Englesby Brook Watershed Restoration Project Final Report

May 2001

Prepared for the City of Burlington
Public Works Department
by
Center for Watershed Protection

ACKNOWLEDGMENTS

The Englesby Brook Watershed Restoration Plan was prepared for the City of Burlington Department of Public Works by a project team consisting of the Center for Watershed Protection and Step by Step. The project team would like to gratefully acknowledge the participation, input, and support of the Project Oversight Committee through the process of developing this Plan. The Project Oversight Committee includes: Lori Fisher (LCC), Bob Kort (NRCS), Al McIntosh (UVM), Don Meals, Jim Pease (VTDEC), Zander Ponzo, Mary Watzin (UVM), and Lin Witherell (E,H,S & L).

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

This report provides a summary of the findings from the three phase Englesby Brook Watershed Restoration Project being conducted by the Center for Watershed Protection (Center) and Lori Barg (Step by Step) for the City of Burlington, Vermont. A Phase I report was prepared and delivered to the City in June 2000.

The primary goal of the Englesby Brook project is to develop a watershed restoration plan that will establish a program aimed at mitigating many of the impacts and stresses that exist on the ecosystem. Specific goals of the watershed restoration plan include:

$ Increase public awareness and expand awareness beyond the Englesby Brook watershed
$ Reduce bacteria loads to Blanchard Beach and strive to make it Aswimmable@ the majority of the time
$ Reduce pollutant load and impact (e.g., toxics, TSS, nutrients, bacteria, etc.) to Lake Champlain
$ Enhance riparian buffer zones and increase stream corridor access
$ Reduce stream channel erosion, improve stream habitat, and maintain stream baseflow
$ Reduce and/or eliminate odor and debris within Englesby Brook
$ Establish a framework to address stormwater policy issues

The approach to developing a watershed management plan for Englesby Brook employs principles of a rapid watershed planning approach, with an emphasis on "stakeholder" involvement to produce a workable plan for implementation of specific management measures.

In addition, a key emphasis of this plan is to view it as a Aliving document@ that is subject to change as more and better information is collected and compiled. An important way to assess the plan is to institute an indicator monitoring program, which gauges the efficacy of the implemented measures and a basis from which to recommend modifications to the plan. Together, the implementation and assessment of the restoration plan effectively becomes a watershed management cycle, where various management issues are revisited on a staggered but regular basis. This management cycle allows for the plan to evolve and grow with changing watershed conditions.

The first phase of the project was a watershed assessment and preliminary plan development stage, where the existing conditions within the watershed were documented and potential management measures put forth. Specific tasks included:

$ conducting a physical and biological stream survey to identify overall stream health and identify specific problem areas;
$ identifying potential stream rehabilitation and stormwater retrofit sites within the watershed;
$ facilitating watershed planning and pollution prevention workshops to engage watershed stakeholders in the planning process; and
$ preparing preliminary recommendations for employing management measures.

In the second phase, the project team prepared conceptual designs, cost estimates and analyses of estimated benefits for specific watershed management measures including stormwater management retrofits and stream rehabilitation efforts.

In the third and final phase, the project team developed management recommendations for public outreach and education, bench mark and long term monitoring to assess the effectiveness of the implemented measures, and a prioritization approach for implementation.

E.1 Background

Englesby Brook is an approximately 1 square mile watershed directly tributary to Lake Champlain (see Figure 1.1). An important community feature in the watershed is Blanchard Beach, which is located at the confluence of Lake Champlain and Englesby Brook. The water quality of Englesby Brook can have a significant impact on the use of the beach. Consequently, limiting the bacteria loads from Englesby Brook is an important goal of this project. Managing the nutrient loads from Englesby Brook is another important management goal, as it can impact the water quality of Lake Champlain, the primary drinking water supply for Burlington and many other municipalities in Vermont and New York.

In general, the mainstem of Englesby Brook flows from east to west. In the headwater areas, there are two unnamed first order tributaries. The current imperviousness of the Englesby Brook watershed is approximately 24 percent. The primary land use in the watershed is single family residential. Other significant land uses include the portions of the University of Vermont Redstone Campus and associated student housing, golf course land, commercial areas predominantly associated with the Shelburne Road corridor, and industrial areas primarily located west of Pine Street in the lower portion of the watershed.

Existing water quality and macroinvertebrate data tend to support the classification of Englesby Brook as an AImpacted@ stream. No fish populations, other than transient fish from Lake Champlain near the mouth, have existed in Englesby Brook since 1993. The macroinvertebrate community in the Brook is in poor condition and the habitat suffers from severe embeddedness and siltation problems.

Portions of the Englesby Brook watershed are serviced by combined sewer systems. Discharges from combined systems to receiving waters can have significant impacts on both the aquatic health of the receiving waters as well as pose a substantial human health risk associated with exposure to bacteria and other pathogens. Efforts on the part of the City of Burlington have largely mitigated the occurrence of overflows in Englesby Brook through the installation of a large underground detention vault that provides necessary storage during storm events. Nevertheless, the combined system adds complexity to the development of an effective watershed plan and must be taken into account when designing stormwater retrofits and developing pollution prevention programs.

Englesby Brook was analyzed during the first phase of the project using a suite of rapid watershed diagnostic techniques including: the impervious cover model, a modified Rapid Bioassessment

Protocol (RBP), and the Simple Method. The impervious cover model was used to assist in establishing realistic watershed management objectives. The modified RBP was implemented to determine the physical attributes of all perennial reaches of Englesby Brook. The Simple Method modeling was undertaken to provide additional pollutant loading information to use in assessing the effect of existing and proposed stormwater facilities. In addition, stormwater retrofit and stream rehabilitation inventories were conducted, in which potential retrofit sites were identified and conceptual-level sketches developed.

The project approach also places an emphasis on getting input and involvement from the public early in the planning process through workshops and oversight committee meetings. The project scope has been developed to ensure that public involvement and participation remains a component of the watershed plan well after the immediate project.

E.2 Analysis

An important task of the Englesby Brook project is to assess the physical characteristics of the stream. A modified Rapid Bioassessment Protocol was implemented to determine the physical attributes of all perennial reaches of Englesby Brook. Walking virtually the entire length of Englesby Brook and its associated tributaries provided the necessary information to develop an understanding of the geomorphological processes that are occurring in the watershed. Specifically, it was possible to identify depositional and erosional reaches, as well as areas where plan form adjustment (i.e., lateral channel movement) was occurring. These field observations are useful for both identifying channel reaches for potential rehabilitation and providing supporting information about the likely sources of specific pollutants.

The physical stream assessment generally found the majority of stream to be impacted by urbanization. A significant reason for the adverse impacts seen in Englesby Brook is that the majority of the watershed developed prior to any stormwater treatment practices being implemented, and therefore there is little capacity in the watershed to control channel erosion or remove stormwater pollutants. Consequently, stormwater retrofits that provide both water quality benefits and channel protection are being pursued as one of the tools of the management plan.

A simple pollutant load modeling analysis was performed to assess the pollutant load being generated throughout the watershed. The analysis looked at loads associated with specific land areas as well as loads associated at specified design points that correspond with candidate stormwater retrofit sites. Based on assumed removal efficiencies, the model enables an estimate of load reduction to be made.

Stormwater retrofit and stream rehabilitation inventories were conducted throughout the watershed to identify candidate sites. Stormwater retrofit sites were prioritized and selected to be carried forward in the design process (Phase II of the project) based on a ranking that weighted criteria such as water quality storage volume provided, property ownership, access, and environmental impacts. A total of 17 candidate stormwater retrofits sites were originally identified and field investigated to verify technical feasibility and to identify the most likely management practice for each site. Four of the 17 candidate sites were abandoned after the field screening for a variety of reasons. Of the remaining 13 sites, seven candidate sites were identified for further investigation through the development of detailed conceptual designs.

Seven stream assessment locations were identified as candidates for stream rehabilitation. The stream rehabilitation site identification process combined sites into a single stream rehabilitation reach where adjacent RBP sampling sites indicated a need for stream channel rehabilitation. The prioritization process identified five distinct stream reach lengths that are recommended for the design concept stage.

Pollution prevention and public education program guidance was developed based on local citizen input as well as national experience with successful approaches. Based on the recommendations developed as part of the pollution prevention guidance, a pollutant load reduction estimate was generated using a spreadsheet model developed by the Center.

E.3 Tier 1 Recommendations

Based on the findings of the analyses, a management plan was developed in which stormwater retrofits and stream rehabilitation sites are prioritized for implementation (designated as Tier 1 projects). Table E.1 and Figure E.1 provide a summary of the structural management recommendations. In addition to these structural recommendations, a series of Tier 1 nonstructural recommendations involving pollution prevention measures and public education approaches are recommended (Table E.2).

Table E.1 Recommended Tier 1 Retrofit and Rehabilitation Projects for Implementation

Recommended Projects for Implementation	Description and Justification
Stormwater retrofit: O8 Wet Extended Detention (ED) Pond	*Description:* This site is located just northwest of the Burlington School District Maintenance facility behind Champlain Elementary School. The site is located entirely on public land. The site concept entails excavating a wet extended detention (ED) facility at the site to receive the discharge from over 100 acres of drainage from the Shelburne Road corridor. The entire water quality storm (i.e., 1 inch rainfall) from this large drainage area will be conveyed to the wet pond. *Justification:* Provides the greatest pollutant load reduction of any proposed retrofit and represents one of the few areas (and perhaps only) where management of the runoff from this drainage area can occur.
Stormwater retrofit: O2 Wet ED Pond **Stream Rehabilitation: SR3** Bank Stabilization	*Description:* Site O2 is located on private property on the northeast corner of the intersection of Shelburne Road and Prospect Parkway. The concept is to create a wet ED facility in the existing landscape depression to provide water quality storage. SR3 is located downstream of Shelburne Rd and involves streambank stabilization. *Justification:* Combines retrofit with downstream stream rehabilitation efforts and provides substantial pollutant load reduction opportunities.

Recommended Projects for Implementation	Description and Justification
Stormwater retrofit: SM5 and SD2 Wet Pond and Culvert Improvement, respectively **Stream Rehabilitation: SR6, SR7, and SR8** Bank Stabilization	*Description:* Site SM5 is on the Burlington Country Club property. The concept involves expanding two of the existing ponds to provide water quality and channel protection storage. The upper pond is located just east of S. Prospect Street near the intersection with Crescent Road. The lower pond is located further to the south in the vicinity of holes # 4 and 13. SD2, a culvert upgrade, is primarily a conveyance improvement that also provides limited water quality treatment. SR6, SR7, and SR8 are stream stabilization improvements located on the golf course. *Justification:* SM5 provides 100% of channel protection storage volume and a large percentage of the 5-year storm which helps the conveyance of site SD2. Combines stream rehabilitation with upstream retrofits to reduce sediment and nutrient load generated at and upstream of the golf course. Consolidates construction disturbances.
Stormwater retrofit: SM1/SM2 Multiple Pond System	*Description:* This site is the location of two existing stormwater ponds on the UVM Redstone Campus. The concept for the site involves converting the two ponds, which are not currently in series, to a single facility to provide both water quality and channel protection storage volume. *Justification:* One of the few opportunities where 100% of the target water quality and channel protection volumes can be provided. Provides initial treatment in the headwaters of the watershed.

Recommended Projects for Implementation	Description and Justification
Stormwater retrofit: SM6 Shallow Marsh Wetland	*Description:* This site is located where there is an existing compost filter just north of Richardson Street and Flynn Avenue. The site concept entails removing the existing filter, realigning the existing stream channel to the north, and construction of a shallow marsh wetland in the vicinity of the current channel to receive the discharge from the water quality storm (i.e., 1 inch rainfall) for the 38 acres of residential land use that drain to the site. About 40 percent of the target water quality volume will be treated by the facility. *Justification:* Good opportunity to use more natural approach to improve the effectiveness in vicinity of current compost filter, which has had a nominal ability to reduce loads. Effectiveness will be enhanced by upstream stream rehabilitation and stormwater retrofit efforts.
Stream Rehabilitation: SR2 Channel Definition with Bioengineering	*Description:* This stream rehabilitation site is located in an area where aggradation (i.e., sediment deposition) has occurred. The concept involves plantings along the main channel to hold sediment in place. *Justification:* A minimum disturbance approach to improving the habitat along this reach. Effect of effort will be largely dependent on success of upstream implementation.

