to turbulence from boating activity or wind effects would likely be much less than 1.0 ppb. An increase of 0.5 to 1.0 ppb in the in-lake phosphorus concentration is not likely to cause a significant nuisance algal bloom similar to that observed in 2003 and 2004.

Existing Phosphorus Loading ("Budget") Analysis

Phosphorus concentrations in lakes are primarily a function of the phosphorus inputs or loading from the watershed over time and the hydraulic characteristics of the lake. Depending on the size of the lake and its flushing rate, the phosphorus concentrations observed in a lake are generally reflective of the amount of phosphorus contributed during the course of a year. Limnologists typically express the estimated phosphorus contributions or loads from each of the known sources in the watershed in terms of an "Annual Loading Budget". There are three basic approaches to developing a phosphorus budget including a measured mass balance approach, a land use export modeling approach or the use of model equations to back calculate the watershed load based on the observed in-lake concentration.

The measured mass balance approach involves frequent measurements of the stream flow rates and in-stream concentrations on a subwatershed basis. Depending on the sampling period and frequency of sampling this approach is generally considered the most accurate but also the most time-consuming and is relatively expensive. This approach may underestimate potential loads if storm event sampling was insufficient to capture peak concentrations and flow rates. The land use export model approach relies on assumed loading rates for various types of land uses based on rates expressed in the literature. This method is generally less accurate and difficult to validate to site-specific conditions but can be useful to evaluate the potential effects of various management alternatives. Various models (equations) have been established using statistical analysis of empirical data to express the relationship between phosphorus loading and in-lake concentrations while accounting for the lake's mean depth and flushing rate. The Vollenweider equation (1976) is one of the more widely used procedures for this analysis that has been considered to be reasonably accurate for calculating the likely in-lake concentration for a given annual phosphorus load and vice-versa. Internal loading from bottom sediments, however, is generally not factored into the equation and the equation assumes the lake is in a steady-state, well mixed condition and, in other words, not thermally stratified into eplimnion and hypolimnion.

The Dufresne-Henry (DH) Study (1981) developed a detailed phosphorus loading analysis using a modified mass balanced approach by collecting phosphorus concentration data from the lake's tributaries, and then estimating the hydrologic inputs based on extrapolated data recorded from the nearby USGS gauging station on the Swift River in Bristol, NH. The results provided reasonably accurate estimates of annual phosphorus inputs from the tributaries to Webster Lake. During the Diagnostic-Feasibility (D-F) study conducted by DES in the late 1980's, additional phosphorus concentration and flow data were collected within various sub-watersheds within the overall Sucker Brook watershed, which helped to identify where the highest increases in phosphorus loading were occurring in the Sucker Brook watershed. The phosphorus inputs from rainfall were also based on measured data.

Table 3.5 presents the estimated annual phosphorus inputs for four main sources during a normal or average precipitation year. The assumptions and methods used in developing these estimates are discussed in detail in the sections below:

Table 3.5
Phosphorus Loading Estimate Based on Dufresne-Henry Study (Normal Year)

Major Source Area	Amount (Kg/yr)	% of Total
Tributaries	458.7 Kg	74.1 %
Rainfall	68.1 Kg	11.0 %
Dry fall	20.4 Kg	3.3 %
Septic Systems	71.3 Kg	11.5 %
	618.5 Kg	100 %

The D-F study results indicated that Sucker Brook, which is the primary tributary to the Lake, contributes about 63% (or 391.4 Kg) of the total annual phosphorus load to Webster Lake while the remaining tributaries account for about 11% of the total annual load. The Sucker Brook load estimate was based on an average in-stream phosphorus concentration of 0.019 mg/l based on biweekly grab sampling results collected over the course of a year and the average annual total hydrologic inflow. The Sucker Brook watershed, which includes Highland Lake accounts for about 80% of the total watershed area draining to Webster Lake. Individually, each of the other tributaries accounted for less than 2.5% of the annual phosphorus total. The estimated average in-stream phosphorus concentrations in the other tributaries ranged from 0.005 to 0.043 mg/l.

Use of Vollenweider Equation to Calculate In-Lake Phosphorus Concentrations

The Vollenweider equation describes the relationship between annual phosphorus loading and in-lake concentrations as influenced by the primary lake response characteristics including mean depth and hydraulic residence time. The equation was derived as a result of a five year study involving over 200 water bodies in 22 different countries (DES 1990: EPA 2005). The equation is widely used to predict the average in-lake phosphorus concentration based on an estimated average annual phosphorus load. The equation can also be used to estimate an acceptable or permissible load to maintain a desired or targeted in-lake phosphorus concentration. The components of the equation are described below:

Vollenweider Equation

$P = (Lp/qs) \times (1/(1 + \sqrt{z/qs}))$;

Where;

P = mean in-lake phosphorus concentration (mg/l);

Lp = annual phosphorus load / lake area, (grams/m^2/year);

z = mean depth (meters)

T= hydraulic residence time = lake volume/annual outflow volume.

qs = areal watershed = z/T

Assuming:

Estimated P Load is 618, 543 grams /year and

Lake area is 2,477,573 m^2, then 618,543 gms/2,477,573 m^2 = 0.250 gm/ m^2/yr.

z = 5.7 meters

T = Lake volume =$1.4 \times 10^7 m^3$ / outflow volume = $2.71 \times 10^7 m^3$ (DES 1991)

= $1.4 \times 10^7 m^3 / 2.71 \times 10^7 m^3$ = 0.52 yr.

qs = mean depth / hydraulic residence time = z/T = 5.7m /0.52 yr = 10.96 m /yr

Thus,

In-Lake P conc. (mg/l) = $(.250 / 10.96) \times (1/ 1 + (\sqrt{5.7/10.96}))$ **= 0.013 mg/l**.

Based on the current estimated annual phosphorus load of 618.5 Kg per year for Webster Lake, the in-lake phosphorus concentration for Webster Lake, using the Vollenweider equation, is estimated to be 0.013 mg/l. This concentration compares very well to the average historical phosphorus concentration of 0.012 mg/l observed in the eplimnion as reported in the VLAP data. Since a major assumption in using the Vollenweider equation is that the lake is well mixed and there is no stratification, the equation may underestimate phosphorus concentrations in lakes that thermally stratify and have higher concentrations at depth such as in the case of Webster Lake. Thus, the actual historical in-lake concentration in Webster Lake would likely be slightly higher if the hypolimnion concentrations were included in the average. Recently, on April 3, 2006, a surface water sample was collected in Webster Lake, immediately after ice-out, when lakes are typically in a well-mixed condition. The phosphorus concentration was reported to be 0.015 mg/l or 15 ppb, which suggests that the average in-lake phosphorus concentration during well-mixed conditions for the entire lake volume may be slightly above the average summer eplimnetic concentration.

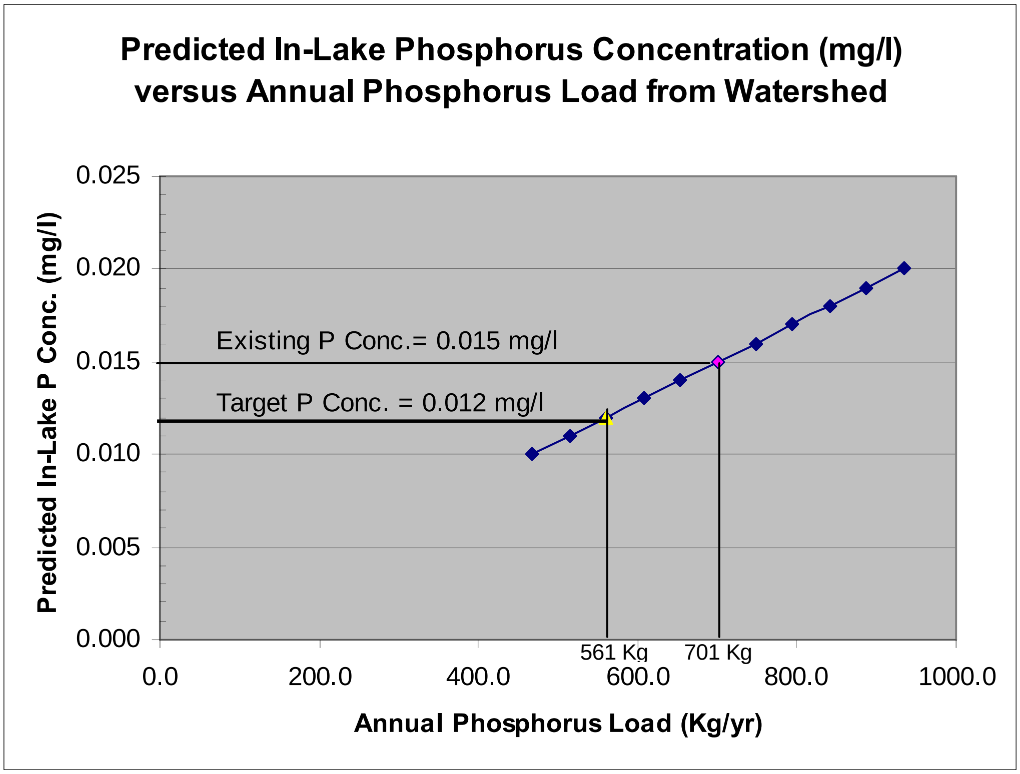
In addition, application of a widely used land use export model (discussed in Section 4.0) suggests that phosphorus loading to Webster Lake could be higher than indicated by the Dufresne-Henry study under well-mixed conditions. These modeling results combined with measured in-lake phosphorus levels at ice-out lead us to conclude that the "true" or "well-mixed" in-lake phosphorus concentration in Webster Lake is more likely 15 ppb instead the 12 ppb that is typically reported by VLAP for the epilimnion or 13 ppb reported in Dufresne-Henry study using the Vollenweider model.

Although the difference between 12 ppb and 15 ppb seems relatively small, it is important to recognize that an average in-lake phosphorus concentration of 0.015 mg/l would indicate that Webster Lake may be transitioning to more mesotrophic/eutrophic conditions rather than oligotrophic /mesotrophic conditions as previously indicated in the Dufresne-Henry study and the 1990 Diagnostic-Feasibility study. At a minimum, it will be important to prevent the in-lake phosphorus concentration from increasing above 15 ppb where one would anticipate algal blooms to become increasingly more common and perhaps for longer durations during the summer months.

Recommended Phosphorus Reduction Goal to Reduce In-Lake Phosphorus Concentrations and Improve Water Quality Conditions

To improve existing water quality conditions, a reasonable goal would be to try to reduce the existing in–lake phosphorus concentration by 2 to 3 ppb to maintain an average in-lake phosphorus concentration closer to 11 or 12 ppb, rather than 13 to 15 ppb. This may seem like a minor difference in concentrations but lake water quality conditions, in terms of water clarity and algal productivity, can be substantially different with an average phosphorus concentration closer to 12 ppb as opposed to 15 ppb. This would provide a buffer against any short-term, episodic influxes similar to those that may have caused the algal blooms in 2003 and 2004. It also allows for some reasonable amount of residential growth that is likely to occur in the watershed in the future. This is consistent with the findings of the previous DES D-F study, which concluded that the Lake was essentially at capacity in terms of phosphorus loading and any future increases would likely result in a decline in water quality conditions.

Using the Vollenweider equation, it estimated that the existing phosphorus load would need to be reduced by about 94.0 Kg/yr to lower the in-lake concentration by 2 ppb and perhaps as much as 140 Kg /yr to lower the concentration by 3 ppb. These load reductions represent about 18 % and 26 %, respectively, of the existing estimated phosphorus load contributed from tributaries and septic systems (i.e. 530 Kg/yr). The next sections describe how this might be accomplished. To strive for even greater reductions may be cost-prohibitive.



4

Estimates of Annual Phosphorus Loads for the Various Sources

This section provides a general assessment of the phosphorus contributions from the various known sources within the watershed and around the shoreline of the Lake. In addition, the various opportunities, limitations and potential costs associated with implementing various control measures that are available to minimize inputs are also discussed. The assessment of the potential phosphorus contributions is based on a combination of previous sampling results, recent watershed modeling done as part of this study and the findings of other studies reported in the literature. In addition, local observations and information provided by members of the Partnership Group and the general public during the public "Listening Sessions" have also been included in this source identification and assessment. The sources are subdivided into two major categories including those in the watershed and those on or along the shoreline of the lake.

Watershed Sources:

Residential Development
Timber harvesting
Pastureland/Manure Spreading / Storage
Storm Runoff from Road Surfaces – Dirt and Paved Roadways

In-lake or Shoreline Sources:

Shoreline Septic Systems
Lawn Maintenance
Sediment Disturbances from Boating Activity
Ice fishing and "bob-house" launching and retrieval
Fire works
Pet Wastes

STEPL Model Analysis

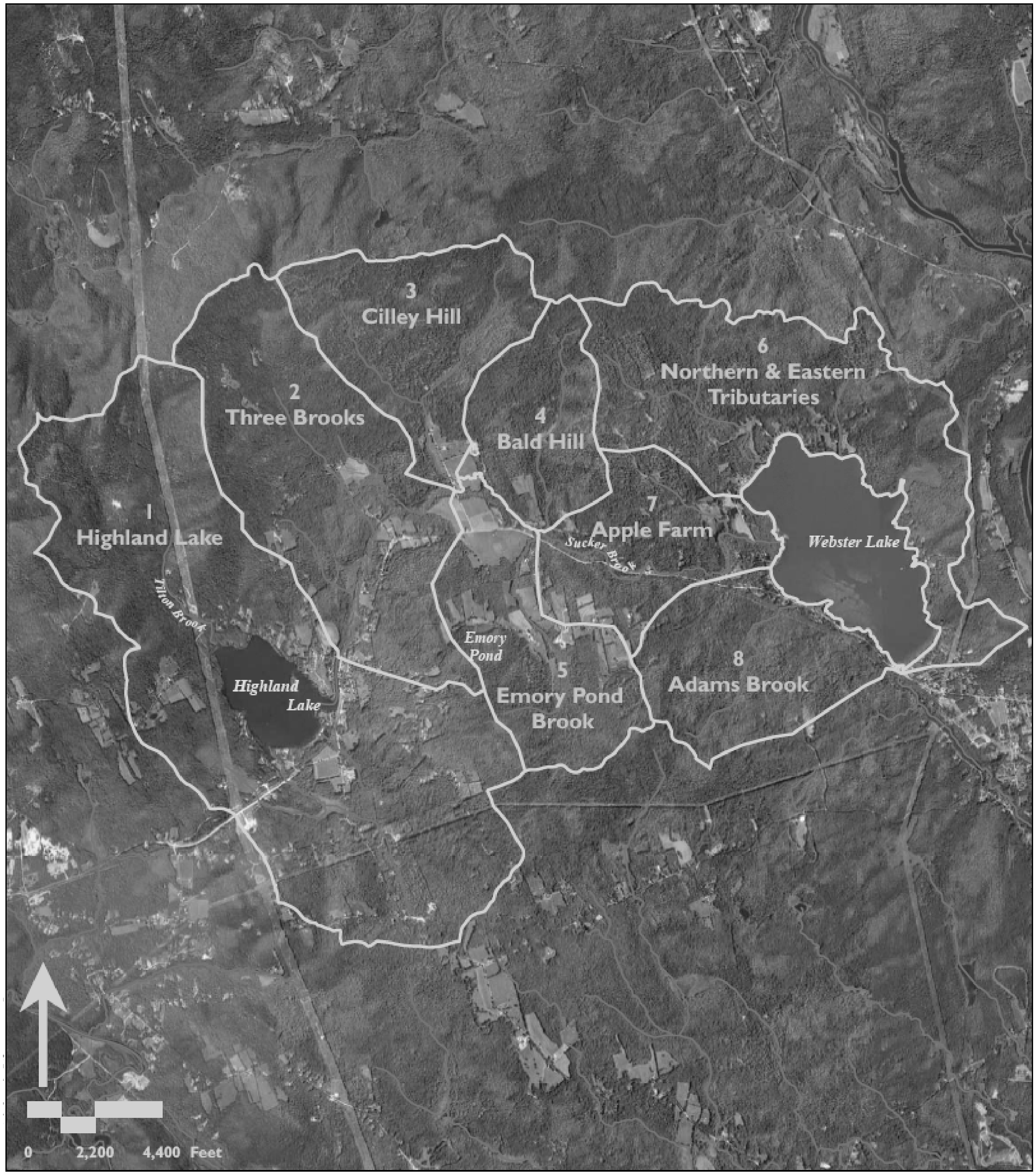
The Spreadsheet Tool for Estimating Pollutant Loading (STEPL) Model is designed to estimate annual nutrient and sediment loads conveyed by surface runoff on a watershed basis. The STEPL Model was developed for the EPA to specifically evaluate the effectiveness of various agricultural related management practices. Annual runoff is determined using the NRCS curve number method that is adjusted for land use conditions and the predominant soil type within the watershed. The relevant precipitation data were based on historical data recorded at the NWS station in Bristol, NH and includes average annual runoff total (inches), average storm rainfall amount and the average number of rainfall days per year. Sediment loads are computed based on the Universal Soils Loss Equation (USLE). The model contains default values for each of the USLE components including the rainfall erosiveness factor (R), soil erodibility factor (K), topographic factor (LS), crop or cover factor (C) and the land management practice factor (P). The estimated nutrient loading is based on the computed annual runoff volume combined with an estimated initial nutrient concentration in runoff adjusted for each land use. The initial concentration can be adjusted by the model user. The nutrient component associated with eroded sediment is also included in the total nutrient loss estimate for the watershed. An initial nutrient concentration in native soils is also included in the model. The model contains expected treatment efficiencies for numerous Best Management Practices (BMPs) that can be evaluated to estimate potential nutrient load reductions through BMP implementation.

The model was used to simulate phosphorus and sediment loads from each of the eight sub-watershed areas that were originally delineated as part of the phosphorus budget conducted back in 1991 DES Diagnostic/Feasibility study (See Figure 4-1). Table 4-1 provides a breakdown of the various land uses within each of the eight sub-watershed areas. The land use categories evaluated include residential development, forested areas, pasture land areas, roadway area.

Table 4-1
Summary of Land Use Areas within Each Subwatershed for Input in STEPL Model

	Area (acres)					
Watershed Area	**Residential**	**Pastureland**	**Forest**	**Roadways**	**Feedlot**	**Total**
W1- Highland Lake	168	180	2701	34	0	3083
W2- Three Brooks	23	102	1429	15	0	1569
W3- Cilley Hill	2	41	839	5	0	887
W4- Bald Hill Brook	2	40	529	2	0	573
W5- Emory Pond Brook	6	224	571	7	0	808
W6- North & East Tribs	104	1	1470	11	0	1586
W7- Apple Farm	23	113	556	13	0	705
W8- South West Tribs	43	6	725	6	0	780
Totals	371	707	8820	93	0	9991

Sources: Based on GIS land cover data contained in the NH GRANIT System and 2001 Lakes Region Planning Commission Land Use data with minor adjustments based on a 2003 Digital Ortho-photo.



Legend

Stream (USGS)

Webster Lake Sub-Watersheds

Figure 4-1

Webster Lake Sub-Watersheds

Franklin & Andover, New Hampshire

Source: Digital Orthophoto captured in 2003 by NAIP and distributed by NH GRANIT.

Vanasse Hangen Brustlin, Inc.

The overall objective was to try to replicate the previous load estimates that were developed as part of the 1990 D-F study for each of the sub-watersheds as well that in the earlier 1981 D-H study. The previous load estimates developed in these studies were based on sampling data collected in tributaries during dry and wet-weather events on a sub-watershed basis but not on a land use specific or individual source basis. The STEPL model does not compute the nutrient contributions from groundwater or base flow. Soils data for the USLE were based on the default values provided by the model and adjusted to representatives general soil types of the Merrimack County. It was assumed that Hydrologic Soil Group C soils were the predominant soil type throughout the watershed area with respect to runoff and infiltration calculations. Sub-watershed areas were determined using Arc Info Vers.9.0 software and NH GRANIT data layers containing USGS topographic and elevation data.

The following presents the selected phosphorus concentrations in runoff used to represent the various land uses based on the literature values presented in Table 4-2.

Table 4-2
Initial Phosphorus Concentrations in Runoff for Each Land Use

	Phosphorus Conc. (mg/l)
Forest	0.015
Pasture	0.30
Residential	0.50 (single family)
Roadways	0.50

Initial Soil P Conc. = 0.031 mg/kg

Table 4-3
Literature Values for Total Phosphorus Concentrations (mg/L)
in Runoff for Various Land Uses

Literature Source	Residential	Pastureland	Forest	Roadways
Default Values for STEPL Model [1]	0.04	0.04	0.015	0.05
National EMC Values[2]	0.40	1.04	0.13	0.35
Schueler[3]	0.46		0.15	
Default Values for Watershed Mgt Model (WMM)[4]	0.52	0.37	0.11	0.43
DES Guidance for Pollutant Loading Estimates[4]	0.40	na	na	0.55
Rhode Island DEM[5]	0.62	na	0.061	0.49

Sources: [1]STEPL User's Guide Manual
[2]CDM, 2004. Merrimack River Watershed Assessment Study;
[3]Schueler, T. 1987. Controlling Urban Runoff; a Practical Manual for Planning and Designing Urban BMPs. Metropolitan Washington Council of Governments. Washington, D.C.
[4]NH DES. 2005. Interim Guidance for Estimating Pre and Post Development Pollutant Loads, October 17, 2005.
[5]Rhode Island Department of Environmental Management: State of Rhode Island Storm Water Design and Installation Standards Manual. September 1993.

Septic system contributions were also estimated using the model based on the input data presented in Table 4-4. The estimated number of septic systems was based on a number of sources including the D-H study septic survey information for sub-watersheds W6, W7 and W8 around Webster Lake, aerial photos for sub-watersheds W2 through W5 and an estimate provided by the Town of Andover, Planning Board Chairman for the Highland Lake sub-watershed. The potential failure rates represent general estimates of the amount of area with shallow seasonal high water tables (i.e., < 18 cm) particularly around the Webster lake shoreline (See Figure 4-2). Based on the Merrimack soil county data, about 36% of the shoreline area (i.e., within 300 feet of the lake) have a shallow depth to the seasonal high water table of less than 24 cm (~10-inches) during the wetter portions of the year. Fortunately, these areas do not coincide with the more densely developed portions of the shoreline such as along Webster Avenue. Thus, it was generally assumed that about 10% of the existing septic systems are located within these soil types and could be potentially failing or poorly functioning. This is reasonably consistent with the D-H study, which estimated that nearly 17% of the septic systems were failing due to shallow seasonal high water tables. It was assumed that some of the shoreline homeowners in these areas had upgraded their systems since the early 1980's. Around Highland lake, only 5% of shoreline was estimated to have a shallow seasonal high water table. The model default value failure rate of 2% was used in the other watersheds.

Table 4-4
Septic System Input Values Used
in the STEPL Model for the Various Sub-watersheds

Watershed	No. of Septic Systems	Population per Septic System	Septic Failure Rate, %
W1- Highland Lake	80	2.43	5
W2- Three Brooks	30	2.43	2
W3- Cilley Hill	2	2.43	2
W4- Bald Hill Brook	2	2.43	2
W5- Emory Pond Brook	7	2.43	2
W6- North & East Tribs	126	2.43	10
W7- Apple Farm	25	2.43	10
W8- South West Tribs	25	2.43	2
Total	297		

Model Results

Table 4-5 presents the results of the STEPL modeling analysis, which indicates a total annual phosphorus loading of 642 Kg from the watershed. This load estimate is about 4 % higher than the previous estimate of 618 Kg presented in the DES D-F study, which includes the direct precipitation and dustfall contributions. The tributary and septic system portions of the D-F estimate were 459 and 71.3 Kg per year, respectively. The tributary and septic system portions of this STEPL Model estimate were 539 and 103 Kg/yr, respectively, or roughly17 and 30% higher than the previous estimate. These higher estimates may reflect more conservative assumptions in included the STEPL Model and may also be more representative of storm runoff related inputs that may or may not have been fully captured in the sampling data.

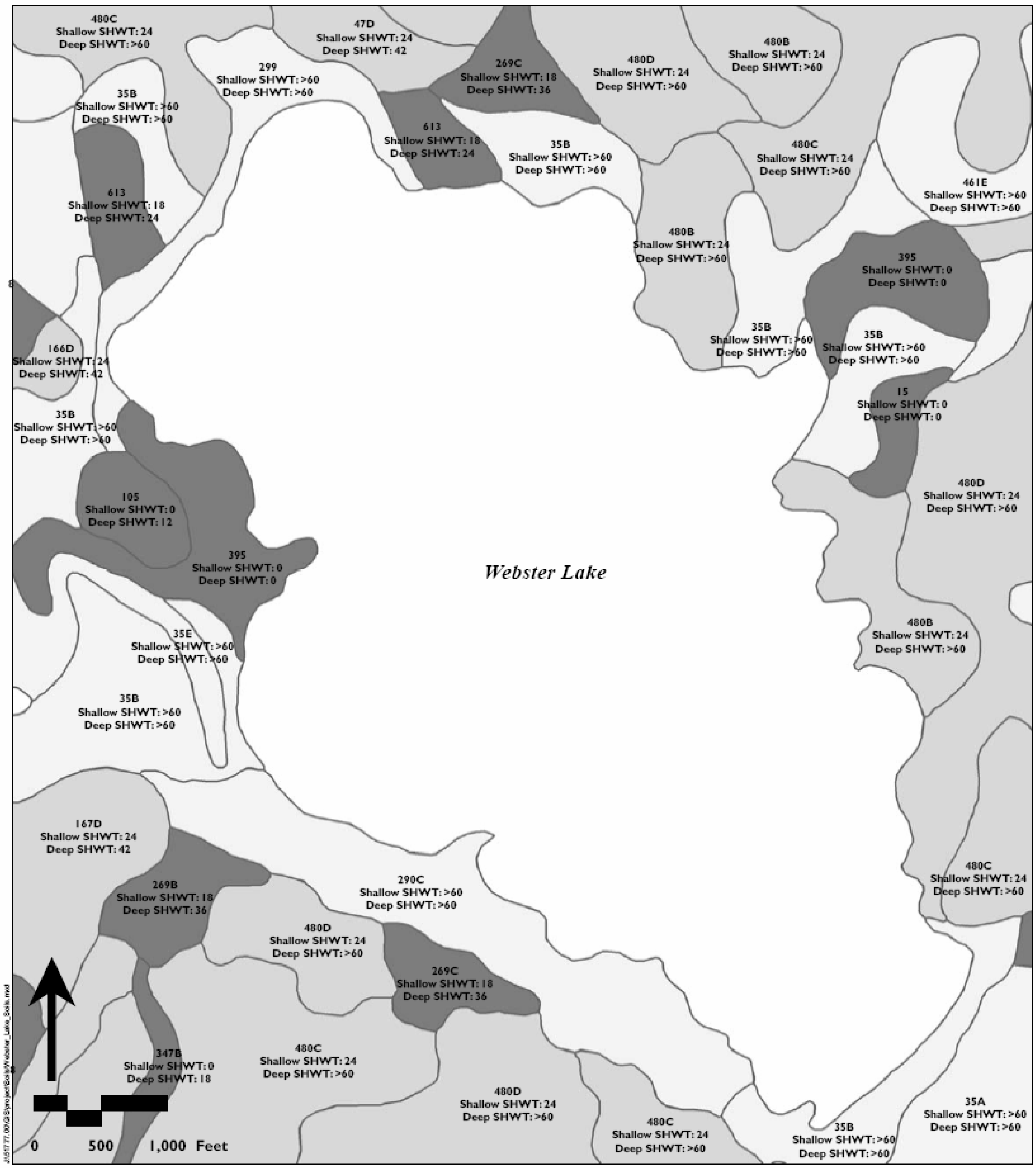
These model results suggest that runoff from pasture land may account for nearly 34% of phosphorus load from the watershed. This is somewhat consistent with sampling results observed in the D-F study, which showed that pasture area was one of the leading sources of phosphorus, especially during certain months of the year when manure spreading takes place. Residential areas accounted for another 26% of the estimated existing load, followed by forested areas at roughly 20% of the total load even though the initial phosphorus concentration in runoff is relatively low. Septic systems and roadways account for 16% and less than 10%, respectively, of the total load. The septic system contribution as a percentage of the total is consistent with the previous D-F study estimate. Although roadway area was suspected to be major source contribution, the results of this modeling suggests it is a relatively small contributor even with a relatively high concentration used in the analysis.

Table 4-5
Estimated Phosphorus Load by Land Use Using the STEPL Model

	Phosphorus Loading By Land Use (Kg/yr)					
Watershed Area	**Residential**	**Pastureland**	**Forest**	**Roadways**	**Septic**	**Total**
W1- Highland Lake *	42.0	32.7	23.3	13.6	12.2	124
W2- Three Brooks	10.5	34.9	23.7	11.1	3.3	84
W3- Cilley Hill	0.9	14.5	14.7	3.8	0.2	34
W4- Bald Hill Brk	0.9	14.5	9.6	1.5	0.2	27
W5- Emory Pond Brook	2.7	79.7	10.1	5.3	0.8	99
W6- North & East Tribs	47.3	0.3	24.4	7.9	69.5	149
W7- Apple Farm	10.5	40.5	9.9	9.7	13.8	84
W8- South West Tribs	19.5	2.2	12.8	4.1	2.8	41
Totals	**169**	**219**	**128**	**57**	**103**	**642**

Notes: * The Highland Lake load was reduced by 45 % to reflect the likely amount of estimated phosphorus load that is retained within the Lake.

For purposes of comparison on a sub-watershed basis, the phosphorus load estimates from previous DES D-F study for the Highland Lake outlet, Bald Hill Brook and Emory Pond Brook sub-watershed were 81.0, 13.8 and 69.5 kg/yr, which are roughly 30 to 50% lower. Although these recent estimates generated by the STEPL model are higher, they are considered to be reasonably valid for use in evaluating the effects of various alternatives. The following sections provide a more detailed discussion of the estimated phosphorus contributions from each of various land uses as well as other sources, based on the existing data available, as well as an assessment of the potential load reductions that could be achieved through various treatment measures.



Legend

Seasonal High Water Table (SHWT) Depth

- Shallow (0-18 cm)
- Moderate (>18-60 cm)
- Deep (>60 cm)

Figure 4-2

Webster Lake: Soils with Seasonal High Water Tables

Franklin
New Hampshire

Source: Soil data is from NRCS, Distributed by NH GRANIT.

Vanasse Hangen Brustlin, Inc.

Watershed Sources

■ Residential Development

Studies have shown that the nutrient export from residential development can be more than 10 times greater than that from forested lands on a per acre basis (MeDEP 1992: DES 1996). The principal causes are three-fold: 1) as impervious areas increase due to roadways, driveways and rooftops so does the volume of runoff carrying various pollutants which ends up in the stream rather infiltrating back in the ground; 2) the increased volumes tend to wash off more sediments and cause erosion in channels and 3) new sources of nutrients introduced as they relate to lawn and garden fertilizers, grass clippings pet wastes and septic systems. Other studies have found that as the percent imperviousness rises above 10% in a watershed, downstream stream channels become more vulnerable to channel scour and stream bank erosion due to the increased peak flow rates (Schuler 1997).

Existing residential area accounts for less than 3% or about 371 acres of the overall Webster Lake watershed.

With respect to Webster Lake, the problem is not so much the existing residential development but the potential for future development in the watershed as development pressures continue to spread further out from the existing developing communities. Existing residential area accounts for less than 3% or about 371 acres of the overall Webster lake watershed, according to land use data generated by the Lakes Region Planning Commission using 2001 statewide aerial photography. This is a relatively small percentage in comparison to other lake watersheds in New Hampshire, particularly in the southern half of the state. The existing residential area is, however, highly concentrated with nearly 75 % of the existing residential area along the shorelines of both Highland and Webster Lake. The residential area in the Highland Lake sub-watershed accounts for about 5% of the watershed area, while in Webster Lake the percentage of residential area is roughly 6.5 % within the immediate drainage area (i.e.. excluding Sucker Brook watershed) around the lake.

At some point in the future, the City of Franklin and the Town of Andover could experience a major increase in development growth given their relative central location within the state. The growing development pressures in the southern portions of the state will eventually progress northward as land area becomes scarce and the southern tier communities reach their development capacity in the coming years. The Lakes Region Planning Commission is currently conducting a build-out analysis for the Andover Planning Board. The results are still in the early stages of development and are not available at this time. The results of this effort, however, will be highly useful in gauging the potential for development growth in both the Highland Lake and Webster Lake watersheds and will form the basis for establishing goals in the next Andover Master Plan Update.

The Town of Andover has had a Temporary Residential Growth Limitation Ordinance that limits the number of building permits that can be issued for new dwelling units each year. This has been in effect since March 2002, following adoption by voters at the Town meeting but will expire on March 31, 2007, unless otherwise extended by a town vote prior to that date. The Build-Out Analysis currently underway will provide critical information as to whether this ordinance should be extended and/or other modifications to current zoning and site plan regulations should be considered. In general, the Town of Andover requires a minimum lot size of 2.0 acres and minimum road frontage of 250 feet for all new lots. New waterfront lots must have minimum 200 feet of waterfront frontage. As part of any new update, the Town of Andover may want consider the establishment of a Lake Water Quality Protection District that could include additional provisions and performance standards for specific sources or uses such as septic system maintenance, forestry practices and construction activities. Additional standards for forestry practices may include greater setbacks from streams and rivers, a timber management and erosion control plan with third party review.

The City of Franklin has also taken steps to limit development growth in its portion of the watershed with the adoption of a Webster Lake Overlay District (initially referred to as the Lake Protection District back in 1990) that was recently amended in 2004. The ordinance specifies a minimum lot size of 108,900 square feet (approx. 2.5 ac) for any new lot within the District, regardless of whether or not it is served by City sewer (up from 40,000 sq. ft.) and minimum road frontage of 200 feet. The following summarizes other major requirements included in the ordinance:

- A 50-foot setback from any surface water or wetland for all new structures and driveways.
- Impervious area is limited to no more than 30% of the lot area;
- A 100-foot setback from any surface water or wetland for any septic system associated with new construction.
- Any expansion or seasonal use change of an existing structure must comply with RSA 485A:38 and seek local building permit approval.
- Application of fertilizers and pesticides is not allowed within 200 feet of any surface water or wetland.
- All runoff from livestock feeding areas shall be directed away form surface water or wetland area.
- No stockpiling or spreading of animal manure on fields or pasture within 200 feet of any surface water or wetland.
- For forestry practices, a minimum of 75-foot vegetated buffer of natural vegetation shall be maintained adjacent to all surface water or wetland areas.

Both communities have been active over the years in working with land preservation organizations to secure conservation easements and open space acquisitions. According to the July 2006 version of *The Andover Beacon*, the Ausbon Sargent Land Preservation Trust (ASPLT) is currently working on securing a conservation easement for the 267–acre Hersey Farm in East Andover with the help of a $173,000 grant received from the Farm and Ranchland Protection Program (FRPP) as part of the US Department of Agriculture Natural Resources Conservation Service. The article states that another $31,000 has been pledged by various individuals and another $71,000 would be needed to complete the project. The easement would preserve the land in an open space and would allow farming to continue in perpetuity but would prohibit any future development of the land. This easement acquisition would represent major step in limiting future residential development in area for land that has some of the highest development potential in the watershed.

Phosphorus Loading From Roads and Roadside Swales

Runoff from roadways and especially dirt roadways was raised by several members of the Partnership Group as being a suspected major source of phosphorus and sediment in the watershed. There are a number of roadways, particularly gravel and/or dirt roadways with relatively steep slopes that drain to and cross over tributaries of Webster Lake, particularly Sucker Brook. Based on a GIS analysis, there is approximately 93 acres of roadway area in the entire watershed area, which represents slightly less than 1.0% of the overall watershed area. About a third or 34 acres of this roadway area is located in the Highland Lake sub-watershed area. Using the STEPL model and a conservative assumption that the average phosphorus concentration in roadway runoff is about 0.5 mg/l, it was estimated that roadways would contribute 57.0 kg (~125 lbs) of phosphorus per year, which is less than 10% of the estimated total annual phosphorus load to the Lake. On an aerial basis, this translates into about 0.61 kg/ac/yr (1.3 lbs/ac/yr) for roadway surfaces, which was the highest loading rate on a per acre basis relative to the other land use categories. This compares closely with the findings of a study conducted in Maine, which showed that the phosphorus loading from rural paved and dirt roadway surfaces ranged from 0.9 to 2.0 lbs/ac/yr with an average rate of 1.75 lbs/ac/yr (Dudley et. al., 1997). The study authors noted that the sediment concentrations in runoff from the unpaved road surface was generally lower than that from the paved surfaces, however, the percentage of finer particles in runoff samples from unpaved roads was often much greater, which tend to convey a higher "biologically-available" phosphorus load. The finer particles take a longer time to settle out of the water column and, therefore, travel longer distances from the source to the lake.

A study conducted by the Maine Department of Environmental Protection (MeDEP) on Madawska Lake, used a phosphorus loading rate of 3.5 kg/ha/yr for both paved and unpaved roadways in the watershed (MeDEP 2000). This loading rate translates into 1.4 kg/ac/yr or 3.1 lbs/ac/yr, and is nearly twice the rate developed by the STEPL model.