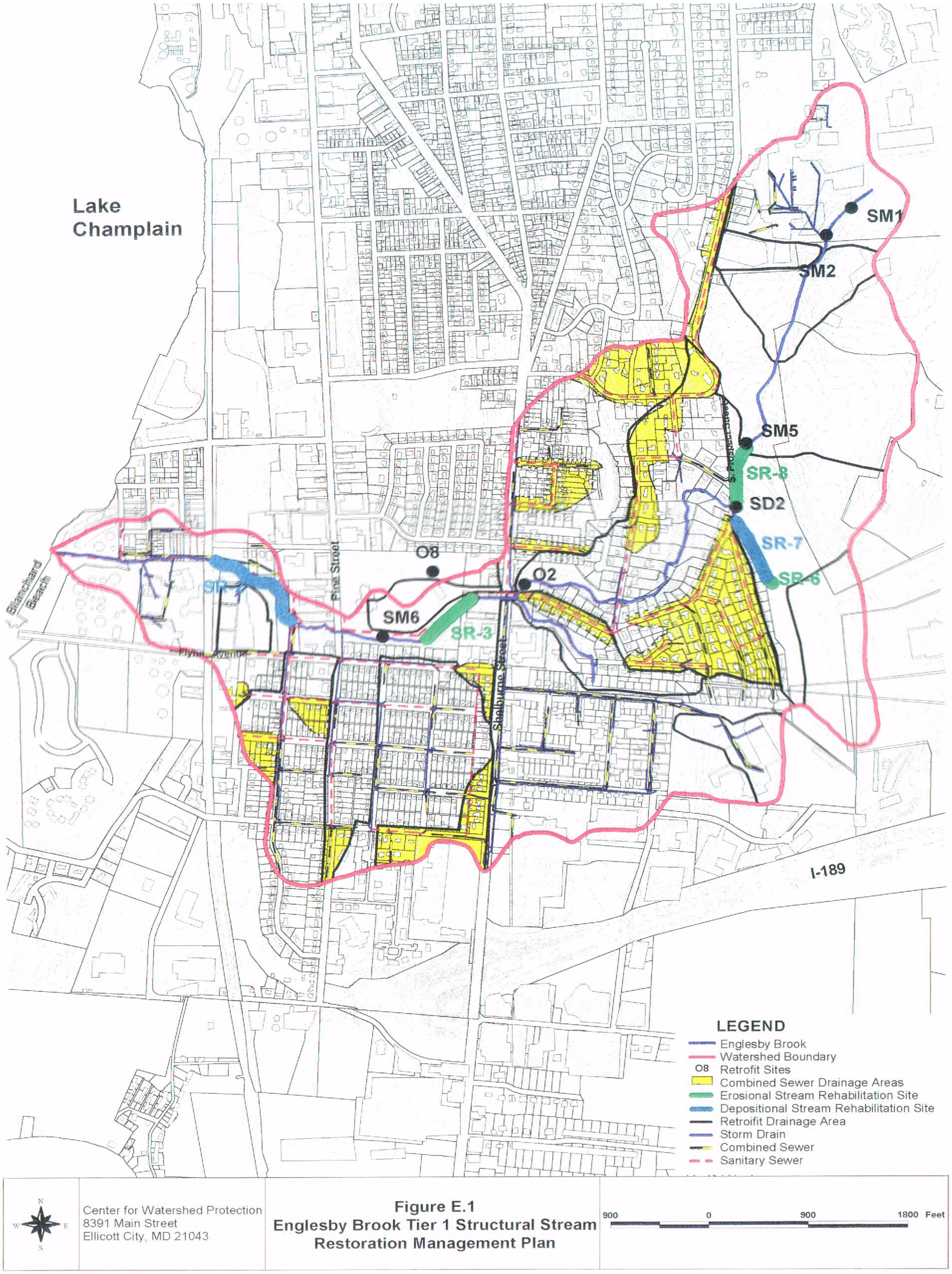

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Figure E.1
Englesby Brook Tier 1 Structural Stream Restoration Management Plan

Table E.2 Tier 1 Nonstructural Pollution Prevention Program Recommendations

Tier 1 Program Recommendation	Program Components
Pet Waste Management	$ Signage and waste disposal stations $ Establishment of dog park $ Fact sheets and limited media campaign
Lawn Care	$ Promotion of soil testing through UVM $ Recognize citizens using proper practices
Disconnection of Directly Connected Impervious Areas	$ Institute downspout disconnection and rain barrel program
Street Sweeping	$ Maintain and enhance current street sweeping program
Illicit Connection Detection and Removal[1]	$ Monitor and eliminate illicit connections
Dumpster Management	$ Locate away from storm drain inlets and riparian buffers $ Promote/require use enclosed holding areas

Using the pollutant load model tool it is possible to develop a planning level pollutant removal capability of the management plan on a watershed basis. Table E.3 presents the results of this analysis.

[1]Through conversations with Burlington DPW staff, it has been hypothesized that if there are no significant illicit connections detected in the Englesby Brook watershed, that there is likely a significant inflow and infiltration (I/I) problem associated with the sanitary and combined sewer systems. This phenomenon is fairly common in old infrastructure areas and is unfortunately a costly undertaking to remediate. I/I assessment and correction is not a specific recommendation of this watershed restoration plan, due to the magnitude of the undertaking and because it is more of a city-wide public works issue. However, I/I may be a significant impact to Englesby Brook and improved information (perhaps through TV video and/or pressure testing) on the severity of the condition would be useful in the overall understanding of the adverse influences within the watershed.

Table E.3 Watershed Load Removed Assuming Tier 1 Management Plan in Place

Tier 1 Structural Retrofit Recommendations	TN (lbs/yr)	TP (lbs/yr)	TSS (lbs/yr)	E. coli (# x 10^9/year)
Total Watershed Load	1071	248	145551	16486
O2	67	18	7082	757
O8	168	37	18302	1780
SM1,SM2	49	12	5542	530
SM5	89	25	9257	980
SM6	22	4	2273	259
SD2	0	0	0	0
Retrofits Removed Load	**397**	**95**	**42456**	**4307**
% of Watershed Load	**37%**	**38%**	**29%**	**26%**
Tier 1 Pollution Prevention Program Recommendations	**TN (lbs/yr)**	**TP (lbs/yr)**	**TSS (lbs/yr)**	**E. coli (# x 10^9/year)**
Total Watershed Load	1071	248	145551	16486
Pet Waste Management	79	11	0	5298
Lawn Care	230	10	0	0
Disconnection of Imp. Areas	9	0	122	19
Street Sweeping	84	10	3779	0
Illicit Connection Removal	15	21	127	1666
Poll. Prev. Removed Load	**417**	**52**	**4028**	**6983**
% of Watershed Load	**39%**	**21%**	**3%**	**42%**
Total Tier 1 Removed Load	**814**	**147**	**46484**	**11290**
% of Watershed Load	**76%**	**59%**	**32%**	**68%**

Based on the proposed Tier 1 management plan, approximately 63% of the watershed will ultimately drain to an effective stormwater management facility, and potentially the entire watershed will be reached at some level with one of the pollution prevention programs. By simply adding the structural and nonstructural pollutant load removal estimates, a planning level projection can be generated for the effectiveness of implementing the Tier 1 measures. Table E.3 shows an estimated 76%, 59%, 32%, and 68% reduction in total nitrogen, total phosphorus, TSS, and E. coli load, respectively using this simplified approach. These projections (except for TSS) are likely a bit higher than what should be expected due to the fact that nonstructural pollution prevention efforts will be occurring upstream of some of the structural retrofit sites. In general, this will lead to reduced pollutant loads being delivered to the structural facilities which often results in somewhat lower removal efficiencies at the structures.

It is important to note that the TSS estimate does not take into account the combined sediment load reduction from water quantity control (in the form of channel protection storage) at the proposed structural retrofit sites and the streambank stabilization efforts. It is difficult to quantify the load reduction associated with these measures; however, it is of note that the identified stream rehabilitation sites have a total length of approximately 1,730 linear feet which is approximately 90% of the total length of eroding stream. Since almost half of the watershed sediment load is estimated to be derived from channel (or non-upland) sources, it is reasonable to assume a total potential watershed sediment load reduction exceeding 50%.

Planning level construction cost estimates were developed for the Tier 1 structural sites. Table E.4 provides a summary of the cost estimates. More detailed cost breakdowns for the stormwater retrofit sites are provided at the end of Appendix G. These costs represent construction costs only, and do not reflect likely additional costs such as: planning/engineering design, geotechnical investigation, construction administration, land acquisition, and legal services.

Table E.4 Planning Level Construction Costs for Tier 1 Sites

Practice Type	Site ID	Estimated Cost [$]
Stormwater Management	O2	$63,000
	O8	$232,000
	SM1,SM2	$65,000
	SM5	$87,000
	SM6	$88,000
	SD2	$66,000
	Sub-Total	**$601,000**
Stream Rehabilitation	SR2	$35,000
	SR3	$75,000
	SR6	$1,500
	SR7	$10,000
	SR8	$15,000
	Sub-Total	**$136,500**
	Total	**$737,500**

It is important to recognize that there are additional operation and maintenance (O&M) costs that need to be taken into consideration for long term planning for any proposed facility. These annual costs can vary, but as a general rule of thumb, are approximately 3-5% of the capital cost of a pond or wetland facility (Caraco, 1998). Appendix H contains guidance and a checklist for the operation, maintenance and inspection of the Tier 1 structural retrofits (i.e., ponds and wetlands).

Estimating costs for the nonstructural programs is challenging and will vary substantially based on outside resources. For example, public education costs can be significantly reduced if they are combined with other efforts that are spearheaded by the Lake Champlain Committee efforts. As a rough planning estimate, it can be assumed that all of the programs listed in Table E.2 can likely be implemented over a one year period in the Englesby Brook watershed for between $80,000 and $120,000. However, to have long-term effectiveness, most of these programs need to be in place and supported over a period of several years or indefinitely (as in the case of street sweeping).

E.4 Keystone Recommendations

There are a number of challenging decisions and evaluations that need to be made in the process of developing a watershed restoration plan. Many of these factors were considered in the development of the Tier 1 recommendations. Nevertheless, the reality of watershed planning and restoration efforts is that there are usually insurmountable obstacles that prevent some of the recommendations from being implemented, whether it be due to property ownership, fiscal, political, or other reasons. With this in mind, the Center has developed what we consider to be the AKeystone Recommendations@ of the proposed Tier 1 management plan. The Keystone Recommendations should be thought of as those practices and programs that will not only provide some of the best opportunities for pollutant load reduction, but also seem to have the most realistic opportunity for being implemented in the watershed. That is certainly not to say that the other projects are less valuable or not worth pursuing further, but rather that the Keystone Recommendations can hopefully be implemented easier than the other Tier 1 recommendations and can help initiate a process which, when measurable improvements in watershed health are observed, will lead to implementation of remaining Tier 1 projects. Table E.5 presents the Keystone Recommendations and provides justification for including them.

Table E.5 Keystone Recommendations and Justification

Keystone Recommendations for Implementation	Justification
Stormwater retrofit: O8	Provides the greatest pollutant load reduction of any proposed retrofit and represents one of the few areas (and perhaps only) where management of the runoff from this drainage area can occur. Site is located on public land which may ease approval process.
Stormwater retrofit: SM5 and SD2 Stream rehabilitation: SR6, SR7, and SR8	Combines stream rehabilitation with upstream retrofits to reduce sediment and nutrient load generated at and upstream of the golf course. Consolidates construction disturbances. Initial indication of a willing partner.
Pet waste management and lawn care education	Together provide the most cost effective form of pollution prevention for nutrient and bacteria loads. Indirectly, the education effort should foster a sense of ownership of the residents in the watershed and increase awareness about the resource that they share.

Keystone Recommendations for Implementation	Justification
Illicit connection detection and removal	This is a critical pollution prevention effort that directly relates to whether Blanchard Beach will reopen and specifically addresses dry weather loads that may impair the beach. There is clearly a bacteria load problem with the infrastructure associated with the Shelburne Road corridor. This type of program should provide conclusive evidence on the primary source of the loads.

E.5 Indicator Monitoring to Assess Effectiveness of Plan

Having a method to assess the efficacy of the implemented measures and a basis from which to recommend modifications to the plan is a critical piece to the overall plan. A goal of the Center's recommended watershed restoration plan assessment approach is to utilize stormwater indicators to the maximum extent practical to guide current and future management decisions. The recommendations are oriented towards conducting inexpensive, repeatable, and scientifically valid monitoring to assess future stream quality health. The monitoring of indicators will provide a key frame of reference and basis for updating and adjusting the Englesby Brook Watershed Restoration Plan.

A total of ten indicators (Table E.6) have been identified and recommended to assess the efficacy of the Englesby Brook Watershed Restoration Plan.

Table E.6 Stormwater Indicator Profile Categories

Indicator Category	Indicator Name
Water Quality Indicators	$ Water quality pollutant constituent monitoring
	$ Human health criteria
Physical and	$ Stream widening/downcutting
Hydrological Indicators	$ Physical habitat monitoring
	$ Increased flooding frequency
Biological Indicators	$ Macroinvertebrate and fish assemblage
Social Indicators	$ Public attitude surveys
	$ Public involvement and monitoring
	$ User perception
Site Indicators	$ BMP performance monitoring

The methodology for assessing watershed restoration efforts and the effectiveness of a stormwater indicator monitoring program is outlined in Figure E.2. It is worth emphasizing again the last step in Figure E.2. Namely, it is critical to view the watershed restoration plan and stormwater indicator program as dynamic and evolving entities. As improved and updated data are collected and analyzed, management priorities and implementation focus may shift. This flexibility will be critical to the overall success of the restoration efforts.

E.6 Public Comments on Draft Final Report

A draft final report of the Englesby Brook Watershed Restoration Plan was issued for public review and comment in January, 2001. Comments ranged from editorial suggestions to technical clarifications. The majority of the submitted comments have been addressed and are reflected in this Final Report. In addition, specific responses were prepared for many of the technical clarifications requested. These responses are provided in Appendix K of this report.

① DEFINE MANAGEMENT FRAMEWORK

Determine who will be responsible for implementation (e.g., Burlington DPW)
Can this program be developed and implemented on a watershed-wide or basin basis (e.g., teaming opportunities with Lake Champlain Committee)?

⇩

② INVENTORY PRIOR AND ONGOING EFFORTS

Identify what programs and studies have already been implemented in the watershed (e.g., Englesby Brook Watershed Restoration Plan, ANR biomonitoring data, USGS gage data).

⇩

③ INVENTORY RESOURCES AND IDENTIFY CONSTRAINTS

Determine manpower and funding limitations.
Identify regulatory-mandated deadlines and programs

⇩

④ DEVELOP AND IMPLEMENT INDICATOR MONITORING PROGRAM

Based on goals, program structure, resources and constraints, select indicators to be used to assess success of stormwater management program. Level II indicators will likely be more quantitative in comparison to Level I techniques. Quantitative analysis is required to identify pollutant sources and assess success of program.

⇩

⑤ ASSESS INDICATOR RESULTS

Analyze indicator monitoring results.
What do the monitoring results indicate about the success of the stormwater management program? Have the indicators accurately reflected the effectiveness of the management program? What do the indicators suggest about the ability of the stormwater indicator monitoring program to measure overall watershed health?

⇩

⑥ RE-EVALUATE WATERSHED RESTORATION PLAN AND MONITORING PROGRAM

Re-evaluate resources and constraints.
Update (if necessary) assessment of baseline conditions.
Review and revise program goals.
Review and revise indicator monitoring program.
Implement revised management program

Figure E.2 Watershed Restoration and Stormwater Indicator Effectiveness Assessment Methodology

SECTION 1. INTRODUCTION

This report provides a summary of the findings from the three phase Englesby Brook Watershed Restoration Project. It builds off of the Phase I report (previously prepared and delivered to the City in June 2000), which was largely devoted to data collection and analysis of both historic and existing conditions. The additional information in this report includes:

- Conceptual designs, descriptions and cost estimates for specific watershed management measures including stormwater management retrofits and stream rehabilitation efforts that were prioritized during Phase I of the project.
- Development of management recommendations for public outreach and education.
- Development of a prioritization approach for implementation of the proposed management measures.
- Pollutant load reduction analyses of estimated benefits from the stormwater management retrofits, stream rehabilitation, and pollution prevention measures.
- Guidance on bench mark and long term monitoring to assess the effectiveness of the proposed measures.

The major sections of this final report include:

- Introduction and Background
- Current Watershed Conditions
- Stormwater and Stream Rehabilitation Retrofit Opportunities
- Public Participation and Planning Workshops
- Pollution Prevention Guidance
- Watershed Management Recommendations
- Follow-up Assessment and Indicator Monitoring

1.1 Why Watersheds?

Urbanizing communities frequently find that their water resources are degrading or have degraded in response to growth and development. They are also discovering that they can only protect these local water resources by thinking on a watershed level. Watersheds are important to any community because they embody our sense of place in the landscape, and their waters are important in our daily life. Some of the many interactions between ourselves and urban watersheds are described in Table 1.1. In a sense, watersheds are the geographic address for our community and provide a common and unifying resource to be good stewards of.

Table 1.1 Some of the Important Aspects of Watersheds and Urban Streams

In Our Daily Life	Where We Recreate	In the Natural Ecosystem
flooding and erosion	fishing	food chain
drinking water	swimming	habitat
food (shellfish, fish)	boating	migratory stop-overs
kids playing in creek	hiking trails and greenways	
property drainage	bird watching	

Communities have many reasons to protect local watersheds--whether for economic benefits, recreation, flood prevention, scenery or the overall quality of life. Different groups of people often have their own unique rationale for protecting watersheds. Some may place a high value on the aquatic biological community living in these waters, while others will be more concerned about reducing stream channel erosion to the real estate in their back yard. Regardless of the reasons, it is clear that most communities now recognize the value of local watershed protection. Englesby Brook is no different in this sense. The Englesby Brook watershed is relatively small in size (approximately 600 acres); however, it is an important resource to the community due to the fact that a public park and beach are located at the mouth of the Brook along the shores of Lake Champlain. The watershed also provides some passive and active recreational opportunities in the form of foot trails and a golf course, respectively. The watershed has been largely developed for approximately 100 years (Pease, 1997). What development does occur is usually infill/redevelopment. As a result, little stormwater management exists in the watershed and, in many locations, the stream has degraded to the point where habitat and recreational functions have been severely limited or altogether lost.

The primary objective of the Englesby Brook Watershed Restoration Project is to develop a watershed protection plan that will establish an implementation program aimed at mitigating many of the impacts and stresses that exist on the ecosystem. Through implementation of the proposed mitigation measures, it is hoped that many of the existing benefits associated with the watershed will be protected and that many of the lost or impaired uses will be restored to both the natural and built environment. Specific watershed protection goals[2] of the plan include:

- Increase local awareness and expand public awareness beyond the Englesby Brook watershed
- Reduce bacteria loads to Blanchard Beach and strive to make it "swimmable" the majority of the time
- Reduce pollutant load and impact (e.g., toxics, TSS, nutrients, bacteria, etc.) to Lake Champlain
- Enhance riparian buffer zones and increase stream corridor access
- Reduce stream channel erosion, improve stream habitat, and maintain stream baseflow

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[2] The listed goals were developed as part of a "brainstorming" workshop with the Project Oversight Committee on February 11, 2000. An initial list of 14 watershed goals was narrowed down to a final list of seven.

- Reduce and/or eliminate odor and debris within Englesby Brook
- Establish a framework to address stormwater policy issues

1.2 Watershed Characterization of Englesby Brook

It is helpful to have a general understanding of some of the major characteristics of the Englesby Brook watershed (e.g., size, location, population, land use, percent impervious, infrastructure, etc.) prior to immersing oneself in the detail of the technical analyses that were performed during this phase of the project. The following discussion provides background information on key watershed characteristics.

Englesby Brook is an approximately 1 square mile watershed directly tributary to Lake Champlain (see Figure 1.1). The confluence of Lake Champlain and Englesby Brook is of particular importance due to the fact that there is a public beach (Blanchard Beach) located there. Consequently, the water quality of Englesby Brook can have a significant impact on the use of the beach. Limiting the nutrient loads from Englesby Brook is also important to the overall water quality of Lake Champlain, which is the primary drinking water supply for Burlington and many other municipalities in Vermont and New York.

In general, the mainstem of Englesby Brook flows from east to west. In the headwater areas, there are two unnamed first order tributaries, one flowing from north to south and the other flowing from south to north. The confluence of these two tributaries is on Burlington Country Club property just north of the intersection of South Prospect Street and Prospect Parkway.

The primary land use in the watershed is single family residential with approximately 3,100 residents living in the watershed (Eisenman *et al.*). Other significant land uses include portions of the University of Vermont Redstone campus and associated student housing (located in the headwater portion of the watershed), golf course land (also located in the headwater portion of the watershed), commercial areas predominantly associated with the Shelburne Road corridor, and industrial areas primarily located west of Pine Street in the lower portion of the watershed. The current imperviousness of the Englesby Brook watershed is approximately 24 percent[3].

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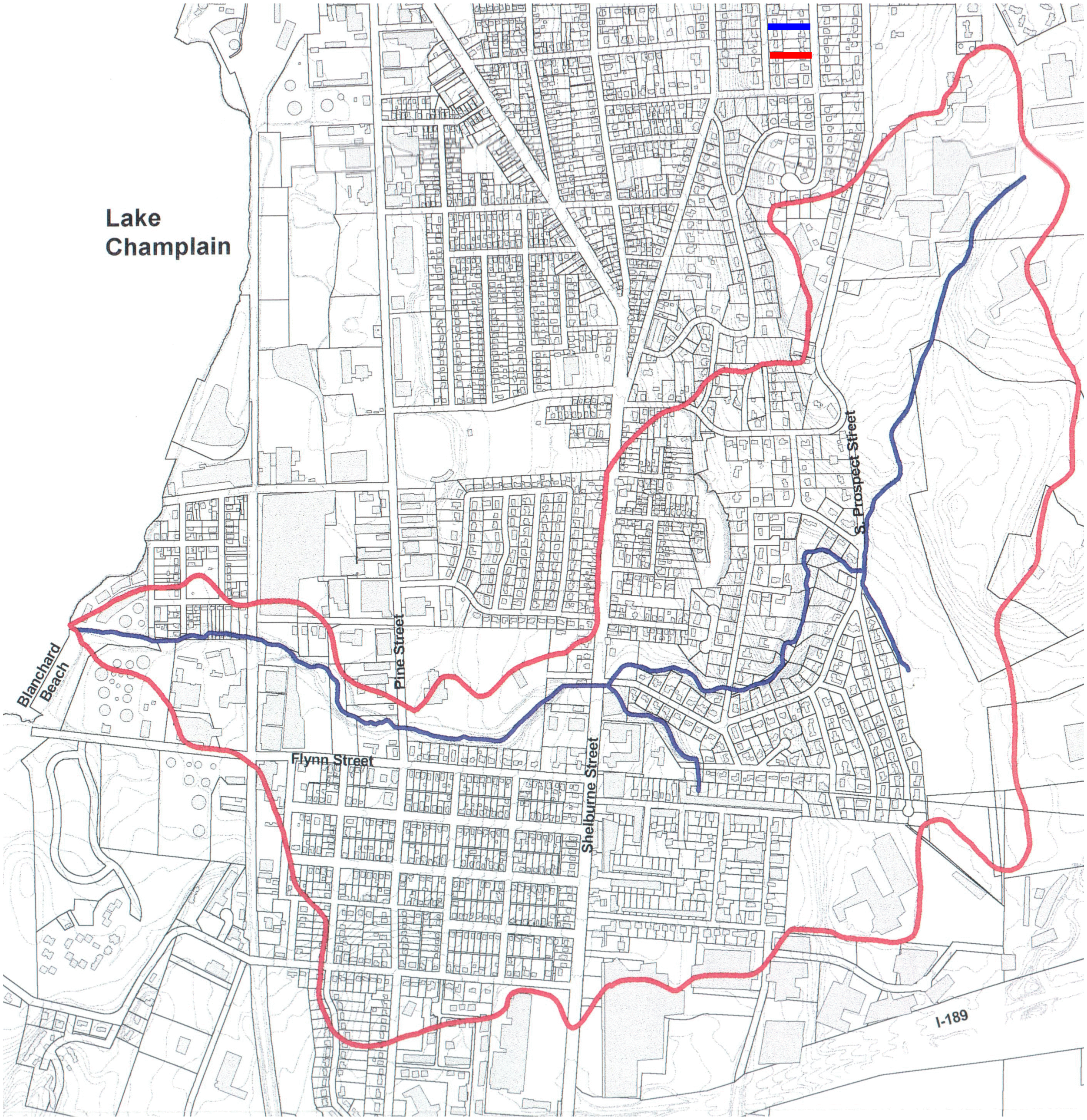
[3] It should be noted that the estimated imperviousness of the watershed was determined using an area and land use analysis and not a rigorous analysis of the GIS coverages that are available. This level of analysis was considered to be adequate, particularly since the GIS coverage available to the Center did not have certain impervious cover information layers such as driveways and sidewalks. In addition, the Center estimate of 24% agrees reasonably well with previous estimates of 20% by Pease (1997).

Figure 1.1 Englesby Brook Watershed Map



LEGEND
Englesby Brook
Watershed Boundary

Based on the management classification scheme developed by the Center for Watershed Protection (1998), Englesby Brook falls into the "Impacted" and "Restorable" watershed categories. This is important in that it helps define realistic expectations of what current watershed conditions are as well as the prospects for improvement in response to mitigation and rehabilitation efforts.

Existing water quality and macroinvertebrate data tend to support the classification of Englesby Brook as an "Impacted" stream. Pease (1997) reported that no fish populations, other than transient fish from Lake Champlain near the mouth, have existed in Englesby Brook since 1993. Quackenbush (1995) reported that the macroinvertebrate community in the Brook was in poor condition and that the habitat suffered from severe embeddedness and siltation problems. Field observations from the Center stream assessment in April 2000 confirmed these conditions.

Typical of older developed urban areas, portions of the Englesby Brook watershed (approximately 14 percent) are serviced by combined sewer systems. In a combined system, sanitary sewage and stormwater runoff are combined in a single pipe system and conveyed to the local wastewater treatment plant. As the infrastructure of these systems age and additional stormwater runoff is generated from new development, combined systems often become overwhelmed during storm events which results in overflows where raw sewage (mixed with stormwater) is discharged directly to a receiving water. The resulting discharges can have significant impacts on both the aquatic health of the receiving waters as well as pose a substantial human health risk associated with exposure to bacteria and other pathogens. Efforts on the part of the City of Burlington have largely mitigated the occurrence of overflows in Englesby Brook through the installation of a large underground detention vault that provides necessary storage during storm events. Nevertheless, the combined system adds complexity to the development of an effective watershed plan and must be taken into account when designing stormwater retrofits and developing pollution prevention programs.

1.3 Impacts of Urbanization and the Influence of Impervious Cover on Stream Quality

The process of urbanization has a profound influence on the hydrology, morphology, water quality, and ecology of surface waters. Impervious cover is an important indicator for measuring the impacts of land development on aquatic systems. Numerous scientific studies have documented the relationship between impervious cover and overall stream health. Much of the technical analysis performed for this watershed project uses impervious cover directly or indirectly to quantify and develop specific mitigation strategies for both instream rehabilitation efforts and stormwater management retrofit conceptual design.

The discussion presented below provides specific detail about some of the key changes in urban streams in general, and Englesby Brook in particular, due to increases in impervious cover levels.

<u>Surface runoff during storm events dramatically increases</u>. Depending on the degree of impervious cover, the annual volume of stormwater runoff can increase by two to 16 times its predevelopment rate, with proportional reductions in groundwater recharge (Schueler, 1994). This also leads to increased instances of nuisance flooding, such as the case with Englesby Brook just west of South Prospect Street. With a watershed imperviousness of approximately 24%, Englesby Brook annual

volume of runoff is probably about 5 times its predevelopment rate[4].

Bankfull and sub-bankfull floods increase in magnitude and frequency. The peak discharge associated with the bankfull flow (i.e., the 1.5 to 2 year return storm) increases sharply in magnitude in urban streams. In addition, channels experience more bankfull and sub-bankfull flood events each year, and are exposed to critical erosive velocities for longer intervals (Hollis, 1975; Booth, *et al*, 1996; and MacRae, 1996).

Channels enlarge. The customary response by an urban stream is to increase its cross-sectional area to accommodate the higher and more frequent erosive flows. This is done by stream bed down-cutting, stream bank widening, or a combination of both. Urban stream channels can enlarge their cross-sectional area by a factor of two to ten, depending on the degree of impervious cover and the age of development in the upland watershed (Caraco, 2000, Arnold, *et al*, 1982; Gregory, *et al*, 1992; and MacRae, 1996). As an example, it is estimated that the channel of Potash Brook, the 7.0 square mile watershed immediately to the south of Englesby Brook with a similar impervious cover, will ultimately enlarge to almost two times the predisturbance cross-sectional area (CWP and MacRae, 1999).

Stream channels are highly modified by human activity. Urban stream channels are extensively modified in an effort to protect adjacent property from streambank erosion or flooding and to cross the streams with bridges and culverts. Headwater streams are frequently enclosed within storm drains, while others are channelized, lined, and/or “armored” by heavy stone. This is the case on the Burlington Country Club property where much of the stream is in pipes under the fairways. Similarly, in the lower portions of the watershed (i.e., west of Pine Street), the stream corridor has been channelized by the placement of fill to establish the industrial corridor (Pease, 1995). Another modification that is unique to urban streams is the installation of sanitary sewers underneath or parallel to the stream channel. According to May, *et al* (1997), 20 to 30% of natural stream channels are modified in typical urban watersheds.

Instream habitat structure degrades. Urban streams are routinely scored as having poor instream habitat quality, regardless of the specific measure or method employed. Habitat degradation is often exemplified by a loss of pool and riffle structure, embedding of stream substrate sediments, shallow depths of flow, eroding and unstable banks, and frequent stream bed dislocation. Historic data by the Vermont Agency of Natural Resources (ANR) and the field assessments performed by the Center in April 2000 provide strong evidence of the impacts described above. Macroinvertebrate and fish community scores on Englesby are poor (Pease, 1997), which reflects poor habitat, and the habitat assessment scores from the April 2000 stream assessment were all substantially lower than the reference stream score (see Section 2.1.1).