Currently, runoff from most roads around the lake is conveyed though roadside swales, which in themselves, can be source of phosphorus through bottom scour and erosion of sediment during heavy rain events. The lower portions of Smiling Hill Rd and Griffin Road in Franklin as well as Sam Hill Road, Emory Pond Road and Hoyt Road in Andover are key locations where bottom scouring and sediment washout has been observed. Approximately 400 to 800 feet of the lower portions of these swales have exposed soils and sometimes loosely deposited sediment that are vulnerable to erosion. These areas need to be re-graded and stabilized with adequately sized rip-rap stone to stabilize the swale during peak flow events. Similar swale improvements were recently completed along much of Route 11 as part of the NHDOT Route 11 Reconstruction Project.

Eroded sediment can carry a fair amount of phosphorus. A recent separate lake study conducted in NH revealed a typical phosphorus concentration of approximately 340 mg/kg in native soil (A. Chapman, pers. Comm. 2006). Using a conservative estimate, that about 6-inches of sediment is washed away each year from the entire lower 500-feet of a swale and the swale base is about 3-feet wide, would result in an annual yield of approximately 16.7 cubic yards or 14.5 tons of sediment for 500-feet of swale. This converts to roughly about

13,150 kg of sediment and approximately 4.5 kg of phosphorus for 6-inches of erosion in 500 feet of swale. For Sam Hill Road and Emory Pond Road, which have relatively steep roadway slopes and both sides of the road have heavily scoured swales, this could amount to about 9.0 kg/yr of phosphorus for each roadway. Hoyt Road, in Andover and Smiling Hill Road in Franklin, which have more moderate slopes and swales generally on one side or the other, could add another 4.5 to 9.0 kg of phosphorus each per year.

Possible Treatment Measures

Smiling Hill Road in Franklin and Sam Hill Road in Andover are perhaps the two priority areas in need of roadside swale stabilization. Approximately 500 feet of Smiling Hill Road drains through roadside swales that empty into the lake near the Griffin Beach parking lot (Appendix E for details). Sam Hill Road has swales on both sides of the road that need stabilization. Re-grading and placing rip-rap stone and enhanced with stone check dams to reduce flow velocity and reduce the potential sediment erosion. Based on recent average NHDOT project bid estimates (published on NHDOT web site), erosion stone generally costs about $45 per ton for material and roughly $2.50 sq, yd for channel stabilization grading. Assuming 3-foot side slopes and a 1-foot base width and a depth of 0.5-foot, roughly 1 cu. yd of erosion stone would be needed for every 6 feet of swale, resulting in a rough material cost of $4,500 per 500 feet of swale. Perhaps another $1000 to $1500 may be needed for geotextile, erosion control seeding, hay bales, check dams, etc. The cost for re-grading is estimated to be roughly $2.50 per sq yd, (based on NHDOT ave bid estimates) or $1,250 for a total cost estimate of about $7,500 for 500-feet of swale. Much of the labor and equipment could be provided by the Franklin DPW. Consultation with the contractor that recently completed the Route 11 reconstruction may be a helpful in refining these costs estimates.

The upper and lower parking lots to Griffin Beach represent other gravel/dirt surface areas in close proximity to the lake that are potential sources of phosphorus. With an area perhaps a 0.5 to 0.75 acre in size and an annual loading rate of roughly 2.0 to 3.0 lbs/ac/year for roadway area, the maximum phosphorus load reduction would be about 0.5 to 2.25 lbs per year. Minimizing soil erosion could be accomplished by using previous pavers or clean crushed stone to retain soil. Pervious pavers would provide long-term benefits and may be easier to maintain but would also much more costly relative to the potential benefit achieved.

With respect to runoff from other paved road surfaces, there are a number of devices on the market that are specifically designed to treat road runoff. The least expensive devices typically range from about $2,500 to $5,000 and consist of screening type devices that are inserted into catch basins to capture the larger sediment particles and other debris. These devices require frequent maintenance (i.e., minimum quarterly) to prevent clogging and generally have sediment removal efficiencies of 10 to 20% and even less for phosphorus. The larger vault or over-sized catch basin type devices range in cost of $10,000 to $20,000 and typically have sediment removal efficiencies of 25 to 40% and perhaps as much as 10 to 20% for phosphorus. More detailed information on these types of devices can be found at a UMASS webs site www.mastep.org. For small driveway areas, small rain gardens have been shown to be effective for the small to moderate rain events. Rain gardens are essentially small depression areas backfilled with a compost-sand mix material that promotes infiltration and maintains high moisture content for plantings.

The difficulty with treating roadway runoff in rural areas is that runoff generally flows as sheet flow to adjacent wetlands and low-lying areas, and only relatively short sections of roadway (i.e., 300 to 500 feet) can be treated or directed to a treatment device. In order to treat 1.0 acre of roadway, nearly 2000 feet of roadway would need to be directed to one location for storm water treatment, assuming an average roadway width of 24 feet. Thus, multiple storm water treatment devices would be required at various locations in order to achieve any significant phosphorus reductions from roadway runoff. Where many of the treatment of devices designed for roadway runoff generally cost upwards to $20,000 per device, these can become exceedingly costly on a per area basis of treatment.

Due top the relatively high cost per area treated or cost per kg of phosphorus potentially removed with the manufactured devices, it is recommended that the Partnership focus on roadside swale stabilization measures as a more cost-effective means of limiting phosphorus contributions to Webster Lake. The other major drawback to the manufactured devices is that many recent studies have found that they are minimally effective if not frequently maintained. This added maintenance is often a deterrent for most municipalities.

■ Livestock, Manure Spreading and Pasture Land

Land application of manure on agricultural land for fertilizer is a widely used practice throughout New Hampshire. Manure as a byproduct of livestock operations is a valuable resource for crop production because it is much more cost effective than chemically based fertilizers. With proper storage, handling and application techniques, land application of manure can be done with minimal effective on downstream water quality. However, depending on when, where and how close applications are to streams or other water bodies, manure applications can also be a significant source of phosphorus. For practical reasons, the first of the year applications are often done in the early-spring to empty out the storage bins that have been accumulating manure over the winter months. Historically, these early applications were done on frozen ground to avoid rutting up the fields or getting equipment stuck in the mud. This practice of applying on frozen ground has been found to result in major losses of nutrients that end up in downstream water bodies. Recent Best Management Practices (BMPs) now recommend that applications are not done on frozen or saturated ground and be done at a minimum within two weeks of the active growing season where vegetation can utilize the nutrients and reduce runoff. Applications should also not be done when rain is forecasted in the next 48 hours or when the ground is saturated from previous rains. Manure should also not be applied within 50-feet and preferably at least 100 feet from any stream or drainage channel.

The sampling data contained in the NHDES D-F Study indicated that, **in February 1980, there was nearly a seven-fold increase in the measured monthly loading going from 4.2 to 28.9 kg between the Three Brooks station and the Dyers Crossing station, which were only about 0.5 mile apart.** On an annual basis, the estimated total phosphorus load increased from 88.0 to 185.0 kg between these two stations, representing a 110% increase. **Nearly 46% of this annual loading increase occurred between February and April.** As shown in Table 4.5, the STEPL Model results indicate that the pasture area in the Emory Pond Brook watershed accounts for a large portion of the phosphorus load from pasture area or roughly 36% (80 kg) of the total pasture load for the entire watershed. This is consistent with the findings of the 1991 D-F Study, where Emory Pond Brook accounted for about 26% (71 kg) of the annual phosphorus load in the Sucker Brook watershed.

Similarly, in pasture areas or other pens, corrals or paddocks where livestock and domestic pets might deposit fecal matter directly into or immediately adjacent to streams and drainage ways, can also be a significant source of phosphorus. Animal waste can also be a major source of bacteria, particularly *E. coli* bacteria.

Based on GIS data, approximately 720 acres of pasture land exists in the Webster lake watershed representing about 7.2% of the total land area. This includes the larger field areas visible from aerial photography but may not include smaller, less obvious horse paddock or livestock pens consisting of one or two acres in size. About 200 acres of this pasture area is in the Highland Lake watershed. Below Highland Lake, the majority of the pasture land exists in the Emory Pond Brook/Dyers Crossing drainage area, which is a principal tributary to a Sucker Brook. The Emory Brook drainage area contains about 240 acres of pasture area that supports two moderate-sized dairy farms, known as the Shaw Farm and Hersey Farm, which have operated for many years and have about 40 to 60 cows each. Up until the summer of 2005, the dairy cows had direct access to Emory Pond Brook as their primary drinking water source. In working with the NRCS and DES, the farm owner has installed a new well to provide an alternative drinking water source and additional fencing to keep the dairy cows out of the Emory Brook in the upper pasture area. The new well and fencing should result in a significant decrease in the amount of phosphorus and bacteria that was being conveyed directly to the stream.

Possible Treatment Measures

Changing the manure management program so that manure is applied only during the growing season, when nutrient uptake is at its highest and runoff potential is at its lowest could reduce phosphorus loading from manure applications. In addition, minimizing or avoiding applications within and directly adjacent to some of the minor drainage swales that exist within the hay fields could substantially reduce the amount of phosphorus loading from these fields (see flowing water in drainage swale in adjacent photo). A minimum application setback of 25 to 30 feet from these drainage swales and as much 100 feet from major stream should be incorporated into the manure management plans. Conducted soil testing to identify to determine nutrient content in soils to match the application to the crop needs would also be strongly encouraged. Perhaps other application methods such as liquid injection to incorporate manure into the soil and make it less vulnerable to wash-off and exposure with runoff could be investigated. The capital costs associated with new technologies or adding more storage facilities are not readily available and would involve further consultation with experts at NRCS.

To reduce phosphorus loading from existing pasture areas, additional fencing in the lower hayfields should be investigated to keep cows out the smaller drainage ways that flow during major rain events and will convey the nutrients and bacteria down to Sucker Brook. Perhaps there are other means of keeping the cows out of the drainage ways through some sort of border plantings. The pasture area sits on a moderate slope with till soils that have limited infiltration capacity, which produces a fair amount of runoff in large rain events. There is a fence along the lower perimeter that abuts the abandoned railroad bed and is about 75 to 100 feet from Sucker Brook. However, the flow from these ditches drains across the railroad bed and into a channel that leads to Sucker Brook (see photo below).

Some of this flow that enters into the lower hayfield drainage swales originates from the road ditch turnouts along Sam Hill Road. These turnouts are generally a good drainage practice to prevent erosion within the roadside ditches but if flow is commingling with manure deposits and then being conveyed to Sucker Brook by these ditches, this would offset the reduction in erosion benefit. To divert back into the roadside ditches would require substantial reinforcement with rip-rap stone and widening of the roadside ditches to handle the increased flow. This could be a relatively costly effort perhaps costing as much in $15,000 to $20,000, with much of it in rip-rap material. Adding more drainage area and flow to these road side swales is not recommended. Perhaps a portion of the drainage swales can be culverted to allow cross over points for cows and maintain full use of the pasture area. The additional fencing is likely to cost in the order of $2,500 to $5,000.

Timber Harvesting

Timber harvesting is suspected to be a significant source of phosphorus on a periodic, short-term basis, if the activity causes uncontrolled sediment erosion that allows sediments to be discharged to a lake or a tributary stream. There is very little sampling data directly related to this activity to develop loading estimates. The greatest threat relates to the phosphorus attached to eroded sediments and other organic debris. Loggers are required to employ proper erosion controls and other BMPs to prevent sediments from entering adjacent streams during and even after the timber harvesting activity have been completed.

Approximately 82 % or over 8,800 acres of the Webster Lake watershed consists of forested area. Based on a review of Intent to Cut Notices filed at the local assessor's offices, timber harvesting is carried out on hundreds of acres each year in the Webster Lake watershed. The majority of this activity typically occurs in the Andover portion of the watershed and particularly, in areas associated with Tucker Mountain and Cilley Hill. The extent to which timber harvesting contributes to phosphorus loading is difficult to estimate since so much depends on the location, duration, size of the cut, time of year, weather conditions, slopes, number of stream crossings, and types of erosion control measures utilized, to name a few.

Most recently, in May and June of 2006, a major timber harvest operation that occurred in the Tilton Brook sub-watershed resulted in highly turbid waters being discharged into Highland Lake on several occasions. According to observations by adjacent landowners, the turbidity levels in Tilton Brook as it entered Highland Lake were exceedingly elevated during rain events. Several samples collected by DES personnel showed turbidity readings more than 10 times higher than the normal baseline levels and well above state water quality standards. Elevated turbidity levels are typically associated with total phosphorus concentrations that are an order of magnitude above background conditions, as demonstrated by previous phosphorus sampling by DES in Sucker Brook.

DES subsequently issued a fine of nearly $40,000 to the logging company for violating to state wetland regulations including not installing proper erosion control measures and other timber harvesting BMPs that would have helped to minimize or prevent the high turbidity discharges into Tilton Brook and eventually Highland Lake. The severity of this fine will certainly send a message to other loggers that proper erosion control and water diversion measures are necessary during timber harvesting activities. Various erosion control measures and BMP details for timber harvesting practices are outlined in the State's BMP Manual for Erosion Control on Timber Harvesting Operations published in 2004 (Appendix F). At a minimum, the BMPs contained in this manual should be referenced in local zoning ordinances as the standard of practice for performing timber harvesting.

The MeDEP TMDL Study for Madawaska Lake, referred to earlier, indicated that the phosphorus loading rate from timber harvesting could be as high as 0.5 to 0.75 kg/ha/year or roughly 15 times greater than that from unmanaged forests at 0.035 to 0.05 kg/ha/yr (MeDEP 2000). The STEPL Model used in this study produced a similar loading rate of 0.036 kg/ha/yr for forested areas. The extent to which any eroded sediment and related phosphorus becomes available downstream to the Lake depends on the location of the cut within the watershed, proximity to major streams, time of year, rainfall conditions, duration of the harvest and whether or not erosion control BMPs are implemented.

Possible Management Options:

The effects of timber harvesting on phosphorus loading are highly variable and are most likely associated with periodic and isolated incidences when logging operations occur in a critical part of the watershed and are done with less than adequate sediment and erosion control measures to prevent the movement of sediment into nearby stream and water bodies. Slopes, time of year, soil conditions and rainfall events are all potential contributing factors. One of the possible solutions would be to increase the oversight and enforcement capabilities to review, monitor and regulate the timber harvesting activity. This responsibility is currently under the jurisdiction of the NH Department of Resources and Economic Development (DRED), Division of Forests and Lands. In the discussions and comments received during the various listening sessions, local officials and landowners expressed serious concerns about the lack of sufficient number of foresters in the DRED Division of Forests and Lands to adequately monitor the amount of timber harvesting activity that occurs in this State. Despite the need and expressed desire to have DRED hire more foresters, this situation is not likely to change in the near future. The additional review and site inspections needed will likely fall on the local communities to fulfill, despite even more limited funds and perhaps less technical expertise to provide this role.

In addition to site inspections, adding more performance standards for forestry practices in local ordinances, as the City of Franklin has recently completed, will be necessary. The Town of Andover and the City of Franklin should consider pursuing an arrangement where they could hire and share a forester either on a contractual or part-time basis to perform the needed monitoring of the harvesting activity in their area. Perhaps other towns in the area would be interested in pooling resources for this effort. The potential costs associated with this concept will be discussed late in the final draft of this document. Some of the suggested standards that could be included in a Watershed Protection Ordinance include:

- imposing greater restrictions as to when, where and the amount of timber harvesting that can occur within the watershed as well as establishing no cut zones of up to 100 feet through local ordinance regulations for some of the larger stream and/or in the direct watershed of the lake; smaller setbacks of perhaps 50 feet may be appropriate for wetland areas or intermittent streams that are not discharging directly to the lake.
- reference the State BMP Manual for timber harvesting in updating or improving local ordinances to require appropriate BMPs for stream crossings, landing areas, etc,
- increasing the extent of temporary and permanent soil stabilization measures and include post-harvesting seeding and mulching for disturbed areas;
- Possible options for funding the professional oversight of timber harvesting activities through a third-party contractual arrangement could include an additional fee as part of the local filing of a wetland permit application or to redirect a small percentage of the local tax collection on timber harvest.

Shoreline and On-Lake Sources of Phosphorus to Webster Lake

Various Shoreline Activities

There are number of human related activities that occur along the shoreline or on the water that can contribute to phosphorus loading. These activities include the use of lawn fertilizers, accumulation of pet wastes, clearing of vegetation, beach replenishment, use of detergents for outside washing and increasing the imperviousness of the property area. Disturbing bottom sediments through the propeller wash during boat motor startup or excessive idling or causing shoreline erosion through boat wakes can also contribute to increased phosphorus. Other activities such as the use of fireworks and allowing debris to fall into the lake can lead to an increased oxygen demand as the material decomposes. On an individual basis, these contributions may be relatively small, but taken as a whole, their impact could make the difference between having a nuisance algae blooms or not, especially when in-lake phosphorus concentrations are approaching the borderline threshold between mesotrophic and eutrophic conditions.

Addressing the potential adverse effects of these activities generally falls under the category of good stewardship of the lake and are typically the least costly to implement because there are no major structural measures or capital costs involved. Shoreline homeowners should be aware that maintaining a healthy stand of native vegetation along the shoreline provides a substantial water quality benefit to the lake and their property values. Minimizing the amount of runoff that directly enters the lake from paved surfaces and disturbed soil areas through the use rain gardens, rain barrels for roof runoff and/or dry wells for driveways and other areas should be a goal of every shoreline homeowner to protect the water quality of the lake. Although there is very little available data, either site-specific or in the literature, to generate a reasonably accurate phosphorus load estimates for these activities, it is possible that as much as 10 to 20 kg/yr of the existing phosphorus load to the lake could be eliminated through a coordinated, long-term plan of education and outreach program designed to educate and change in human behavior. The education and outreach plan is discussed in greater detail in Chapter 6.0 of this document.

Water Level Management/Dam Operations

Shoreline erosion tends to be exacerbated when water levels in the lake are above normal due to the increased inflow during major rain events and the added water is not immediately released at the outlet dam, which is controlled by the DES Dam Bureau. During high water level periods, additional shoreline areas are exposed to the forces of wave activity caused by boating or wind effects. This issue was raised as a serious problem at one of the listening sessions. One of primary problems is that often times additional flow is released at the upstream Highland Lake outlet dam, which is controlled by the Town of Andover, but these releases are not coordinated with the DES Dam Bureau, which operates the Webster Lake outlet dam. Following a major rain event, this added inflow accumulates in Webster Lake, raising the water levels, until the excess water is released by the Dam Bureau. The Operations and Maintenance Plans for the two dams need to be coordinated so that each agency notifies the other one when there are releases from the dam.

Shoreline Septic Systems

Shoreline septic systems that are poorly functioning, improperly installed or inadequately sized can be significant sources of phosphorus. Information related to the ages, types of systems and exact locations of shoreline septic systems around Webster Lake is limited. As part of the 1981 Water Quality Investigation for Webster Lake, prepared by Dufresne-Henry, Inc., a survey of shoreline septic systems around Webster Lake was conducted. The general findings of the Dufresne-Henry study survey are presented below:

1 There were a total of 176 homes around the lake: 147 first-tier homes (lots having direct access to the lake) and another 29 second-tier homes (lots on other side of shoreline road).
2 65% or 94 of the first tier homes were considered seasonal;
3 Nearly 17% or 29 of the 176 home were considered to have potentially failing systems because the separation distance from the bottom of leach field to seasonal high water table was less than 2 feet.
4 47 systems were less than 50 feet from the lake and at least 15 systems were within 25 feet of the lake.
5 Approximately 42 systems were located less than 4 feet above the seasonal high water table.

The Dufresne-Henry study estimated that about **71.3 Kg (157 lbs) or roughly 12 % of the total annual phosphorus load 618 Kg (1,346 lbs) to Webster Lake was** contributed from shoreline septic systems**.** This load estimate was based on the following assumptions:

- Failing systems were assumed to retain only 20% of the phosphorus contained in septic effluent (year-round homes had an effluent P conc. of 17 mg/l and seasonal homes had an effluent P conc. of 11 mg/l; the P conc. was lowered in seasonal home to reflect that washing machines were not likely in seasonal homes).

- Non-failing or properly functioning septic systems were assumed to retain 95% of the phosphorus in septic leachate and have an effluent P conc. of 0.11 mg/l, based on the results of soil column testing study conducted by the University of Massachusetts using secondary treated wastewater effluent.

In the end, nearly 96% or 68.8 kg of the estimated total estimated phosphorus load from septic systems was attributed to 29 homes that were considered to have potentially failing systems. These systems were considered failing because they had less than a 2–foot separation distance from the seasonal high water table based on existing soil mapping*. Although this presumption was not verified through any field sampling or lab testing, it is reasonable to expect a less phosphorus retention in soils under these systems given the shorter path and the propensity for soil conditions to be anaerobic near the water table. Eighteen of the 29 homes were considered to be seasonal and the other eleven homes were assumed to be year-round**. Eleven (11) year-round homes attributed for the bulk of the phosphorus load at 53.7 kg/yr or roughly 4.8 kg per system and the other 15.2 kg/yr was attributable to 18 seasonal homes with failing units or 0.8 kg per system.** Distance to the lake was not factored into the loading estimate and could be a significant factor.

***NOTE**: Current DES subsurface disposal design standards require a separation distance of 4 feet from the bottom of leach field to the seasonal high water table and a horizontal distance of 75 feet from any water body.

Potential Additional Phosphorus Inputs from Seasonal to Year-Round Home Conversions

The septic system survey conducted in the early 1980s as part of the Dufresne-Henry study indicated that, at the time, there were a total of 176 homes around the lake; 147 homes were considered first-tier homes (i.e., lots having direct access to the lake) and another 29 second-tier homes (i.e., homes that were within 300 feet but on the other side of the lake perimeter road. Of the 147 first-tier home, 64% or 94 homes were used for seasonal purposes, while the other 53 homes were considered year-round. The field survey information also indicated that 70% of the first-tier homes were within 75 feet of the Lake and thus, may have limited ability to meet the more recent DES septic systems design setback of 75 feet if the systems were to be upgraded for year-round use.

Recently, members of the Partnership Group have suggested that there are now many more homes being used for year-round use compared to the 1980s. The difference in phosphorus loading from year-round use as compared to seasonal use can be substantial, especially if the septic system does not meet current design standards. In calculating the phosphorus load from septic systems, the D-H study assumed that water usage increased from 45 to 75 gallons per capita per day (gpcd) going from a seasonal home to a year-round home primarily because washing machines were assumed to be more likely to be available in year-round homes. More importantly, is that there is a considerable difference in the volume of discharge from septic systems used over 365 days versus possibly only 90 days. Using the same assumption (i.e., that nearly 17% of all systems were failing and only 20% of the phosphorus was retained in soils beneath these systems), the D-H study

The D-H study estimated that the annual phosphorus load from septic systems would increase about 170% from 71.3 kg/yr to 192.1 kg/yr, if 54 more homes that are within 75 feet of the lake were converted to year-round use. This added load was estimated to increase the in-lake phosphorus concentration by as much as 4.0 ppb. The load estimate was based on a worst-case analysis by assuming all of these year-round conversions would have potentially failing systems (i.e., only 20% phosphorus retention) because of the limited distance of 75 feet to the lake and, as a result, may or may not be upgraded nor adequately sized to meet current DES standards. Using a more realistic assumption that perhaps 17% of these new 54 year-round systems might fail or not adequately function because of shallow depth to seasonal high water table (similar to the original estimate), then the annual phosphorus load from shoreline septic systems is estimated to increase by about 45 kg/yr for a total load of about 116 kg/yr. This increased phosphorus load could raise the in-lake phosphorus concentration by 1.5 to 2.0 ppb. Ascertaining the number of lake-front homes that are now used for year-round use would be extremely useful in updating the phosphorus load estimate from septic systems. In summary, if the average in-lake phosphorus concentration was estimated to be 0.013 mg/l back in the early 1980s, then it would be appear that the conversion of seasonal homes to year-round use, may have increased in-lake phosphorus concentration to 14.5 to 17.0 mg/l, depending on the number of homes that have been converted, the number of homes that have upgraded their systems, soil conditions and whether or not the loading to these systems have increased.

Based on a review of DES Subsurface System application/approval records over the last 18 years, approximately 60 homeowners along Webster Ave and Lake Shore Ave have applied for DES approval to install a new or upgrade their septic system. Refer to Appendix D for copies of various DES fact sheets related to septic system requirements and approvals. This data base should be used to continually update the status of various systems around the lake.

Possible Management Options

Some of the possible measures that could be considered:

- Conduct an updated homeowner survey for shoreline septic systems to collect data on types, age, usage, system upgrades, distances to the lake.
- Septic System locations should be determined using GPS positioning equipment.
- The Webster–Highland Lakes Partnership Group should coordinate with DES Subsurface Bureau to host a local workshop to get an update on phosphorus reduction options using the latest septic system technologies.

Potential Phosphorus Reductions from Possible Sewer Extension

The Dufresne-Henry study provided an assessment of potential phosphorus load reductions if sewer mains were extended around portions of the Webster Lake shoreline. Based on the previous loading estimate generated in the D-H study, if all the wastewater from the 176 homes around the lake were directed to the Franklin City sewers system, this would reduce the phosphorus load by 71.5 kg or roughly 12% of the total load. The D-H Study assumed that nearly 17% of the systems were failing because of shallow depth to seasonal high water tables. The STEPL Model produced a load estimate of 95 Kg/yr, with an assumed failure rate of 10%.

Cost estimates for sewer extensions developed in a recent engineering study (Levy Engineering, Inc, May 2004), indicated that to extend sewer down both sides of the lake (Webster Ave and Lake Ave) would cost about $5,625,000 and would require at least seven (7) pump stations. Assuming 20% of the cost was paid by a DES Grant and a 20-year bond was used to fund the remainder at a 5% interest rate, the annual payment was estimated to be roughly $361,000 to fund this project. However, construction costs have increased considerably over the last few years, and, it may be reasonable to add 20 to 30% to this cost estimate that is now two years old. If the amount of phosphorus reduced by extending sewer and eliminating the use of septic systems around the Webster Lake shoreline ranges from the high estimate of 95 Kg/year, the resulting cost for each kilogram of phosphorus eliminated would be about $75,000, assuming the 2004 estimated project cost has increased by 25% per year and would now cost about $7.5 to 9.5 million. The benefits would also depend on whether all homeowners would be willing to connect to the sewer even if the upfront connection costs were paid by the City. Some homeowners may prefer to stay on individual septic systems and not pay the quarterly sewer use fee. In addition, the possibility that extending sewer into new areas could stimulate new residential growth in other areas of the watershed must be considered even if new zoning regulations are in place.

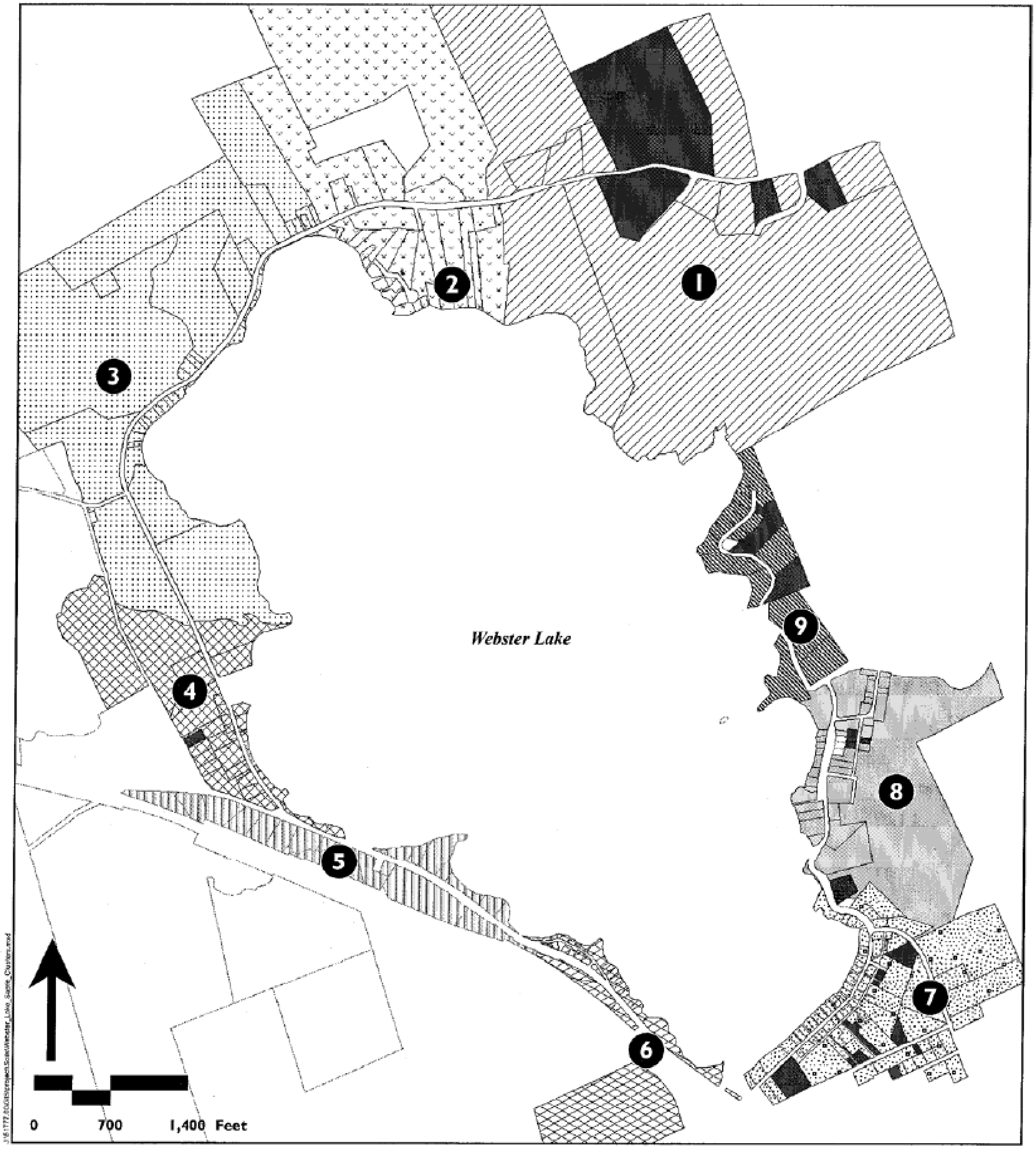
Community Septic System Alternative

The other possible option for reducing the effects of poorly functioning and/or failed septic systems is through the use of community septic system that would service a certain segment of shoreline homes in the more problematic areas. A community septic system collect sanitary waste water from a group of homes and then discharge/treat the effluent into a common leach field set back far enough from the lake (i.e., 300 feet) where phosphorus loading becomes a non-issue. These systems are becoming more common in areas where soil types are less than ideal or there are subsurface constraints or setback conditions that will not meet the septic system design requirements. Areas with small house lots or shallow depth to groundwater would be best suited for these types of systems. The City or Homeowner Association must also own a large enough parcel to locate the common leach field about 300 feet from the lake.

Figure 4-3 illustrates possible community septic cluster areas around the lake, the number of homes in each cluster area and the vacant parcels that are currently owned by the City of Franklin. The homes along Webster Ave, as shown as Cluster #7, appears to be a good location for a community septic system because of its relatively high density, small lots and the close proximity of many of the existing systems to the lake. Based on a review of the tax parcel data, the City also already owns several parcels in this area that are setback more than 300 feet from the lake and could be used as potential leach field sites. There are approximately 45 homes along Webster Ave, from Route 11 to Griffin Beach, that are within 300 feet of the lake. As a worst-case assumption, it is assumed that about 15 to 20 % of the homes in this area have failing or poorly-functioning systems because of the small lots, age of the homes and close proximity to the lake. This would mean that roughly 7 to 9 homes may have failing or poorly functioning systems. Based on the septic system P loading information presented in the earlier D-H study and assuming that these are all year-round homes, the annual load estimate would range between 35 and 45 kg/yr if the 7 to 9 homes had failed systems (20% P retention) and between 17 and 22 kg/yr for poorly-functioning systems (40% P retention). Based on these assumptions, a community septic system along Webster Ave might result in an estimated load reduction of 20 kg/yr to 40 kg/yr depending on whether the estimated 7 to 9 homes have failing or poorly-functioning systems, respectively.

Other areas that may be potentially well-suited for community septic systems include Area 8 and 9 as depicted on the map and located farther down Webster Avenue past Griffin Beach. These areas have soil types not conducive for septic systems with a shallow depth to the seasonal high water table, as shown earlier on Figure 4-2, and also several vacant lots owned by the City. These areas do have fewer homes, larger lots for the most part and perhaps newer homes as well, which means there may be less benefit an perhaps a lower potential load reduction for these areas. A septic system survey would be needed to better assess the existing conditions and potential benefits of a community system.

The estimated order of magnitude cost to install a community septic system along Webster Ave is approximately $900,000, which includes $9,000 per home to install a pre-treatment tank (Wastewater Alternatives, Inc), $50,000 to install 1,000 linear feet of a force sewer main, $100,000 for a pumping station, $150,000 for the leach field and another $150,000 for a 15% contingency and design fee. This does not include any permitting costs or additional pre-construction site investigations costs. Wastewater Alternatives, Inc has recently a number of septic system units around the lake and should be consulted to get a more information about the components of a community septic system. Their business number is (603) 783-8042. A final design analysis would be needed to develop a more accurate cost estimate.



Legend

Septic Cluster (# of Parcels with Houses)
- 1 (6)
- 2 (32)
- 3 (53)
- 4 (25)
- 5 (22)
- 6 (30)
- 7 (76)
- 8 (31)
- 9 (14)

- Parcel
- Vacant Parcels 300' from Shoreline (2003)

Vanasse Hangen Brustlin, Inc. VHB

Figure 4-3

Webster Lake
Proposed Septic Clusters

Franklin
New Hampshire

Source: Data from NHDES and the Town of Franklin

5

Summary of Management Objectives and Possible Action Steps

The following section summarizes various management objectives and possible action steps or activities that could be employed to reduce phosphorus loading and improve water quality These activities are summarized in Table 5.1 for the various source categories and are discussed in detail below.

Watershed Activities and Sources

Residential Growth

Objective: **Limit Future Development Growth to account for no more than 10% of the Watershed Area.**

Action Steps:

1. Establishing an on-call watershed coordinator for the first 12 to 18 months following the completion of this Plan to assist in zoning updates, grant applications, education and outreach efforts, oversee a septic mgt plan as well other tasks would be highly effective in implementing the various recommendations included in this Plan.

2. The Town of Andover should consider incorporating similar standards of the Lake Protection Zoning District Ordinance adopted by the City of Franklin. The Franklin ordinance establishes various performance standards and buffer setbacks for land use activities and minimum lot size and dimensions for residential development. The designated land area would include the Highland Lake watershed and perhaps 3,000 feet of either side of Sucker Brook from Highland Lake to the City of Franklin.

3. Site Plan and Subdivision Regulations should be reviewed and updated as necessary in both communities to insure future development activities include proper Best Management Practices to treat storm water runoff and for erosion control purposes. Third-party engineering review and water quality impact assessments should be required for all projects within the designated lake protection district.

4. The City of Franklin and Town of Andover should collaborate with non-profit land trust organizations and pursue other funding sources to acquire conservation easements or fee-simple land purchases for the remaining large undeveloped parcels around the lakes.

Table 5-1. Webster Lake Water Quality Improvement/ Implementation Plan

Estimated Source Contributions				Implementation						
		Est. Annual P. Load (Kg/yr)				Est. Load Reduction (Kg)		Estimated Cost[3]	Cost Per Kg Reduced	
Source	Location	Low	High	Treatment Measure	Removal Efficiency[4]	Low	High	(x 1,000's)	(x 1,000's)	Priority
Septic Systems	Webster Lake	70[1]	95[2]	1) Sewer Extension Around Lake Shoreline	50 -100%[5]	36	95	$ 7,500	$ 80 -200	Low
				2) Install Community Septic Systems in priority areas (ex. Webster Ave).	20–60%	20	40	$ 750 -950[6]	$ 19 – 48	Mod
				3) Develop Septic System Mgt Plan - Detailed Inventory w/ GPS - Homeowner Survey - Education & Outreach w/ vendors - Coordinate Pump-outs Days - Increase Inspections (link to bldg permits, real estate transactions, etc)	5– 10%	5	10	$ 10 – 20	$ 1.0 – 4.0	High
Road Runoff	Smiling Hill Rd	4.5	9	1) Stone Swale Rehabilitation/ Armoring	40-60%	1.8	5.4	$ 7.5 -9.5	$ 1.4 – 5.3	High
	Lake Ave	0.6	1.4	2) Grass Swale (near power line)	25-40 %	0.1	0.6	$ 5–10	$ 8.3–100	Mod
	Griffin Beach Parking lot	1.0	3	3) Pervious Pavers/ Pavement	60-80 %	0.6	2.4	$ 60 - 75	$ 25 – 125	Mod
	Sam Hill Rd	9.0	12	4) Stone Swale Rehabilitation/Armoring.	40-60 %	3.6	7.2	$ 15 - 18	$ 2.1 – 5.0	High
Timber Harvesting	Andover/Franklin	45	121	1) Increase Inspections of Logging Operations through on-call Forester.	40-60 %	18	73	$ 2 – 5	$ 0.03 – 0.3	High
				2) Update Zoning Ordnances to adopt more stringent timber harvesting. standards incl. 100 ft no-cut buffers to all surface water bodies (see Sec 5.0).	20–40 %	9	48	$ 5 – 15	$ 0.1 – 1.7	High
Pasture - Manure Mgt	Emory Pond / Dyers Crossing/ Sam Hill Rd	65	80	1) Install additional fencing to keep cows out of the smaller drainage ways.	10-25 %	6.5	20	$ 2 - 5	$ 0.5 -3.0	High
				2) Establish no application buffers of 25 to 30 feet along smaller drainage ways.	20-40 %	13	32	$ 10 -20	$0.4 - 1.5	High
				3) Change manure application timing to growing season only.	40-50 %	26	40	$ 25–75	$ 0.6- 3.0	High
Residential Development	Andover/Franklin	30[7]	60[7]	1) On-Call Watershed Coordinator / Planner to Update Local Ordinances	20–40 %	6	24	$ 10 -15	$0.13 – 0.65	High
				2) Continue to Pursue Open Space Acquisitions (eg. 100 ac acquisition)	50–100 %	15	60	$100-1,000	$1.6 - 67	Mod

Notes:

[1] The low phosphorus load estimate for septic systems is based on data contained in the DES D/F Study. [2]The high load estimate for septic systems was derived from the STEPL model using conservative assumption of a 10% failure rate for septic systems.