Stream crossings and potential fish barriers increase. Many forms of urban development are linear in nature (e.g., roads, sewers, and pipelines) and cross stream channels. The number of stream

[4] The runoff volume comparison is based on the ratio of different runoff coefficients between the existing conditions and predevelopment conditions, where the runoff coefficient is a function of impervious cover.

crossings increases directly in proportion to impervious cover (May, *et al* 1997), and many crossings can become partial or total barriers to upstream fish migration, particularly if the stream bed erodes below the fixed elevation of a culvert or a pipeline. On the Englesby Brook mainstem, there are at least six major crossings.

Riparian forests become fragmented, narrower and less diverse. The important role that riparian forests play in stream ecology is often diminished in urban watersheds, as tree cover is often partially or totally removed along the stream as a consequence of development (May, *et al* 1997). Even when stream buffers are reserved, encroachment often reduces their effective width, and native species are supplanted by exotic, non-native trees, vines and ground covers.

Water quality declines. The water quality of most urban streams during storm events is consistently poor. Urban stormwater runoff contains moderate to high concentrations of sediment, carbon, nutrients, trace metals, hydrocarbons, chlorides and bacteria (Schueler, 1987). While considerable debate exists as to whether stormwater pollutant concentrations are actually toxic to aquatic organisms, researchers agree that pollutants deposited in the stream bed exert an undesirable impact on the stream community. Sediment samples collected in the early 1990s from Englesby Brook indicated elevated levels of metals such as silver, zinc, nickel, lead and copper (Quackenbush, 1995). The concentrations reported were at levels where biological effects have been observed by researchers.

Aquatic diversity is reduced. Urban streams are typified by fair to poor fish and macroinvertebrate diversity, even at relatively low levels of watershed impervious cover or population density. The ability to restore pre-development fish assemblages or aquatic diversity is constrained by a host of factors: irreversible changes in carbon supply, temperature, hydrology, lack of instream habitat structure, and barriers that limit natural recolonization. Englesby Brook macroinvertebrate data indicate a poor presence of Ephemeroptera/Plecoptera/Tricoptera (EPT) species (indicators of good water quality) and a strong presence of Oligocheata (worms) and Turbellaria (flat worms), both indicators of poor water quality (Quackenbush, 1995).

1.4 Rapid Watershed Planning Approach

Because impervious cover is a good indicator of stream health, coupled with the fact that it is a parameter that is fairly easy to measure on a watershed basis, it is a useful management tool in the watershed planning and protection process. Under the rapid watershed planning approach advocated by the Center, the impervious cover model is used to provide a preliminary diagnosis of stream health along with a suite of management options based on realistic expectations of what can be achieved in a given watershed. The model identifies three general stream types based on impervious cover ranges and offers general recommendations for planning goals and objectives. The three stream types are: sensitive streams (0-10% imperviousness); impacted streams (11-25% imperviousness), and non-supporting streams (>25% imperviousness). A fourth designation is given to impacted or non-supporting streams for streams that have potential to be restored or rehabilitated to the next best classification level (e.g., move from a non-supporting designation to an impacted designation). The reader is referred to *Rapid Watershed Planning Handbook* for a more detailed discussion of the impervious cover model (CWP, 1998).

Using rapid watershed diagnostic techniques such as the impervious cover model and other field assessment protocols (e.g., The Rapid Bioassessment Protocol and stream retrofit inventory) allows watershed managers to devote more time and money to the implementation strategies as opposed to just studying the problems.

The Englesby Brook Watershed Plan is being developed around the basic philosophy that watershed planning is a process to get communities to make better choices about future growth and watershed behavior. In particular, the broad goals of the Englesby Brook Watershed Plan are that it be:

< **scientifically credible**–based on the best science that is available;

< **democratic**–in that a group of real citizens and watershed interest groups can help prepare them;

< **effective**–such that we are reasonably confident that we can achieve the water resource goals set for the watershed if the plan is fully implemented;

< **economically defensible**–so that the needs for economic growth are balanced against the benefits of watershed protection; and

< **rapid**–to avoid "over studying" the watershed and delaying the actual mitigation and improvement efforts. Therefore, a brief planning phase should quickly lead to on the ground implementation of specific management tools within a 2-year time frame.

1.5 Stormwater Retrofitting and Stream Rehabilitation

Most urban watersheds such as Englesby Brook are already impacted to some degree and often have little or no existing stormwater controls. In these types of watersheds, planning is generally focused on existing impacts, as opposed to being protection or conservation oriented. Managers are faced with the prospect of addressing problem areas. Common mitigation approaches are to implement stormwater retrofits and stream rehabilitation practices.

Retrofits are structural stormwater management measures for urban watersheds designed to help reduce pollutant loads, minimize accelerated channel erosion, promote conditions for improved aquatic habitat, and correct past mistakes. Simply put, these stormwater treatment practices are inserted in an urban landscape where little or no prior stormwater controls existed.

Stream rehabilitation practices can include streambank stabilization, habitat creation, riparian reforestation, and wetland creation and enhancement. For this phase of the Englesby Brook study, the stream rehabilitation focus is primarily on opportunities for streambank stabilization using both "hard" or structural practices and bioengineering practices (practices that employ live vegetation).

Retrofits and stream rehabilitation practices come in many shapes and can address water quality treatment, channel protection, and flood control. In most cases, at least some kind of practice can be installed. However, fiscal restraints, pollutant removal capability, and watershed capture area must all be carefully weighed in any retrofit selection criteria. The key to a successful program is to follow a systematic and straightforward process toward implementation. Retrofitting and stream rehabilitation are still more of an art than a science, and planners and designers who take an innovative approach will go a long way towards successfully planning, designing, and building stormwater retrofit and stream rehabilitation projects.

Where feasible, stormwater retrofits and stream rehabilitation practices should be implemented in a coordinated fashion so that the resulting stream and watershed benefit can be maximized. For example, the effectiveness and success of a stream stabilization project will be enhanced if it is implemented in connection with upstream volume control of stormwater runoff (i.e., a stormwater retrofit).

Stormwater retrofitting and stream rehabilitation inventories were conducted as part of the Englesby Brook study. These inventories are critical in the development of a comprehensive watershed management plan that prioritizes areas for implementation. Section 3 of this report details the inventories. The stormwater retrofit inventory identified 13 feasible sites as candidates for stormwater quantity and/or quality retrofits. A ranking system (see Section 3) was used to prioritize the sites based on the ability of the retrofit to provide target water quality and quantity protection while minimizing the impacts such as tree loss and utility relocation. Detailed concept plans were prepared under Phase II of this project for the highest ranking sites (see Section 3 and Appendix G). Section 3 also describes the stream rehabilitation inventory that was conducted. Fewer stream rehabilitation sites were identified than retrofit sites, and a less rigorous ranking analysis was applied to these sites. In general, priority reaches for stream rehabilitation are tied closely to the fact that there is a high ranking stormwater retrofit site just upstream.

1.6 Englesby Brook Stakeholders

In a real sense, every current and future resident of a watershed is a stakeholder, even though they may be unaware of this fact. Watershed stewardship programs can increase awareness and broaden community support to implement watershed plans. The ideal group of stakeholders for designing a subwatershed plan are generally determined by the level of interest of local parties in conservation and resource protection issues. The list of non-agency and agency stakeholders that are involved at various levels in the Englesby Brook project are listed in Table 1.2.

Table 1.2 Stakeholders in the Englesby Brook Watershed Management Process

Non-agency Stakeholders	Agency Stakeholders
Lake Champlain Committee Citizens of Ward 5 University of Vermont Burlington Country Club Green Mountain Power Corporation	Burlington Department of Public Works Vermont Agency of Natural Resources Natural Resources Conservation Service
Note: See Section 4 for discussion on representative stakeholder involvement to date.	

The Englesby Brook project approach is structured in a way to involve the public at various levels throughout the course of the project. The proposed project approach places an emphasis on getting input and involvement from the public early in the planning process. This allows for contentious issues to be identified and addressed early and helps to identify issues which are important to watershed residents. Establishing stakeholder pride and ownership in the plan leads to a greater chance of project success. Specific components of the public involvement approach are described below.

Two planning workshops were held early in the planning process (March and May 2000) with interested stakeholders (see Section 4 for a summary of the workshops). The March workshop focused on public education and pollution prevention campaigns, while the May workshop focused on the preliminary findings of the stream assessment and retrofit inventory. At each workshop, the stakeholders participated in actual watershed exercises, such as making recommendations for a pollution prevention outreach and public education program and proposing alternative retrofit concepts for a site. In addition to the workshops, the planning process involves a series of meetings with the Englesby Brook Oversight Committee to provide updates and progress reports to stakeholder representatives.

Section 5 and Appendix F document and highlight the most critical behaviors to modify and specific strategies for modifying these behaviors. Media outreach techniques that have been identified as the most effective ways to influence these behaviors are also be identified. In addition, concepts developed by the public at the pollution prevention workshop have been incorporated into the framework of the plan. The guidance provided for developing a public outreach and education program will be instrumental to fostering a strong public involvement in the protection and upkeep of Englesby Brook, as well as other Burlington watersheds.

1.7 Scope of Study

As previously mentioned, the Center approach to developing a watershed management plan for Englesby Brook employs the principles of a rapid approach, coupled with an emphasis on "stakeholder" involvement to produce a workable plan for implementation of specific management measures.

The planning process consisted of three phases of development: a watershed assessment stage, a conceptual design stage, and a plan preparation stage. In the assessment stage, the project team documented existing conditions within the watershed. Key tasks the Center performed for this phase of the project were to:

- conduct a rapid biological, physical and chemical stream survey to identify overall stream health and identify specific problem areas
- identify potential stream rehabilitation and candidate stormwater retrofit opportunities within the basin
- develop pollutant load estimates associated with specific land uses to assist in the analysis of retrofit prioritization

- facilitate watershed planning workshops to engage stakeholders in the watershed planning process, and
- prepare initial recommendations for employing management measures

In the second phase, the project team prepared conceptual designs, cost estimates, and analyses of estimated benefits for specific management measures such as stormwater management retrofits, stream rehabilitation, and pollution prevention.

In the third phase, the project team combined the information from the first two phases to develop a “road map” for stewardship of the watershed for the years to come. In summary, this management plan includes management recommendations, prioritization of structural and nonstructural stormwater treatment practices, municipal program recommendations, public education opportunities, and recommendations for follow-up plan assessment.

SECTION 2.CURRENT WATERSHED CONDITIONS

This section summarizes the results of several watershed assessments that have been conducted for this project. The following assessments were conducted during Phase 1 of the project:

- physical stream assessment,
- pollutant load modeling, and
- pollution prevention survey

The discussion in this section has been limited to a presentation of findings and results of these analyses. Many of the results from these analyses have been taken into consideration in the development of the stormwater retrofit and stream rehabilitation concept designs (see Section 3).

2.1 Physical Stream Assessment

An in-stream assessment technique was performed to evaluate overall stream channel conditions. A modified Rapid Bioassessment Protocol (RBP) (USEPA, 1999) was implemented to help assess the physical attributes of all perennial reaches of Englesby Brook. In this protocol, observations are recorded at specified intervals and wherever unique conditions or potential problems are apparent. Evaluation categories include channel stability, channel scouring and deposition, physical in-stream habitat, water quality, and bank and riparian vegetative condition. Findings of the modified RBP are used to identify candidate sites for stream rehabilitation. A more detailed description of the methodology and findings of the assessment is provided below.

Walking virtually the entire length of Englesby Brook and its associated tributaries provided the necessary information to develop an understanding of the geomorphological processes that are occurring in the watershed. Specifically, it was possible to identify depositional and erosional reaches as well as areas where plan form adjustment (i.e., lateral channel movement) was occurring. These field observations are useful for both identifying channel reaches for potential rehabilitation and providing supporting information about the likely sources of sediment and other specific pollutants.

As an example, this study is interested in understanding the amount and predominant sources of sediment in the watershed. The field observations that were made suggest that Englesby Brook is not exhibiting the characteristics that are most commonly found in streams with similar watershed urbanization (i.e., approximately 24% impervious cover). Most urban streams experience high bank erosion. Trimble (1997) estimated that bank erosion accounted for about two-thirds of the measured instream sediment load of an urban stream. In contrast, geomorphologists have found that bank erosion in rural streams comprises between 5% and 20% of the annual sediment budget (Walling and Woodward, 1995; Collins et al., 1997). Englesby Brook, however, does not have nearly as much bank erosion as might be expected based on the urbanized nature of the watershed. In fact, based on field observations and modeling results (see Section 2.2), it appears that the majority of the sediment load in Englesby Brook originates from upland sources, as opposed to being bank derived. This finding suggests that locating stormwater retrofits at strategic locations in the watershed should have a significant effect on reducing the sediment load delivery to the stream and Lake Champlain.

2.1.1 Modified Rapid Bioassessment Protocol (RBP)

The Center for Watershed Protection and Lori Barg, with help from the City of Burlington and ANR staff, assessed and characterized the physical characteristics of approximately 2.5 miles of flowing stream within the Englesby Brook watershed. This assessment was performed using a modified version of the habitat and physiochemical assessment portion of the field method known as the Rapid Bioassessment Protocol. This technique was modified to ensure compatibility with project objectives and resources for the study area. The modified RBP was used to evaluate roughly 20 physical stream conditions at stations located at 400-foot intervals (between 12 and 13 observation points per mile), or wherever unique conditions or potential problems were apparent. Evaluation categories included channel substrate condition, channel stability, channel scouring and deposition, physical in-stream habitat, water quality, and riparian habitat and vegetative condition.

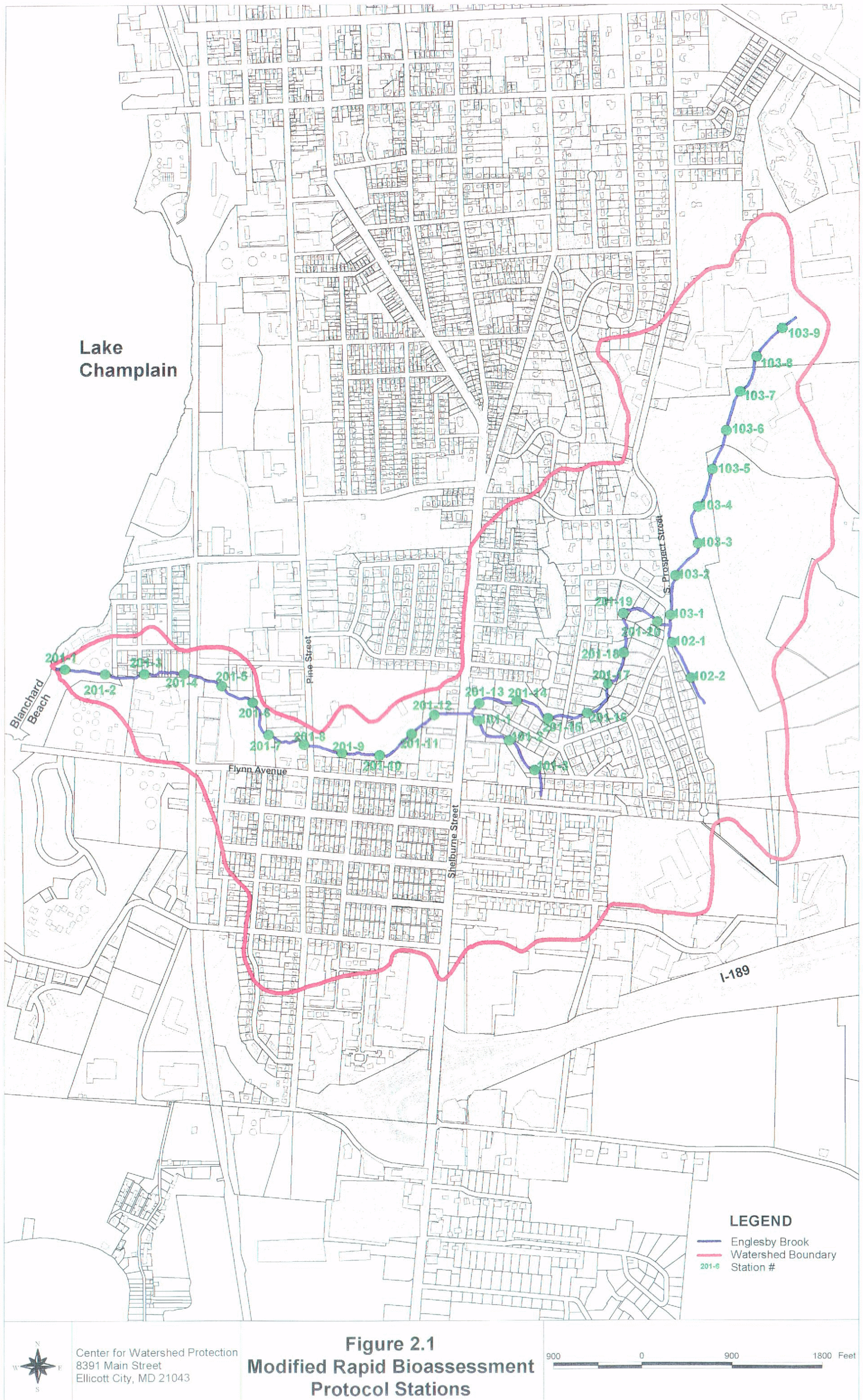
A reference station was evaluated outside of the watershed to provide a comparison point for the analysis. Reference stations serve as a benchmark representing the "best attainable" situation for a given geographic region. The reference station was located on Allen Brook just south of interstate 89 near the town of Williston. Allen Brook was used as the reference station location because:

- it is a relatively unimpacted stream (less than 5% impervious cover upstream of the station);
- it shares the same general geological and climatological characteristics;
- the Vermont ANR has an established biological and chemical sampling station at the location; and
- the location and access to the station were convenient.

Figure 2.1 illustrates the stream reaches and sampling stations that were identified for assessment using the modified RBP protocol. The station numbering convention is based on the order of the stream. For example, the mainstem of Englesby Brook (from the mouth to South Prospect Street) is a second order stream, while the two tributaries on the Burlington Country Club property are considered first order streams. The numbering system uses a three digit order identification followed by a station number. Stream stations were numbered from downstream to upstream. Under this convention, the first order tributary to the southeast of the intersection of Shelburne Road and Prospect Parkway is numbered 101, with stations ranging from 101-1 (downstream) to 101-3 (upstream). Similarly, the south and north first order tributaries on the golf course are numbered 102 and 103, respectively.

A total of 34 stations were initially identified for assessment (see Figure 2.1). Due to the presence of ponds, culverts/pipes, or an absence of baseflow, nine stations were not evaluated. Data sheets for each of the 25 Englesby Brook stations and 1 Allen Brook station are included along with photographs in Appendix A.

Figure 2.1 Modified Rapid Bioassessment Protocol Stations



A major component of the physical stream assessment is the habitat assessment. The purpose of the assessment is to provide a comparison basis for different locations along Englesby Brook. Because it has already been well documented by historical sampling that Englesby Brook has a limited biological community[5] (Pease, 1997 and Quackenbush, 1995), the assessment is not so much intended to evaluate the locations for fish and macroinvertebrate habitat improvement as it is meant to provide a relative sense of the significant areas of sediment deposition and bank failure. The habitat assessment uses a scoring system which provides a numeric score for each station based on ten evaluation criteria.

1. Epifaunal Substrate: Assessment of the relative quantity and variety of natural structures in the stream, such as cobble (riffles), large rocks, fallen trees, logs and branches, and undercut banks, available as refuge, feeding, or sites for spawning and nursery functions of aquatic macrofauna.
2. Embeddedness: Assessment of the extent to which rocks (gravel, cobble, and boulders) and snags are covered or sunken into the silt, sand, or mud of the stream bottom.
3. Velocity/Depth Regime: Assessment of the patterns of velocity and depth as they relate to the ability of the stream to provide and maintain a stable aquatic environment.
4. Sediment Deposition: An indirect assessment of the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of deposition.
5. Channel Flow Status: Evaluation of the degree to which the channel is filled with water.
6. Channel Alteration: Evaluation of large-scale changes in the shape of the stream channel.
7. Frequency of Riffles: Evaluation of the sequence of riffles occurring in a stream.
8. Bank Stability: Assessment of whether the stream banks are eroded (or have the potential for erosion).
9. Vegetative Protection: Assessment of the amount of vegetative protection afforded to the stream bank and the near-stream portion of the riparian zone.
10. Riparian Vegetative Zone Width: Assessment of the width of natural vegetation from the edge of the stream bank out through the riparian zone.

Scores ranging from 0 to 20 are assigned for each of the ten habitat criteria, the sum of which provides the numeric score for the station. A total of 200 points are available. Qualitatively, each criteria is described as either "optimal", "suboptimal", "marginal", or "poor." Table 2.1 provides a summary of the station scores. The table indicates that the score for the reference station on Allen Brook was 181. The Englesby Brook station with the highest score, 201-20 (just south of South Prospect Road), was 139, or 74% of the reference condition. The median habitat score of all the Englesby Brook stations was 80. Figure 2.2 shows the comparison of the Englesby stations with the Allen Brook reference station. Of particular note is the fact that the habitat scores show a significant decline downstream of Crescent Street.

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[5] Englesby Brook is subject to drying up during prolonged periods of drought (e.g., summer of 1999) and during winter freeze cycles, thereby limiting the viability of a productive biological community.

The results from the habitat assessment also provide valuable information when isolating on individual criteria such as bank stability and riparian zone width or groups of criteria such as embeddedness and sediment deposition. Based on this approach, the findings of the habitat assessment can be summarized into four general categories: sediment deposition, bank erosion/slope failure, floodplain/channel alterations and macroinvertebrate community.

Sediment Deposition

The stream system itself contains a series of alternating erosional and depositional reaches based primarily on channel slope and the presence of grade controls such as culverts. Areas where there

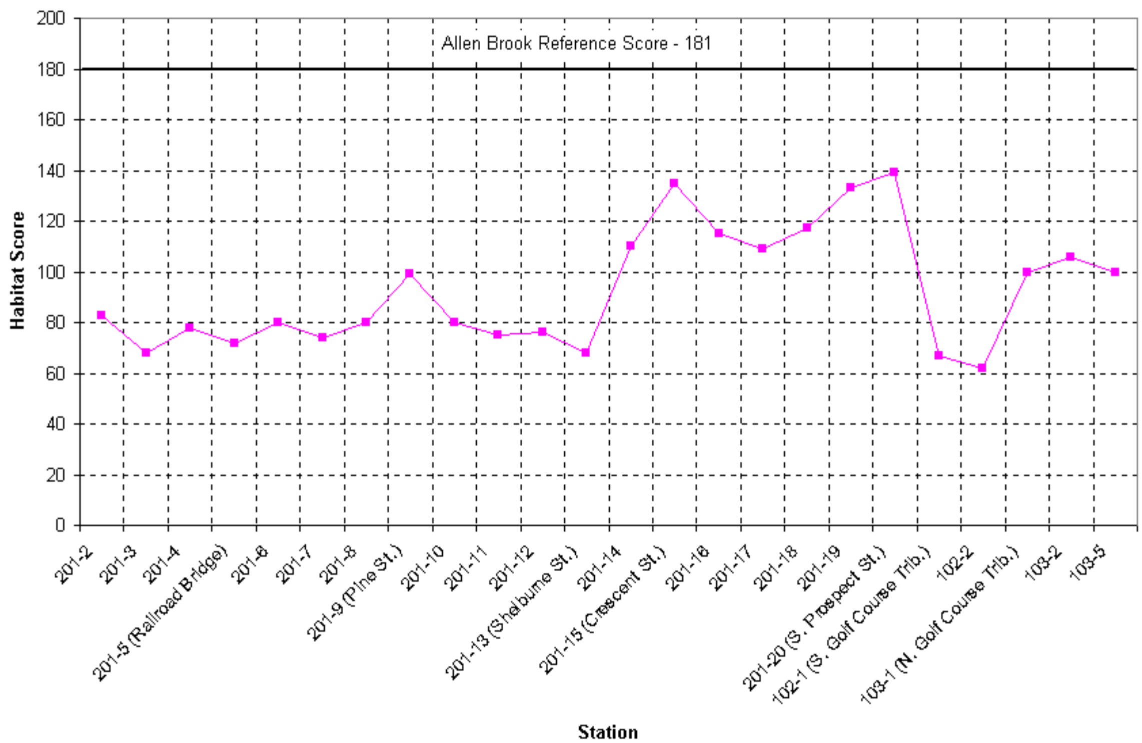


Figure 2.2 Englesby Brook Habitat Assessment Scores

is gentler slope or culverts that may be undersized will cause velocities to slow and sediment to drop out and deposit in the channel or floodplain. Major depositional areas in Englesby Brook include:

- The 400 foot reach immediately upstream from Lake Champlain (stations 201-1 and 201-2)
- The reach between the railroad culvert and Pine Street (stations 201-5 through 201-9)
- The reach immediately above Shelburne Road (stations 201-13 and 201-14)
- The southern tributary on the golf course (stations 102-1 and 102-2)

Table 2.1 Summary of Habitat Scores for Englesby Brook

Station	Epifaunal Sub.	Embeddedness	Velocity/Depth	Sed. Depostion	Channel Flow	Channel Alt.	Freq. of Riffles	Bank Stability		Veg. Protection		Rip. Veg. Zone Width		Total
								Left	Right	Left	Right	Left	Right	
Reference	19	19	18	19	18	19	19	9	9	8	8	8	8	181
201-1	NOT APPLICABLE DUE TO BACKWATER EFFECT FROM LAKE CHAMPLAIN													
201-2	8	2	4	3	18	15	2	7	7	6	6	1	4	83
201-3	5	5	8	3	15	8	11	2	2	2	2	2	3	68
201-4	8	5	8	5	15	7	11	2	3	5	5	2	2	78
201-5	3	3	4	1	13	8	8	8	8	6	6	2	2	72
201-6	4	1	5	1	13	18	4	8	8	6	6	3	3	80
201-7	5	1	6	1	13	8	6	8	8	6	6	3	3	74
201-8	5	2	6	2	13	13	7	8	8	6	6	2	2	80
201-9	10	5	10	10	16	11	9	6	6	6	6	2	2	99
201-10	6	4	5	4	8	11	8	6	6	6	6	5	5	80
201-11	5	5	10	5	11	8	11	3	3	4	4	3	3	75
201-12	10	5	10	6	10	7	10	3	3	4	4	3	1	76
201-13	5	2	4	2	10	11	8	6	6	5	5	2	2	68
201-14	10	8	11	10	13	11	11	7	7	7	7	4	4	110
201-15	11	14	14	13	15	15	15	7	7	7	7	5	5	135
201-16	10	11	11	6	13	16	11	7	7	7	7	3	6	115
201-17	11	6	10	6	11	16	11	6	6	6	6	7	7	109
201-18	11	6	11	9	9	16	13	7	7	7	7	7	7	117
201-19	12	7	14	13	11	17	16	7	7	9	9	5	6	133
201-20	17	14	10	16	16	16	12	7	7	8	8	0	8	139
102-1	8	2	5	3	10	6	6	5	7	3	8	2	2	67
102-2	8	2	5	3	10	5	6	3	7	1	8	1	3	62
103-1	7	7	14	11	15	14	17	4	2	6	1	2	0	100
103-2	8	16	7	18	13	13	7	9	9	2	2	1	1	106
103-5	9	11	8	8	13	7	8	9	9	7	7	2	2	100

Bank Erosion/Slope Failure

Figures 2.3 and 2.4 show the bank stability scores for the right and left banks, respectively, at each station. The data indicate that there are three prominent areas where bank stability is poor and erosion is a significant sediment source. These locations are (from downstream to upstream) just downstream of the railroad crossing (stations 201-3 and 201-4), just downstream of Shelburne Road (stations 201-11 and 201-12), and at locations on each of the two first order tributaries on the golf course (stations 102-2 and 103-1). In addition, there are isolated areas of erosion above Crescent Street to below South Prospect Street (stations 201-16 through 201-19)