[3] The cost estimates represent general order of magnitude estimates for comparing and prioritizing the various treatment measures. Additional design details and analysis of site constraints will be necessary to develop a more accurate cost estimate for the recommended infrastructure improvements.

[4]Removal efficiency estimates are based on either literature data and/or best professional judgment where no data exists- these removal efficiencies are general estimates for comparison purposes only.

[5]The potential effectiveness of sewer extension depends on whether every homeowner would connect to the sewer if it was available.

[6] The approx. costs for community septic systems is roughly between $16,000 to $21,000 per home assuming 45 homes along Webster Ave. This does not include land acquisition costs for a leach field area.

[7] These phosphorus load estimates represent potential future loads for a hypothetical residential development that involves 100 acres of land within the watershed.

Table 5-2. Webster Lake Water Quality Improvement / Implementation Plan - Assumptions

Source	Annual Load	Removal Efficiency/ Cost Estimate/ Load Reduction
Septic Systems	1) The low estimate for all septic systems around Webster Lake is based on 1981 D-H Study data suggesting 17% or 29 of the 176 first tier homes have potentially failed systems. 64 % were seasonal homes and 36% year-round (i.e. 18 seasonal and 11 year-round). 2) High estimate is based on the estimated loading produced by the STEPL Model.	1) Removal efficiency for sewer extension would depend on partial or complete extension around entire shoreline and how many homeowners are willing to connect. The connection or hookup fees to each home are not included in the cost estimate for the sewer extension discussed below. 2) Total cost to extend the mainline sewer around the entire lake to connect all shoreline homes based on 2004 Levy Engineering Report plus 25% escalation in construction costs over last two years; 3) Est. low phosphorus load reduction for community system assumes installation for 45 homes along Webster Ave with possibly 8 homes having partially or poorly functioning systems due to min. distance to shoreline and annual load rate of 2.5 kg/yr/system (40% soil retention). The estimated high load reduction assumes that these estimated 8 homes have failed systems with an annual load rate of approximate 5 kg/yr/system (20% soil retention) based on an assumed leachate P conc. of 11 mg/l used in D-H study. 4) Cost Estimate for Community System based on use of Wastewater Alternatives, Inc STEP units for each home at $9,000/unit ($450,000), plus pump station ($100,000), 20,000 gpd leach field ($150,000), 1,000 linear feet of force main ($50,000 and 15% contingency ($150,000). Other design, permitting, land purchase and pre-construction site work fees are not included. A Final design analysis would be needed to develop a more accurate cost estimate. 5) Low and high load reduction estimates for the Septic Mgt Plan assumes that at least one or two homeowners with either poorly functioning or failed systems, respectively, within 75-foot of the lake will replace and upgrade their system due to increased awareness of their poor septic system condition. The estimated costs for the various Septic Mgt Plan components include apprx. $3-5K to conduct the GPS inventory, another $2-4K to conduct a homeowner survey, $3-5K to provide an Education and Outreach program (incl. mailer-brochure to 200 people and a one-time, ½ day workshop. Advertising pump-out days would add $0.5-.5K (no rebate incentive included) and increased staff time to conduct inspections for real estate transactions would be $2-4K. **The replacement cost for septic systems is estimated to be $15,000 and assumed to be paid by homeowner and is not included in this Plan.**
Road Runoff	1) The estimated low and high P load of 0.6 to 1.4 kg/ac/yr is based on STEPL Model results and a MeDEP study, respectively, with max. road area treated at 1 acre. 2) The estimated P load for roadside swales is about 4.5 kg/yr per 500 feet of swale assuming 6-inches of sediment loss per year. The low and high estimate is based on whether there is a swale on one or both sides of the road. The estimated load for Sam Hill Road was prorated to account for a longer swale length at this location.	1) The phosphorus removal efficiency for rip-rap lined swales was assumed to be 10-25% based on various literature sources including NHDES's Best Management Practices for Urban Runoff (1996). 2) The phosphorus removal efficiency for grass swales and pervious pavers was assume to range between 25 to 40 % and 60 to 80%, respectively, depending site conditions and underlying native soils. 3) The cost estimates for stone swale stabilization is estimated to about $7,500 for 500-feet of swale for labor, equipment and materials. The cost estimate for the parking lot for pervious pavers was assumed to be around $4 to $5 per sq foot just for the materials. The costs for labor and equipment were not readily available and depends on the level of effort required in replacing the sub-base but perhaps the equipment and labor could be provided by municipal services and/ or DPW (as well as for the roadside swale stabilization).

Source	Annual Load	Removal Efficiency/ Cost Estimate/ Load Reduction
Timber Harvesting	1) The annual loading for timber harvesting was estimated to range from 0.56 to 0.75 kg/ha/yr based on the MeDEP study, referenced earlier, which indicated that managed forests had 15 to 20 times higher loading than unmanaged forests. Timber harvesting in the watershed was assumed to occur over 200 to 400 acres or 81 to 162 hectares per year, based on a general review of the intent-to cut notices provided by Andover and Franklin over last 4 or 5 years.	1) The estimated removal efficiency of 40 to 60 % resulting from increased inspection of logging operations represents a minimal level of performance based on best professional judgment recognizing that it is highly dependent on the timing and location as well as the prevailing weather and soil conditions. 2) A moderate removal efficiency is anticipated for an updated zoning ordinance to include BMPs, setbacks and performance standards for timber harvesting but inspections are not necessarily conducted on a regular basis. Zoning updates in combination with inspections and enforcement would provide the highest level of protection for reducing P loads from timber harvesting. 3) The cost estimate for contracting an independent Forester to provide inspection services was based on discussions with Ron Klemarczyk of Forestry Resource Consultants in Rumney, NH. A more detailed analysis of the potential timber harvest area, its location, access and duration would be needed to develop a more accurate cost estimate. 4) The cost estimate to update and/or create a new zoning ordinance to address timber harvesting practices assumes some professional assistance may be needed by the Town of Andover. The actual costs may be lower if no assistance is needed. T**he added costs borne by loggers to implement the required erosion control measures are not included in this cost estimate.**
Pasture Management	1) The low and high estimate of annual loading from pasture and manure applied areas represent the loads projected by the previous DES D/F study and the more recent projection using the STEPL model, respectively.	1) The estimated removal efficiencies for the various pasture management measures are general estimates that are considered to get progressively better starting with additional fencing to maintain a 25 to 30-foot buffer along the smaller drainage ways within the pasture to minimize the opportunity for cows to deposit waste in these swales. 2) A slightly better removal efficiency would be expected if a similar 25 to 30-foot no manure application buffer was established along the smaller drainage ways that was demarcated by fencing or through vegetative plantings. 3) Restricting manure applications to the growing season only is estimated to have a relatively high removal efficiency of 40 to 50 % based on the sampling data collected in the 1991 DES D/F study showing that most of the annual phosphorus load from pasture areas occurred during the month of February and April. 4) The added cost to increase manure storage for an added 1 to 2+ months is assumed to be range from $25,000 to $75,000 but depends on the existing storage capacity at the individual farms.
Residential Development	1) To develop an annual loading for future residential development it was assumed that 100 acres of land was developed for residential use over next 5 years. The low and high estimate is based on loading rates of 0.3 kg/ac/yr and 0.6 kg/ac/yr, based on previous literature values and the STEPL model results, respectively.	1) Funding an on-call watershed coordinator for the first 12 to 18 months is estimated to cost $10,000 to $15,000 depending on the time frame. Through zoning updates and educ. & outreach efforts, future loading assoc. with residential development could be reduced by apprx.20 to 40 % (Center for Watershed Protection Rpt (1998)). 2) Pursuing open space acquisitions is considered to be highly effective and could reduce future phosphorus loads by as much as 50 to 100 % for each acre of undeveloped land potentially developed into new residential use. Much depends on how likely the land would be developed, the development type and density, its location within the watershed and whether there are any existing activities that would continue on the acquired or preserved land. The Build-out analysis currently being done in Andover would help to prioritize critical areas. 3) Land preservation costs are widely variable and could range from $500 per acre to acquire the development rights to perhaps as high as $30,000 per acre or more for fee-simple purchases. For a general cost estimate, it was assumed that 100 acres of land was preserved in the future at estimated cost range of $1,000 to 10,000 per acre.

Pasture and Manure Management

Objective: **Minimize Phosphorus Loading from Livestock Feeding Areas and Manure Storage Facilities and Manure Fertilized Fields.**

Action Steps:

1. Continue to work with the NRCS and the Hersey Farm and Shaw Farm owners to install additional fencing along drainage ditches within pasture areas and, at a minimum, along the lower 500 feet of any swale or channel that drains to Sucker Brook or its tributaries. Specific locations would include the lower fields on the east side of Sam Hill Road and the lower portions of the pasture areas on the south side of Route 11 and west of Emory Pond Brook.
2. Incorporate buffer setbacks in local ordinances for manure applications.
3. Coordinate with farm owners to work with NRCS to develop a manure management plan that encourages use of the latest manure applications technologies and schedule applications during the growing season when vegetation is well established. The Management Plan will coordinate storage needs with application timing, rates and rotation of appropriate spreading areas.
4. Identify and work with other property owners that have small livestock pens and horse stables to insure proper management of wastes and use of vegetative buffers to reduce the potential wash off, conveyance and discharge of manure wastes into nearby streams and drainage channels.
5. Encourage possible composting of manure through mixing yard waste and/or other organic material to assist in moisture control and vector management.

Timber Harvesting

Objective: **Limit the Amount of Phosphorus And Sediment Contributions From Timber Harvesting Activities that Occur within the Watershed.**

Action Steps:

1. Increase the amount of oversight and inspection frequency for timber harvest activities through greater coordination with NH DRED Division of Forests and Lands Personnel or, alternatively, through a contracted Forester, as discussed below.
2. The City of Franklin and the Town of Andover should coordinate to develop a possible cost-sharing arrangement with an independent Forester to provide inspection services for logging operations and to enforce performance standards and use of BMPs to control erosion and nutrient loss. The details

of the performance standards and BMPs will need to be defined in local ordinances or referenced to appropriate state guidance documents (e.g., Best Management Practices for Erosion Control on Timber Harvesting Operations in NH. 2004). **NOTE:** A contracted Forester will have to be granted authority by the municipal governing body to act on the municipality's behalf as an agent to enforce locally established or state-required timber harvesting regulations.

3. The Town of Andover should consider adopting a Watershed Protection Ordinance to establish various performance standards for forestry practices and other activities that would increase setback requirements, riparian corridors, BMP Implementation, and require timber management plans for major harvests that would include incremental phasing, review and inspection reporting and contingency planning for unusual weather events.

4. Consult and coordinate with the DRED Division of Forestry and Lands and DES representatives to discuss the need for a regional or statewide workshop to update foresters and local officials on proper BMPs, new technologies and the need for requiring licensed foresters for all harvesting of a certain size or within a sensitive resource area.

Road Runoff

Objective:

Identify and Implement Appropriate Measures to Treat Roadway Runoff in Several Key Locations to Reduce Phosphorus and Sediment Loading from Roadway Surfaces

Action Steps:

1. Coordinate with the VLAP program to collect samples as part of the tributary monitoring from the culvert across Webster Ave near Griffin Beach and former public boat launch to acquire phosphorus concentration data for this discharge.

2. Stabilize roadside swale along Smiling Hill Road near Griffin Beach using rip-rap stone and install stone check dams to reduce flow velocity. Rip-lap lining would be similar to that installed in roadside swales along Route 11. Rip-rap should be placed all the way down the lake in main channel with some vegetation shrub-type plantings along lake shoreline and swale banks.

3. Seek additional funding through 319 Grant Program to fund installation pervious pavers within the lower Griffin Beach parking area near the lake.

4. Investigate the possibility of creating a grass swale along Lake Ave within power line easement to treat roadway runoff. May need to conduct topographic survey to along Lake Ave to determine the drainage area and appropriate outlet location of the swale

5. Coordinate with the Town of Andover to investigate possible cost-sharing

and/or providing in-kind services to stabilize and reinforce side-slopes in roadside swales along base of Sam Hill Road and Hoyt Road to reduce sediment erosion during large storm events.

Shoreline Activities and On-Lake Activities

Shoreline Septic Systems

Objective: **Develop a Septic System Management Plan that Would Maintain an Up to Date Inventory of all Shoreline Septic Systems and Identifies Problem Areas, Outline Maintenance Schedules and Replacement/ Upgrade Approvals.**

Action Steps:

1. Conduct a homeowner survey to update the inventory of exiting septic system survey information to develop an improved data base that tracks DES approval dates, construction dates, types of systems, soils data, seasonal vs. year round usage, etc.

2. Using GPS equipment, locate each septic system and adjacent resource area. Survey data would then be linked to GIS Tax Map parcel layer to display relevant information.

3. Coordinate with DES and perhaps various septic system vendors to host a technology demonstration workshop at the lake.

4. Consult with DES and septic system vendors to initiate a demonstration project to compare phosphorus removal efficiencies through actual sampling of installed systems using advance treatment versus conventional systems. **NOTE: Wastewater Alternatives, Inc. has installed numerous new systems around the lake due to their advantage of being allowed a smaller leach field because of their advance treatment mechanisms and, thus, would be a good candidate to conduct a parallel performance test between conventional vs advanced treatment ; Contact Wastewater Alternatives at 603-783-8042.**

5. Update Watershed Protection Ordinance to require an onsite inspection by a licensed septic designer for all new additions requiring a building permit or for any real estate transaction.

6. The Lake Association and City personnel should establish incentives to conduct regular tank pump-outs through either reimbursements or volume discounts with septic tank contractors. This not only encourages the practice but may enable tracking as to how often it is being done.

Education and Outreach

Objective: **Provide A Long-Term Education And Outreach Plan That Continues To Educate And Update Shoreline Homeowners, Lake Users And Other Stake Holders About The Benefits Of Good Stewardship On The Lake And Surrounding Lands.**

Action Steps:

1. Develop and constantly update website to enable homeowners to educate themselves through posted material and links to other relevant websites.

2. The Lake Association and City personnel should coordinate and host annual workshops to invite key professionals and/or vendors to update shoreline home owners on the latest technologies for various issues.

3. Collaborate with DES and local schools and universities to promote and encourage students to conduct special environmental investigations regarding various aspects of the lake.

4. The Lake Association should coordinate to develop appropriate signage to promote headway speeds along shoreline areas and discourage the discharge of any material from boats:

5. The Lake Association and City personnel should post signs to encourage cleanup of pet wastes and discourage feeding of waterfowl.

6. The Lake Association and City personnel should adopt the Education and Outreach Plan contained in Section 6.0 and secure additional funds to retain the services of an Education and Outreach coordinator on a contractual basis.

6

Education and Outreach Plan

"How lovely to think that no one need wait a moment. We can start now, start slowly changing the world."
—Anne Frank

Introduction, Purpose, and Approach

The Partnership has identified several activities that may be harmful to the water quality in the watershed. The Partners have an opportunity to work together to implement at the local level recommendations and activities that will improve water quality.
The Associations' website as well as that of the Partnership, http://www.webster-highlandlakespartnership.org, are tools to disseminate information and resources. However, the Partnership should consider employing other and more direct strategies such as community based social marketing (CBSM) principles to foster sustainable behavior.

Community based social marketing relies on the principle that behavior change is best sustained when stakeholders are contacted directly to learn about their feelings and values. The resulting insight is used to determine where barriers to behaviors exist and to work with individuals and groups to remove the impediments and add incentives. Removing as many barriers or impediments as possible and providing incentives is more effective than passively offering information. For example, despite years of physicians and public health officials consistently and pervasively disseminating the message that smoking causes cancer, emphysema, and other illnesses, people still begin smoking, continue to smoke, or fail to quit. Disseminating information has not changed these individuals' behaviors. However, some studies have shown that when tobacco prices or taxes increase, some smokers will quit.

Steps to applying community based social marketing principles include conducting a search for and review of existing literature, qualitative research, observational studies, focus groups, and surveys (both pre- and post-campaign). An excellent resource for this approach is the book *Fostering Sustainable Behavior* by Doug McKenzie-Mohr and William Smith (cbsm.com). ToolsofChange.org offers additional resources.

The purpose of this plan is to introduce active vs. passive outreach strategies that include direct contact with watershed residents and stakeholders and incorporate community based social marketing principles:

Residential Land Use and Management

- The Webster Lake Association and the Highland Lake Association should provide information to their respective memberships. The Partnership website could be a repository for information and materials that are transferable throughout the watershed with each Lake Association website linking to it.

Outreach Activities

- Create demonstration site with a green lawn and adequate buffer that allows for a view while providing privacy, shade, and a lovely framed perspective of the lake or stream.
- Work with local suppliers to stock soil testing kits and lower-impact fertilizers and provide coupons and directories for "where to buy."
- Invite a nursery or landscaping firm conversant in and supportive of native plantings and vegetated buffers to make a presentation.
- Invite stakeholders to a picnic at a demonstration site.
- Have neighborhood district or area representatives visit landowners (who participated or didn't participate in the demonstration picnic) with where to buy directories and coupons as a follow-up and to assure that everyone receives the information and incentives.
- Follow-up with landowners to find out if they implemented buffer plantings and if not, why.

Other Land Use and Management

- Logging and farming are land uses that can promote open space, minimize impervious surfaces, and provide a cultural and element that is essential to rural life. Those operations that area challenged by hydrology, ledge, and steep slopes can contribute to nutrient loading and the introduction into the watershed of other substances harmful to water quality.

Outreach Activities

- Provide loggers with NH Department of Resources and Economic Development Best Management Practice manuals when applying for intents to cut. Post and publicize these resources on the Partnership, Lake Associations, and City and Town websites.
- Identify foresters and loggers who would act as harvesting neighborhood district or area representatives. These representatives would receive notice from the City and Town when an intent to cut is filed and would make a field visit to the harvest site to share BMP manuals, fact sheets, and offer assistance and resources. A similar approach should be applied to agricultural operations. Because permits are not required for ongoing agrarian activities, the visits should be made on an ad-hoc basis.
- The Partnership and its member's lake associations and city and town should consider recognizing exemplary operations as demonstration sites and bestow an annual award that is well publicized through out the region. The Partnership could invite State Senators and House Representatives along with municipal officials.

Shoreline Septic Systems

Properly designed and maintained septic systems can help preserve water quality. Most homeowners are not aware of their own septic system's age, condition, or maintenance record. For many homeowners, their first knowledge of their own systems is when there is a failure. Some "work around" failures causing harm to their own health and that of others.

Outreach Activities

- The Partnership should review the Granite State Designers and Installers Association *Septic System Recordkeeping File and Owner's Guide*. This tabbed file folder contains information about system maintenance as well as a form to document septic design, location, and maintenance records. Because this folder was produced with public funds, it may be duplicated without copyright infringement.
- The Partnership may wish to revise and customize the produce a bulk quantity. The Partnership could solicit and negotiate from haulers and maintenance firms incentive coupons that could be included with the folder. Those firms providing coupons could be listed on a directory handout also included in the file.
- Direct distribution is important. Partnership representatives should include the folder in "Welcome Wagon" packages and at City and Town offices where permit applications are distributed.
- The Partnership's City and Town and Lake Association staff and volunteers should consider delineating areas in the watershed where someone is a local neighborhood district or area contact. Not only would this representative be available for questions and to provide referrals to resources but also he/she would commit to visiting each house in that districts or area, introducing his/herself, and providing the septic folder and resources.

Recreation

Fast-moving boat traffic may contribute to phosphorus and other nutrients being introduced in the water column where they can facilitate algal blooms. Because it isn't likely that the current NH Department of Safety (NHDOS) process for applying no-wake zones and speed limits will consider most environmental issues, the Partnership may wish to focus its efforts on gaining compliance for the current no-wake within 150 feet of shore regulation

Outreach Activities

- The Partnership should contact NHDOS Marine Patrol to determine if additional personnel can be present on the lakes.
- The Partnership may be able to work with NHDOS Marine Patrol on recruiting additional Auxiliary personnel.
- Volunteers can work with residents and visitors (at the access points) to provide information and speak with them about their lake use and habits. If possible, contact information can be gathered for future surveys and focus groups.

Fireworks

Some studies have shown that the materials contained in the wrapper material around fireworks can contribute to nutrients in lakes and streams. Others suspect that there may be trace levels of heavy metals in the fireworks that can be released into water bodies when they are detonated over them. These materials can introduce nutrients and/or other materials harmful to water quality and human and wildlife life. The noise, odors, and light can be disruptive to wildlife.

Outreach Activities

- Designate one evening for Independence Day fireworks and encourage through publicity everyone's participation on that one date.
- Investigate finding receptacles that can effectively circumvent the debris going into the lake. If possible, customize the receptacle with a message and distribute using the neighborhood district or area strategy.
- Use this neighborly one-on-one opportunity to learn about fireworks detonation habits and explore with the individuals their willingness to contribute to a single and central display where pollutants can be controlled and minimized.

The Partnership as a Clearinghouse

Although the Partnership should strive for behavior change, providing information, resources, and referrals are still important first steps toward awareness and then change. The Partnership should provide on its Webster-HighlandLakesPartnership.org website a page where resources and documents can be posted or links to them can be posted. This includes links to other organizations that have good resources on their websites including state and federal agencies; state-level associations; local lake and watershed associations; and private industry such as nurseries, landscaping, and septic maintenance and hauler firms.

7

Summary of Recommended Measures to Improve Water Quality

Table 7-1 provides a listing of the various recommended measures to reduce the pollutant contributions from identified sources.. In addition, a general assessment of the priority is also provided based primarily on the relative source contribution and cost–effectiveness of the treatment measure.

These measures were selected based on their estimated cost-effectiveness, their estimated relative contribution to the decline in lake water quality, the availability of resources and the general assessment of the difficulty in implementation. The associated cost estimates are very preliminary and would require further investigations to develop more accurate estimates.

Table 7.1 - Summary of Recommended Measures		
Description of Measure	**Targeted Implementation**	**Estimated Cost***
1.0 Develop a Septic System Management Plan -On ground Property Owner Survey -GPS system locations -Develop GIS data base w/system data, location, soils data, maintenance schedule -Contact local septic haulers to develop pump-out discounts	June- Nov 2007	$10-15,000
2.0 Investigate possible cost-sharing with Andover to provide initial funding for the services of an on-call Forester to monitor and inspect timber harvesting operations in the area	Immediate	$2,000- $5,000
3.0 Fund/Contract a Part-Time Watershed Coordinator provide Laison between Andover and Franklin - Coordinate zoning updates, build-out analyses, etc. - Coordinate education and outreach efforts - Provide consultation to interested property owners for suggestions on drainage and landscaping measures (i.e. rain gardens for roof drains, driveway runoff, etc). owners and other stakeholders. - Assist in preparing grant applications for 319 funds	May 2007– Sept 2008	$12,500
4.0 Stabilize/Improve Roadside Swales Along Smiling Hill Rd	July–Aug. 2007	$7.5 -$10,000
5.0 Apply for Section 319 funds to Improve/Stabilize Swales along Sam Hill Road and Hoyt Road in Andover	Sept. 2007	$15 to 20,000
6.0 Coordinate with NRCS to assess need for additional fencing or culverts to isolate drainage ways from pasture areas and manure spreading areas	Spring 2007	$2,500
7.0 Provide/Subsidize Use of Rain Barrels to reduce roof runoff for Shoreline Property Owners	Spring 2007	< $2,500
* Cost estimates are preliminary rough estimates		

8

References

Center For Watershed Protection. 1998. Nutrient Loading from Conventional and Innovative Site Development.

Dufresne-Henry, Inc. 1981. Water Quality Management Investigation, Webster Lake. Franklin, New Hampshire.

Dudley, R.W. S. A. Olson and M. Handley. 1997. A Preliminary Study of Runoff of Selected Contaminants From Rural Maine Highways. U.S. Geological Survey; Water Resource Investigations Report 97-4041.

Levy Engineering, Inc. May 2004. Preliminary Cost Estimate: Webster Lake Sewer Report: addressed to Brian Sullivan, Public Works Director, City of Franklin, NH.

Maine Dept of Environmental Protection. 1986. Phosphorus Export From Low-Density Residential Watershed and An Adjacent Forested Watershed, Jeffrey Dennis; Lake and Reservoir Management Volume II, Proceedings of the Fifth Annual Conference and International Symposium on Applied Lake and Watershed Management.

Maine Dept of Environmental Protection. 2000. Madawaska Lake: Total Maximum Daily Load for Total Phosphorus, Final Lakes TMDL Report DEPLW 2000-12.

McGuinn, Beth. July 2006. $173,000 Grant To Help Protect Hersey Family Farm, Article in *The Andover Beacon.*

NH Department. of Environmental Services. 1990. Webster Lake Diagnostic/Feasibility Study. Staff Report. WSPCD 90-6.

NH Department of Environmental Services. 1996. Best Management Practices For Urban Stormwater Runoff.

NH Department of Agriculture, Markets, and Food. April 2002. Manual of Best Management Practices (BMPs) for Agriculture in New Hampshire. Discussion of Nutrient Best Management Practices in New Hampshire. Reprinted.

Schuler, T. R., 1987. Controlling Urban Runoff: A Practical Manual For Planning and Designing Urban BMPs. Metropolitan Washington Council of Governments.

U.S. Environmental Protection Agency. 2005. Handbook for Developing Watershed Plans to Restore and Protect Our Waters. DRAFT. EPA 841-B-05-005.

Vollenweider, R.A. 1976. Advances in Defining Critical Loading Levels for Phosphorus in Lake Eutrophication. Mem. Ist. Ital. Idrobiol. , 33:53-88.

Appendix A
Public Meeting
Slide Presentations

Appendix A
Public Meeting
Slide Presentations

June 27, 2006

Vanasse Hangen Brustlin, Inc.
Hutchins Consulting Services
Naturesource Communications

Study Objectives

- Identify Causes for Lake Water Quality Decline.
- Identify Feasible Measures to Improve and/or Prevent Further Degradation in Lake Water Quality.
- Increase Awareness and Educate Stakeholders on How Human Activities Can Affect Lake Water Quality.

Step-Wise Approach

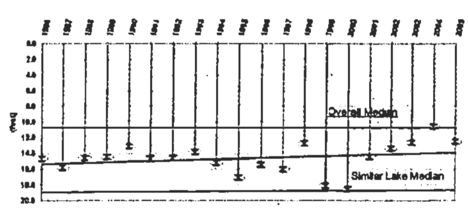
- Encourage and Listen to Public Input
- Identify Primary Water Quality Concerns
- Develop Specific Goals for Improvement
- Identify Possible Measures and Assess Potential Improvement
- Develop an Implementation Plan for Most Cost-Effective Solutions
- Outline a Monitoring to Measure Effectiveness

Signs of Water Quality Decline

- Lower Transparency (trending from 12 to 14 feet to 10 to 12 feet).
- Increased Abundance of Blue-Green Algae
- Increased Turbidity and Bacteria Readings in certain tributaries.
- Prevailing Low Dissolved Oxygen Levels at Depth.

Historical Webster Lake Transparency Data

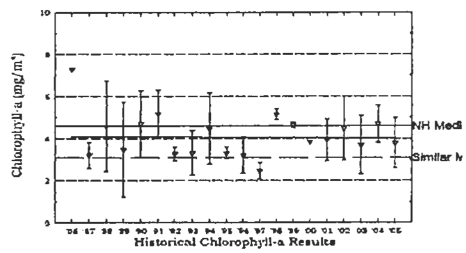
(Secchi Disk Depth in Feet)



Source: 2005 VLAP Annual Rpt

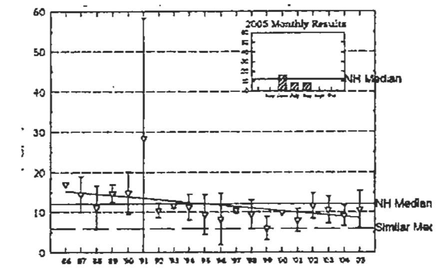
Cyanobacteria

Historical Chlorophyll-a Concentration Data



Historical Phosphorus Data

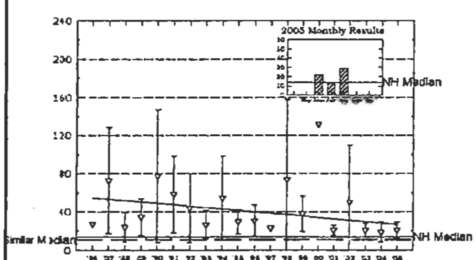
Epilimnion



Source: 2005 VLAP Annual Rpt

Historical Phosphorus Data

Hypolimnion

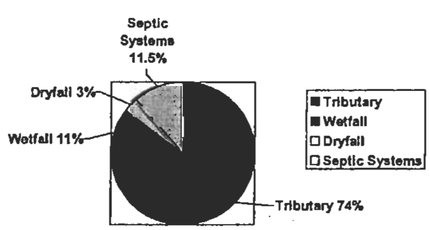


Source: 2005 VLAP Annual Rpt

Keys to a Successful Watershed Management Plan ?

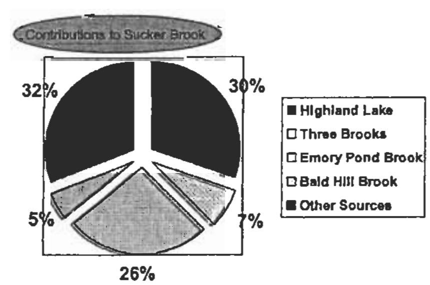
- Local **Stakeholder Involvement** and Support
- **Scientific Understanding** of the Lake Responses to Watershed Inputs and In-Lake Activities
- **Feasible Recommendations** Based on Existing Lake Data and Engineering Expertise

Approx. 74% of Annual Phosphorus Load to Lake is from Tributary Inflow



Source: 1990 DES Diagnostic Study

Approx. 81% of Annual Phosphorus Load From Tributaries is from Sucker Brook



Source: 1990 DES Diagnostic Study

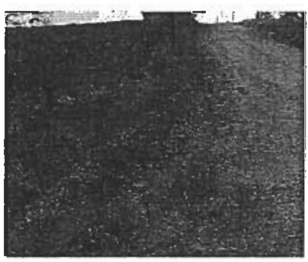
Additional Sampling Activities in 2006

- Stormwater Sampling in Sucker Brook at Key Locations
- Additional Phosphorus Sampling at Lower Depths
- Shoreline Conductivity Survey
- More Frequent Monitoring of Algal Blooms
- In-lake Monitoring During Weekend Activity

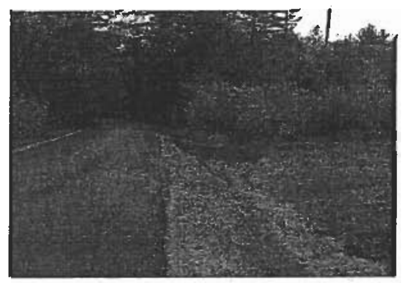
Possible Areas of Focus

- Stormwater BMPs
  - Gravel Roads (ID key locations for grassed swales, level spreaders, diversion berms, etc).
- Review/Update Land Use Zoning and Site Plan Requirements
  - Riparian Corridors
  - Erosion Control Plans/Review
- Education & Outreach –
  - Benefits of Septic System Maintenance
  - Pet Waste Disposal

Roadside Ditches



Lake Ave Drainage



Flow Diverted Across Webster Ave

Lake Shore Rd Bridge

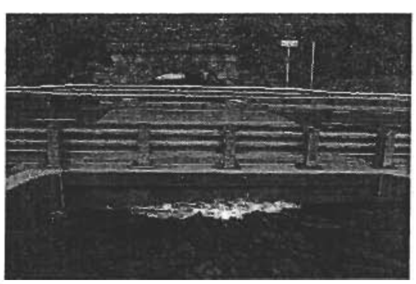
Riparian Buffers

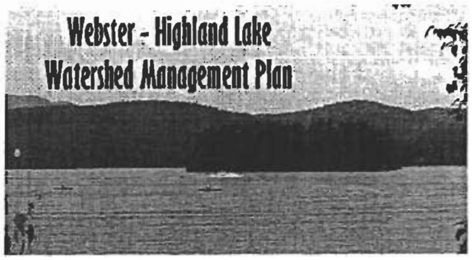
May Flood –Sucker Brook

May Floods

Where the Kayaks Meet the Road

Lake outlet





July 10, 2006

Vanasse Hangen Brustlin, Inc.
Hutchins Consulting Services
naturesource communications

Study Objectives

- Identify causes for lake water quality decline
- Identify feasible measures to improve and/or prevent further degradation in lake water quality
- Increase awareness and inform stakeholders on how human activities can affect lake water quality

Step-Wise Approach

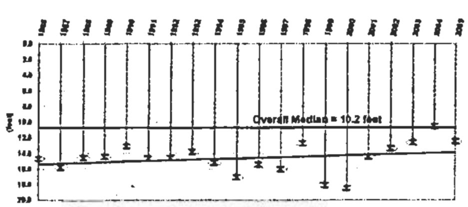
- Encourage and listen to public input
- Identify water quality primary concerns
- Develop specific goals for improvement
- Identify possible measures and assess potential improvement
- Develop an implementation plan for most cost-effective solutions
- Draft and implement an outreach strategy for sustainable results
- Outline a monitoring plan to measure effectiveness

Signs of Water Quality Decline in Webster Lake

- Lower transparency (trending from 12 to 14 feet to 10 to 12 feet).
- Increased abundance of blue-green algae
- Increased turbidity and bacteria readings in certain tributaries.
- Prevailing low dissolved oxygen levels at depth.

Historical Webster Lake Transparency Data

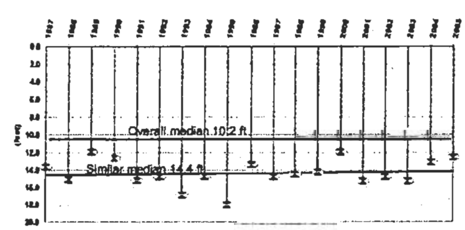
(Secchi Disk Depth In Feet)



Source: 2005 VLAP Annual Rpt

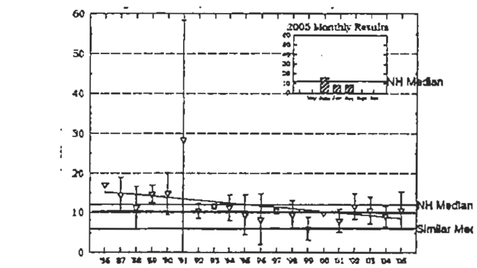
Historical Highland Lake Transparency Data

(Secchi Disk Depth In Feet)



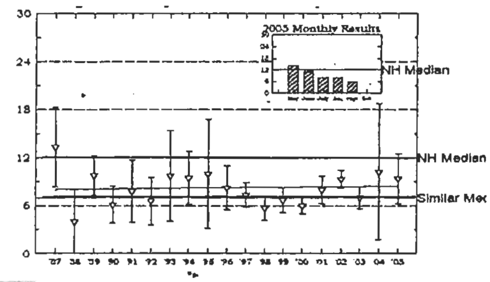
Source: 2005 VLAP Annual Rpt

Webster Lake Phosphorus Data
Epilimnion



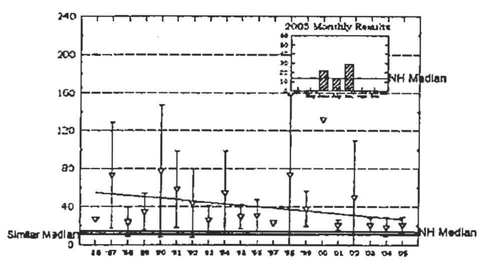
Source: 2005 VLAP Annual Report

Highland Lake Phosphorus Data
Epilimnion



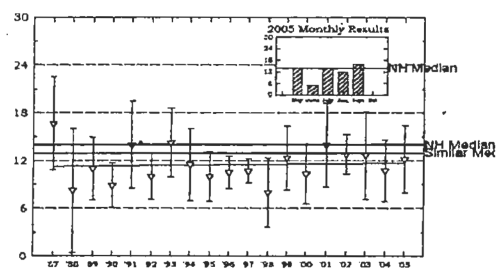
Source: 2005 VLAP Annual Report

Webster Lake Phosphorus Data
Hypolimnion



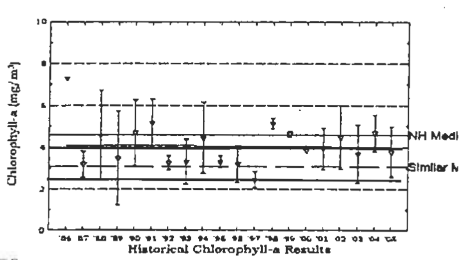
Source: 2005 VLAP Annual Report

Highland Lake Phosphorus Data
Hypolimnion

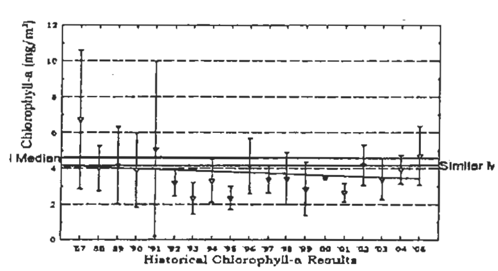


Source: 2005 VLAP Annual Report

Webster Lake Chlorophyll-a Concentration Data



Highland Lake Chlorophyll *a* Data

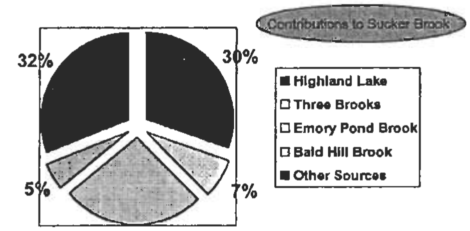


Source: 2005 VLAP Annual Report

Keys to a Successful Watershed Management Plan

- Local **Stakeholder Involvement** and support
- **Scientific Understanding** of the lake responses to watershed inputs and in-lake activities
- **Feasible Recommendations** based on existing lake data and engineering expertise

Approx. 81% of Annual Phosphorus Load From Tributaries is from Sucker Brook

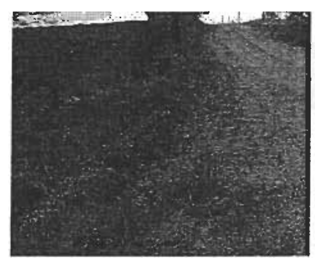


Source: 1990 DES Diagnostic Study

Possible Areas of Focus

- Stormwater BMPs
  - Gravel roads (ID key locations for grassed swales, level spreaders, diversion berms, etc).
- Review/update land use zoning and site plan requirements
  - Riparian corridors
  - Erosion control plans
- Education and outreach
  - Benefits of septic system maintenance and
  - Pet waste proper disposal

Roadside Ditches



Riparian Buffers

Timber Harvesting – turbidity

Floatable Debris and Turbidity

Your listening session

- Please share
  - Your thoughts on the proposed Plan
  - Your local observations
  - What you would like the Plan to address

Contact us

Barcieri@vhb.com

603.644.0888 x2504

Visit

webster-highlandlakespartnership.org

Appendix B
Interim Interpretative Data Summary Report

Report 1: Water Quality Management Investigation; "Dufresne-Henry Report." 1981.