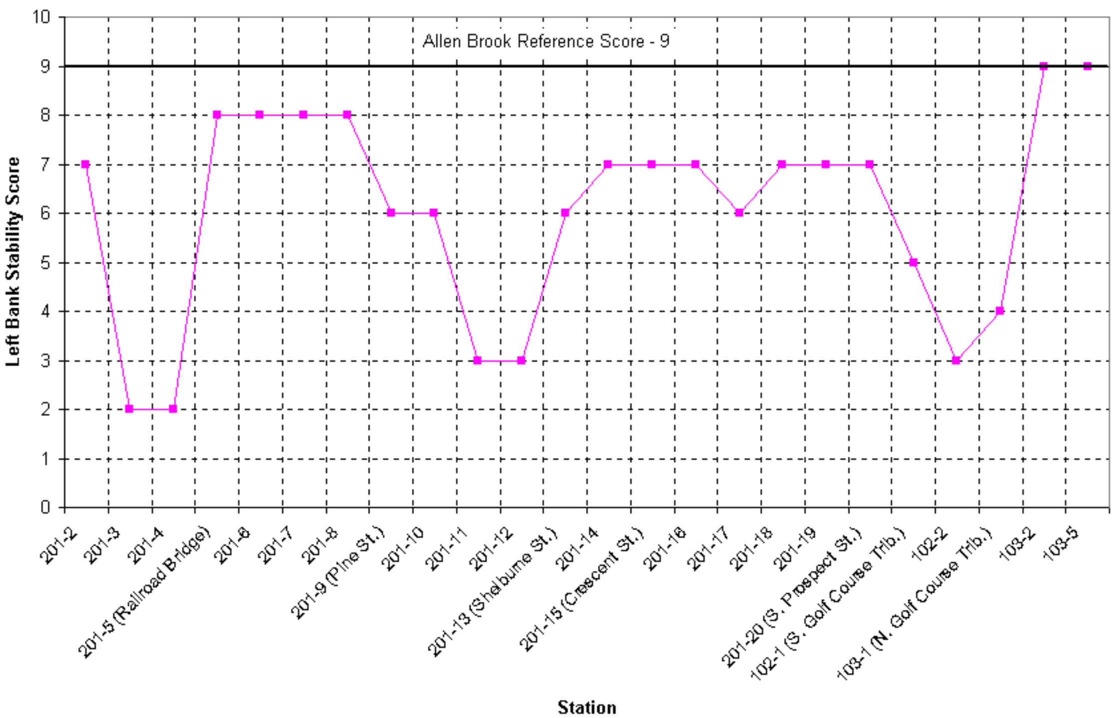


Figure 2.3 Englesby Brook Left Bank Stability Scores

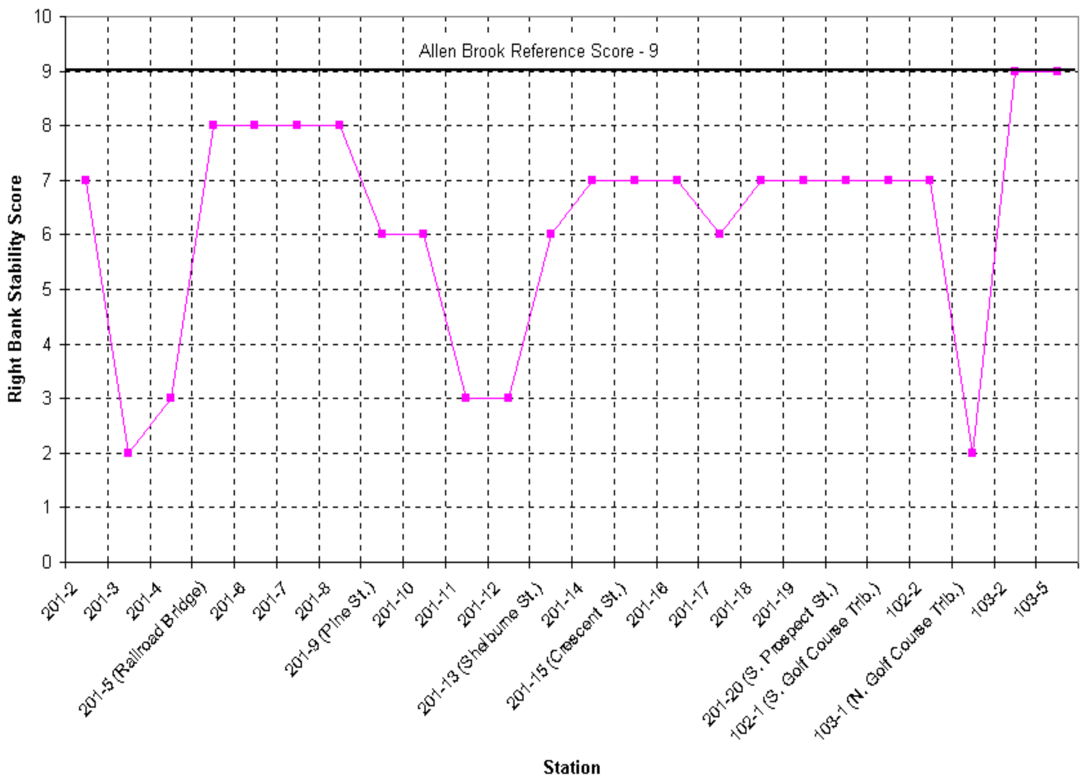


Figure 2.4 Englesby Brook Right Bank Stability Scores

Floodplain/Channel Alterations

Channel alterations were observed along several reaches of the stream, usually in association with areas downstream of culvert crossings (stations 201-3 through 201-3, 201-11, and 201-12) or areas where there has been vegetative management right up to the stream edge (201-20, 102-1, and 102-2). The areas where turf grass management is to the steam edge can be easily restored by allowing native vegetation (e.g., shrubs and ground cover) to establish in these areas.

Macroinvertebrate Community

A rapid assessment of macroinvertebrates (consisting of a random sampling of cobbles and boulders at riffles) at each of the 25 stations on Englesby Brook found that macroinvertebrate quality was poor in the lower watershed (below Shelburne Road) and improved in the upper watershed (above Shelburne Road). The presence of a poor community (i.e., pollution tolerant species) in the lower watershed was likely due to poor habitat due to deposition (see Figure 2.2) or toxicity from stormwater. Improved habitat and fewer stormwater outfalls are the likely factors contributing to the improved community in the upstream sections. These findings are consistent with historic data collected by Vermont Agency of Natural Resources (Pease, 1997).

2.2 Pollutant Load Modeling Analysis

A pollutant load modeling analysis was performed to assess the relative contribution of pollutants from various land uses and watershed areas. This analysis assists in identifying primary pollutant generators, which is useful in the development of management strategies that can target specific source areas. For example, if commercial areas are the most significant source of sediment in the watershed, a high frequency street sweeping program in this area may prove to be an important management strategy. The watershed area analysis used the candidate retrofit site locations (see Section 3.1) as assessment points to help evaluate the effectiveness of the different proposed retrofits. This assists in the development of the overall watershed management plan by identifying the candidate sites that provide the highest pollutant removal capability and by providing an indication of how many retrofits are necessary to achieve meaningful pollutant reduction in the watershed (e.g., a 50% reduction in sediment load).

Two methods were used to compute loading estimates for total suspended sediment (TSS), total phosphorus (TP), total nitrogen (TN) and Escherichia coli (E. coli): 1) the Simple Method (Schueler, 1987), in which subwatershed loads for different land uses were summed to determine a total load, and 2) a flow weighted concentration method based on flow and concentration data obtained from the United States Geological Survey (USGS) gaging station on Englesby Brook[6]. Both methods were used to estimate loads for the entire Englesby Brook watershed, and the Simple Method was used for individual catchments or sewersheds. The loads at the gaging station were also computed to check the accuracy of the Simple Method for predicting the total storm load.

The Simple Method estimates stormwater runoff pollutant loads for chemical constituents as a product of annual runoff volume and pollutant concentration. The model is useful because it provides reasonable results for a limited amount of input data including drainage area, impervious cover, pollutant concentrations, and annual precipitation. It is worth noting that the Simple Method is an "end-of-pipe" model, meaning that it does not take into account additional pollutant dynamics that occur in receiving waters such as bank erosion, biological uptake, and dilution from subsurface flows.

[6] The USGS gaging station is located approximately 100 feet downstream of the railroad culvert. The drainage area tributary to the gage is approximately 580 acres, or about 20 acres less than the total watershed area. The station was established in the fall of 1999 and provides real time data. The data can be viewed at the following internet site, http://vt.water.usgs.gov/CurrentProjects/Englesby/Englesby.htm.

The equation for the Simple Method is as follows (Schueler, 1987):

L=[(P) (Pj) (Rv) / 12] (C) (A) (2.72)

where:

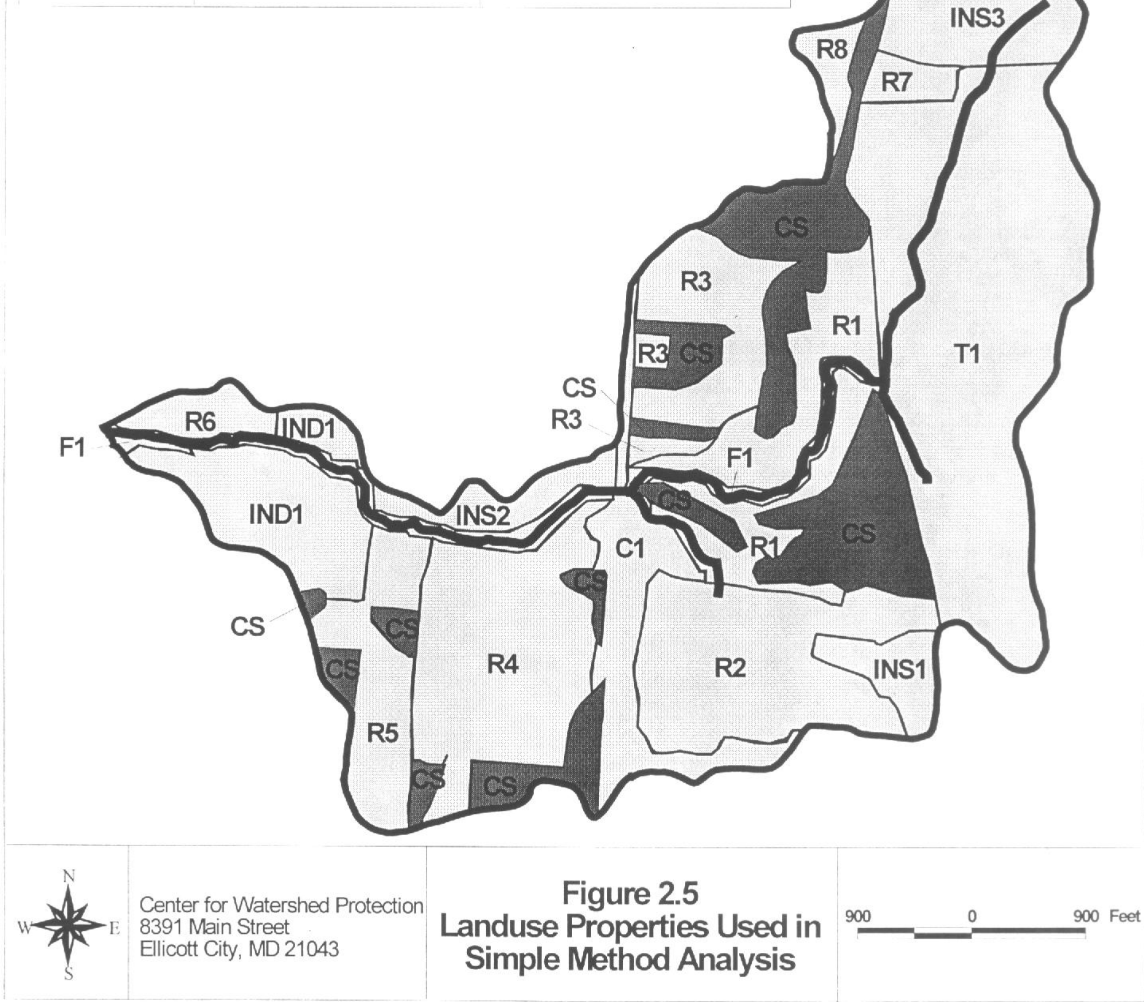
L	=	load (in pounds/year)
P	=	annual precipitation (in inches) [33 inches for Burlington (Eisenman *et al.*)]
Pj	=	.9 correction factor based on 10% of storms not producing any runoff
Rv	=	runoff coefficient (dependant on level of imperviousness)
C	=	flow weighted mean concentration for pollutants (in mg/l except for bacteria in #/100ml)
A	=	contributing area (in acres)
2.72	=	conversion factor

In the case of Englesby Brook, the pollutant concentrations (i.e., "C") used in the analysis are based on data from the Richardson Street compost filter (Burlington DPW, 1997), end-of- pipe monitoring data from various Vermont locations (Pease, 2000), and national averages. A summary listing of these concentrations are presented in Appendix B. Runoff volumes (Rv) for the equation are based on impervious cover.

Annual loads for the whole watershed and the breakdown for various land use designations are listed in Table 2.2 and illustrated in Figure 2.5. Impervious cover estimates and drainage areas are also listed in Table 2.2. The combined sewer areas are listed in the table; however, they are not included in the calculation of the total loads, as the vast majority of the combined system load should be receiving treatment at the wastewater treatment plant. Some of the line items for the annual loads correspond to drainage areas that contain one or more existing stormwater management facilities. While most of the existing facilities do not provide substantial water quality benefits, there is some treatment that is occurring due to a limited amount of residence time and settling and uptake. To account for this, a removal efficiency was assigned for these facilities that reflected a poorly operating facility (from a water quality treatment standpoint). For example, the existing wet ponds at the UVM Redstone campus were assigned a TSS removal efficiency of 25%. By contrast, a properly designed, constructed, and maintained wet pond, would be expected to remove approximately 80% of the TSS load.

Figure 2.5 Land Use Polygons Used in Simple Method Analysis

Polygon ID	Landuse	General Location
R1	Residential	Prospect/Crescent
R2	Residential	Proctor/Hadley
R3	Residential	Shelburne North
R4	Residential	Richardson St.
R5	Residential	Foster St.
R6	Residential	West End Residential
R7	Residential	UVM Housing
R8	Residential	Redstone
C1	Commercial	Shelburne Rd./Outlet
IND1	Industrial	West End Industrial
INS1	Institutional	Rice High School
INS2	Institutional	Champlain Elementary
INS3	Institutional	UVM
T1	Turf	Burlington County Club
F1	Forest	Riparian Corridor
CS	Combined Sewer	Throughout Watershed



		Drainage	Imp.	Annual Loading Rates				Annual Load			
Land Use	Location	Area	Cover	TN	TP	TSS	E. Coli	TN	TP	TSS	E. coli
		(Acres)	%	lb/acre	lb/acre	lb/acre	# 10^9/acre	lb/year	lb/year	lb/year	# 10^9/year
Residential	MDR (1-4 du/acre)										
	Prospect/Crescent	39.7	25	3.3	0.4	138	25	132	15	5,496	1,002
	Proctor/Hadley	50	25	3.3	0.4	138	25	166	18	6,922	1,262
	Shelburne North	31	25	3.3	0.4	138	25	103	11	4,292	782
	Richardson St.	59.3	25	3.3	0.4	138	25	197	22	8,209	1,497
	Foster St.	27.2	25	3.3	0.4	138	25	90	10	3,766	686
	West End Resid	8.5	28	3.6	0.4	152	28	31	3	1,292	236
	TH/ MF (>8 du/acre)										
	UVM Housing	6.4	45	5.5	0.9	305	42	32	5	1,466	224
	Redstone	6.5	45	5.5	0.9	305	42	28	4	993	187
Commercial	*Shelburne Rd/Outlet*	26	50	7.5	1.5	373	46	194	39	9,695	1,193
Industrial	*West End Indust*	34.6	50	6.0	1.0	403	46	209	35	13,935	1,588
Institutional	*Rice High School*	11	30	4.3	0.5	179	29	47	5	1,969	323
	Champlain Elem	11.3	30	4.3	0.5	179	29	49	5	2,023	332
	UVM	43	30	3.9	0.6	215	29	150	23	6,927	1,061
Turf	*BCC*	131	10	1.7	0.4	70	13	216	48	8,725	1,626
Forest	*Riparian Corridor*	25.8	0	0.0	0.2	100	12	-	5	2,580	310
Combined Sewer	Crescent/Redstone	27.5									
	Prospect	29.6									
	N. Shelburne	7.8									
	Foster/Richardson	19.3						-	-	-	-
Total		595.5	24	3.3	0.5	161.0	24.7	1,644	249	78,289	12,308

Table 2.2 Simple Method Loads Based on Land Use[7]

Pollutant loads were also estimated for the basin at the USGS gage below the railroad crossing, to provide a rough calibration of the Simple Method total watershed load estimate. Two separate estimates were generated independently for the gage. The Center performed an analysis based on preliminary data that were provided by the USGS. A second analysis was performed by Ms. Laura Medalie (2000) of the USGS with a more complete period of record. Details of the Center analysis are provided below. The reader is referred to Medalie (2000) for the details of the USGS analysis.

Flow, TSS, TN, and TP data are available for most of the period of record for the gage (August 1999 – May 2000). Loads were computed by taking a flow weighted average concentration and multiplying by the annual volume of runoff at the gage. It was necessary to prorate the annual volume due to an incomplete flow record. This was accomplished by correlating the rainfall associated with the Englesby flow record and extrapolating this relationship out to approximate an

[7] As previously mentioned, the estimated imperviousness of the watershed was determined using an area and land use analysis and not a rigorous analysis of the GIS coverages that are available. This level of analysis was considered to be adequate, particularly since the GIS coverage available to the Center did not have certain impervious cover information layers such as driveways and sidewalks. In addition, the Center estimate of 24% agrees reasonably well with previous estimates of 20% by Pease (1997).

average year. The baseflow portion of the total load was subtracted out to allow for a comparison with the estimates made with the Simple Method (which only accounts for annual stormwater runoff). The baseflow was estimated by inspection of the gage hydrograph during both low flow periods (late summer and winter) and high flow periods (spring). Due to the limited amount of record, this estimate should be considered a rough approximation.

A comparison of loads calculated using the Simple Method and loads calculated using gage data (both the Center analysis and Medalie's) indicate that there is fairly strong agreement between the two methods (see Table 2.3). The table shows that there is a significantly higher TSS load calculated by the gage method; however, this is to be expected because the Simple Method does not take into account the sediment load generated from the stream bank erosion. Based on the modeling results, the channel contribution to the total load is approximately 50 percent which is consistent with both literature values and field observations (see Section 2.1 discussion). Estimates for the other parameters are within the same order of magnitude which is acceptable given the fact that both analyses are rather simplistic and there are no verification data available.

Table 2.3 Comparison of Stormwater Loads Between Gage Data and the Simple Method

Estimated Annual Stormwater Runoff Pollutant Load	TN (lbs/year)	TP (lbs/year)	TSS (lbs/year)	E. coli (# x 10^9/year)
USGS (Medalie, 2000)	1,082	259	155,079	No Data
USGS Gage (Center analysis)	1,071	248	145,551	16,486
Simple Method	1,644	249	78,289	12,308

Annual unit loads for stormwater runoff were also calculated at the gage and seem to be in the normal range for an urbanized watershed, with calculated yields of 0.54 lbs/acre/year of total phosphorus, 2.6 lbs/acre/yr of total nitrogen and 302 lbs/acre/year of total suspended sediment (Horner *et al.*, 1994).

Having demonstrated that there is reasonable agreement between the USGS gage data and the Simple Method analysis, the Simple Method was then used to calculate the loads tributary to the candidate retrofit sites to analyze the importance (in terms of percent of the total watershed load draining to the site) and effectiveness (in terms of the percent of the total watershed load that can be treated and removed by the site) of the candidate sites. The untreated loads draining to each candidate retrofit site are presented in Table 2.4. (See Section 3 for a detailed discussion of the candidate retrofit sites and Figure 3.1 for the location and tributary drainage areas to the sites.)

Table 2.4 Simple Method Loads Associated With Candidate Retrofit Design Points

Candidate Retrofit Sites				Annual Loading Rates				Annual Load			
Site ID	Location	Drainage Area (Acres)	Imp. Cover %	TN lb/acre	TP lb/acre	TSS lb/acre	E. coli # billion/acre	TN lb/year	TP lb/year	TSS lb/year	E. coli # billion/year
O2	*UVM*	49.4	35	4.4	0.7	245	33	196	30	9,077	1,390
	BCC	131	10	1.7	0.4	70	13	216	48	8,725	1,626
	Prospect Residential	31.5	25	3.3	0.4	138	25	105	12	4,361	795
	Redstone Residential	6.5	45	5.5	0.9	305	42	28	4	993	187
	Riparian Forest	6.5	0	0.0	0.2	100	12	-	1	650	78
	Total	224.9	18					545	95	23,805	4,076
O3	*Rice High School*	11	30	4.3	0.5	179	29	47	5	1,969	323
O6	*Champlain Elementary*	5.3	25	3.7	0.4	154	25	20	2	815	134
O7	*Flynndog*	6.5	75	8.8	1.5	584	67	57	9	3,796	432
O8	*Proctor/Hadley*	50	25	3.3	0.4	138	25	166	18	6,922	1,262
	Rice High School	11	30	4.3	0.5	179	29	47	5	1,969	323
	Shelburne Rd/Outlet	26	50	7.5	1.5	373	46	194	39	9,695	1,193
	Shelburne North	31	25	3.3	0.4	138	25	103	11	4,292	782
	Total	118	31					510	74	22,878	3,560
SM1,SM2	*UVM*	43	30	3.9	0.6	215	29	150	23	6,927	1,061
SM3	*UVM Housing*	6.4	45	5.5	0.9	305	42	32	5	1,466	224
SM5	*UVM*	49.4	35	4.4	0.7	245	33	196	30	9,077	1,390
	Redstone Residential	6.5	45	5.5	0.9	305	42	28	4	993	187
	Part of BCC	96.4	10	1.7	0.4	70	13	158	35	6,285	1,181
	Total	152.3	20					382	69	16,354	2,758
SM6	*Richardson St.*	38	25	3.3	0.4	138	25	126	14	5,261	959
SD1	*UVM*	49.4	35	4.4	0.7	245	33	196	30	9,077	1,390
	BCC	14.6	5	1.1	0.3	48	9	13	3	349	88
	Total	64	28					209	33	9,426	1,478
SD2	*UVM*	49.4	35	4.4	0.7	245	33	196	30	9,077	1,390
	BCC	131	10	1.7	0.4	70	13	216	48	8,725	1,626
	Redstone Residential	6.5	45	5.5	0.9	305	42	28	4	993	187
	Total	186.9	18					441	82	18,794	3,203
SD3	*Flynn Coop*	25	25	3.3	0.7	138	25	83	18	3,461	631

The percentage of the total load for the watershed transported to each candidate retrofit site is presented in Table 2.5. These percentages were calculated by dividing the load associated with the drainage area tributary to a candidate retrofit (Table 2.4) by the total load from the watershed, as estimated from the USGS gage data (Table 2.3, Center estimate). The gage load data were used to reflect the entire watershed, including channel derived pollutant sources, such as sediment, that are not delivered to most of the candidate retrofit sites.

Figure 2.6 graphically shows the percentage of the total load for the watershed transported to each candidate retrofit site for each of the four pollutants. Based on these estimates, as much as 90% of the total watershed load will be subject to some level of treatment, assuming all of the retrofits are implemented. The only significant areas of the watershed that will not potentially receive treatment are the areas downstream of the USGS gage near the mouth of the stream. This is because there are no proposed retrofits in these areas due to space and other logistical limitations.

Table 2.5 Percent of Total Watershed Load Delivered to Candidate Retrofit Site

Candidate Site ID	TN	TP	TSS	E. coli
O2	51%	38%	16%	25%
O3	4%	2%	1%	2%
O6	2%	1%	1%	1%
O7	5%	4%	3%	3%
O8	48%	30%	16%	22%
SM1,SM2	14%	9%	5%	6%
SM3	3%	2%	1%	1%
SM5	36%	28%	11%	17%
SM6	12%	6%	4%	6%
SD1	20%	13%	6%	9%
SD2	41%	33%	13%	19%
SD3	8%	7%	2%	4%

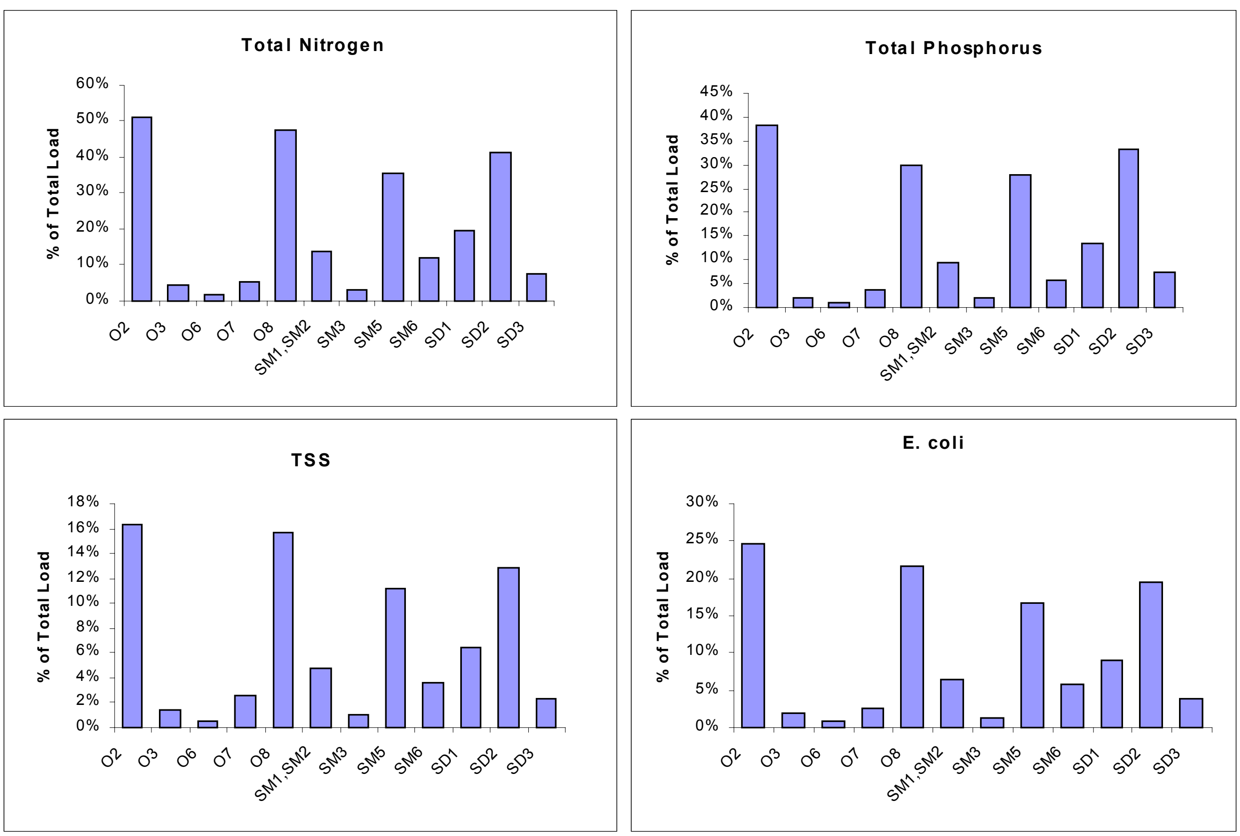


Figure 2.6 Total Watershed Load Delivered to Each Candidate Retrofit Site

Table 2.6 presents the reduction in load for the identified parameters assuming that the retrofit is in place. Pollutant removal efficiencies were determined from national data that the Center has compiled in a database (CWP, 2000). The values are presented in Appendix B. From inspection of Table 2.6, it is evident that there are two candidate retrofit sites, O8 and SM5, that can provide significant pollutant reductions to the watersheds. In the absence of SM5, O2 can provide similar removal for a slightly larger drainage area[8]. After these three sites, there is a significant drop off in the percent of total load that can be removed. This is mostly due to the fact that the other candidate sites are treating smaller drainage areas than O8, SM5, and O2. Section 3.1 provides a more in depth analysis of the benefits of the individual retrofit sites.