General Description: First major study of Webster Lake (precursor to the 1990 Diagnostic/ Feasibility Study; Tasks performed include; monthly and weekly water quality sampling in tributaries; flow measurements; lake sampling; lake bathymetry measurements; subwatershed delineation, land use inventory, sanitary survey of shoreline septic systems; determination of phosphorus budget; estimates of potential phosphorus reductions for several management alternatives (See Below).

<u>Management Alternatives Evaluated</u>

1. Sewering shoreline homes along Webster Ave and Lake Shore Ave,
2. Diverting 30 and 60 % of spring time flow from Sucker Brook to below lake outlet.
3. Use of sedimentation basins to reduce phosphorus concentrations in Sucker Brook during spring time flow (Mar-May).

DATA COLLECTED
Sampling Data

- Ave. P conc. in tribs. ranged from 0.005 to 0.043 mg/l; highest in Sucker Brk;
- Sucker Brook had an ave P conc. of 0.019 mg/l; peak conc. of 0.061 mg/l,
- Ave P conc. in precipitation was 0.026 mg/l; median of 0.015 mg/l based on 33 samples collected from 1973 to 1980,
- In-lake surface P conc. averaged 0.011 mg/l; with an ave of 0.016 mg/l over entire water column and a high of 0.142 mg/l in hypolimnion (12 meters).

Septic System Data

- In 1980, 96 of the 147 first-tier homes (lake frontage) and 30 of the 2nd tier homes were surveyed,
- 50% of surveyed systems were 10 to 20 yrs old,
- Nearly 50% of the 96 1st tier systems were w/in 50 feet of lake,
- Approx. 57 of the 1st tier homes were seasonal; 31 were year-round,
- Two systems had actual breakout observed and were failing,
- Sixteen systems were < 2 ft above water table.
- !5 systems along Webster Ave were < 25 ft from lake; 26 were < 50 ft from lake,
- 12 systems along Webster Ave were < 2 ft above water table,
- 3 systems consisted of cesspools.

Estimated Phosphorus Impact From Future Year –Round Conversions

- The P load was estimated to increase by 192.1 Kg or roughly 31 % if the 54 seasonal homes within 75 ft of lake were converted to year-round use.
- Septic system P load from the then 176 1st tier homes was 71.3 Kg based on an assumed Phosphorus concentration of 0.011 mg/l/person for seasonal and 0.017 mg/l/person for year-round (diff being washing machines in yr homes).

RELEVANT RESULTS

Phosphorus Budget

- Existing Annual Phosphorus Load to lake = 618.5 Kg (normal precipitation year);, Annual load of 618.5 Kg translates to ave. in-lake P conc of 0.013 mg/l.; based on Vollenweider Equation
- Breakdown of Ave. Annual Phosphorus Sources
    - 74 % comes from watershed (tribs. & unsampled sources)
    - Sucker Brook; 52 % of total; 63% of watershed portion,
    - Shoreline septic systems; 12% of total,
    - atmospheric deposition (wet and dry); 14 % of total

Findings of Alternatives Evaluation

- Analysis concludes that sewering all 147 1st tier homes would reduce P load to lake by 71.3 Kg (12% total) and reduce in-lake P conc. by 1 to 2 ppb to 12 ug/l or 0.012 mg/l. (could be more if > 64% homes are now YR use).
- Sewering 43 homes along Webster Ave from Rte 11 to Griffin Beach would reduce P Load by 20.8 Kg and would produce in-lake P conc. of 0.013 mg/l (no measurable effect and also depends on # of homes & 64% YR homes).
- Sewering 37 homes along Lake Shore Drive and North Shore Rd could reduce P load by 17.9 Kg and produce an in-lake P conc. of 0.013 mg/l (same assumptions and limitations as above).
- Diversion of 30 and 60 % of Sucker Brook flow during March, April, and May could reduce P Load by 96.1 and 192.0 Kg, respectively, and would result in estimated in-lake P conc. of 0.013 and 0.012 mg/l, respectively. (P conc. did not drop as much because retention time is also changed)
- Treating 30 and 60 % of Sucker Brk flow with sedimentation basins was estimated to reduce P load by 56.9 and 113.8 Kg (assume 40% removal) and would drop estimated in-lake P conc. to 0.012 and 0.011 mg/l, respectively. (assumes an average P conc of 0.027 mg/l in Sucker Brk during spring months). (not a feasible option – sediment basins would have to be > 5 acres).
- Study also predicted a possible major increase in phosphorus loading (192 Kg or roughly 31% increase), if the 54 remaining seasonal homes within 75 feet of the lake are converted to YR use without upgrading septic system.

Items that need further Review:

- Assumed P concentration of 17 mg/l per person in septic effluent
- Number and percentage of 1st tier homes that are seasonal vs year-round use – number of upgrades
- Whether there are homes still using cesspools
- Review and ID areas where homes/septic are w/in 2 ft of groundwater table.
- Obtain in-lake P sampling data described on page 37.
- Review future population estimates, land-use breakdown and rough build-out analysis on pages 3 to 17 and especially Table 7 on page 17.

Interpretation of Findings: Developed an average annual phosphorus loading estimate of 618 Kg per year based on tributary sampling data, which translates into average annual in-lake phosphorus concentration of 0.013 mg/l, which compares favorably with the observed average phosphorus concentration of 0.014 mg/l in the epilimnion, based on sampling data from 1986 to 1988. Study suggests 74% of the phosphorus was due to tributary inputs, 14% due to atmospheric or "Bulk" precipitation and 12% due to septic systems. Several management alternatives were evaluated including extending sewer to shoreline homes, diversion of Sucker Brook flow to the lake outlet during spring months and treatment of Sucker Brook via settling ponds during spring runoff. Diverting or treating 60% of the Sucker Brook flow through sedimentation basins during March to May was the alternative that showed the greatest potential reduction in the in-lake phosphorus concentration by roughly 0.002 mg/l. This study authors suggested that the amount of phosphorus contributed from bottom sediments was considered relatively minor because the anoxic portion of the hypolimnion was estimated to be about 2 % of the total lake volume.

The study authors conclude "that the most reasonable long-term goal, in terms of lake and watershed management, is to try to slow the trend toward eutrophication. It is questionable whether any restoration actions to improve in-lake water quality (such as dredging, nutrient inactivation, etc.) would be cost- effective. Preservation of the existing lake conditions via implementation of comprehensive phosphorus control measures in the watershed and near shore area would be a more realistic goal."

Report 2) Webster Lake Diagnostic / Feasibility Study, NH Department of Environmental Services, prepared in 1990.

General Description: As the study title indicates, there were two distinct portions of this study: one providing a diagnostic assessment of the lake water quality and watershed conditions and the other involves a feasibility assessment of various restoration/management alternatives. The diagnostic study focused on improving the phosphorus budget analyses, particularly for the Sucker Brook watershed, initially developed as part of the 1981 Dufresne-Henry study. The study confirmed that Sucker Brook watershed was a major source of phosphorus contributing about 63% (391 Kg) of the estimated 618 Kg of phosphorus entering Webster Lake on annual basis. Other lake tributaries accounted for another 11 %, septic systems contributed 12 % and atmospheric deposition accounted for another 14% of the total load. Additional details concerning Sucker Brook phosphorus sources are discussed below:

Management Alternatives Evaluated

This study evaluated the feasibility of several in-lake management / restoration alternatives. These included in-lake algal treatments as well as artificial circulation, hypolimnetic aeration, sediment removal and alum treatments.

Sucker Brook Phosphorus Sources

To gain a better understanding of the sources of phosphorus in Sucker Brook watershed, bi-weekly water quality sampling and stream flow measurements were conducted at 12 locations including 5 stations within Sucker Brook, four tributaries to Sucker Brook and three seasonal or intermittent streams. The following table summarizes the results of the phosphorus sampling;

Table 1.0 –Summary of Tributary Loads to Sucker Brook

Source	Annual Load (Kg)	Percent of total	April Load (Kg)	Percent of Annual
Highland Lk outlet**	81.0	31.0	19.0	23.0
Cilley Hill Brook	5.1	2.0	1.5	29.0
Emory Pnd Brk	69.5	26.0	30.5	44.0
Bald Hill Brk	13.8	5.2	2.7	19.5
Apple Farm Brk	2.9	1.1	1.1	38.0
Sucker Brook outlet**	265.0	100.0	124.5	47.0

The summary of phosphorus sources in the Sucker Brook watershed shows that the Highland lake outlet and the Emory Pond Brook watershed account for 31.0 and 26 % of the total phosphorus load from Sucker Brook, respectively, and represent two of the largest contributors. Unmonitored sources or direct runoff to the brook represented another major source accounting for another 28 % (74 Kg) of the total phosphorus from Sucker Brook. The unmonitored sources were determined based on the difference between the amount measured at the Sucker Brook outlet and that measured from all other sources. The other three streams accounted for less than 10 % total annual contributions from Sucker Brook.

Nearly half or roughly 47 % of the total phosphorus contribution from Sucker Brook occurred during the month of April. More than 90 percent of the unmonitored source contribution occurred during the month of April. The percentage contributed during April was much smaller in the more forested or less developed watersheds of Cilley Hill Brook and Bald Hill Brook. This would suggest that amount of disturbed soil and/or increased runoff due to impervious surfaces are important factors in contributing to phosphorus load during the Spring season.

The other significant finding of DES' Sucker Brook watershed investigation is that the largest observed increase in phosphorus loads occurred between the Three Brooks station and the Dyers Crossing station where the annual phosphorus load jumped from 88.0 to 185.0 Kg. About 80 % of this increase occurred during the months of February, April, May and July with the largest monthly increase occurring during the month of February. These major increases could be related to large runoff or snowmelt events or could be due to certain land use activities or disturbances that occurred during these months such as manure spreading on agricultural fields, timber harvesting or both.

In addition, a limited predictive modeling procedure was conducted to assess the lake's capacity to accept additional phosphorus from future development. The results indicated that the average chlorophyll *a* concentration would likely increase from 5.0 mg/m^3 to 6.0 mg/m^3 if 67 additional homes were built in the watershed. A 1.0 mg/m^3 increase in chlorophyll *a* increase can reduce water clarity or transparency by 1.5 feet.

Study 3: Recent NHDES Sucker Brook Sampling for *E. coli* bacteria 2004-2005

General Description: NHDES conducted a nine sampling events during the course of 2004 and 2005 to try identify bacteria sources (*E. coli*) within the Sucker Brook watershed. There is no report associated with this investigation, the following is an interpretative summary of the salient findings gleaned from the sampling results provided in an Excel spreadsheet and a map of the sampling stations, provided by Andy Chapman of the NHDES Watershed Management Bureau.

Sampling Approach;
In 2004, 7 events were conducted on May 13, June 25, 29 and 30, July 27 & Nov 4
In 2005, 3 sampling events were conducted June 28, July 18 and Oct 25;

During 2004, generally 11 to 12 locations located throughout Sucker Brook were sampled during each event. In 2005, the sampling was more focused on Bald Hill Brook along Philbrick Road and the lower part of Sucker Brook.

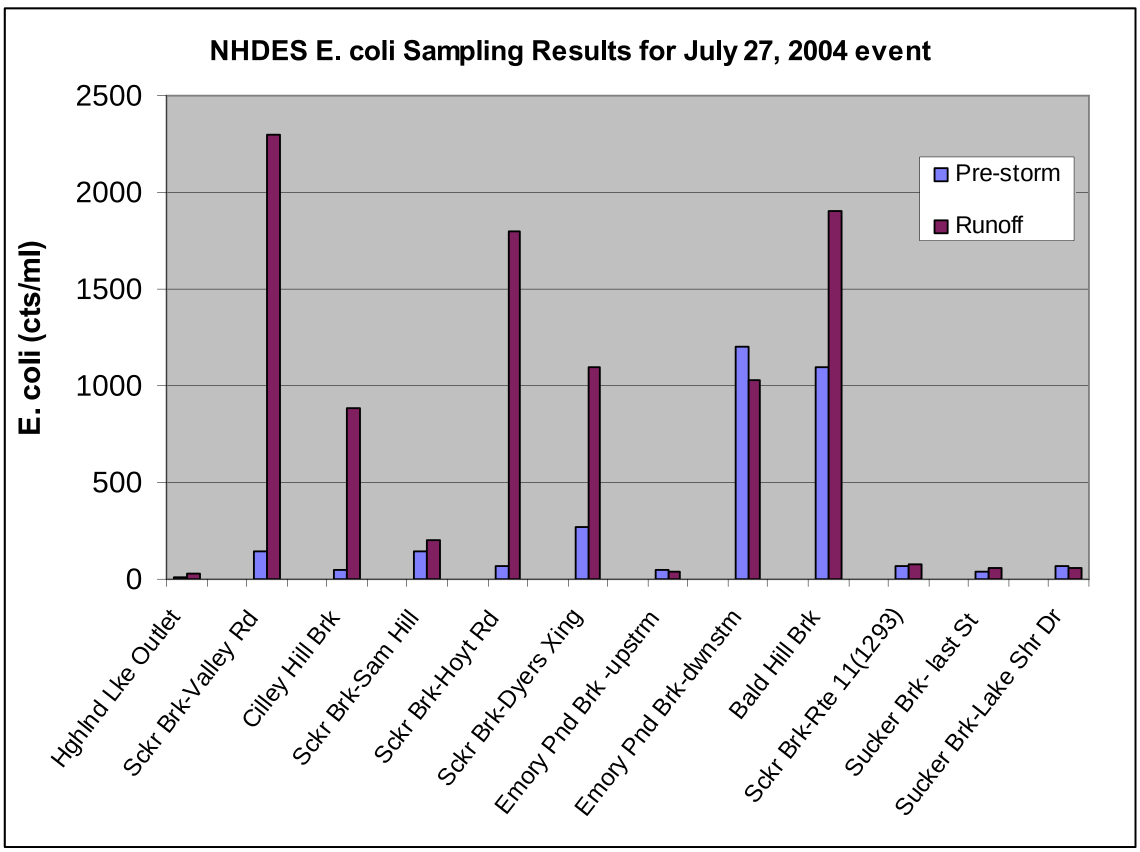
On June 29, 2004, total phosphorus was also sampled in the Sucker Brook at the Lake Shore Drive crossing and upstream at the Hoyt Road crossing. The sample results are shown below:

Location	Total Phosphorus
Sucker Brook at Lake Shore Dr.	0.048 mg/l
Sucker Brook at Hoyt Road	0.012 mg/l

Review of Bacteria Sampling Results
Results from six events showed relatively low bacteria (E. coli) levels (i.e., generally 10 to 80 cts/100 ml, except for a few higher readings of 140 and 210 cts/ml in Sucker Brook at the Valley Road crossing on June 25 and 29, 2004, respectively. During the June 25, 2004 event, Emory Pond Brook had an E. coli reading of 280 cts/ml.

The highest readings were observed on July 18, 2005 when Sucker Brook at Lake Shore Drive had an E. coli reading of 13,600 cts/ml. This magnitude of this level suggests a significant source in the watershed and perhaps one that is close by in the lower reaches of Sucker Brook. Further upstream, at Dyers Crossing, the E. coli reading was 4,700 cts/ml in a sample that was taken about an hour later. The lower level upstream could indicate that the source(s) of bacteria is located in between these two stations, or it could be just a function of the upstream sample being taken an hour later in the storm after the "first-flush" of runoff had already passed through this station. The other samples collected during this event were from Bald Hill Brook along Philbrick Road, which also had elevated readings of 2,500 to 3,300 cts/ml, but were lower than the readings recorded in Sucker Brook either upstream at Dyers Crossing or downstream at Lake Shore Drive.

The results from the July 27, 2004, are perhaps the most revealing in terms of where the highest increases in E. coli levels occur during a storm event. During this event, a pre-storm sampling round was first collected followed by a second sampling round an hour or later once rainfall and runoff began. The results are shown below in order of flow path from Highland Lake to Lake Shore Drive just before Sucker Brook enters Webster Lake.



These results clearly show major increases in bacteria following the initial first flush of runoff at certain locations, specifically at the Valley Road Crossing, Hoyt Road crossing and Dyers

Crossing. Substantial increases were also observed in Cilley Brook and in Emory Pond Brook based on the difference in upstream and downstream samples in Emory Pond Brook. Interesting enough, the pre-storm samples in Emory Pond Brook and Bald Hill Brook had E. coli levels above 1,000 cts/ml where everywhere else E. coli levels in pre-storm samples were generally below 100 cts/ml. These elevated levels in pre-storm samples indicate that the source is essentially in the stream and not necessarily transported by runoff. This could be due to natural wildlife contributions but is more likely due to livestock entering in the stream. The major increases observed between pre-storm and runoff samples are also likely due to animal wastes in adjacent pasture areas and perhaps manure fertilized cropland adjacent to Sucker Brook or Cilley Brook. The greatest spike was observed in Sucker Brook at the Valley Road crossing, which warrants further investigation. This location had elevated bacteria levels during other sampling events as well. Surprisingly, the bacteria levels were observed to be relatively low at the lower end of Sucker Brook at the Lake Shore Drive crossing when most recently in 2005, especially on July 18, 2005, this location had an extremely high level of 13,600 cts/ml.

Variable results were observed in the other two 2005 events conducted on June 28 and October 25. During the June event, five stations were sampled including Lake Shore Drive and Dyers Crossing and 3 stations on the Bald Hill tributary. An upstream station on the Bald Hill tributary had a minor spike of 130 cts/ml but the downstream station had a reading of 20 cts/ml. The Dyers Crossing and Lake Shore Drive stations had readings of 40 and 30 cts/ml, respectively. The same stations were sampled on October25th plus an additional upstream station on the Bald Hill tributary. The Lake Shore Drive and Dyers Crossing stations had the highest readings of 1,370 and 890 cts/ml, respectively, while the Bald Hill tributary had readings ranging from 100 to 230 cts/ml with higher readings observed higher up in the watershed.

The variability in the bacteria sampling results is perhaps due in large part to the varying intensity of rainfall and runoff during each rain event as well as being due to differences in sample timing within the rain event. The results of at least two sampling events indicate that there may be a fairly significant source of bacteria near Lake Shore Drive since lower levels were observed further upstream during the same events. The extremely high level of 13,600 cts/ml observed on July 18, 2005 certainly warrants further investigation.

In addition, the findings of the July 27, 2004 event clearly indicate that there are locations within the watershed where there are other major sources of bacteria that, at a minimum, cause localized spikes in of E. coli within Sucker Brook above the state water quality standards during storm events. The evidence is not clear as to whether these sources continually affect bacteria levels in Webster Lake but it is quite likely these same sources are also sources of nutrients and particularly phosphorus, which would affect water quality in Webster Lake.

Study 4: Septic System Survey Data; Prepared by Jeanne Galloway of the Caring Community Network of Twin Rivers, dated August 12, 2004.

General Description: This report provides a review of the City's property files for lots within the Lake Protection Zone. Each file was reviewed seeking information regarding the age, location, type and permit status of the sewage disposal system. Eighty-five (85) lots have permitted sewage disposal systems while another 44 lots generally had older system with some notes regarding the location of their system.

Description of Findings: Of the 44 lots that have no permit according to the DES Subsurface records, there are currently 25 lots that have systems that are 25 years or older, if there have been no updates since this report has been prepared. Fourteen (14) of these systems are now 30 years or older, again, if not updates have taken place. Twenty (20) years is generally considered to be maximum age of an effective septic system in well drained soils. A follow-up survey should be conducted to see if any these systems have been updated. Many of these homes with little or no data are located in the Tier 1 zone along Webster Ave and Lake Shore Drive. This is a major data gap that should be reviewed to gain some certainty about possible septic system loading.

Seven of the more recent permitted systems are restricted for SEASONAL USE ONLY and another 4 systems are required to use holding tanks. These restrictions are indicative of the small areas and/or poor soil restrictions for septic design. Twenty-nine (29) are pumped systems and twenty–two are using advanced technology with 10 Eljien systems and another 12 Environseptic systems.

Report 5 - Webster Lake – Summary of Available In-Lake Water Quality Data from VLAP and other Reports

Water quality data have been collected from Webster Lake for more than 25 years. The first comprehensive effort of data collection was undertaken by Dufresne-Henry (Water Quality Management Investigation Webster Lake Franklin, NH 1981), with the actual sampling being done from fall 1979 to late summer 1980. A second comprehensive effort was undertaken by NHDES (Webster Lake Diagnostic Feasibility Study, 1990), with the actual in-lake sampling being conducted from fall 1987 to early winter 1988. In addition, Webster Lake volunteers have participated in the NHDES Volunteer Lake Assessment Program (VLAP) since 1986, taking Secchi depth measurements and gathering water samples for analysis for total phosphorus and chlorophyll *a* several times each year during the summer period. These data collectively form the basis of this summary of existing water quality.

The data from all sources cited above clearly establish that Webster Lake is a mesotrophic body of water. Various trophic state indices developed by NHDES and others also support a mesotrophic classification. Summer epilimnetic total phosphorus concentrations have averaged perhaps 8-12 parts per billion (ppb) for the last 10 years or more and maximum concentrations during that same time period have not exceeded ~15 ppb. According to NHDES guidelines for lake monitoring parameters, these concentrations place Webster Lake in the "average" category, and somewhat less than the median value of 12 ppb for all NH lakes. Furthermore, evaluation of nearly 20 years of VLAP data shows a statistically significant declining trend in epilimnetic total phosphorus levels which suggests that nutrient loading from all sources may be gradually declining.

Review of chlorophyll *a* data leads to similar conclusions. Chlorophyll *a* has historical averaged between 3 and 5 ppb for the summer, with recent maximum values almost always less 6 ppb. NHDES guidelines indicate that the average levels would result in a "good" classification, somewhat better than the NH median of 4.6 ppb. Even so, some of the maximum values exceed the "good" category, and while not at "nuisance" levels, they would place occasional Webster Lake chlorophyll *a* values at "more than desired" levels. There is no statistically significant trend in the long-term chlorophyll *a* data which suggests that concentrations are neither increasing nor decreasing. Given the natural variability of phytoplankton activity, this is not unexpected.

Secchi depth measurements also support a mesotrophic classification. Historic summer averages range from 4 to 5.5 meters, with the minimum value always above 2 meters. NHDES guidelines would place these values in the "good" to "exceptional" category, considerably greater than the State median value of 3.2 meters. Nevertheless, there is a statistically significant, declining trend in Secchi depth that is not explained by either the total phosphorus or chlorophyll *a* data. This trend his been particularly noticeable in the most recent 5-7 years, with minimum values declining steadily from approximately 5 meters in 1999 to ~2.2 meters in 2005.

Furthermore, other water quality indicators suggest that the mesotrophic classification may be somewhat misleading. Hypolimnetic total phosphorus levels have been elevated substantially above State median levels for the entire period of record. Even though there has been a statistically significant declining trend in these phosphorus concentrations, elevated levels could be playing a continuing role in contributing to occasional water quality problems. In addition, various species of blue-green algae, cyanobacteria - the so-called nuisance phytoplankton, have become more dominant components of the total phytoplankton assemblage in recent years, especially latter in the summer.

In addition, the State has attempted in this year's Biennual VLAP Report to compare lakes to "similar" lakes rather than to NH lakes as whole as has been done in the past. Although Webster Lake compares very favorably to the median conditions of all NH lakes, it compares far less favorably to the median conditions for similar NH lakes. In fact, Webster Lake chlorophyll *a* concentrations are ~1 ppb higher, epilimnetic total phosphorus concentrations at least 4 ppb higher and Secchi depths nearly 2 meters lower than median values for lakes that the State has determined to be similar.

We conclude that while all traditional measures of trophic state strongly suggest a mesotrophic state for Webster Lake, other occasional water quality measurements provide contrary signals and suggest that traditional measures may not be telling the whole story. Declining trends in transparency and increasing dominance by blue-green algae with occasional noticeable bloom conditions are of considerable concern, but available data do not clearly identify a cause. We will continue exploring potential causes in the evaluation and modeling stage of this project.

Appendix C

DES Shoreline Conductivity Survey Results

Webster Lake Conductivity Survey

By Josh Spaulding

Date of Survey: June 30, 2006
Field Staff: Josh Spaulding and Matt Richards

On Friday June 30th of 2006 we completed an experimental conductivity survey of Webster Lake in Franklin NH. The purpose of the survey was to experiment with using conductivity readings to identify and locate failed septic systems which could potentially be causing serious problems polluting the lake. Conductivity values, measured in micro Siemens per centimeter (µS/cm), were taken around the perimeter of the lake and at the center deep spot for calibration. The values were measured approximately 2 feet deep from a boat as a team went around the lake, attempting to keep as close to shore as safe navigation would allow.

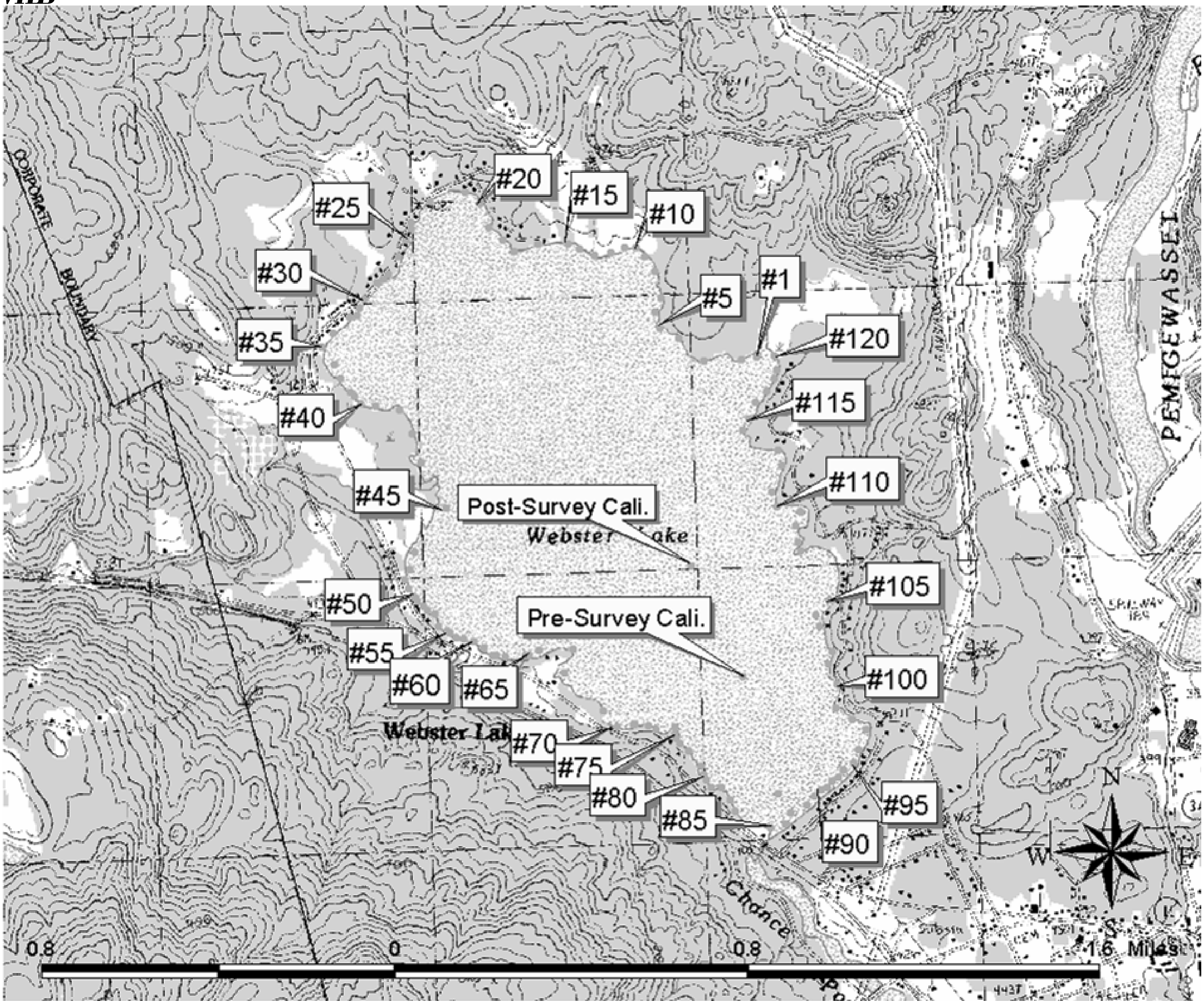
Electrical Conductivity is the measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions or sodium, magnesium, calcium, iron, and aluminum cations. Organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current very well and therefore have a low conductivity when in water. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity. For this reason, conductivity measurements are reported as conductivity at 25° C.

An electrical conductivity sensor consists of two electrodes exactly one centimeter apart. A constant voltage is applied across the electrodes and an electrical current runs through the water. The current measured is proportional to the concentration of dissolved ions in the water. The measured current (measured in µS/cm) holds a direct relation to the measure of Total Dissolved Solids (TDS) (measured in mg/l).
2 µS/cm = 1 mg/l. The TDS measurement is preferred for final data because it gives a more tangible measurement.

In our survey we measured the conductivity in over 120 locations around the lake; we then took that data and looked for any spikes or anomalies present. The EPA currently has no specific standards for electrical conductivity or TDS. It does however have Secondary Maximum Contamination Levels (MCL's), which are loose tolerances. These simply state that a water body or source should not have TDS levels greater then 500mg/l. Water levels equal to that or greater would show signs of hardness, colored water, staining, and salty taste.

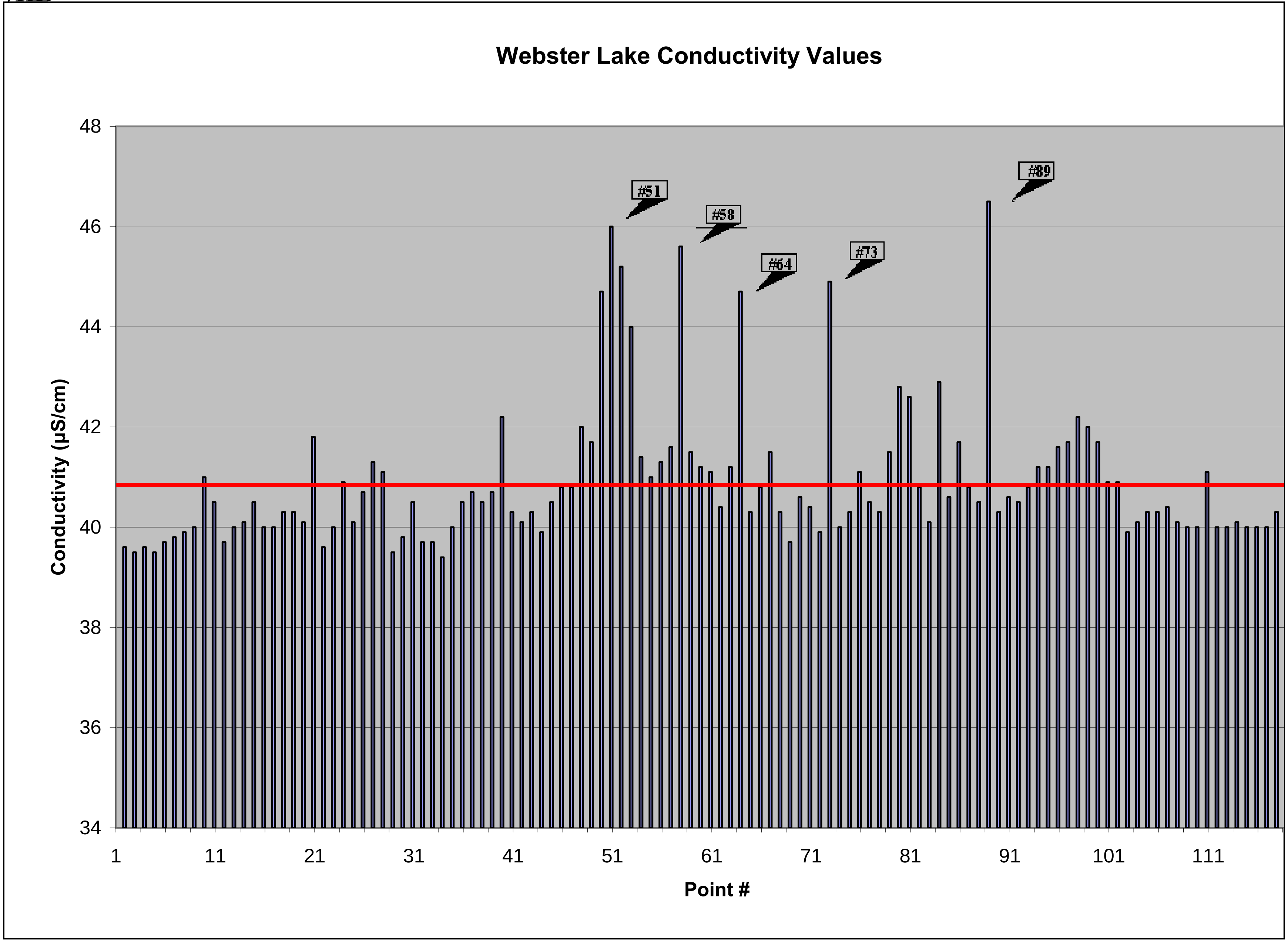
Knowing of course we wouldn't find levels that high in New Hampshire our goal was slightly different. Because contaminates enter the lake from different distances and through different soils, their concentration upon reaching the lake cannot be expected to be a standard indicating value. We set out searching for a spike in the average levels someplace around the lake's perimeter which would indicate higher conductivity levels entering the lake through the groundwater. This spike would hopefully lead us in a direction of search for lake pollutants.

Analysis of our data showed several things. The lake had an average of
40.84 µS/cm. We found one solid spike and four other anomalies indicating higher conductivity levels. We were hoping to find more dramatic spikes in the data but those we found ranged 4 to 6 µS/cm higher then the average. With the data completed we face the question of how to bracket levels of conductivity, and determine what levels of increase are worth investigating.


#1
#5
#10
#15
#20
#25
#30
#35
#40
#45
#50
#55
#60
#65
#70
#75
#80
#85
#90
#95
#100
#105
#110
#115
#120
Post-Survey Cali.
Pre-Survey Cali.
Webster Lake
Webster Lake
CORPORATE BOUNDARY
PEMIGEWASSET
Chance Pond
N
S
E
W
0.8
0
0.8
1.6 Miles

VHB

Point #	Conductivity (µS/cm)	Temp (°C)	Point #	Conductivity (µS/cm)	Temp (°C)	Point #	Conductivity (µS/cm)	Temp (°C)
1	39.7	23.4	43	40.3	24.4	85	40.6	23.9
2	39.6	23.4	44	39.9	24.2	86	41.7	24
3	39.5	23.4	45	40.5	23.2	87	40.8	23.9
4	39.6	23.5	46	40.8	23.4	88	40.5	23.6
5	39.5	23.5	47	40.8	23.5	89	46.5	23.7
6	39.7	23.7	48	42	24.5	90	40.3	23.9
7	39.8	23.7	49	41.7	23.6	91	40.6	23.9
8	39.9	23.8	50	44.7	23.7	92	40.5	23.9
9	40	23.9	51	46	23.6	93	40.8	23.9
10	41	24	52	45.2	24.1	94	41.2	23.9
11	40.5	24	53	44	24.3	95	41.2	23.9
12	39.7	23.5	54	41.4	24.2	96	41.6	23.9
13	40	23.9	55	41	24.2	97	41.7	23.9
14	40.1	24	56	41.3	24.1	98	42.2	23.8
15	40.5	24	57	41.6	24.2	99	42	23.9
16	40	23.5	58	45.6	24.2	100	41.7	24
17	40	23.8	59	41.5	24.2	101	40.9	24
18	40.3	23.9	60	41.2	24.1	102	40.9	24.1
19	40.3	24	61	41.1	23.9	103	39.9	23.8
20	40.1	24.1	62	40.4	23.9	104	40.1	23.9
21	41.8	23.7	63	41.2	23.9	105	40.3	24
22	39.6	23.7	64	44.7	24	106	40.3	24.1
23	40	23.7	65	40.3	23.9	107	40.4	24
24	40.9	23.6	66	40.8	23.8	108	40.1	23.9
25	40.1	23.6	67	41.5	23.7	109	40	23.8
26	40.7	23.6	68	40.3	23.8	110	40	23.8
27	41.3	23.5	69	39.7	23.4	111	41.1	24.2
28	41.1	23.5	70	40.6	23.2	112	40	24
29	39.5	23.5	71	40.4	24	113	40	24
30	39.8	23.6	72	39.9	23.9	114	40.1	24
31	40.5	24.2	73	44.9	23.6	115	40	23.9
32	39.7	23.7	74	40	23.7	116	40	24
33	39.7	23.9	75	40.3	23.7	117	40	24
34	39.4	23.7	76	41.1	23.5	118	40.3	24.4
35	40	23.5	77	40.5	23.6	119	39.9	24
36	40.5	24.2	78	40.3	23.7	120	39.8	23.9
37	40.7	24.2	79	41.5	23.6			
38	40.5	24.2	80	42.8	23.7			
39	40.7	24.3	81	42.6	23.7			
40	42.2	24.3	82	40.8	23.7			
41	40.3	24.4	83	40.1	23.8			
42	40.1	24.3	84	42.9	24.1			



Webster Lake Conductivity Values
Conductivity (µS/cm)
48
46
44
42
40
38
36
34
1
11
21
31
41
51
61
71
81
91
101
111
Point #
#51
#58
#64
#73
#89

Appendix D
DES Fact Sheets of Septic Systems

Appendix D
DES Fact Sheets of Septic Systems

Subsurface Systems

Environmental Fact Sheet

New Hampshire Department of Environmental Services
29 Hazen Drive Concord NH 03301

SSB-1 **2000**

Replacement Of A Failed Subsurface Disposal System

What is a Failed Subsurface Disposal System?

New Hampshire Revised Statutes Annotated (RSA) 485-A:2 defines failure as "the condition produced when a subsurface sewage or waste disposal system does not properly contain or treat sewage or causes or threatens to cause the discharge of sewage on the ground surface or into adjacent surface or groundwater."

Special Requirements for Replacing a Failed Subsurface Disposal System.

To ensure prompt and effective replacement of a failed subsurface system, the following steps must be taken:

1. The Town Health Officer, or other local official responsible for health code enforcement, must prepare a written statement verifying that the existing system is in failure. This statement must be submitted to DES with the application to replace the existing system.

2. If construction approval is granted, the construction must be completed within 90 days. Failure to complete construction and obtain operational approval of the system within the 90-day period will result in invalidation of DES approval.

3. In the event that your construction approval becomes invalid as a result of exceeding the 90-day construction period, a request for extension must be submitted to the Department of Environmental Services, Water Supply and Pollution Control Division. The request for extension must include all the information required by New Hampshire Administrative Rule Env-Ws 1004.08 (b).

This fact sheet is intended as a basic source of information concerning the replacement of a failed subsurface disposal system; It is not intended to replace the administrative rules contained in Env-Ws Chapter 1000. It is also important to remember that some municipalities have additional requirements, and you should check with your local officials before beginning any project.

For Further Information

For more information concerning subsurface disposal systems contact:

N.H. Department of Environmental Services

Water Division
Subsurface Systems Bureau
29 Hazen Drive
P.O. Box 95
Concord, NH 03302-0095
Telephone: (603) 271-3501
Fax: (603) 271-6683

Subsurface Systems

Environmental Fact Sheet

New Hampshire Department of Environmental Services
29 Hazen Drive Concord NH 03301

SSB-2 **1991**

Care And Maintenance Of Your Septic System

What is a septic system?

- A septic system is a two part treatment and disposal system designed to condition untreated liquid household waste (sewage) so that it can be readily dispersed and percolated into the subsoil. Percolation through the soil accomplishes much of the final purification of the effluent, including the destruction of disease-producing bacteria.
- A septic tank provides the first step in the process by removing larger solid materials, decomposing solids by bacterial action, and storing sludge and scum. The liquid between sludge and scum is then passed along to the leaching area for final treatment and absorption into the ground. Remember: A properly maintained septic system will adequately treat your sewage.

What should I do to maintain my septic system?

- Know the location of your septic tank and leaching area.
- Inspect your tank yearly and have the tank pumped as needed and at least every three years.
- Do not flush bulky items such as throw-away diapers or sanitary pads into your system.
- Do not flush toxic materials such as paint thinner, pesticides, or chlorine into your system as they may kill the bacteria in the tank. These bacteria are essential to a properly operating septic system.
- Repair leaking fixtures promptly.
- Be conservative with your water use and use water-reducing fixtures wherever possible.
- Keep deep-rooted trees and shrubs from growing on your leaching area.
- Keep heavy vehicles from driving or parking on your leaching area.

For more information:

If you have any questions regarding your septic system, please contact:

N.H. Department of Environment Services
Water Division
Subsurface Systems Bureau
PO Box 95
29 Hazen Drive
Concord, NH 03302-0095
Telephone: (603) 271-3501
Fax: (603) 271-6683

Subsurface Systems

Environmental Fact Sheet

New Hampshire Department of Environmental Services
29 Hazen Drive Concord NH 03301

Print Version

SSB-6 **1991**

Buying A Home Or Business? Questions You Should Ask On Sewage Disposal

When purchasing a home or business it is important to inquire about the sewage disposal system on the property. The following are suggested questions to ask the owner before you buy.

- What type of sewage disposal system serves the property, a municipal sewer system or a septic system? (If there is running water in the structure, it must have one or the other.) Note: If the property is served by a municipal sewer system, you usually don't need to inquire further.

- Is the lot part of a state approved subdivision? If so, try to get the subdivision approval number. If the lot was created prior to 1967, there will be no state approval for the subdivision since the state approval program was not implemented until July 1, 1967. This may affect the marketability and development potential of a lot. For previously developed lots, it may prohibit further expansion or conversion.

- Has the septic system received both state approvals for construction and operation? If so, does the owner have a copy of the approved plans, or the construction approval and approval for operation numbers? **Please note:** If the lot has questionable characteristics such as ledge outcrops or steep slopes, it is strongly advised to have a site assessment performed by a permitted septic system designer.

- Does the number of bedrooms on the approval match the number of bedrooms in the house? (There is no problem if there are less than the approved number of bedrooms.)

- Where is the system located, in particular, where is the tank clean-out located?

- How old is the septic system?

- When was the last time the tank was pumped? (This becomes particularly important if a garbage disposal has been used.)

- Do you have a maintenance record for the system? (While a maintenance record is not required, it is a good idea to get one if possible.)

- Has the system ever failed, or are there signs of failure like soggy grass or odor?

- What type of water supply serves the structure, municipal water supply or well?
- If there is a well, where is it located?
- Is the well a dug well or a drilled well?
- Is the well properly sealed?
- Has the well water ever been tested? If so, when? What were the results?
- Has the well ever been disinfected? If so, when?

For Further Information:

If you have any questions concerning septic systems, contact:

NH Department of Environmental Services
Water Division
Subsurface Systems Bureau
PO Box 95
29 Hazen Drive
Concord, NH 03302-0095
Telephone: (603) 271-3501
FAX: (603) 271-6683

Wednesday, Dec. 20, 2006

Home

About DES
DES Programs
Public Information
Rules/Regulatory
Business Center
OneStop Data

What's New?
Sign up for e-news

A-Z Topics List

Subsurface Systems

Environmental Fact Sheet

New Hampshire Department of Environmental Services
29 Hazen Drive Concord NH 03301

Print Version

SSB-8 **2003**

"Approval For Operation" Requirements For Subsurface Disposal Systems

- **Inspections**

The New Hampshire Department of Environmental Services (DES) is required by RSA 485-A:29 to inspect all newly constructed subsurface disposal systems within seven business days after receipt of a written request for inspection from the installer or owner.

Inspections are made to ensure that the subsurface disposal systems are installed in strict accordance with plans approved for construction by DES' Subsurface Systems Bureau.

The inspection process includes steps to verify that the proper materials have been used in the construction of the system and to ensure that the design intent has been met. Additionally, the DES inspector will make observations as to the distance from the system to seasonal high water, wetlands, and surface waters.

- **Copies**

Once the inspector determines that the system meets all of the requirements of RSA 485-A, a written Approval for Operation will be completed. Copies of the Approval for Operation are provided to the owner, the town in which the system is located, and the State of New Hampshire.

- **Requests**

Requests for inspection of approved construction may be made by calling the appropriate DES field office, the locations of which are listed on the back. Any request made by telephone should be supplemented by a written request.

- **Subsurface Regional Offices**

Region I
Frederick Treiss
80 Glen Road
Gorham, NH 03581
(603) 466-5379
FAX (603) 466-5148

Region 6
James Berg
Sawyers Brook Plaza, Unit 7
PO Box 1283
Grantham, NH 03753
(603) 863-3266
FAX (603) 863-0257

Region 3

Region 7

Brenda Hayward
PO Box 628
Riverbend Professional Bldg.
Alton, NH 03810-0628
(603) 524-7730
FAX (603) 875-7731

Dennis Plante
360 Corporate Drive, Suite 2
Portsmouth, NH 03801
(603) 431-8141
FAX (603) 430-2142

Region 4
Eric Merrill
260 Elm Street, Suite 5
Milford, NH 03055-4758
(603) 673-0405
FAX (603) 672-0494

Region 8
Real Mongeau
PO Box 95
29 Hazen Drive
Concord, NH 03302-0095
(603) 271-2182
FAX (603)271-6683

Region 5
Peter Hammen
PO Box 95
29 Hazen Drive
Concord, NH 03302-0095
(603) 271-2913
FAX (603) 271-6683

Region 9
Douglas Smith
50 Northwestern Drive
Building A Unit 108
Salem, NH 03079
(603) 893-3637
FAX (603) 893-3602

- **Additional Information**

For more information concerning subsurface disposal systems contact:

N.H. Department of Environmental Services
Water Division
Subsurface Systems Bureau
PO Box 95
29 Hazen Drive
Concord, NH 03302-0095
Telephone (603) 271-3501
FAX (603) 271-6683

Print Version

NH.Gov | Privacy Policy | Accessibility Policy

Subsurface Systems

Environmental Fact Sheet

New Hampshire Department of Environmental Services
29 Hazen Drive Concord NH 03301

Print Version

SSB-9 **1999**

Repair/Replacement of Existing Septic Systems Without Obtaining Prior DES Approval.

Often, homeowners and permitted septic system installers and designers ask the N.H. Department of Environmental Services (DES) if an existing failed septic system can be replaced without obtaining an Approval for Construction or an Approval for Operation from DES. The answer is yes, provided that the following conditions from administrative rule Env-Ws 1003.10 are met.

A septic tank may be replaced with one or more tanks of the same or larger size, without DES approval. This replacement of *tanks* only (not leachfields), applies to commercial and non-commercial systems.

To see if your system qualifies for replacement, please answer the following questions.

1. **Is the septic system serving a commercial building?** YES ☐ NO ☐

   A commercial building is anything other than a one or two family private residence. If you answer yes to this question, you need to obtain a construction approval to replace the system.

2. **Is the leaching portion of the septic system within 75 feet of any surface water?** YES ☐ NO ☐

   Surface water is a lake, pond, stream, river, tidal water, marsh or other body of water, natural or artificial. If you answer yes to this question, you must obtain a construction approval in order to replace the system.

3. **Is the leaching portion of the septic system within 75 feet of any wells?** YES ☐ NO ☐

   If you answer yes to this question, a construction approval is needed prior to any work on the system.

4. **Is the leaching portion of the septic system less than 24 inches above the seasonal high water table?** YES ☐ NO ☐

   This will have to be determined by a permitted designer or homeowner reading a test pit dug next to the existing septic system. Again if the answer is yes, a construction approval is needed.

Remember, if you've answered yes to any of the above

questions, your septic system does not qualify for Repair and Replacement of Existing systems under Env-Ws 1003.10.

Please note, only New Hampshire permitted installers and designers or a homeowner for his/her domicile, can do repair work on existing septic systems. Additionally, it is necessary to submit a Repair/Replacement Questionnaire to DES. A copy of this questionnaire can be obtained in the appendix of the Env-Ws 1000 rules or by calling (603) 271-3711.

This fact sheet is intended as a general summary of regulations concerning the replacement of a subsurface disposal system; it is not intended to replace the Administrative Rules contained in Env-Ws Chapter 1000. It is also important to remember that some municipalities may have additional requirements. Therefore, you should check with your local officials before beginning any project.

For more information concerning subsurface disposal systems contact:

N.H. Department of Environmental Services
Subsurface Systems Bureau
29 Hazen Drive, PO Box 95
Concord, New Hampshire 03302-0095
Telephone: (603) 271-3711
Fax: (603) 271-6683

Subsurface Systems

Environmental Fact Sheet

New Hampshire Department of Environmental Services
29 Hazen Drive Concord NH 03301

Print Version

SSB-10 **1993**

Selling Developed Waterfront Property
Site Assessment Study Required

Relevant Law: RSA 4:40-a, 485-A:2, 485-A:39.
Relevant Adm. Rule: Env-Ws 1025

Statutory Requirements

Prior to executing a purchase and sale agreement for any "developed waterfront property" using a septic disposal system, an owner shall, at his expense, engage a permitted subsurface sewer or waste disposal system designer to perform an on-site assessment study.

"Developed waterfront property" means any parcel of land which is contiguous to or within 200 feet of a great pond as defined in RSA 4:40-a and upon which stands a structure suitable for either seasonal or year-round human occupancy. A **great pond** is defined in RSA 4:40 as "... a public water body of more than 10 acres." (Note that a site assessment study must be conducted whenever any part of the property is within 200 feet of the great pond, not merely when the structure or the septic disposal system is within 200 feet of the water.)

The site assessment study is a report prepared by a DES-permitted septic system designer that you as the seller hire to determine if your site meets the current standards for septic disposal systems established by DES.

The assessment originally had been required prior to listing or offering the waterfront property for sale, but effective January 1, 1993, it will be required prior to executing a purchase and sale agreement and must include an on-site inspection. The Site Assessment form may be found in the Appendix Section of Administrative Rules Env-Ws 1000 or may be obtained from DES' Subsurface Systems Bureau.

For More Information Contact:

NH Department of Environmental Services
Water Division
Subsurface Systems Bureau
PO Box 95
29 Hazen Drive
Concord, NH 03302-0095
Telephone: (603) 271-3501
Fax: (603) 271-6683

Print Version

Subsurface Systems

Environmental Fact Sheet

New Hampshire Department of Environmental Services
29 Hazen Drive Concord NH 03301

Print Version

SSB-12 **2003**

Approved Technologies for Septic Systems

Over the past several years, the N.H. Department of Environmental Services (DES) has approved many new innovative technologies for the treatment and disposal of wastewater to subsurface systems. All new "innovative/alternative" systems for on-site treatment or disposal of wastewater below the ground (usually referred to as "septic systems") need approval from DES under the provisions of NH Administrative Rule Env-Ws 1024, which allows general and provisional approvals. The following is an overview of the various products and technologies that DES has approved to date. But before listing the currently approved systems, we must present these caveats and warnings:

- Systems are listed in random order.
- Mention of a company name, system or device in this list does not constitute DES approval to use that system or device to address any specific problem. Consult a licensed septic system designer to determine what solutions may be appropriate for your problem.
- PUMP OUT YOUR SEPTIC TANK **BEFORE** THERE'S A PROBLEM. Many times, a "technological" solution is not necessary because ordinary maintenance may solve the problem. See Env-Ws 1023 for operating requirements. Also see the other Fact Sheets in DES's SSB series for useful information on septic system operation.
- Where a designer specifies a certain product, such as a brand of septic tank effluent filter, and a different (but similar) brand is used in the actual installation, DES requires the written concurrence of the system designer before approving the tank/septic system for operation.

Leaching Systems

Stone/pipe - field, trench, drywell	"Standard" systems.
Chambers - concrete, plastic	"Standard" systems, but field sizing may be product-specific. See approved design manual.
"Enviro-Septic" system	A "standard" system, field sizing is product-specific. See approved design manual.
"Geo-Flow" system	A "standard" system, field sizing is product-specific. See approved design manual.
Eljen "In-Drain"	A "standard" system, but field sizing is product-specific. See approved design manual. Manufacturer's review for larger commercial

	systems.
Ruck "A-Fin"	A "standard" system, field sizing is product-specific. See approved design manual. Manufacturer's review required for larger commercial systems.

Mechanical treatment devices , with general DES Approval for leach field reduction:

Norweco "Singulair"	Biological treatment.
Amphidrome Recirculating Batch Reactor	Biological treatment.
Wastewater Alternatives, Inc. "The Clean Solution"	Biological treatment.
Jet Package Sewage Treatment Plant	Biological treatment.
Spec Industries AIRR trickling filter	Biological treatment.
SeptiTech Recirculating Trickling Filter	Biological treatment.
BioMicrobics FAST system	Biological treatment.
Zabel SCAT biofilter	Biological treatment.
Orenco AdvanTex system	Biological treatment.
MicoSepTec EnviroServer system	Biological treatment.
CMS ROTORDISK	Biological treatment.
Aeration Systems, LLC, OxyPro system	Biological treatment.
BioClere system	Biological treatment.

Mechanical treatment devices, provisional DES Approval for leach field reduction:

Provisional approval is granted for newer technologies per Env-Ws 1024.06 (d) for cases where DES finds that "... there is not sufficient operating history or other valid data to allow general use of the technology... " Provisional approvals are granted for a limited number of applications for a limited period of time. The applicant is required to do performance monitoring of each installation and report the results to DES.

SeptiTech Recirculating Trickling Filter	Biological treatment. The provisional approval is for leach field size reductions beyond that in SeptiTech's General approval.
BioMicrobics FAST System	Biological treatment. The provisional approval is for leach field size reductions beyond that in BioMicrobic's General approval.
WasteTech STM 2000 unit	Physical treatment.

For new construction where a mechanical treatment device with a reduced-size leach field, under a General or Provisional approval, is proposed for use on a lot that was created prior to adoption of DES subdivision rules, the design submitted shall demonstrate sufficient capacity to construct a full sized leaching facility on the lot.

All mechanical systems require on-going professional maintenance. The person doing the maintenance must be a licensed treatment plant operator. See DES Fact Sheet WD-WEB-2 for information in the licensure program. A Grade 1-OIT license is usually considered sufficient for systems listed here.

Other approved, or approvable, treatment devices and methods:

M.C.C., Inc. "Cajun Aire"	Mechanical unit, approved under Env-Ws 1024.
Cromaglass Sequencing Batch Reactor	Mechanical unit, approved under Env-Ws 1024.
"White Knight," "Pirana"	These are mechanical devices that are inserted into an existing septic tank to provide treatment of the effluent leaving the tank. They are allowed for rehabilitation of failed systems.
Constructed Wetlands	Innovative, has been approved for a few sites. Significant engineering required.
Spray Irrigation	Has been approved for a few sites. Very significant engineering and Groundwater Discharge Permit required. A major issue is control of access to the area where spraying occurs. There are significant public health concerns with coming into contact with partially-treated wastewater.
Sand Filters	Innovative, has been approved for a few sites. Significant engineering required.

Other systems & devices

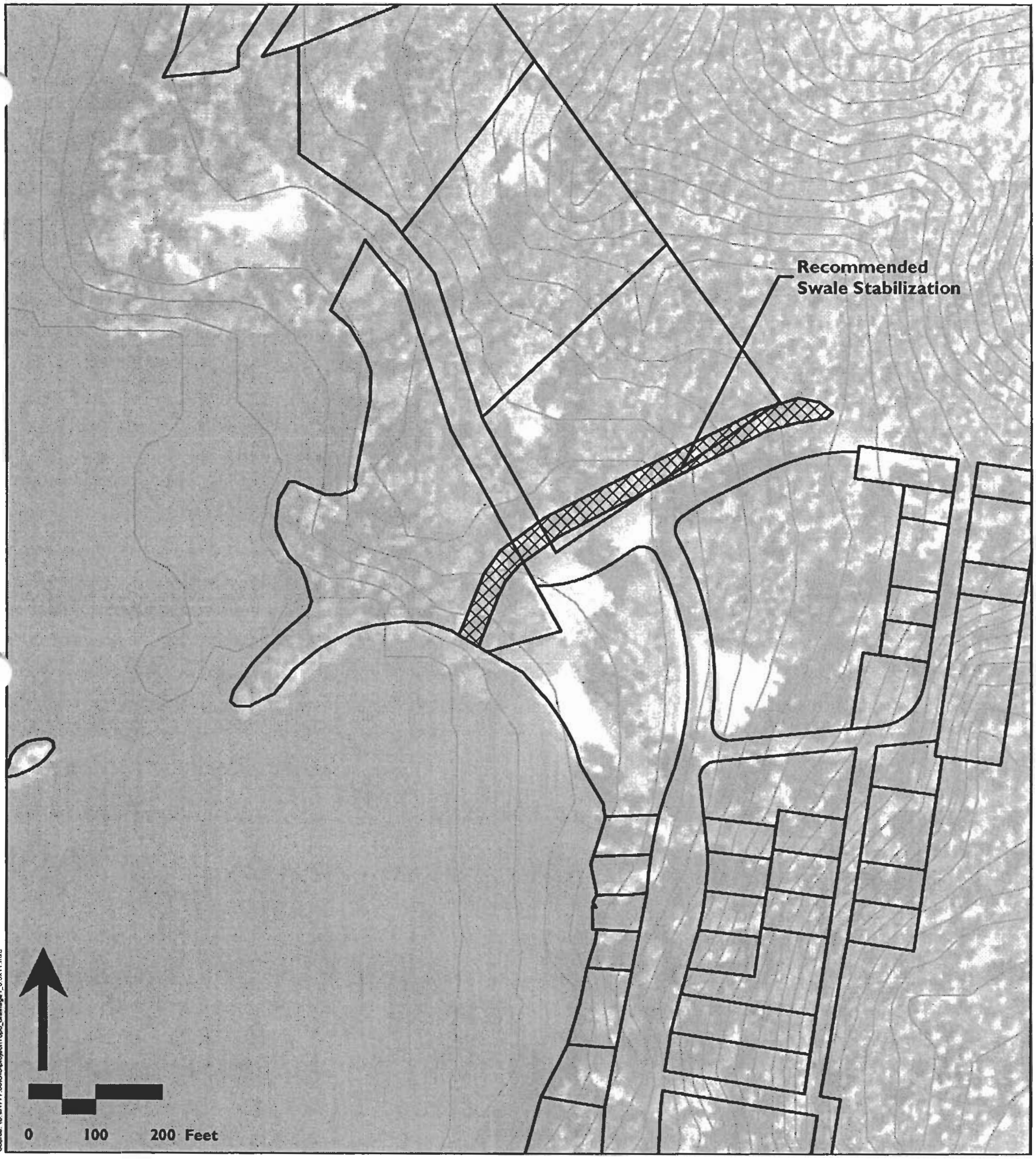
Septic tank effluent filters	Allowed and encouraged.
Presby "Maze"	Device inserted into septic tank. 30% reduced field size allowed for commercial systems.
Holding Tank	Only applicable in very limited circumstances, see Env-Ws 1022.03
Composting toilets	Allowed, but no leach field reduction allowed for the remaining wastewater whenever the building has running water.
"Mini dry well" and privies	Only allowed for buildings with no running water.

For more information:

For more information about the above list, or to apply for approval of an innovative/alternative product from DES, please contact: James Falicon, NH Department of Environmental Services, 29 Hazen Drive, Concord, NH 03301; (603) 271-2915.

Appendix E
Roadside Swale Stabilization Areas

Appendix E
Roadside Swale Stabilization Areas



Legend

5-Foot Contour

Parcels

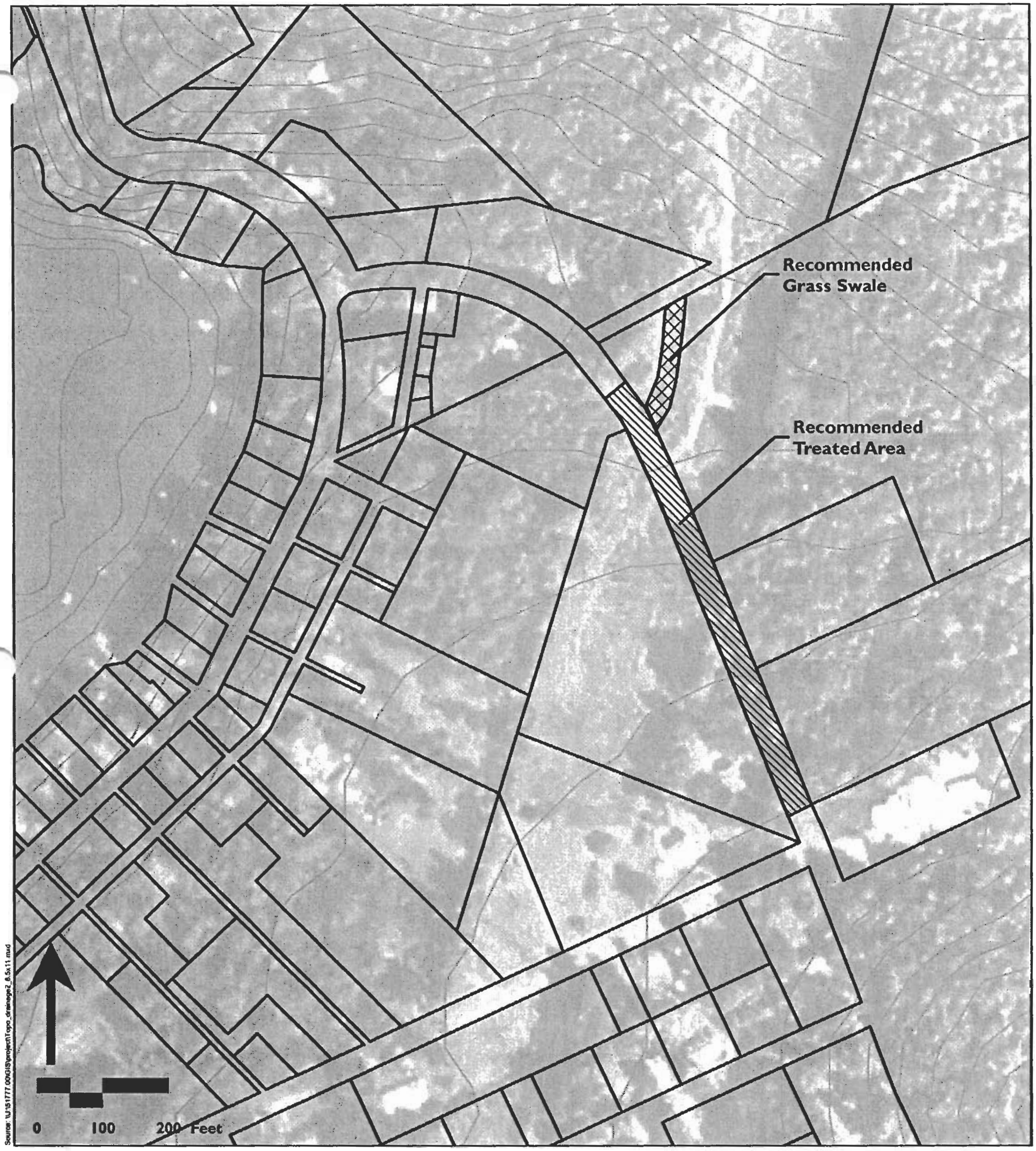
Figure 1

Existing Drainage Conditions - Area 1

Franklin & Andover,
New Hampshire

Source: Digital Orthophoto captured in 2003 by NAIP and distributed by NH GRANIT. Contour data are from USGS, distributed by NH GRANIT.

Vanasse Hangen Brustlin, Inc. VHB



Legend

5-Foot Contour

Parcels

Figure 2

Existing Drainage Conditions - Area 2

Franklin & Andover, New Hampshire

Source: Digital Orthophoto captured in 2003 by NAIP and distributed by NH GRANIT. Contour data are from USGS, distributed by NH GRANIT.

Vanasse Hangen Brustlin, Inc. VHB

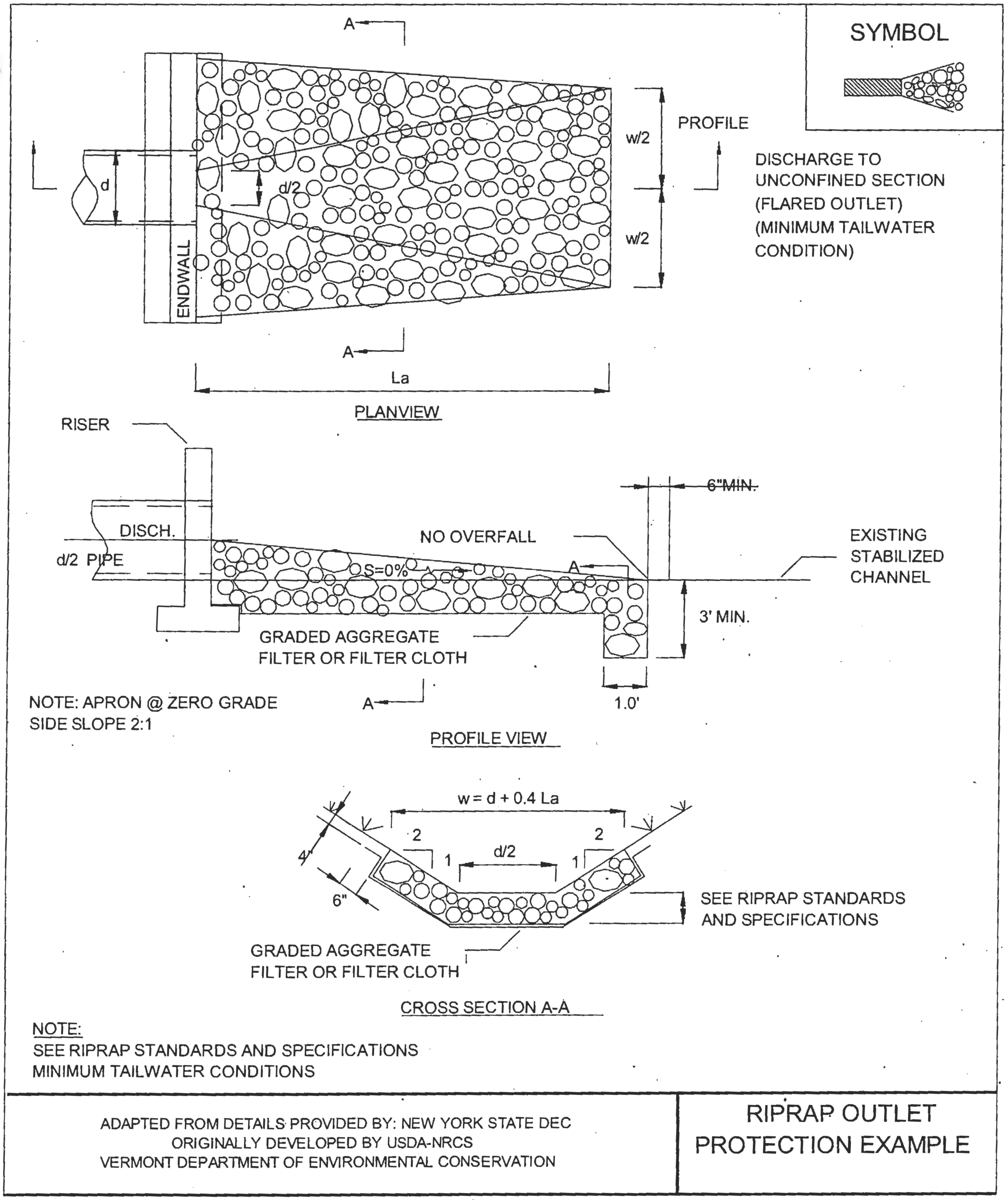


Figure 4.26a Riprap Outlet Protection Detail (1)

Appendix F
NH BMP Manual for Erosion Control on Timber Harvesting Operations

Appendix F
NH BMP Manual for Erosion Control on Timber Harvesting Operations

BEST MANAGEMENT PRACTICES for

Erosion Control on Timber Harvesting Operations in New Hampshire

2004

INTRODUCTION

Every timber harvesting operation involves some risk of soil erosion and sedimentation that may affect water quality. With a common understanding of the risks and through the use of this publication, the forest industry, landowners, and the government working together can protect our state's water resources.

This publication is primarily a reference and training tool designed to help foresters and loggers become better informed about the best management practices for reducing soil erosion and controlling sedimentation from timber harvesting activities.

When using this publication, it is important to remember that for every situation encountered, there may be more than one correct method to prevent erosion and sedimentation. Flexibility and understanding are important, since the intent of any best management practice is to **keep sediment out of the streams**.

ACKNOWLEDGMENT

The author has drawn freely from the publications listed in the reference section and received assistance and suggestions from county, state, and federal foresters as well as the forest industry. The reader is urged to consult these publications if detailed information beyond the scope of this publication is desired. When needed, help and advice for the implementation of the Best Management Practices can be obtained from any of the agencies listed in the Available Assistance Section. Your comments about this publication are welcome.

Assistance in the preparation of this publication was contributed by:

! State of New Hampshire - Department of Resources & Economic Development
  Division of Forests and Lands

! State of New Hampshire - Department of Environmental Services
  Water Supply and Pollution Control Division
  Water Resources Division
  Wetlands Bureau

! University of New Hampshire Cooperation Extension

! USDA - Natural Resource Conservation Service

! USDA - Forest Service - White Mountain National Forest

! USDA - Forest Service - State and Private Forestry

! New Hampshire Timberland Owners' Association

! Numerous professional loggers and foresters who have reviewed drafts

DEFINITIONS

Best Management Practices - Proper methods for the control and dispersal of water on truck roads, skid trails, and log landings to minimize erosion and reduce sediment and temperature changes in streams.

Bog - A low-lying area with standing water or saturated soil for a significant portion of the year that is dominated by grass-like vegetation, shrubs and dwarf trees and which has a thick vegetative mat under foot.

Erosion - Wearing away of the surface of the land, by action of water or wind due to timber harvesting operations.

Facultative Species: Trees and shrubs that are equally likely to occur in wetlands or uplands (estimated probability 34-66%).

Facultative Upland Species: Trees and shrubs that usually occur in uplands (non-wetlands) (estimated probability 67-99%), but occasionally found in wetlands (estimated probability 1-33%).

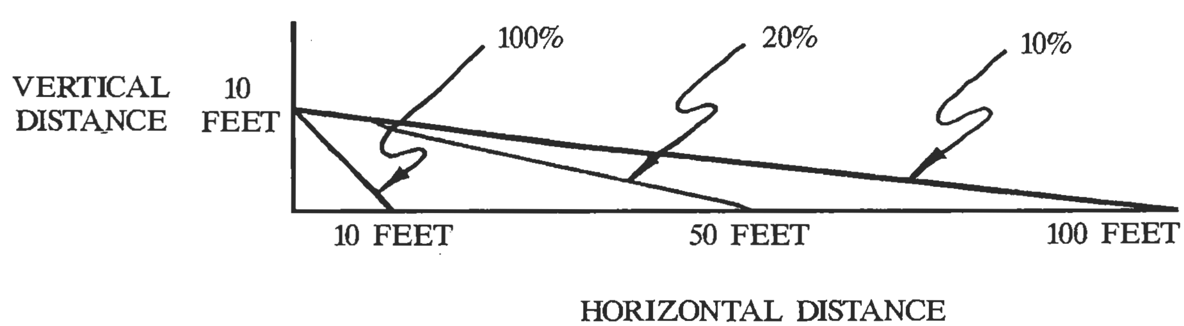
Facultative Wetland Species: Trees and shrubs that usually occur in wetlands (estimated probability 67-99%), but occasionally found in uplands (non-wetlands) (estimated probability 1-33%).

Forested Wetland - A wetland where trees are the dominant plants.

Freshwater Wetland - An area that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetland permits are required for any dredge, fill, or construction in a wetland, intermittent or perennial stream or other surface water.

Geotextile - A product used as a soil reinforcement agent and as a filter medium. It is made of synthetic fibers manufactured in a woven or loose non-woven manner to form a blanket like product.

Grade - Expressed in percent, the distance a road or trail rises or falls over a horizontal distance. For



example, a road or trail that rises or falls 10 feet over 100 feet in horizontal distance has a 10% grade.
Intermittent Stream - A water course that flows in a well defined channel during the wet periods of the year or after major storms.

Marsh - A low-lying area with standing water or saturated soil for a sufficient portion of the year that is dominated by reeds, cattails, sedge, or grasslike vegetation.

Minimum Impact Forest Management Project - A temporary wetland crossing for forest management or timber harvesting purposes which is less than 50 feet in length and requires less than 3,000 square feet of fill, and which follows the Best Management Practices.

Mulch - A natural or artificial layer of plant residue or other materials covering the land surface that conserves moisture, holds soil in place, aids in establishing plant cover, and minimizes temperature fluctuations.

Obligate Upland Species: Trees and shrubs that almost always occur in uplands (non-wetlands) (estimated probability >99%).

Obligate Wetland Species: Trees and shrubs that almost always occur in wetlands (estimated probability >99%).

Perennial Stream - A watercourse that flows throughout the year or nearly so (90 percent) in a well defined channel. Same as a live stream.

Riprap - Rock or other large aggregate that is placed to protect streambanks, bridge abutments, outflow of drainage structures, or other erodible sites from runoff.

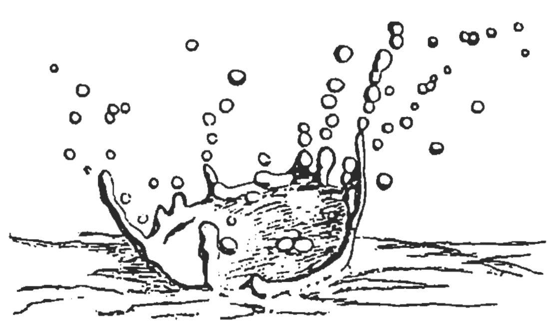
Sediment - Soil material that has been detached, transported, suspended, or settled in water.

Slope - Degree of deviation of a surface from the horizontal, measured as a numerical ratio, as a percent, or in degrees. Expressed as a ratio, the first number is the horizontal distance (run) and the second number is the vertical distance (rise), as 2:1. A 2:1 slope is a 50% slope. Expressed in degrees, the slope is the angle from the horizontal plane, with a 90 degree slope being vertical (maximum) and a 45 degree slope being a 1:1 slope.

Stream - Any channel for the passage of surface water having a defined bed and banks whether natural or artificial, with perennial or intermittent flow.

Swamp - A tree or shrub wetland, with standing water or saturated soils for a sufficient portion of the year, that often has a "hummocky" appearance and buttressed roots. Dominant full sized trees may include red maple, black ash, black willow, black spruce, tamarack, or white cedar.

Wetland - An area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic (water loving) vegetation and which has soils indicative of wet conditions.



PLANNING THE OPERATION

When the forest floor is disturbed and truck haul roads and skid trails are constructed, the natural filtering action of the soil is reduced. Trucks and skidders may compact the underlying soil. When it rains or the snow melts, surface water is not readily absorbed. Instead, the surface water flows into the roads and trails which can act as channels that increase the velocity and volume of the water as it flows downhill. As the water flows it may erode the soil and destroy the road and other capital improvements.

Water quality management through systematic planning helps prevent erosion. This kind of management can be achieved by planning and laying out the roads and skid trails correctly, and by finding ways to get the water off the roads and trails as quickly as possible, before erosion can accelerate. Careless construction leads to rebuilding, lost time, higher costs and harm to soil, water, and fish habitat.

If systematic planning does not take place before the operation begins, then there is the risk that the ditches, the crossdrains, culverts and water bars may not provide adequate drainage.

Guidelines:

Layout

! Obtain topographic maps, soils maps, aerial photographs and property maps.

! Use topographic maps, soils maps, and aerial photos to identify streams, forested wetlands, other bodies of water, steep slopes, flood plains, property boundaries, and harvest area boundaries.

! Locate the property lines and the area to be harvested on each of the maps and photographs.

! Walk the area and see how the land lays and where the stands for harvesting are located.

! Outline areas on the maps that are near streams, ponds, lakes, or wetlands, and mark very steep and very wet areas, and areas with poor timber.

! Consider the following for maximum erosion control:

Minimize the amount of soil disturbance
Minimize the amount of cut and fills
Minimize the number of stream crossings
Provide adequate drainage of the road and main skid trail area
Plan buffers around sensitive areas

- Draw on the maps the proposed location of your haul roads, main skid trails, and log landings. Look for the best placement on slopes, the position of streams and wetlands, possible stream crossings, and areas of soil instability.

- Walk the proposed location of haul roads and main skid trails. Establish control points along the way. These should be points you can identify on a map, aerial photograph, and on the ground.

- Flag this route as you walk in. Check skidding distances on both sides of your proposed route.

- Walk back out following your flagged route.

    1. Adjust flagging to take advantage of natural features that will make road and trail construction and drainage easier.

    2. Check the grades to make sure that they meet guidelines for truck haul roads and skid trails.

    3. Flag areas suitable for landings and borrow pits.

    4. Make sure the route provides the best access to present and future harvest areas.

- Draw on your maps the final proposed location of your truck haul roads, skid trails, stream crossings, erosion control devices, etc.

- Be aware of applicable state and local laws which relate to timber harvesting, wetlands, surface waters and fish and wildlife habitat. Obtain all necessary permits prior to any construction or timber harvesting. (See Logging and the Law)

Construction

During the construction of truck haul roads and skid trails, there are certain activities that must be planned because they directly relate to the amount of erosion that can occur.

- **Timing -** Most problems can be prevented or minimized by timing the harvesting operation to take advantage of seasonal conditions.

    1. Winter harvesting to take advantage of snow cover and frozen ground.

    2. Bridge construction and culvert installation should be done during summer when streamflow is low.

3. On streams having important fisheries value, bridge and culvert installation should be avoided during egg incubation period of October to April.

4. If construction is necessary, it should be done well ahead of time to permit disturbed soil to stabilize before the road or trail is to be used.

! **Design** - The entire road and trail system should be designed before any construction begins. This process may seem to take more time, but the system will be more efficient, less costly, and easier to maintain.

1. **Grade** - Keep grades low except where short, steep sections are needed to take advantage of favorable topography and to avoid excessive cut and fill.

2. **Width** - The width of the road or trail should be designed for the equipment to be used on the timber harvesting operation.

3. **Angle** - Consider the proper angle for cuts and fills in designing roads on varying types of soils and rock materials. Make road cuts reasonably steep in order to minimize surface exposed to erosion.

4. **Alignment** - Avoid the toes of slopes, breaks in a slope, and running parallel to a streambank.

5. **Surface** - Crushed rock and gravel may be needed to keep the road surface from washing out during rainfall and runoff.

6. **Drainage** - Provisions must be made for the passage of surface water from adjacent slopes, as well as for rapid drainage of the roadbed itself.

7. **Stream Crossings** - All crossings sites should be selected at right angles to the stream and should not interfere with natural streamflow.

Retirement

A plan should be developed that provides for the retirement of truck haul roads, skid trails, and log landings.

! Smooth and shape all road and landing surfaces.

! Remove all temporary culverts and replace them with water bars, broad based dips, or ditches.

! Permanent culverts must be sized properly and provisions made for their continued maintenance.

! Remove all temporary stream and wetland crossings.

! Seed, mulch, lime, and fertilize.

ARE YOU IN A WETLAND?

Wetlands Characteristics:

Hydrology, or the presence of water in or above the soil;

Signs on the surface of the ground include:

! Waterstained (dark) or silt covered leaves;

! Lines of organic debris such as leaf litter on tree and shrub stems above soil surface;

! Water or silt stained plant stems;

! Swollen bases of tree trunks (an adaptation to wet soils);

! Exposed plant roots (an adaptation to wet soils).

Soils, which show observable features when saturated or flooded for long periods of time;

Signs in the soil include:

! Sphagnum moss on the surface;

! A thick upper layer of peaty organic matter;

! Soils mostly neutral grey in color (greyed), or grey soils with rust colored (orange-brown and yellow-brown) splotches within 18" of the surface.

Vegetation, which is usually composed of a predominance of species suited to hydric (largely anaerobic) soil habitats.

Signs in the composition of plant species include:

! More than half the plant species being those that grow most often in wetland soils. Plant species have been classified by the US Fish & Wildlife Service based on how frequently they occur in wetlands. All plants, including herbaceous groundcovers, are important in wetland determination. However, only trees and shrubs are included here because there are fewer species than herbaceous plants, they are more easily identified by most people and they can be observed and identified at all times of the year. The species are grouped into five categories, listed here from most to least wetland adapted:

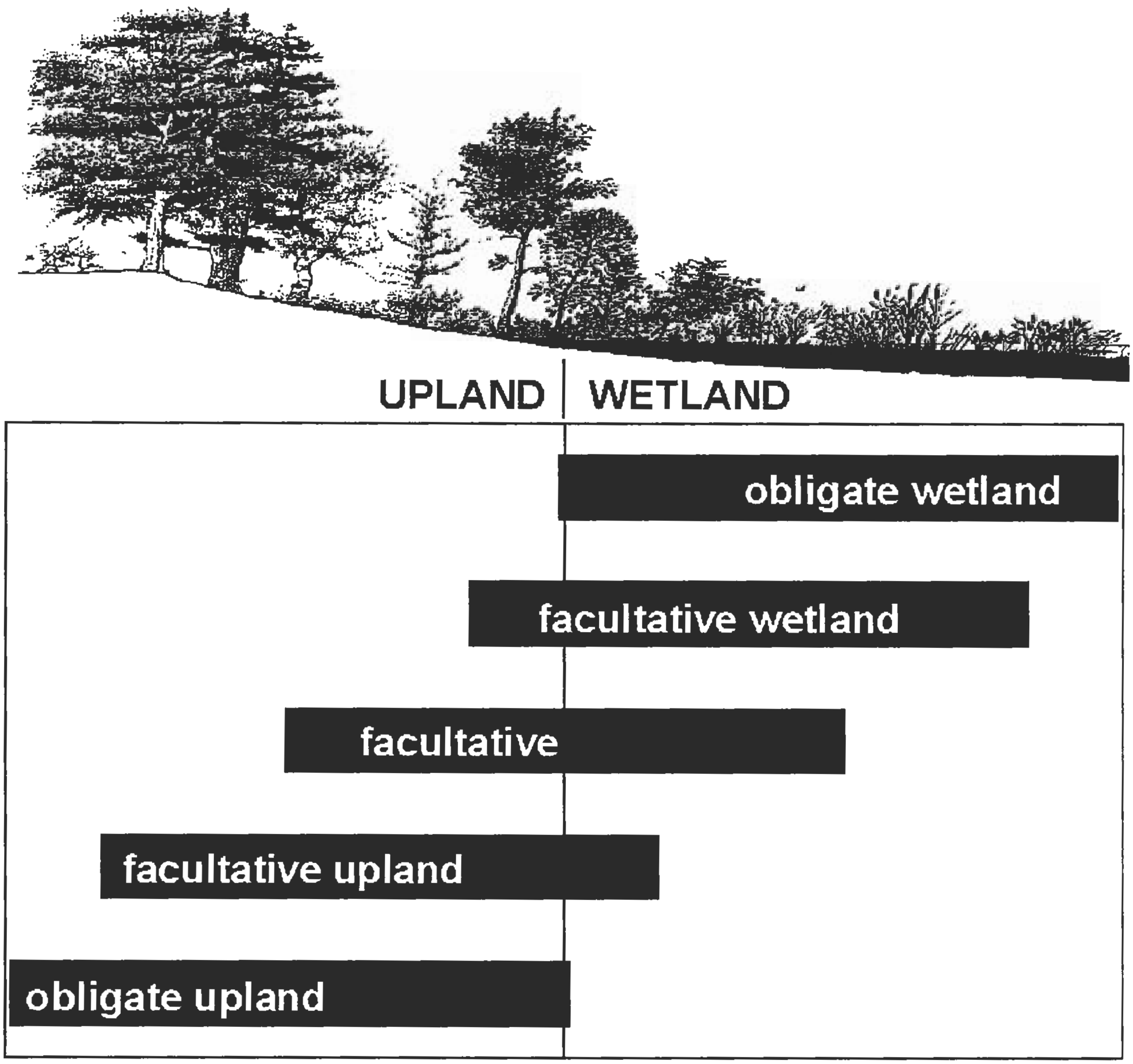
Obligate Wetland..Species occur more than 99% of the time in wetlands.

Facultative Wetland.....................................Species occur between 67-99% of the time in wetlands.

Facultative...Species occur equally in uplands and wetlands.

Facultative Upland...Species occur between 1-33% of the time in wetlands.

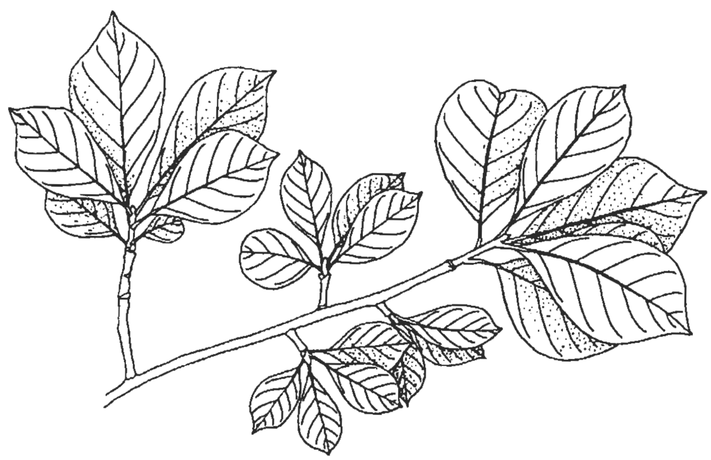
Obligate Upland...Species occur less than 99% of the time in wetlands.



Care must be taken when estimating wetland conditions using only plants. One reason is that common trees in the most marginal (least wet) wetlands (forested wetlands) are often the facultative species Red maple and Balsam fir and the facultative upland species Eastern hemlock. Even White pine and other species more commonly found in drier sites will grow on raised hummocks in a forested wetland. In these cases, a survey of the shrubs present will often provide a better indication of wetland conditions, as will groundcovers if they are present. In many forested wetlands, Highbush blueberry and Winterberry holly are common and readily identified at any time of the year.

The technical determination of wetland boundaries incorporates all these characteristics, but is not practical for informal determination of whether you are working in a wetland. However, a rough estimate of a wetland boundary can be made using the signs given above. Begin by finding an area that seems obviously to be a wetland. Then, walk toward the upland, noting changes in vegetation as you go. If possible, sample the soil for the characteristics and look for above-ground signs noted above. When you no longer observe a majority of wetland plants or soil conditions, consider this the approximate wetland edge. This process can be repeated at intervals around the wetland edge, marking as you go.

If you're not sure about wetland determination, refer to section in this manual on Available Assistance.



FREQUENCY OF OCCURRENCE OF SELECTED NEW HAMPSHIRE *SHRUB SPECIES* IN WETLANDS AND UPLANDS

OBLIGATE WETLAND SPECIES (>99% in wetlands, <1% in uplands)

Buttonbush	*Cephalanthus occidentalis*
Cranberry, Large	*Vaccinium macrocarpon*
Cranberry, Small	*Vaccinium oxycoccos*
Labrador Tea	*Ledum groendlandicum*
Leatherleaf	*Chamaedaphne calyculata*
Mountain Holly	*Nemopanthus mucronatus*
Rose, Swamp	*Rosa palustris*
Rosemary, Bog	*Andromeda polifolia*
Sumac, Poison	*Toxicodendron vernix*
Sweetgale	*Myrica gale*

FACULTATIVE WETLAND SPECIES (67 - 99% in wetlands, 1 - 33% in uplands)

Alder, Speckled	*Alnus rugosa*
Arrow-Wood	*Viburnum recognitum*
Azalea, Swamp	*Rhododendron viscosum*
Blueberry, Highbush	*Vaccinium corymbosum*
Chokeberry, Red	*Aronia arbutifolia*
Dogwood, Red Osier	*Cornus stolonifera*
Dogwood, Silky	*Cornus amomum*
Elder, American	*Sambucus canadensis*
Maleberry	*Lyonia ligustrina*
Rhodora	*Rhododendron canadense*
Spicebush	*Lindera benzoin*
Steeple-Bush	*Spiraea tomentosa*
Winterberry Holly	*Ilex verticillata*
Withe-Rod	*Viburnum cassinoides*

FACULTATIVE SPECIES (Likely to occur equally (34 - 66%) in uplands and wetlands.)

Bayberry	*Myrica pensylvanica*
Chokeberry, Black	*Aronia melanocarpa*
Cranberry, Mountain	*Vaccinium vitis-idaea*
Ivy, Poison	*Toxicodendron radicans*
Meadow-Sweet	*Spiraea latifolia*
Nannyberry	*Viburnun lentago*
Pepper-Bush	*Clethra alnifolia*

Raspberry, Red	*Rubus idaeus*
Rhododendron, Rosebay	*Rhododendron maximum*
Rose, Virginia	*Rosa virginiana*
Sheep-Laurel	*Kalmia angustifolia*
Yew, American	*Taxus canadensis*

FACULTATIVE UPLAND SPECIES (1 - 33% in wetlands, 67 - 99% in uplands)

Barberry, European	*Berberis vulgaris*
Barberry, Japanese	*Berberis thunbergii*
Bitter-sweet, American	*Celastrus scandens*
Blackberry, Allegheny	*Rubus alleghaniensis*
Blueberry, Lowbush	*Vaccinium angustifolium*
Elder, Red	*Sambucus racemosa*
Hazel-nut, Beaked	*Corylus cornuta*
Hobble-Bush	*Viburnum lantanoides*
Juniper, Creeping	*Juniperus horizontalis*
Laurel, Mountain	*Kalmia latifolia*
Rose, Rugosa	*Rosa rugosa*
Teaberry (Checkerberry)	*Gaultheria procumbens*
Witch-Hazel	*Hamamelis virginiana*

OBLIGATE UPLAND SPECIES (< 1% in wetlands, >99% in uplands)

Juniper, Common	*Juniperus communis*
Sumac, Smooth	*Rhus glabra*
Sumac, Staghorn	*Rhus typhina*
Sweet Fern	*Comptonia peregrina*
Viburnum, Maple-leaved	*Viburnum acerifolium*

FREQUENCY OF OCCURRENCE OF SELECTED NEW HAMPSHIRE *TREE SPECIES* IN WETLANDS AND UPLANDS

OBLIGATE WETLAND SPECIES (>99% in wetlands, <1% in uplands)

Atlantic White Cedar	*Chamaecyparis thyoides*

FACULTATIVE WETLAND SPECIES (67 - 99% in wetlands, 1 - 33% in uplands)

Black Ash	*Fraxinus nigra*
Green Ash	*Fraxinus pensylvanica*
River Birch	*Betula nigra*
Northern White Cedar	*Thuja occidentalis*
American Elm	*Ulmus americana*
American Larch	*Larix laricina*
Silver Maple	*Acer saccharinum*
Swamp White Oak	*Quercus alba*
Balsam Poplar	*Populus balsamifera*
Black Spruce	*Picea mariana*
Sycamore	*Platanus occidentalis*
Tupelo (Black Gum)	*Nyssa sylvatica*
Black Willow	*Salix nigra*

FACULTATIVE SPECIES (Likely to occur equally (34-66%) in uplands and wetlands.)

Gray Birch	*Betula populifolia*
Yellow Birch	*Betula alleghaniensis*
Cottonwood	*Populus deltoides*
Slippery Elm	*Ulmus rubra*
Balsam Fir	*Abies balsamea*
Honey Locust	*Gleditsia triacanthos*
Ironwood	*Carpinus caroliniana*
Red Maple	*Acer rubrum*

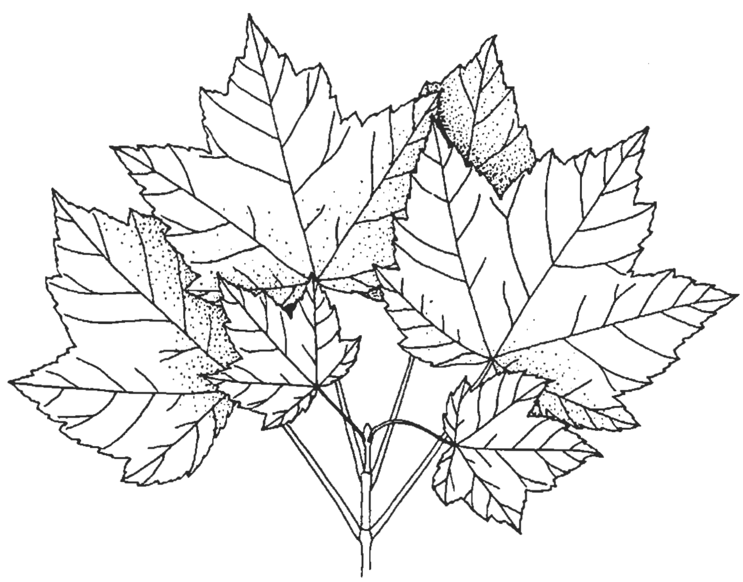
FACULTATIVE UPLAND SPECIES(1 - 33% in wetlands, 67 - 99% in uplands)

White Ash	*Fraxinus americana*
Big-tooth Aspen	*Populus grandidentata*
Quaking Aspen	*Populus tremuloides*
Basswood	*Tilia americana*
American Beech	Fagus grandifolia

Paper Birch	*Betula papyrifera*
Sweet Birch	*Betula lenta*
Butternut	*Juglans cinerea*
Red Cedar	*Juniperus virginiana*
Black Cherry	*Prunus serotina*
Choke Cherry	*Prunus virginiana*
Fire Cherry	*Prunus pensylvanica*
Flowering Dogwood	*Cornus florida*
Eastern Hemlock	*Tsuga canadensis*
Shagbark Hickory	*Carya ovata*
Hop Hornbeam	*Ostrya virginiana*
Black Locust	*Robinia pseudoacacia*
Striped Maple	*Acer pensylvanicum*
Sugar Maple	*Acer saccharum*
Red Oak	*Quercus rubra*
White Oak	*Quercus alba*
White Pine	*Pinus strobus*
Pitch Pine	*Pinus rigida*
Red Pine	*Pinus resinosa*
Sassafras	*Sassafras albidum*
Red Spruce	*Picea rubens*
White Spruce	*Picea glauca*
Black Walnut	*Juglans nigra*

OBLIGATE UPLAND SPECIES (< 1% in wetlands, >99% in uplands)

None



TRUCK HAUL ROADS

Definition:
A road system, temporary or permanent, installed for transportation of wood products from the landing by truck.

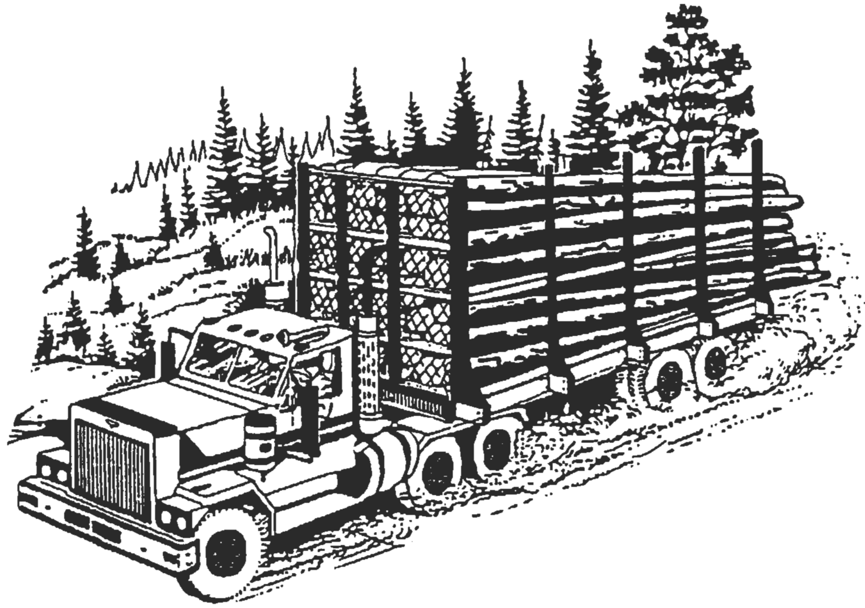
Purpose:
To provide for an efficient transportation system for forest products from the landing while also protecting forest land and water quality, for recreation, forest fire access, or other needed forest management activities.

Condition Where Practices Applies:
Where area and volume to be harvested makes it necessary and economically feasible to install such a road system.

Guidelines:

! A well thought out efficient transportation system will minimize the area disturbed and vulnerable to erosion.

! Keep the length of the truck road, from the log landing to a public highway, to a minimum. Have gravel or wood chips for about 200 feet prior to entering on a public highway to keep mud off of the highway.



! Road grades should be kept to 10% or less. Steeper grades are permissible for short distances. Long level sections are difficult to drain properly. Grades between 3% and 5% are desirable.

! Place roads on high ground with gentle grades. Avoid sharp curves. Use a fifty foot minimum radius for large trucks.

! Minimum tread width is 10 feet for one-way traffic and 15 feet for two-way traffic. Increase the tread width by a minimum of 4 feet for trailer traffic.

! Use a geotextile construction fabric underlayment when constructing roads on poorly drained surface.

! Move surface water quickly off road surfaces and onto undisturbed forest floor. Ditches should be used to efficiently divert water away from the road surface. Water entering a roadway should be moved under or away from the roadway before gaining sufficient flow and velocity to erode ditches. Drainage ditches should not end where they will feed water directly into streams or other surface waters. (See Erosion Control Devices)

! If streams must be crossed, do so by the most direct route and preferably at right angles to the stream. A bridge, culvert, or food of acceptable design may be required. (See Stream Crossings)

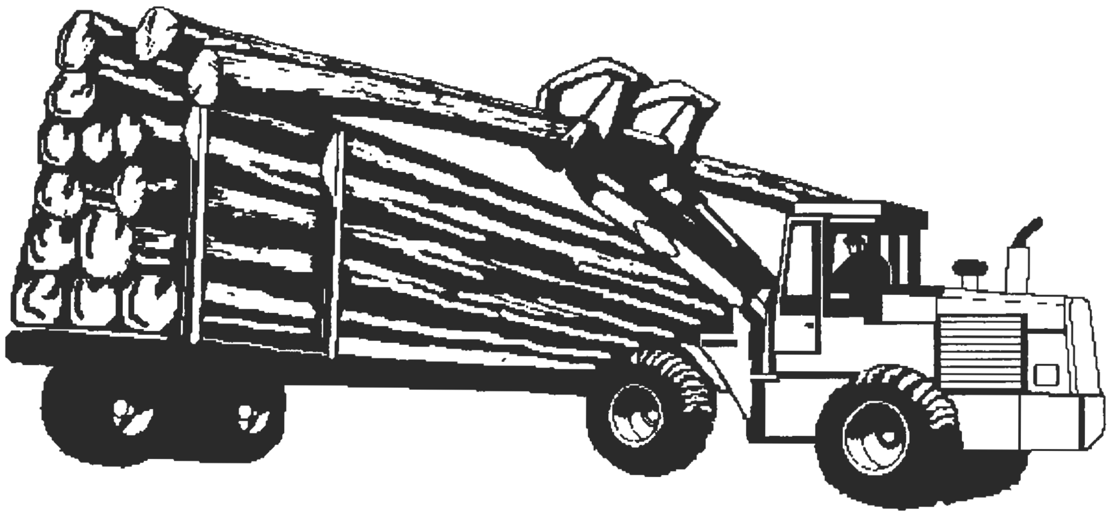
! Road grades approaching stream crossings shall be broken and surface water dispersed so it will not reach the watercourse. (See Erosion Control Devices)

! Restrict vehicle traffic on soft roads during Spring and Fall mud seasons.

! Restrict vehicle traffic during heavy rains.

! Do not allow skidding on truck roads.

! Check with the State of New Hampshire - Department of Transportation or the local town



officials to determine if a driveway permit is required.

SKID TRAILS

Definition:
An unsurfaced, single lane trail system usually steeper and narrower than a truck road and used for skidding harvested products.

Purpose:
To bring logs, tree lengths, or other roundwood products from the stump to a log landing or concentration area.

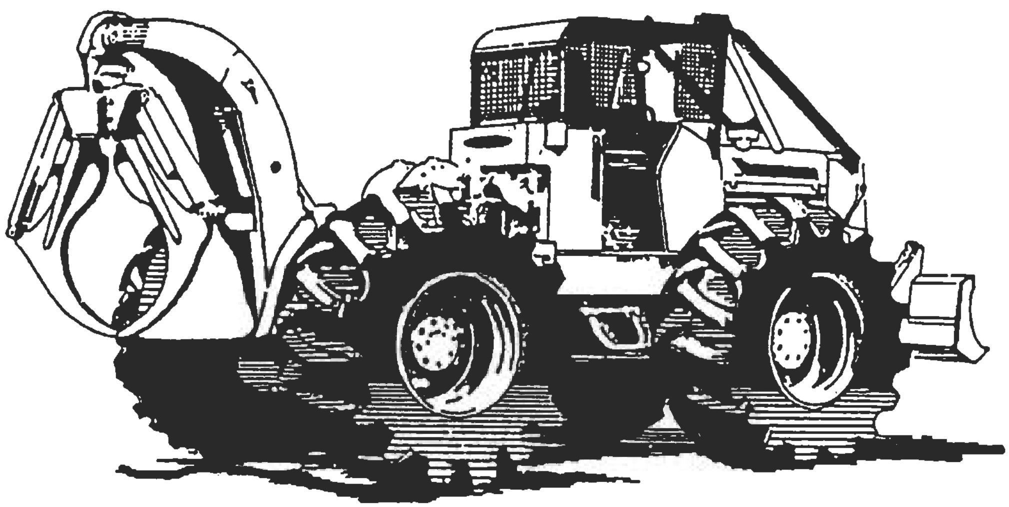
Conditions Where Practice Applies:
Use where harvested products must be brought to one location for sawing, chipping or loading. Where topography and size of operation make this the most economical means of collecting logs, trees, or other roundwood products.

Guidelines:

! A well thought out efficient transportation system will minimize the area disturbed and vulnerable to erosion.

! Trail grades should be kept to 15% or less. Steeper grades are permissible for shorter distances.

! Plan skid trails from the top down.



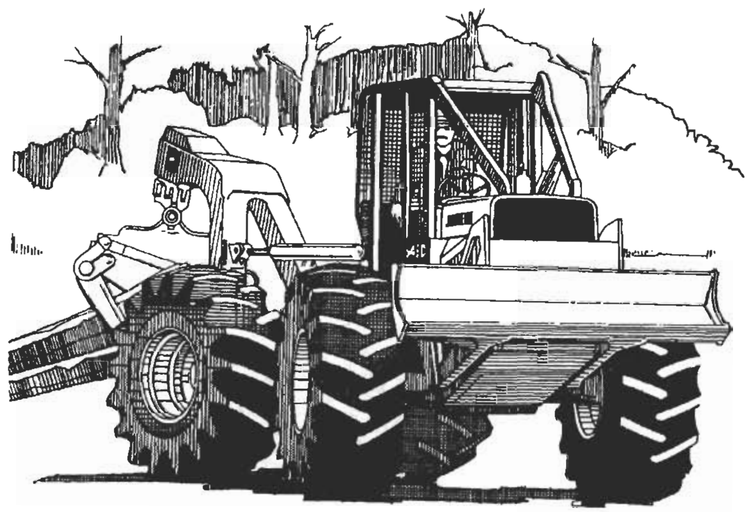
! Locate skid trails to take advantage of natural cross drainage.

! Use reverse grades and provide upgrade turns where natural reverse grades are not available. (See Erosion Control Devices - Reverse Grades)

! Major skid trails should be located away from streams, ponds, lakes, and wetlands. (See Erosion Control Devices - Streamside Management Zone)

! Move surface water quickly off trail surfaces and on to undisturbed forest floor. (See Erosion Control Devices)

! If streams must be crossed, do so by the most direct route and preferable at right angles to the stream. A bridge, culvert, or ford of acceptable design may be required. (See - Stream Crossings)



! Trail grades approaching stream crossings shall be broken and surface water dispersed so it will not reach the water course. (See Erosion Control Devices)

! **At no time will logs be permitted to be skidded or equipment driven through flowing streams.**

! Skid across slope where feasible.

! Skid uphill to the log landing whenever possible so that water running in the skid trails is dispersed away from landing.

! Silt fencing, haybale erosion checks or water diversions shall be used to prevent soil from skid trails from entering streams and other surface waters.

! Use brush to minimize rutting in soft soil.

LOG LANDINGS

Definition:
An area where harvested logs and trees are temporarily stored and assembled.

Purpose:
To provide an area where forest products are sorted and loaded onto trucks for transport to a mill.

Conditions Where Practice Applies:
Should be so located as to minimize the adverse impact of skidding operations in sensitive areas and on the natural drainage pattern

Guidelines:

! Landings should not be located in streamside management zone.

! Set landings back 100 feet or more from streams, ponds, lakes, and wetlands.

! If landings cannot be set back 100 feet from streams, pond, lakes, and wetlands, sediment traps should be used to minimize sedimentation from surface runoff. Adequate streamside management zone should be left between landings and water courses.

! Locate landings away from low or poorly drained areas.

! Locate landings on gently sloping ground that allows for good drainage.

! Landings should be sized to the minimum required for the area to be cut, the equipment used and the diversity of products produced.

! Construct diversion ditch around uphill side of landings where seepage and lateral flow of water may be a problem.

! Provide adequate drainage on approach trails so that drainage does not enter landing area.

! Divert water draining from landings so that it does not enter truck roads, skid trails, or flow directly into streams, ponds, lakes, or wetlands.

! Servicing of equipment on site must be done in such a way that old oil, hydraulic fluid, etc., should be properly contained and removed from the site and disposed of in accordance with proper waste disposal procedures.

STREAMSIDE MANAGEMENT ZONE

Definition:
A protective strip of undisturbed forest soil between disturbed areas (skid trails, truck roads, and log landings) and a water course (stream, pond, lake, and wetlands).

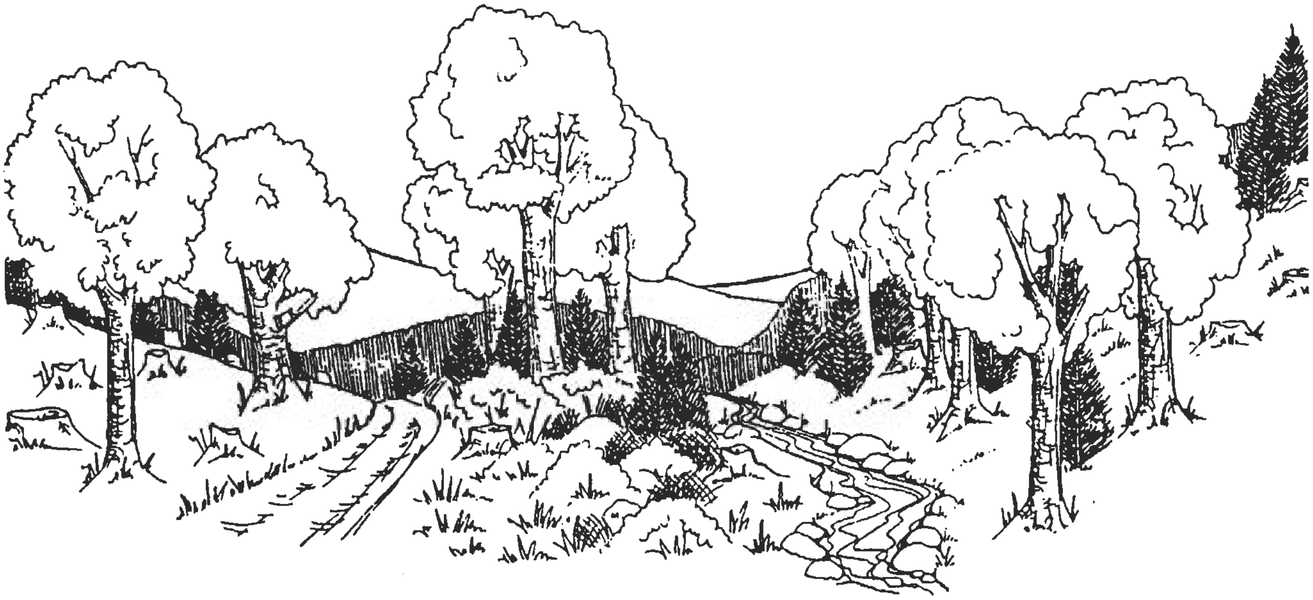
Purpose:
To provide an undisturbed zone to slow runoff, allowing sediment to settle and be filtered out before reaching a water course.

Conditions Where Practice Applies:
Should be maintained between all water courses and truck roads, major skid trails, or log landings where soil has been exposed.

Guidelines:

! The streamside management zone should be protected to prevent exposure of mineral soil. Equipment operation in this area should be limited. If mineral soil is exposed, it should be stabilized by seeding and/or mulching as soon as possible.

! Harvesting practices which do not expose mineral soil may take place in the streamside management zone such as felling and winching of timber.



- No log landings should be within the streamside management zone.

- Truck roads and major skid trails should not be within the streamside management zone except when entering and leaving stream crossings.

- New Hampshire law limits harvesting near surface waters and public roads.

STREAMSIDE MANAGEMENT ZONE WIDTHS

Side slope (percent)	Width (feet)
0 - 10	50
11 - 20	70
21 - 30	90
31 - 40	110

Note: Add 20 feet for each additional 10 percent of side slope.

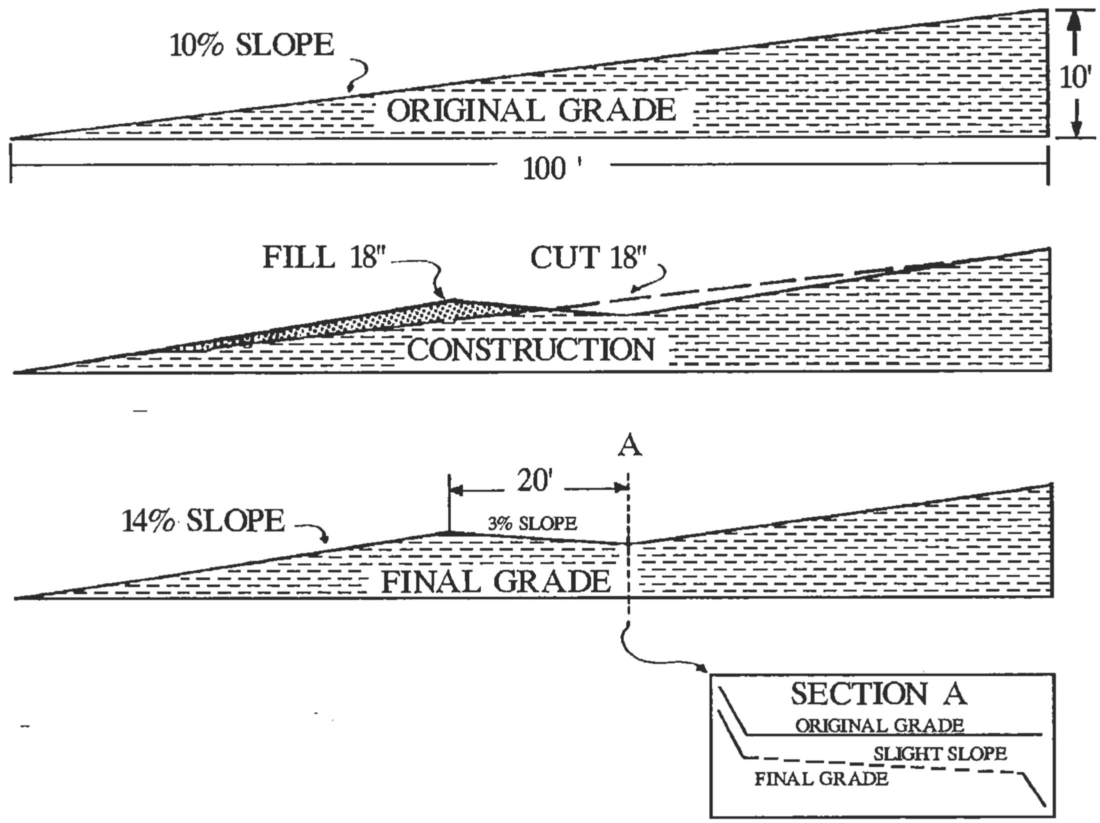
BROAD BASED DIPS

Definition:
A dip and reverse slope in a truck road surface with an outslope in the dip for natural cross drainage.

Purpose:
To provide cross drainage on insloped truck roads to prevent build-up of excessive surface runoff and subsequent erosion.

Conditions Where Practice Applies:
Use on truck roads and heavily used skid trails having a gradient of 10% or less. May be substituted for other cross drainage structures where no intermittent or permanent streams are present.

Guidelines:



- Proper construction requires an experienced bulldozer operator.
- Installed after the basic roadbed has been constructed and before major hauling use.
- On grades steeper than 8%, surface dips with stone (approx. 3" diameter) or gravel.
- Use dips on approaches to steep declines in heavily used skid trails.
- Discharge area should be protected with stone, grass sod, heavy litter cover or slash and logs to reduce the velocity and filter the water.

SPACING FOR BROAD BASED DIPS

Road Grade (percent)	Spacing Between Dips (feet)
2	300
4	200
6	165
8	150
10	140
12	130

WATER BARS

Definition:
An excavated channel with earthen or reinforced berm constructed across a truck road or skid trail.

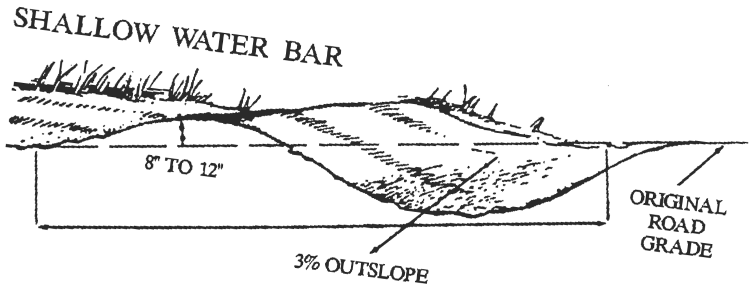
Purpose:
To intercept and divert water from side ditches and truck road or skid trail surfaces, minimizing erosion by decreasing the slope length of surface water flow.

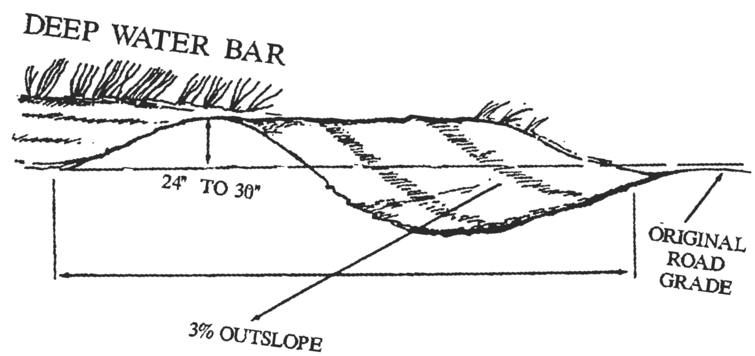
Conditions Where Practice Applies:
On any sloping truck road or skid trail where surface water runoff may cause erosion.

Guidelines:

! Start placement of water bars at the farthest skid trail and work back to the log landing and then to the truck road.

! Install water bars with a skidder blade, dozer blade, excavator or by hand.


SHALLOW WATER BAR
8" TO 12"
ORIGINAL
ROAD
GRADE
3% OUTSLOPE


DEEP WATER BAR
24" TO 30"
ORIGINAL
ROAD
GRADE
3% OUTSLOPE

- Install water bars at the top of any sloping road or trail and at proper spacing along steep sections.

- Water bars may be shallow or deep depending on the need.

- Soil should be left along the lower side of the water bar.

- Should be constructed at a 30° - 35° angle downslope from a line perpendicular to the direction of the truck road or skid trail.

- Should drain at a 3% outslope onto undisturbed litter or vegetation.

- The uphill end of the water bar should extend beyond the side ditch line of the road or trail to fully intercept any water flow.

- The downhill end of the water bar should be fully open and extended far enough beyond the edge of the road or trail to disperse runoff water onto undisturbed forest floor.

- Place rocks, slash, or logs to disperse water coming from a water bar.

- If the road or trail is to be kept open after the harvesting operation, the following guidelines should be used in order to preserve effective water bars.

  -Reinforce the water bars
  -Keep travel to a minimum
  -Use only in dry weather
  -Make frequent inspections
  -Maintain as needed

SPACING FOR WATER BARS

Road/Trail Grade (percent)	Spacing Between Water Bars (feet)
2	250
5	135
10	80
15	60
20	45
30	35

REVERSE GRADES

Definition:
A short rise in a downhill skid trail that forces any water in the trail to drain off to the side. Obtained by turning the skid trail up the hill a short distance then turning downhill again.

Purpose:
To break the grade of the skid trail as often as practical, therefore limiting slope length.

Condition Where Practice Applies:
Where additional drainage can be provided by taking advantage of natural cross drainage on sidehill locations.

Guidelines:

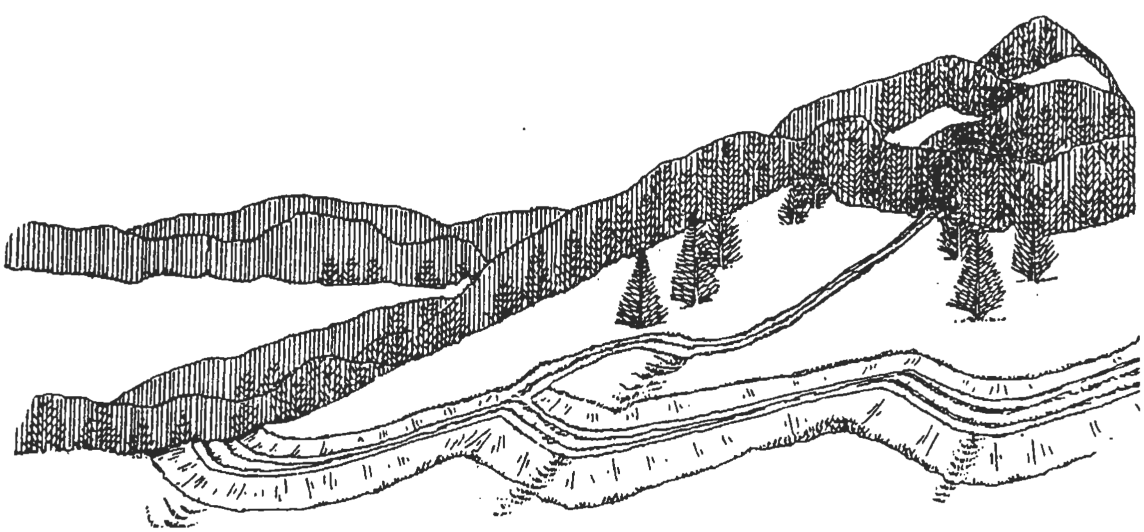
! Reverse grades are commonly applied to only skid trails.

Requires greater planning and layout of trail system.

! Use in conjunction with other water control measures.

! Requires minimum construction time and low maintenance.

! Unsuitable on very steep terrain and hardpan soils.



CROSS DRAINAGE CULVERTS

Definition:
Corrugated pipe, well casing, dredge pipe, or other suitable material placed under a truck haul road or major skid road to transmit ditch runoff and seeps from a drainage area of less than 10 acres.

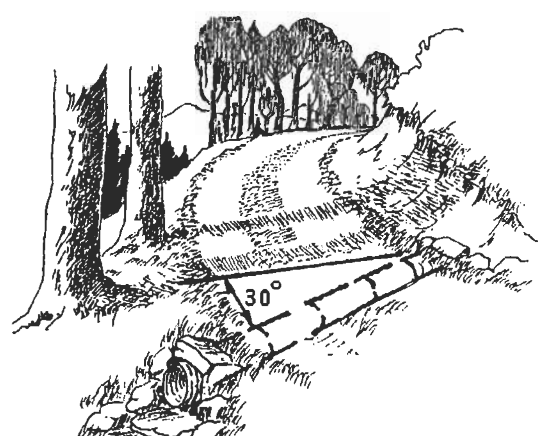
Purpose:
To collect and transmit water flows from side ditches and seeps, under truck haul roads and major skid trails safely without eroding a drainage system or road surface.

Conditions Where Practice Applies:
For any size operation where cross drainage of storm water is required temporarily or permanently.

Guidelines:

! This is the most expensive method of road cross drainage and should be used where heavy use is anticipated during and after the harvesting operation.

! When sizing culverts for temporary roads, allow for periods of high flow, such as spring runoff or cloudbursts.



! The minimum size culvert to be installed is 12 inch diameter and 20 feet in length.

! When constructing roads on sidehill locations, ditch the uphill side of the roadway to intercept surface runoff.

! Allow inlet end of culvert to extend into side ditch so that it intercepts water flowing in the ditch. Construct a berm across the side ditch to assist in diverting water into the culvert.

! Allow outlet end of culvert to extend beyond any fill and empty onto an apron of rock, gravel or logs.

- Space culverts according to road grade:

  On gentle slopes (1-2%)..................................300 feet

  On moderate slopes (3-10%)............................150 feet

  On steep slopes (10%+)........................100 feet or less

- Culverts should be installed at a 30-35 degree angle downgrade.

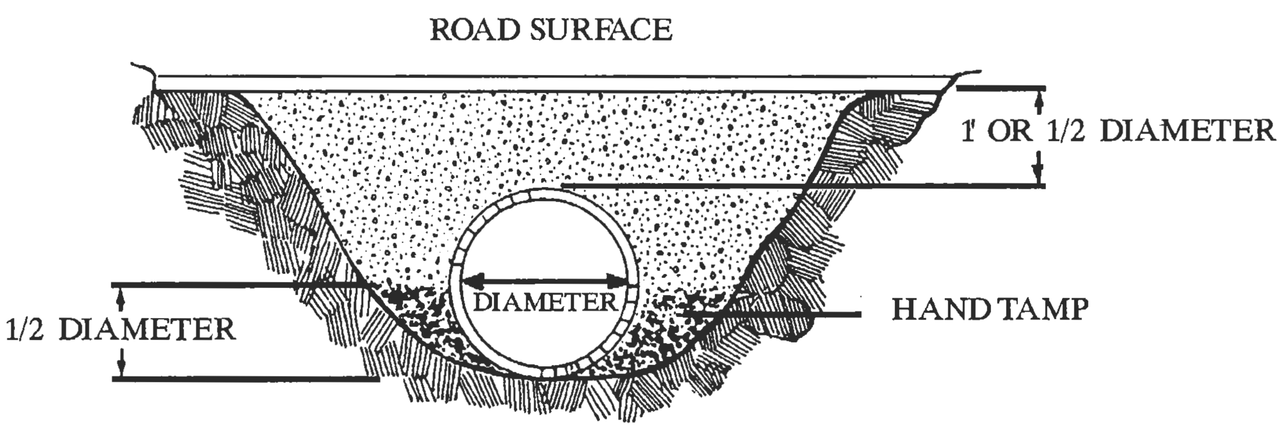
- Culverts should be sloped at least 5 inches for every 10 feet of length to permit self-cleaning.

- When harvesting operation has been completed, the road should be stabilized by installing water bars and removing all pipe culverts from truck roads which will not be maintained.

- Culverts, when not maintained, are very likely to become blocked with rocks, ice or other debris. Runoff water can become rerouted over and around the culvert and may wash out sections of road into brooks, streams, ponds or wetlands. It is important to clean culverts regularly. Check after every storm.

- Culvert size selection should be based on the size of the drainage area of the watershed and should be able to handle the largest flows.

- Estimate drainage area by taking measurements on a USGS topographic map, using contour lines to define the drainage limits. The Natural Resource Conservation Service can assist you with determination of drainage area.



OPEN TOP CULVERTS

Definition:
A wooden, concrete, or slotted steel pipe culvert placed across truck haul roads to convey surface runoff and side ditch flows across to downslope side.

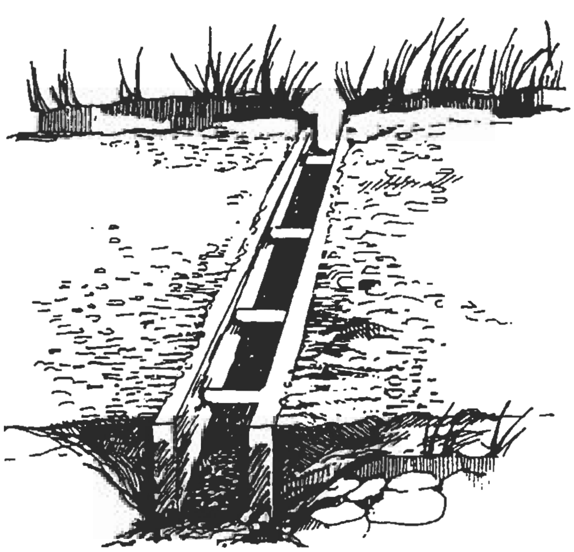
Purpose:
To collect and direct road surface storm runoff and upslope side ditch flows across road without eroding drainage system or road surfaces.

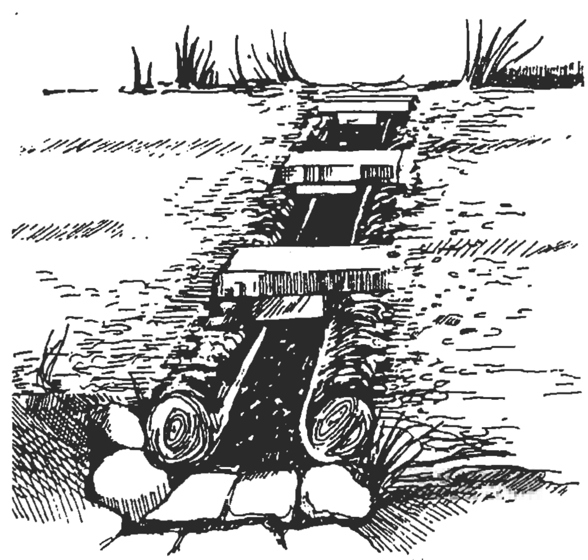
Conditions Where Practice Applies:
This practice is a temporary or permanent drainage structure for truck haul roads. Properly built and maintained, it can be used for cross drainage on roads of smaller operations as a substitute for a cross drainage culvert. This practice should not be used for handling intermittent or live streams or skid trail cross drainage.

Guidelines:

! Can be constructed of cull logs or from sawn lumber. If made of durable wood or treated material, these culverts will give many years of service.

! Install flush with the road surface and skewed at an angle not less than 30 degrees downgrade.





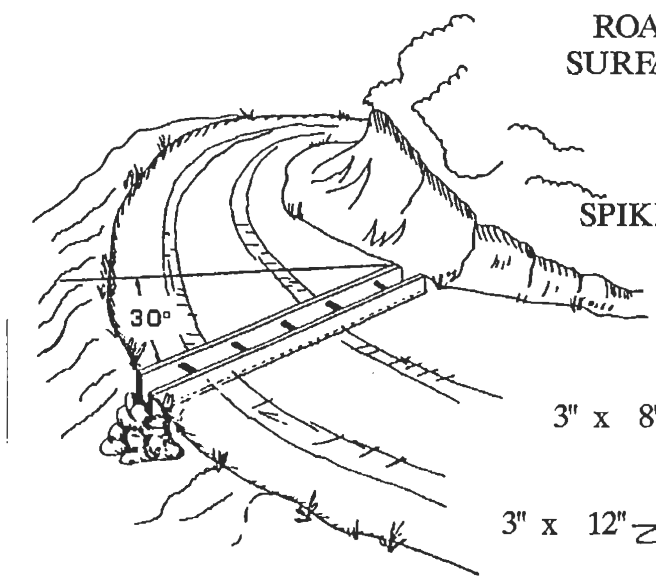
! Allow the inlet end to extend into the cut slope or side ditch so that it intercepts water.

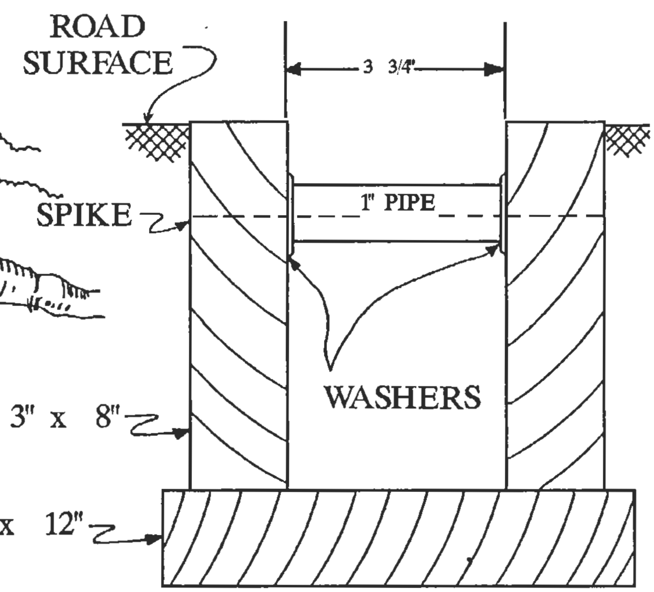
! Allow outlet end to extend beyond any fill and empty onto an apron of rock, gravel or logs.

! Open top culverts must be cleaned regularly to remove sediments, gravel, and logging debris to allow normal function of structure at all times.

SPACING FOR OPEN TOP CULVERTS

Road Grade(percent)	Spacing Between Culverts(feet)
1 - 2%	300
3 - 10%	150
10%+	100 or less



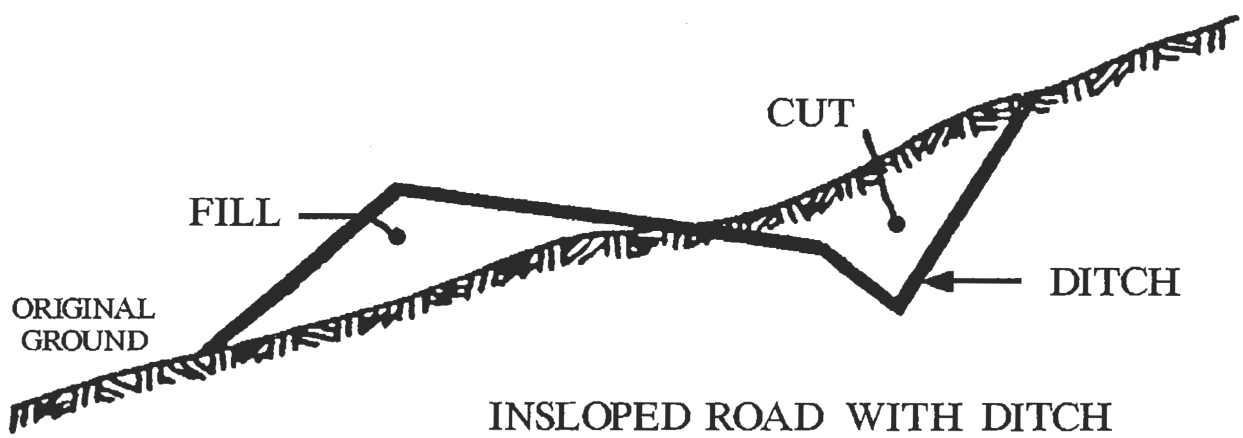


INSLOPING

Definition:
A section of road is sloped slightly (1-3%) toward the cut bank.

Purpose:
Effective way of limiting erosion because water is removed from the road surface quickly and diverted directly to the inside ditch which will carry the water into a culvert.

Condition Where Practice Applies:
Used when the soils are easily saturated or highly erodible. This will limit the amount of ditch water which will flow on to unstable fills.



INSLOPED ROAD WITH DITCH
(cross section)

OUTSLOPING

Definition:
A section of road sloped slightly (1-3%) from the cut bank to the outside edge of the road bed.

Purpose:
To prevent erosion by diverting runoff from a road surface on to undisturbed forest floor.

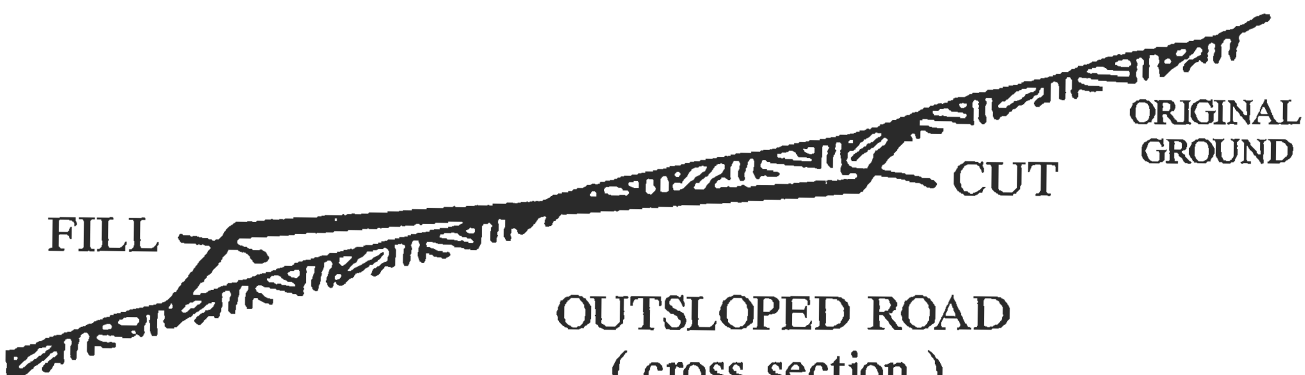
Condition Where Practice Applies:
Used when the area is entirely rock, or when water can be diverted on to undisturbed forest floor.

Guidelines:

! Outsloping on fill is not desirable.

! For safety, do not use for trucking during freezing weather.

! Do not use on silty or hardpan soils when wet or if seeps are present.



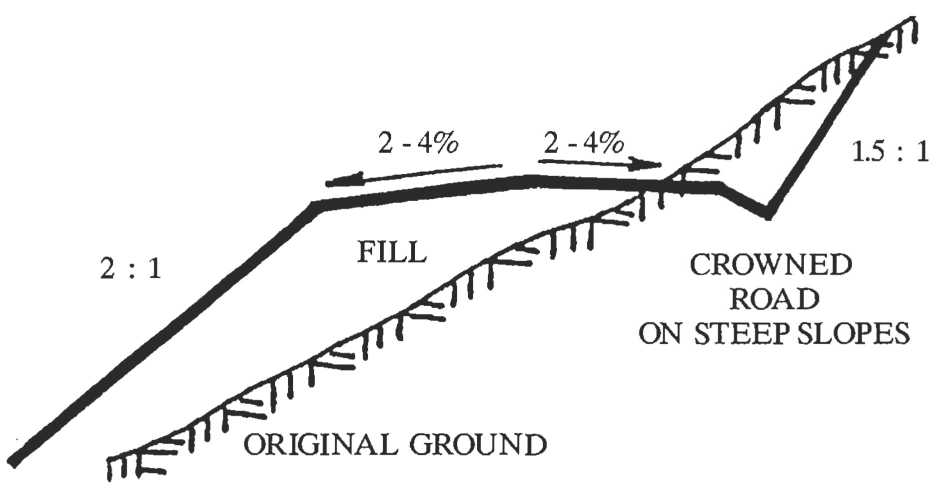
OUTSLOPED ROAD
(cross section)

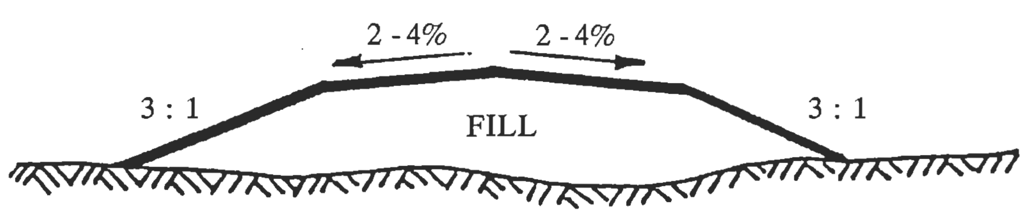
CROWNING

Definition:
A section of road is sloped slightly (2-4%) from the center line of the road to the outside edges of the roadbed.

Purpose:
Effective way of limiting erosion because water is removed from the road surface quickly and diverted directly onto the forest floor or into a ditch which will carry the water into a culvert.

Conditions Where Practice Applies:
Used when soils are easily saturated or highly erodible when adjacent areas are relatively level with roadbed or on steep side hills.





CROWNED ROAD

Guidelines:

CORDUROY

Definition:
Crossing of a wet area where there is not a defined channel using poles or cull logs as a roadbed.

Purpose:
To be used as a wet area crossing by a skid trail where it is necessary to provide soil stability.

Conditions Where Practice Applies:
To be constructed on wet soils subject to rutting and extreme compaction by timber harvesting equipment

Guidelines:

- Use geo-textile fabric or other appropriate bedding.
- Place 8 - 10 inch diameter poles or cull logs side by side in wet area to serve as a roadbed.
- Place poles or cull logs perpendicular to the direction of travel across wet area.
- The top width of corduroy roadway should be at least 10 feet.
- Shall not be crossed when they are overtopped with water.
- After corduroy roadway has been overtopped with water, repair and maintenance will be required.
- Corduroy roadway should be inspected regularly.
- May be left in place after harvesting operation has been completed.

TEMPORARY BRIDGE

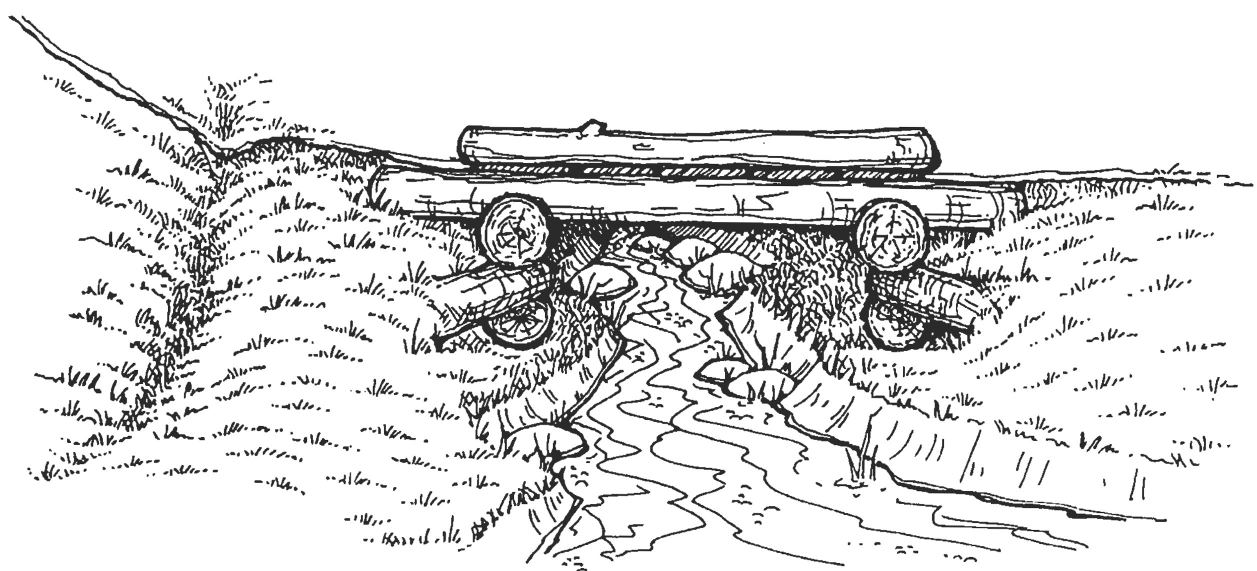
Definition:
A structure of wood and steel materials installed across a natural or constructed channel or stream.

Purpose:
To carry a single lane haul road or skid trail over a stream to enable more direct routing while keeping equipment and products out of the water.

Conditions Where Practice Applies:
Where restrictions such as topography or property lines make it necessary to cross a stream. Stream crossings are a major concern in the construction and use of a truck haul roads and skid trails because of the potential for large amounts of sediment to enter a stream. Keep the number of stream crossings to a minimum.

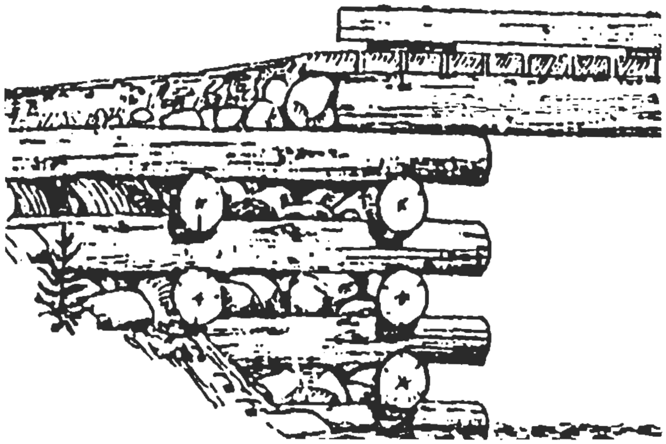
Guidelines:

- Install bridges at right angle to the stream. A maximum of 15 degree skew may be allowed as an exception where approach conditions are difficult.
- Align approach and exit with the bridge's center line with as little curvature as possible.
- Stream alignment should be straight at the point of crossing and of uniform profile.

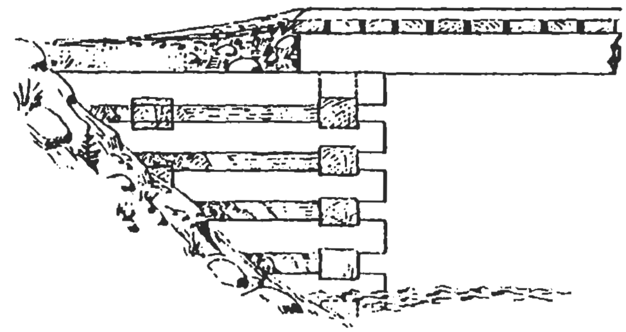


! Minimum acceptable bridge width is 10 feet.

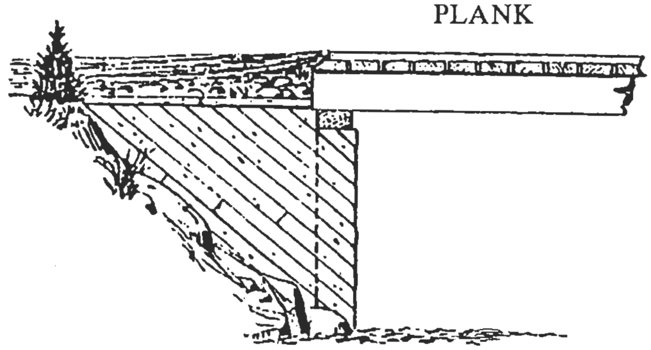
! Firmly anchor abutments out of the water in stable bank material and parallel to the stream channel. Do not narrow stream channel with abutments.



PREFABRICATED CRIB



PLANK



! Acceptable abutment materials can be rock, logs, sawn timbers or a combination of any of the above. (See Logging and The Law)

! Place abutment aprons or approaches as close to gradient of bridge surface as possible. Avoid abrupt rises and drops from bridge gradient to apron gradient. (See Logging and The Law)

! Stringer material may be either logs, sawn timbers or steel.

! Match center line gradients of span and stringers with that of the road or trail.

! It is recommended that a registered engineer be contacted to design the bridge.

! Log stringers should have a flat upper bearing face to accept a plank deck as well as a flat bearing surface on abutments. Placement of log stringers on abutments should alternate small and large ends.

! Deck material shall be placed perpendicular to the stringer direction and be tight.

! A curb shall be installed along the outer sides of the deck and be fastened tight to the deck. Minimum size will be 6" x 6" and will run the entire length of the span. Pole timbers can also be used, but must be straight and of sound quality.

! The bridge must be anchored so that it will not wash out during high water.

! Old trailer beds make excellent temporary bridges over small streams.

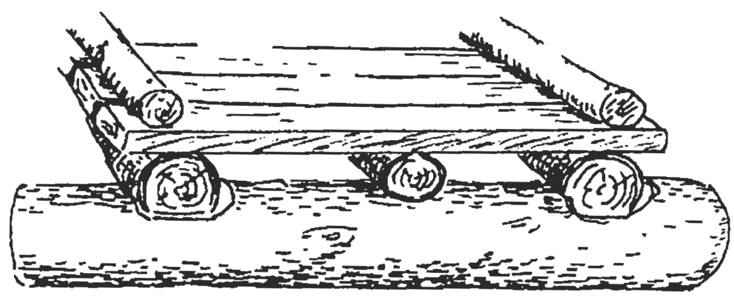
! Placement of bridges that require work in the stream should be done when the water level is low and in as short a period of time as possible. (See Logging and The Law)

! Do not gravel the deck. The gravel holds moisture that will cause the deck to rot.

! When the harvesting operation has been completed, stabilize the area by removing all bridges from truck haul roads and skid trails which will not be maintained.

! Road and trail grades approaching stream crossings shall be broken and surface water dispersed so it will not reach the watercourse. (See Erosion Control Devices)

! Find stream banks that are firm and level and approaches that are reasonably level for a distance of 50 feet on each side of the stream crossing.



STONE FORDS

Definition:
Stream crossing using the stable stream bottom or stone fill as the roadbed.

Purpose:
To be used on a truck haul road as a stream crossing rather than a bridge or culvert.

Conditions Where Practice Applies:
Perennial Stream Ford - Can be constructed and used during periods of low flow. When drainage area exceeds one square mile, a log box culvert should be installed.

Guidelines:

! Installation of fords is permissible only when it is not feasible to construct a bridge or install a pipe culvert, i.e. streams having no or low banks.

! Fords are prohibited on all streams in watersheds tributary to drinking water intakes or reservoirs for public and private water supplies, where the ford is within 2,000 feet of such intake or reservoir.

! Shall not be crossed when they are overtopped with water.

! **Skidding across stone fords is prohibited.**

! Construct on sound stable stream bottoms, whenever possible.

! Use geotextile fabric or other appropriate bedding for approaches. Do not use in stream.

! Use angular rock fill material of at least 75% greater than 5 inches in diameter. Use larger sizes for large drainage areas.

! Use 2 inch round stone on surface of ford to protect tires from sharp edges of angular rock.

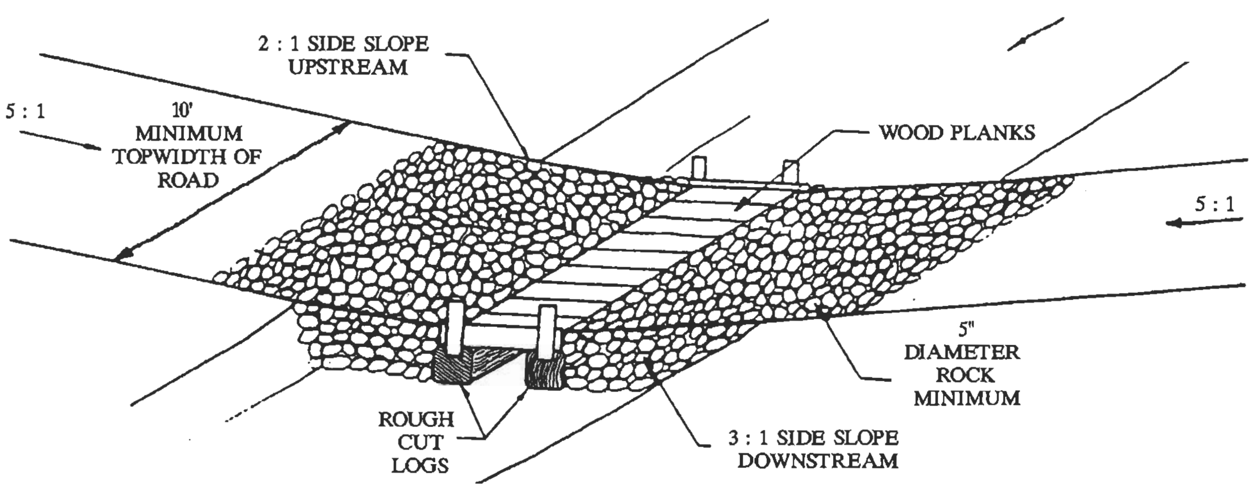
! Height of fill should be at least 1/2 foot above low flow water level. However, total fill should not to exceed 2 feet above stream bottom.

! The top width of the fords should be at least 10 feet.

! Side slopes of fords should be greater than or equal to; 2:1 upstream and 3:1 downstream.

- After fords have been overtopped with water, repair and maintenance will be required.
- Do not place gravel or fill on the top of stone fords.
- The log box culvert may float during overtopping and should be anchored.
- Large stones or boulders on the downstream face of a stone ford will increase its life.
- Roads and trail grades approaching stream crossings shall be broken and surface water dispersed so it will not reach the stream. (See Erosion Control Devices)
- Find stream banks that are firm and level with approaches that are reasonably level for a distance of 50 feet on each side of the stream crossing.

Number of 15"x15" Log Box Culverts	**Drainage Area (Square Miles)**	
	Shallow/High Elevation Soils	Normal Soils
1	1 - 5	1 - 8
2	5 - 10	8 - 17
3	10 - 15	17 - 20
4	15 - 20	



POLED FORDS

Definition:
Temporary stream crossing in a defined channel using poles or cull logs as the roadbed.

Purpose:
To be used as a stream crossing rather than a bridge or culvert.

Conditions Where Practice Applies:

Can be constructed and used during periods of no or low flow. Fords are used for crossing streams with light use truck haul roads and skid trails where there is limited potential for sedimentation of the stream.

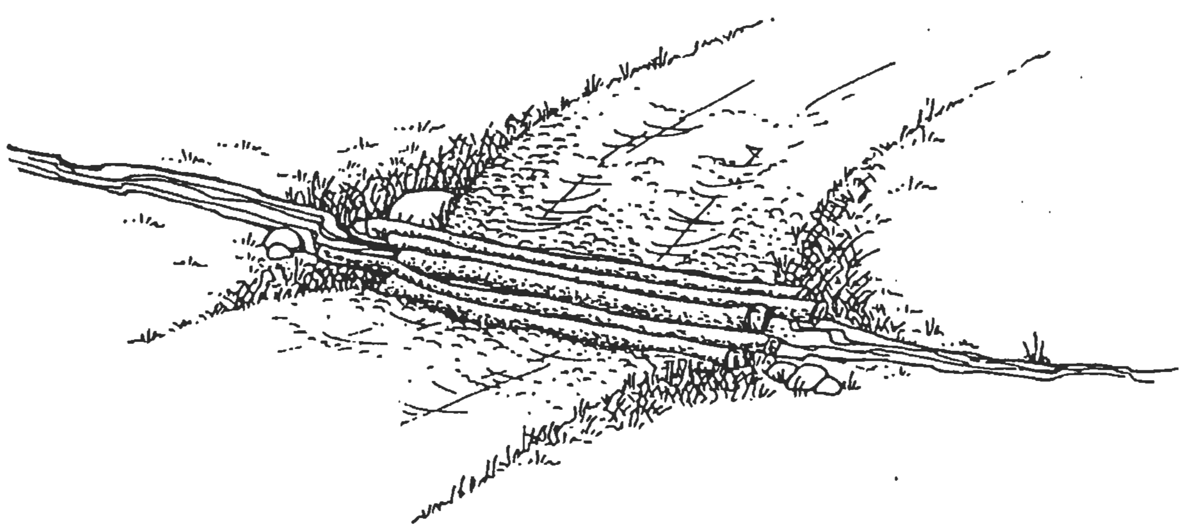
Guidelines:

! Installation of fords is permissible only when it is not feasible to construct a bridge or install a pipe culvert, i.e. streams having no or low banks.

! Fords are prohibited on all streams in watersheds tributary to drinking water intakes or reservoirs for public and private water supplies, where ford is within 2,000 feet of such intakes or reservoir.

! Shall not be crossed when they are overtopped with water.

! Constructed on sound stable stream bottoms.



- Use geo-textile fabric or other appropriate bedding if needed to stabilize the approaches to the crossing.
- Find stream banks that are firm and level with approaches that are reasonably level for a distance of 50 feet on each side of the stream crossing.
- Place 8 - 10 inch diameter poles or cull logs side by side on the stream bed to serve as the roadbed.
- The top width of these fords should be at least 10 feet.
- Poles and logs must be removed immediately after use.
- After fords have been overtopped with water, repair and maintenance will be required.
- Poled fords should be inspected regularly to make sure the stream is not becoming turbid.
- Do not gravel or fill over poled fords.

STREAM CULVERTS

Definition:
Corrugated pipe, well casing, dredge pipe or wooden box culvert placed under a truck haul road or major skid road to permit crossing of an intermittent or live stream.

Purpose:
To transmit water flow of intermittent or live streams under truck haul roads and major skid trails. To carry a single lane haul road or skid trail over a stream to enable more direct routing while keeping equipment and products out of the water.

Conditions Where Practice Applies:
Where restrictions such as topography or property lines make it necessary to cross a stream. Stream crossings are a major concern in the construction and use of truck haul roads, major skid roads, and skid trails because of the potential for large amounts of sediment to enter a stream.

Guidelines:

! Keep the number of stream crossings to a minimum.

! Culvert size selection should be based on the size of the drainage area of a forested watershed and should be able to handle the largest stream flows.

! Estimate drainage area by taking measurements on a USGS topographic map, using contour lines to define the drainage limits. The Natural Resource Conservation Service can assist you with determination of drainage area.

! Install a culvert/emergency spillway when the expected life of the stream crossing is greater than the duration of the harvesting operation.

! Construct during periods of no or low flow and in as short a period of time as possible.

! Install culvert crossing at right angle to the stream. A maximum of 15 degree skew is allowed as an exception where approach conditions are difficult.

! Align approach and exit with culvert crossing center line with as little curvature as possible.

! Road and trail grades approaching stream crossings should be broken and surface water dispersed so it will not reach the watercourse. (See Erosion Control Devices)

SIZING PIPE CULVERTS FOR STREAM CROSSINGS

Acres of Drainage: Shallow and High Elevation Soils	Acres of Drainage: Normal Forest Soils	Recommended Pipe Culvert Diameter in Inches
2	9	12
4	16	15
7	25	18
12	40	21
16	55	24
27	84	30
47	130	36
64	190	42
90	260	48
120	335	54
160	400	60
205	550	66
250	640	72

! Stream alignment should be straight at the point of crossing and of uniform profile so as not to obstruct the flow of water.

! Find stream banks that are firm and level and approaches that are reasonably level for a distance of 50 feet on each side of the stream crossing.

! Minimum acceptable culvert crossing top width is 10 feet.

! Place culverts in the natural drainage channel.

! Place culverts on the same grade as the stream bed. The minimum culvert grade is 2-4%.

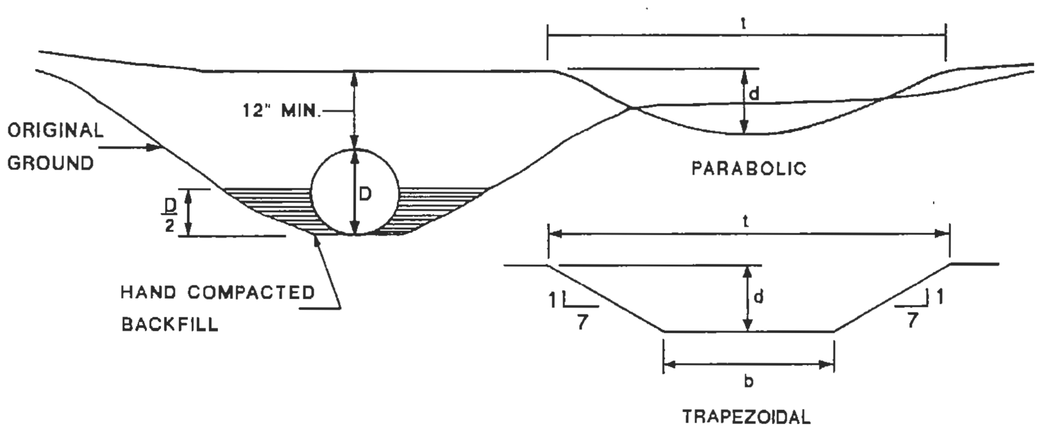
Pipe Culvert Diameter in Inches	Suggested Emergency Spillway Dimensions				
	Parabolic (ft.)		Trapezoidal (ft.)		
	d	t	d	t	b
12	0.5	12.0	0.5	11.5	4.5
15	0.5	12.0	0.5	11.5	4.5
18	0.5	17.0	0.5	15.0	8.0
21	0.75	12.0	0.75	13.5	3.0
24	0.75	22.0	0.75	19.5	9.0
30	1.0	23.0	1.0	22.5	8.5
36	1.0	33.0	1.0	29.0	15.0
42	1.0	44.0	1.0	36.0	22.0
48	1.0	55.0	1.0	44.0	30.0
54	1.5	45.0	1.5	44.0	24.0
60	1.5	52.0	1.5	48.5	27.5
66	2.0	49.0	2.0	54.0	26.0
72	2.0	55.0	2.0	58.0	30.0

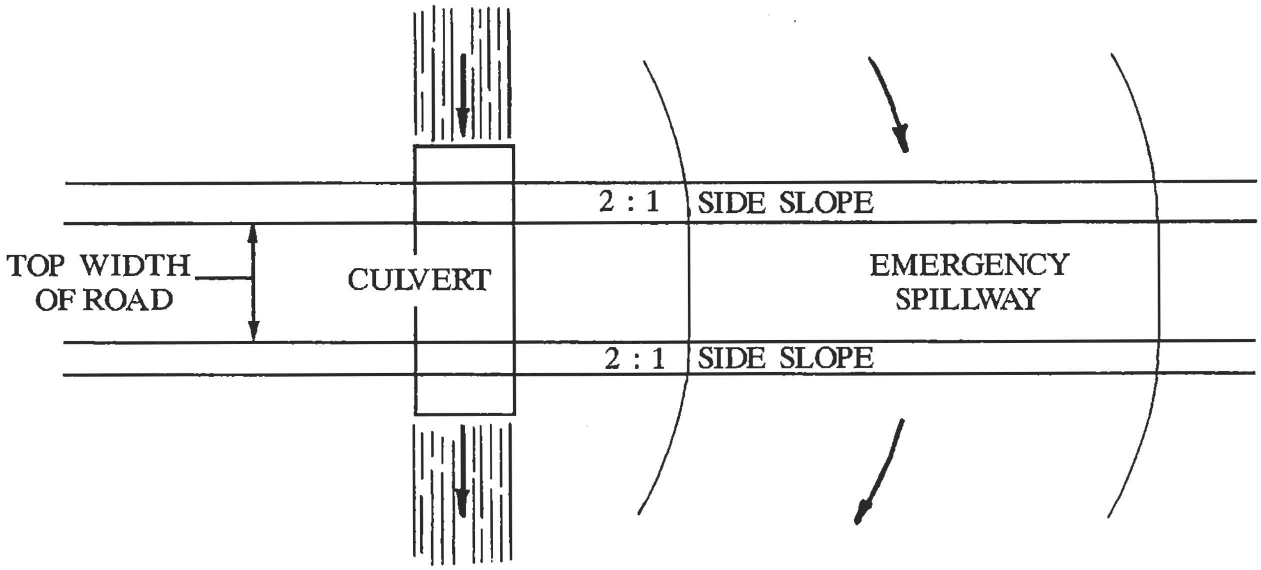
Design Assumptions:

! Entire drainage is forested
! Culverts sized for (2) year storm flow
! Emergency spillway sized for (10) year storm flow

! Inlet should be located on or below the stream bed, not above it.

! Avoid placing fill under the culvert to obtain the desired grade.





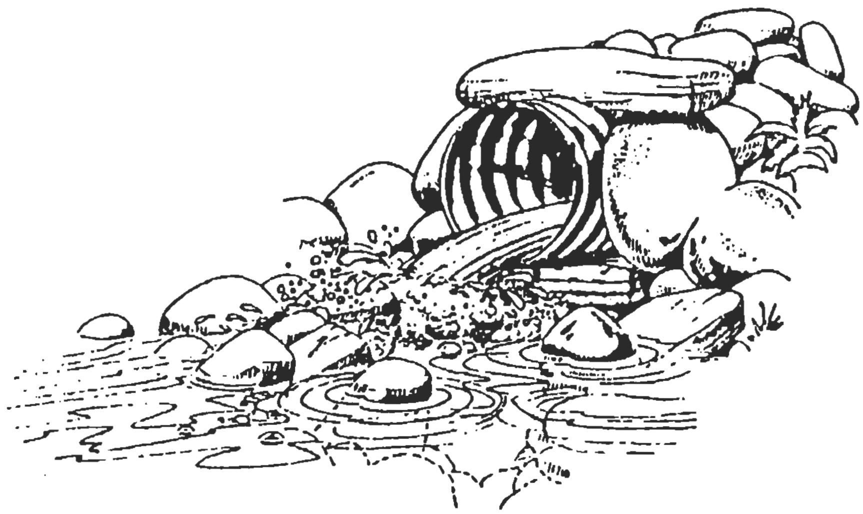
- Seat the culvert(s) and pack with clean washed stone; fill to half the diameter of the culvert and hand tamp.

- Cover culvert with a minimum of (1) foot of clean stone material or one-half the culvert diameter, whichever is greater. If adequate cover cannot be achieved, then (2) smaller culverts should be installed.

- Allow inlet and outlet ends of the culvert to extend at least (1) foot beyond the toe of the fill.

- Protect the upstream end of the fill around the culvert from erosion by placement of a rock header.

- Protect the downstream end of the fill around the culvert from erosion by seeding and mulching and providing riprap.



HAUL ROAD, SKID TRAIL, AND LOG LANDING STABILIZATION

Definition:
Planting vegetation such as grasses and legumes on exposed mineral soil and erodible segments of truck haul roads, skid trails, or log landings.

Purpose:
To permanently stabilize the site; to reduce damages from sediment and runoff, provide wildlife food value and habitat; enhance natural beauty; maintenance of the right-of-way is desired.

Conditions Where Practice Applies:
Areas of exposed mineral soil that are subject to erosion and where a permanent vegetative cover is needed.

Guidelines:

! Old or new water diversion structures such as water bars, culverts, broad based dips, etc., must be operative before stabilization is initiated.

! Where feasible, prepare a seedbed by grading, removing debris, and scarifying the soil to a minimum depth of 3 inches. When the area to be seeded has been recently loosened to the extent that an adequate seedbed exists, no additional treatment is required.

! Lime and fertilizer should be thoroughly applied to the seedbed as indicated by soil test.

1. Lime to a pH of 6.0, but in the absence of a soil test, apply a minimum of 2 ton/acre of ground agricultural limestone (high magnesium).

2 Fertilize at the rate of 500 pounds of 10-10-10 per acre.

! Mulch, such as straw, hay, woodchips, or bark, retains soil moisture, important for seed germination, and protects the soil surface from erosion due to runoff. Mulch can be used to: (1) promote natural revegetation or (2) protect seeds that have been spread over an area. If you seed, apply mulch immediately afterward.

! Seeded areas should be closed off from all use until cover is adequately established.

! Inspect all seeded areas for failures and make necessary repairs.

! Grasses and other herbaceous cover can stabilize bare mineral soil and minimize erosion. It is a good practice to seed disturbed areas following harvesting.

! Close off vehicle access with a gate, fence, boulders, or with a large tree felled across the road.

! Mulch seedings and anchor on slopes or where subjected to concentrated flow.

! Track in seed with a dozer whenever possible to improve germination and establishment, especially when seeding flatpea or crownvetch and on sandy, droughty sites.

Seeding Mixtures for Permanent Seedings[1]

Area/Purpose	Drainage Class	Soil pH	Shade	Appropriate Mixture[2]	(lbs./Ac)
Winter Roads Landings Wildlife	Poorly	5.0-7.5	Moderate to None	Reed Canarygrass Birdsfoot Trefoil Redtop	15 10[3] 2
Roads Trails Landings Burned Over	Excessively to Somewhat Poorly	4.5-7.5	Heavy to None	Creeping Red Fescue Tall Fescue Redtop	20 20 2
Roads Trails Landings Burned Over Brush Control	Excessively to Somewhat Poorly	5.5-7.5	Moderate to None	Flatpea Tall Fescue Redtop	20[3] 15 2

Roads Landings Wildlife	Well to Moderately Poorly	5.0-7.5	Moderate to None	Creeping Red Fescue Birdsfoot Trefoil Redtop	20 8[3] 2
Roads Landings Wildlife	Well to Moderately Well	5.5-7.5	Moderate to None	Crownvetch Tall Fescue Creeping Red Fescue Redtop	15[3] 15 10 2

[1]Seeding Dates. Seed disturbed areas as soon as possible. Seed early in the spring as soon as the ground can be worked and in the late summer - early fall based on local recommendations.

[2]Include 10-20 lbs.\ac. of winter rye when seeding after Sept. 15th. On critical areas or droughty sites, apply hay or straw mulch at the rate of 90 lbs./1000 sq. ft. Anchor mulch on steep slopes or where subjected to concentrated flow.

[3]Inoculate legumes separately with an inoculant which is specifically recommended for the legume being seeded.

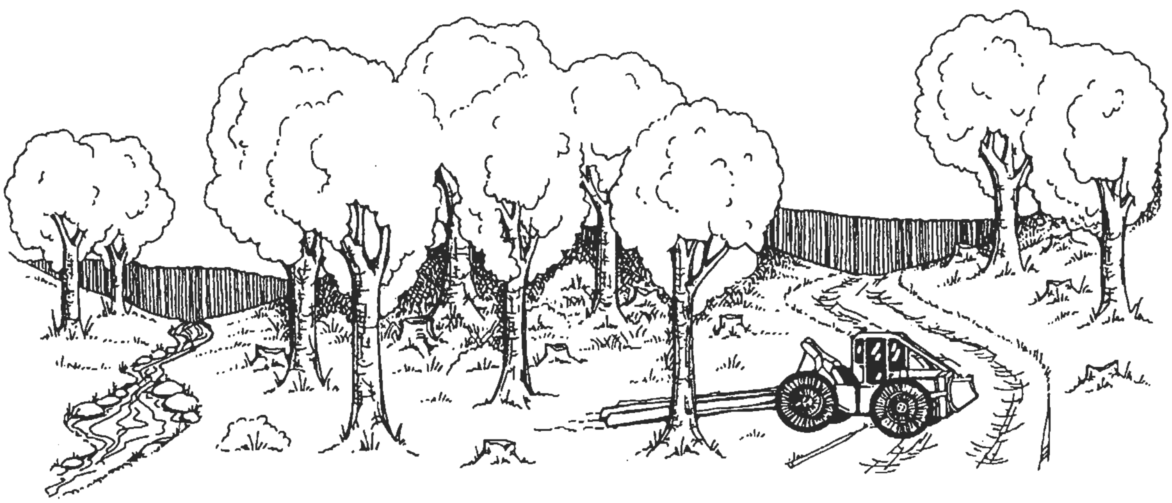
Seeding Mixtures for Temporary Seedings[1]

For Excessively Well to Somewhat Poorly Drained Soils

Area/Purpose	Soil pH	Shade	AppropriateMixture[2](lbs./Ac.)	
Roads Trails Landings Burned Over	4.5-7.5	Heavy to None	Creeping Red Fescue Redtop	40 2
Roads Trails Landings	5.5-7.5	Heavy to None	Annual Ryegrass	40
Roads Trails Landings Wildlife	5.5-7.5	Moderate to None	Winter Rye	112

[1]Seeding Dates. Seed disturbed areas as soon as possible. Seed as early in the spring as the ground can be worked and in the late summer - early fall based on local recommendations.

[2]On critical areas or droughty sites, apply hay or straw mulch at the of 90 lbs./1000 sq. ft. Anchor mulch on steep slopes or where subjected to concentrated flow.



WETLANDS PERMITTING

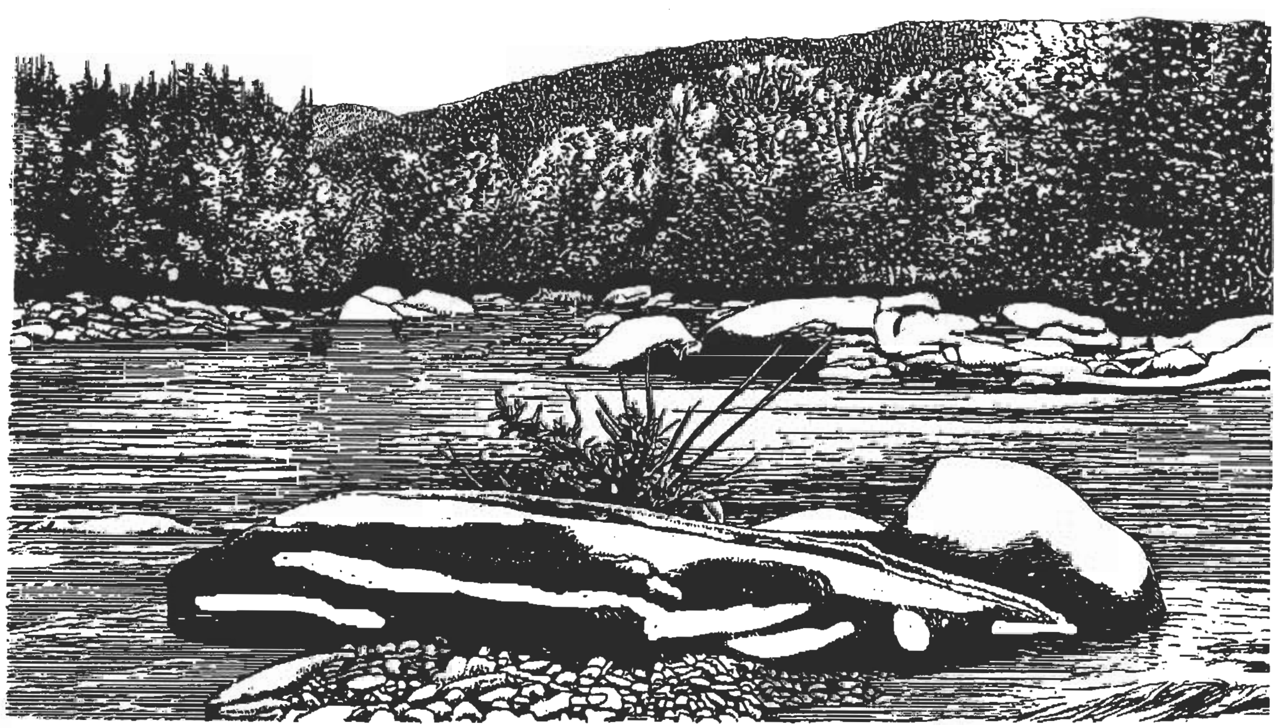
Timber harvests which involve stream or wetland crossings require a wetlands permit. The level of harvesting impacts on a wetland dictates the type of wetland permit required. There are three types of actions: minimum, minor, and major.

MINIMUM IMPACT WETLANDS PERMIT

The minimum impact wetlands permit is attached to the intent to cut form. A minimum impact wetlands permit is only allowed under the following circumstances:

- Forest management harvests only - land conversion projects require a separate dredge and fill permit;
- Wetland impacts of less than 3,000 square feet;
- Permanent culverts or rock fords which do not exceed 15 feet in width and 50 feet in length;
- Stream crossings up to 10 feet in width;
- Wetland crossings of up to 50 feet in width.

To complete the minimum impact wetlands permit, simply fill in the one page questionnaire, prepare a map of the harvest area using a USGS topographic map showing all wetland crossings and pay an



additional fee of $25. Forest harvesting can begin as soon as local officials sign the intent to cut.

EXCAVATING AND DREDGING PERMIT

If the timber harvest has minimum impacts but the land is being converted to other than non-forest uses, or if a logging operation will result in wetland impacts greater than those described above, a dredge and fill permit from the New Hampshire Wetlands Bureau will be required. Applications for these permits are available at town and county conservation district offices. Permit applications, a detailed plan, proof of notification of abutters and fees based on the square footage of impacted wetlands are required. When the application and accompanying materials are submitted to the Bureau, four copies of each must also be provided to the town clerk. The town clerk keeps one and sends the other copies to the selectmen, planning board, and conservation commission. Town clerks may charge an administrative fee of up to $10.

RSA 482-A:3 Excavating And Dredging Permit; Certain Exemptions

I. No person shall excavate, remove, fill, dredge or construct any structures in or on any bank, flat, marsh, or swamp in and adjacent to any waters of the state without a permit from the wetlands board. The permit application together with a detailed plan and a map showing the exact location of the proposed project, along with 4 copies of the permit application, plan and map, shall be submitted to the town or city clerk, accompanied by a filing fee in the form of a check made out by the applicant to the New Hampshire wetlands board. The permit application fee shall be $50 for minimum impact projects. Fees for minor and major projects shall be assessed based on the area of dredge or fill proposed and the number of boat slips requested. The rates shall be $100 per boat slip and $0.025 per square foot. At the time the permit application is submitted to the city or town clerk, the applicant shall provide postal receipts or copies, verifying that abutters, as defined in the rules of the wetlands board, and except as further provided in said rules, have been notified by certified mail. The postal receipts or copies shall be retained by the municipality. The town or city clerk shall immediately sign the application and forward by certified mail, the application, plan, map and filing fee to the wetlands board. The town or city clerk shall then immediately send a copy of the permit application, plan and map to the local governing body, the municipal planning board, if any, and the municipal conservation commission, if any, and may require an administrative fee not to exceed $10 plus the cost of postage by certified mail. One copy shall remain with the city or town clerk, and shall be made reasonably accessible to the public. The foregoing procedure notwithstanding, applications and fees for projects by agencies of the state may be filed directly with the wetlands board, with 4 copies of the application, plan and map filed at the same time with the town or city clerk to be distributed as set forth above.

MINIMUM SHORELAND PROTECTION STANDARDS

RSA 483-B:9

V. The following minimum standards shall apply to the protected shoreland provided that forestry, involving water supply reservoir watershed management or agriculture conducted in accordance with best management practices, shall be exempted from the provisions of this chapter:

(a) Natural Woodland Buffer

(1) Where existing, a natural woodland buffer shall be maintained within 150 feet of the reference line. The purpose of this buffer shall be to protect the quality of public waters by minimizing erosion, preventing siltation and turbidity, stabilizing soils, preventing excess nutrients and chemical pollution, maintaining natural water temperatures, maintaining a healthy tree canopy and understory, preserving fish and wildlife habitat, and respecting the overall natural condition of the protected shoreland.

(2) Within the natural woodland buffer of the protected shoreland under conditions defined in RSA 483-B:9,V the following prohibitions and limitations shall apply:

(A) Not more than a maximum of 50 percent of the basal area of trees, and a maximum of 50 percent of the total number of saplings shall be removed for any purpose in a 20-year period. A healthy, well-distributed stand of trees, saplings, shrubs and ground covers and their living, undamaged root systems shall be left in place.

(B) [REPEALED 1992, 235:28, I.]

(C) Trees, saplings, shrubs and ground covers which are removed to clear an opening for building construction, accessory structures, septic systems, roadways, pathways, and parking areas shall be excluded when computing the percentage limitations under subparagraph (a)(2)(A).

(D) Dead, diseased, unsafe, noxious or fallen trees, saplings, shrubs, or ground cover may be removed. Their removal shall not be used in computing the percentage limitations under subparagraph (a)(2)(A).

(E) Stumps and their root systems which are located within 50 feet of the reference line shall be left intact in the ground.

(F) Dead and living trees that provide dens and nesting places for wildlife are encouraged to be preserved.

(G) Planting efforts that are beneficial to wildlife are encouraged to be undertaken.

ALTERATION OF TERRAIN

An alteration of terrain permit application must be filed if the harvest is being done to clear and stump land for non-forest uses. The permit is required if and more than 100,000 square feet (a little more than 2 acres) or 50,000 square feet in the shoreland protection zone (RSA 483-B:9, V) of land are affected. Alteration of Terrain permits are available at county conservation district offices and the Water Supply and Pollution Control Division of the New Hampshire Department of Environmental Services (DES).

485-A:17 Terrain Alteration

I. Any person proposing to dredge, excavate, place fill, mine, transport forest products or undertake construction in or on the border of the surface waters of the state, and any person proposing to significantly alter the characteristics of the terrain, in such a manner as to impede the natural runoff or create an unnatural runoff, shall be directly responsible to submit to the division detailed plans concerning such proposal and any additional relevant information requested by the division, at least 30 days prior to undertaking any such activity. The operations shall not be undertaken unless and until the applicant receives a permit from the division. The division shall have full authority to establish the terms and conditions under which any permit issued may be exercised, giving due consideration to the circumstances involved and the purposes of this chapter, and to adopt such rules as are reasonably related to the efficient administration of this section, and the purposes of this chapter, Nothing contained in this paragraph shall be construed to modify or limit the duties and authority conferred upon the division of water resources under RSA 482 and RSA 482-A.

II. The division shall charge a fee for each review of plans, including project inspections, required under this section. The fee shall be based on the extent of contiguous area to be disturbed. Except for RSA 483-B:9, the fee for plans encompassing an area of at least 100,000 square feet but less than 200,000 square feet shall be $100. For the purposes of RSA 483-B:9, the fee for plans encompassing an area of at least 50,000 square feet but less than 200,000 square feet shall be $100. An additional fee of $100 shall be assessed for each additional area of up to 100,000 square feet to be disturbed. No permit shall be issued by the division until the fee required by this paragraph is paid. All fees required under this paragraph shall be paid when plans are submitted for review and shall be deposited in the treasury as unrestricted funds.

III. Normal agricultural operations shall be exempt from the provisions of this section. The division may exempt other state agencies from the permit and fee provisions of this section provided that each such agency has incorporated appropriate protective practices in its projects which are substantially equivalent to the requirements established by the division under this chapter. Timber harvesting operations shall be exempt from the provisions of this section. Permits shall be granted for timber harvesting operations provided that the department of revenue administration's intent to cut form is completed.

485-A:32 Prior Approval; Permits

III. No person required to submit subdivision plans pursuant to paragraph I shall commence the construction of roads within the lot, tract or parcel proposed to be subdivided, by clearing the land thereof of natural vegetation, placing any artificial fill thereon, or otherwise altering the land, nor shall he do any other act or acts which will alter the natural state of the land or environment, unless the subdivision plan relating thereto has been submitted and approved in accordance with the requirements of this chapter. Nothing in this paragraph shall be construed to prevent the taking of test borings, the digging of test pits, or any other preliminary testing and inspection necessary to comply with the requirements of the division of water supply and pollution control relative to information necessary for review and approval of the subdivision plans.

REFERENCES

Barto, J. and Babcock, E.J., *Forest Laws of New Hampshire*, 1984, Society for the Protection of New Hampshire Forests, Concord, New Hampshire.

Brown, Darlene B., *Best Management Practices for Silvicultural Activities in Pennsylvania's Forest Wetlands*, 1993, Pennsylvania State University and Pennsylvania Hardwood Development Council, State College, Pennsylvania.

Clinch, B. and Logan, B., *Montana Forestry Best Management Practices*, 1991, Montana Department of State Lands, Missuola, Montana.

Finlay, J.C. Brandt, R.C., Clifton, W., and Piper, R., *Controlling Erosion and Sedimentation from Timber Harvesting Operations*, 1986, Pennsylvania State University, Cooperative Extension Service, University Park, Pennsylvania and The Commonwealth of Pennsylvania, Department of Environmental Resources, Harrisburg, Pennsylvania.

Goodhue, S., *Twelve Ways to Reduce Soil Erosion and Stream Pollution on Logging Jobs*, 1975, New Hampshire Division of Forests and Lands, Department of Resources and Economic Development, Concord, New Hampshire.

Goodhue, S., Kinder, R., and Stuart, G., *Timber Harvesting Practices for Controlling Erosion*, 1979, New Hampshire Water Supply and Pollution Control Commission, Concord, New Hampshire.

Hartung, R.E., and Kress, J.M., *Woodlands of the Northeast - Erosion and Sediment Control Guides*, 1977, USDA Soil Conservation Service, NETSC, Broomall, Pennsylvania and USFS State and Private Forestry, Upper Darby, Pennsylvania.

Haussman, R.F., and Pruett, E.W., *Permanent Logging Roads for Better Woodlot Management*, 1978, USDA Forest Service, State and Private Forestry, Broomall, Pennsylvania.

Holaday, Steve, *Wisconsin's Forestry Best Management Practices for Water Quality - Field Manual*, 1995, Wisconsin Department of Natural Resources, Bureau of Forestry, Madison, Wisconsin.

Kent, B., Nelson, K., Todd, F., *The Land Use Handbook - Section 6, Erosion Control on Logging Jobs*, 1981, Land Use Regulation Commission, Department of Conservation, Augusta, Maine.

Kittredge, David B., Jr., and Parker, Michael L., *Massachusetts Best Management Practices Timber Harvesting Water Quality Handbook*, 1989, University of Massachusetts Cooperative Extension, Amherst, Massachusetts.

Kochenderfer, J.N., Wendel, G.W. and Kidd, W.E. Jr., *Woodlot Management: Building Roads*, 1987, West Virginia University, Extension Service, Parsons, West Virginia.

Lants, R.L., *Guidelines for Stream Protection in Logging Operations*, 1971, Oregon State Game Commission, Portland, Oregon.
Magee, Dennis W., *Freshwater Wetlands - A Guide to Common Indicator Plants of the Northeast*, 1981,The University of Massachusetts Press, Amherst, Massachusetts.

Mississippi Forestry Association, *Mississippi's Best management Practices Handbook*, 1989, Jackson, Mississippi.

McEvoy, T., *Proceeding - Forest Water Qaulity and Erosion Control in Vermont*, 1986, School of Natural Resources, UVM, Burlington, Vermont.

Murphy, A. and Connick, J., *Forest Transportation Systems - Roads and Structures Manual*, 1985, Seven Islands Land Company, Bangor, Maine.

Paff, W.D., *Lean Streams Handbook for Loggers*, 1982, West Virginia Department of Natural Resources, Charleston, West Virginia.

State of Florida, *Silviculture - Best Management Practices*, 1993, Florida Department of Agriculture and Consumer Services, Tallahassee, Florida.

State of Maryland, *Forest Harvest Access Practices*, 1988, Department of Natural Resources, Forest Park and Wildlife Service, Annapolis, Maryland, Maryland Forest Association, Salisbury, Maryland, Maryland Lumbermen's Association, Baltimore, Maryland.

State of Maryland, *Maryland's Guide to Forest Harvest Operations and Best Management Practices*, 1992, Department of Natural Resources, Resource Conservation Service, Annapolis, Maryland.

State of Maryland, *Soil Erosion and Sediment Control Guidelines for Forest Harvest Operations in Maryland*, 1993, Department of Natural Resources, Annapolis, Maryland.

State of Minnesota, *Water Quality in Forest Management - "Best Management Practices in Minnesota"*, 1989, Minnesota Department of Natural Resources, Division of Forestry.

State of Minnesota, *Protecting Water Quality and Wetlands in Forest Management: Best Mangement Practices in Minnesota*, 1995, Minnesota Department of Natural Resources, Division of Forestry.

State of New Hampshire, *Information on Timber Harvesting Laws in New Hampshire*, 1986, New Hampshire Division of Forests and Lands, Department of Resources and Economic Development, Concord, New Hampshire.

State of Texas, *Texas Best Management Practices for Silviculture,* 1993, Texas Forestry Association, Lufkin, Texas.

State of Texas, *Forestry Best Management Practices for Water Quality - Circular 286*, 1993, Texas Forest Service, College Station, Texas.

State of Vermont, *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont*, 1987, Department of Forests, Parks, and Recreation, Waterbury, Vermont.

Tiner, Ralph W. Jr., *Field Guide to Nontidal Wetland Identification*, 1988, Institute For Wetland and Environmental Education and Research, Sherborn, Massachusetts.

U.S. Fish and Wildlife Service, *List of Plant Species That Occur in Wetlands: Northeast (Region 1)*, Biological Report 88(26.1), 1988 - 1995 Supplement, Hadley, Massachusetts.

Van Ryn, Tammara, *A Guide to the Forest Laws of New Hampshire,* 1995, Society for the Protection of New Hampshire Forests, Concord, New Hampshire.