Table 2.6 Estimated Watershed Load Removed at Each Candidate Retrofit Site

	TN (lbs/year)		TP (lbs/year)		TSS (lbs/year)		E. coli (# x 10^9/year)	
Total Watershed Load	**1071**	**(%)**	**248**	**(%)**	**145551**	**(%)**	**16486**	**(%)**
O2	119	11.0%	31	13.0%	12569	9.0%	1345	8.0%
O3	8	1.0%	1	1.0%	630	0.0%	45	0.0%
O6	10	1.0%	1	1.0%	693	0.0%	47	0.0%
O7	21	2.0%	5	2.0%	2854	2.0%	142	1.0%
O8	168	16.0%	37	15.0%	18302	13.0%	1780	11.0%
SM1,SM2	49	5.0%	12	5.0%	5542	4.0%	530	3.0%
SM3	9	1.0%	2	1.0%	973	1.0%	93	1.0%
SM5	126	12.0%	35	14.0%	13083	9.0%	1379	8.0%
SM6	22	2.0%	4	2.0%	2273	2.0%	259	2.0%
SD1	31	3.0%	7	3.0%	3393	2.0%	333	2.0%
SD2	1	0.0%	0	0.0%	188	0.0%	10	0.0%
SD3	10	1.0%	4	1.0%	1038	1.0%	32	0.0%

The estimated removed loads of all the candidate sites in Table 2.6 cannot be summed to generate an overall removal because some of the proposed retrofits are "nested" within each other, which would lead to overestimating the cumulative performance. For example, site O2 has several candidate sites (e.g., SM1/SM2, SM3, SM5, SD1, and SD2) within its drainage area. Therefore, care needs to be taken when estimating the reduction in load for the entire watershed when considering different candidate retrofits.

Research conducted by the Center on stormwater management ponds in series indicates that the

[8] While site O2 has a tributary area that is about 73 acres less than SM5, the two sites have similar pollutant load reductions. This is because the concept design at site O2 is only providing treatment for about 66% of the target water quality volume due to space limitations, as opposed to the 100% treatment that site SM5 is providing.

second pond in series provides substantially less (about 50% less) removal capability. This is due, in part, to the shift in particle size distribution in the second pond. Monitoring data show that the first pond in series typically does a good job at removing the larger size particles (sand and silt), such that by the time the flow reaches the second pond the particle size distribution is dominated (in concentration and mass) by the clay size particles. Clay particles are particularly hard to remove because of the very small size, weight, and slow settling velocities. As a result of these processes, it is appropriate to assign a lower removal efficiency for the second pond in series (CWP, 2000).

Using this approach, the Englesby Brook proposed retrofit load reduction presented in Table 2.6 can be reanalyzed using progressively lower removal efficiencies for the ponds lower down in the series. A variation that was incorporated into the analysis was to assume that any new drainage area that was introduced between practices would be subject to the higher removal rates of the practice. Table 2.7 provides a summary of the analysis. The analysis indicates that, with all of the retrofits in place, the projected pollutant load removed would be 44%, 45%, 35%, and 30% for total nitrogen, total phosphorus, TSS, and E. coli, respectively. Section 5 presents a refinement of this analysis to assess the effect that the proposed management plan has on reducing the pollutant load in the watershed.

Table 2.7 Watershed Load Removed Assuming All Candidate Retrofit Sites in Place

Candidate Site ID	**TN (lbs/yr)**	**TP (lbs/yr)**	**TSS (lbs/yr)**	**E. coli (# x 10^9/year)**
Total Watershed Load	1071	248	145551	16486
O2	67	18	7082	757
O3	8	1	630	45
O6	10	1	693	47
O7	21	5	2854	142
O8	168	37	18302	1780
SM1,SM2	49	12	5542	530
SM3	9	2	973	93
SM5	89	25	9257	980
SM6	22	4	2273	259
SD1	19	5	2073	203
SD2	0	0	0	0
SD3	10	4	1038	32
Total Removed Load	**474**	**113**	**50718**	**4869**
% of Watershed Load	**44%**	**45%**	**35%**	**30%**

2.3 Pollution Prevention Survey

A pollution prevention survey was conducted for both residential and institutional areas (RIA) and commercial/industrial/retail areas (CIR) in the Englesby Brook watershed. The purpose of the survey is to identify potential trends in pollutant sources across different land uses. Identifying these "source area" trends is useful in the development of pollution prevention and public education programs. For example, there is at least one residential area in the watershed that has multiple homes with downspouts directly connected to the driveways and ultimately, the storm drain system. Simple education on alternative methods to direct the downspouts to pervious surfaces (e.g., rain barrels, downspout extentions, etc.) will reduce the surface runoff and associated pollutant load from these sites.

A total of 13 areas were assessed as part of the survey (see Figure 2.7). Seven of the areas were classified as CIR and six were classified as RIA. Appendix C contains the completed survey forms along with photo documentation of the conditions. A summary of the key findings and recommendations are presented in Table 2.8.

It is worth noting that while the survey was limited to the Englesby Brook watershed, the prevalent trends and problem areas observed go beyond the watershed and can be viewed as a general characterization for the entire City of Burlington. This is important because it means that pollution prevention and public education guidance that is developed as a component of this watershed plan will be largely transferable to other areas in the City.

The information collected from the pollution prevention survey will serve two important purposes. First, the findings will assist in the development of the watershed management plan described in Section 5. The development of the management plan will take into consideration the major pollution generating areas when establishing a prioritization for implementation. Combining proposed retrofits and stream rehabilitation efforts with targeted source area clean-ups will yield a more substantial benefit to the stream than a random implementation of the measures. Moreover, when the community observes the improvements that result from the combined management approach, it will be more aware of the pollution sources that affect the watershed, and it will become better stewards of the watershed.

Second, the results from the pollution prevention survey provide community-specific information about behaviors and tendencies of individuals and businesses that will be incorporated into the strategy outline to be developed for the pollution prevention, outreach and education program. The effectiveness of these program strategies will be highlighted through the implementation of the management plan for Englesby Brook. One of the goals of the strategy is to have Englesby Brook serve as a useful demonstration tool that will generate support for similar pollution prevention efforts in other City of Burlington watersheds.

Figure 2.7 Pollution Prevention Survey Assessment Locations

Table 2.8 Findings and Recommendations of the Pollution Prevention Survey

Residential and Institutional Areas (RIA)	
Findings	**Recommendations**
< Downspouts are connected directly to impervious surfaces in both residential and institutional areas. < Snow storage at institutional sites tends to be directly on impervious surfaces and overtop catch basins, which enables efficient delivery of pollutants to the stream. < Exposed soils related to snow removal and vehicles driving on turf areas was a frequent condition at institutional sites.	< Route downspouts to pervious areas or encourage the use of rain barrels[9]. < Snow storage should be targeted for pervious areas with significant buffer from stream or inlets. Consider engineered facilities (such as swales with underdrains). < Install bollards to prevent vehicle traffic from disturbing areas. Consider regrading of exposed soil areas to create swales or lower lying areas for snow storage and infiltration.
Commercial, Industrial, and Retail (CIR)	
Findings	**Recommendations**
< Trash is prevalent on sites, often in conjunction with dumpster management, but also in the form of large dumping areas. < Fuel and other automotive pollutants at gas stations receive no treatment prior to entering drainage system < Snow storage tends to be directly on impervious surfaces and overtop catch basins, which enables efficient delivery of pollutants to the stream. < Exposed soils related to snow removal and vehicles driving on turf areas was a frequent condition. < Pet waste appeared to be substantially higher on vacant lots located between industrial and residential areas. < Noticeable accumulation of sediment in road gutters and parking lots presumably associated with winter deicing operations.	< Encourage a more rigorous dumpster maintenance program and require large dumping areas to be removed < Install runoff controls at gas stations. < Snow storage should be targeted for pervious areas with significant buffer from stream or inlets. Consider engineered facilities (such as swales with underdrains) < Install bollards to prevent vehicle traffic from disturbing areas. Consider regrading of exposed soil areas to create swales or lower lying areas for snow storage and infiltration. < Place signage on vacant lots about cleaning up pet waste to keep fecal levels down in the lake and provide disposal stations. < Emphasize street sweeping program after major snow melt periods.

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9 Rain barrels effectively attenuate stormwater runoff during the growing season. The stored water is used to provide supplemental irrigation to gardens and landscaped areas. During the winter months, it may be appropriate to disconnect the system to avoid problems with ice blockage. The practice has been successfully implemented in northern cities such as Toronto.

SECTION 3. STORMWATER RETROFIT AND STREAM REHABILITATION OPPORTUNITIES

In April 2000, the Center team, with help from the City of Burlington and ANR staff, conducted stormwater retrofit and stream rehabilitation inventories for Englesby Brook. This section describes the process of locating and identifying potential retrofit and rehabilitation sites for Englesby Brook. Figure 3.1 illustrates the location of the candidate sites. Appendix D contains the stormwater retrofit inventory sheets where each site is described in detail and a conceptual sketch of the most likely retrofit option is presented. The stream rehabilitation sites were identified as part of the stream assessment work described in Section 2.1.1 and Appendix C.

3.1 The Watershed Retrofitting Process

Ideally, stormwater management practices, which are designed to maintain water quality, control flooding, protect stream channels, or meet other watershed goals, are put in place as development occurs. When sites are designed in this way, a plan can be developed with stormwater management in mind by providing the necessary contours, space, and other features necessary to accommodate these practices. Unfortunately, the majority of Englesby Brook was developed with no stormwater treatment practices. As presented in Section 1, stormwater retrofits are being pursued as one of the tools of the Englesby Brook watershed management plan. The primary purpose of a retrofit is to provide water quality treatment to reduce the pollutant loading to the stream and channel protection storage to reduce the amount of stream channel erosion occurring during stormwater runoff events.

Watershed retrofitting should be viewed as a long term process involving a myriad of disciplines from natural resources management, to engineering design, to public policy and education. Since every watershed is different, it is challenging to break such a complicated process into a step-wise, "cookbook" approach. However, there are eight basic elements that are key to a successful retrofitting effort. Table 3.1 presents this step-by-step approach to stormwater retrofitting developed by the Center staff over the past several years. The table also indicates the status of each step at this point in the development of the watershed management plan for Englesby Brook.

As indicated in the table, the retrofit process at this stage is not yet complete for Englesby Brook. Under Phase II of the project, the highest ranking retrofits were carried forward to the conceptual design stage (see Step 5, in Table 3.1). Section 3.3 presents the results of the ranking and Section 6 and Appendix G provide the details for the highest ranking retrofits.

Retrofits come in many shapes and sizes, from large regional retention ponds that provide a variety of controls, to small on-site facilities providing only water quality treatment or groundwater recharge for smaller storms. Some kind of practice can usually be installed in most situations. But fiscal restraints, pollutant removal capability, practical physical limitations and watershed capture area must all be carefully weighed in any retrofit selection criteria.

Figure 3.1 Candidate Retrofit and Stream Rehabilitation Sites

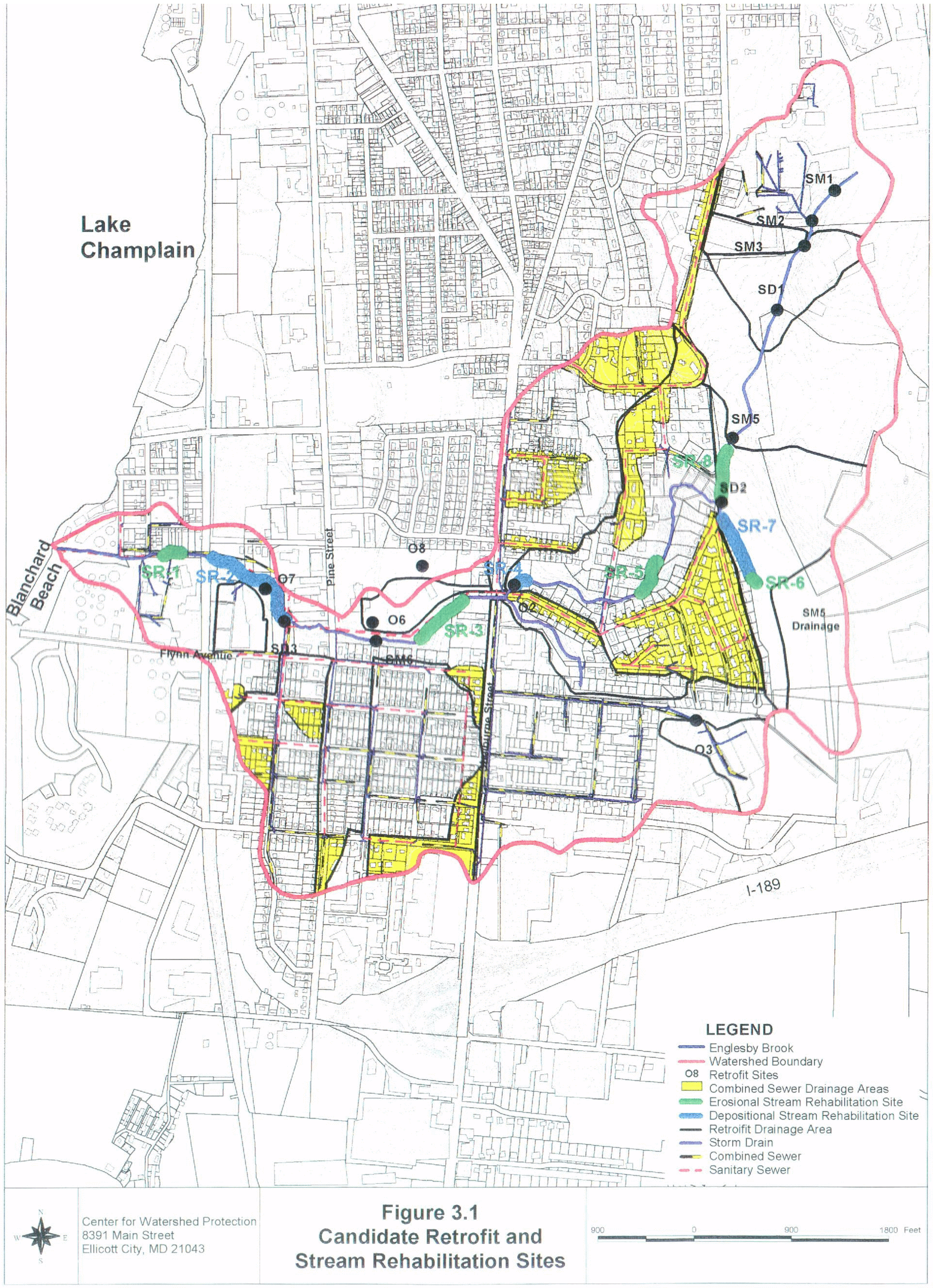

Table 3.1 Basic Elements of a Stormwater Retrofitting Implementation Strategy

Step	Element	Purpose	Englesby Status
1.	Preliminary Watershed Retrofit Inventory	Identify potential retrofit sites	U
2.	Field Assessment of Potential Retrofit Sites	Verify that sites are feasible and appropriate, produce concept designs.	U
3.	Prioritize Sites for Implementation	Set up a priority for implementing future sites	U
4.	Public Involvement Process	Solicit comments and input from the public and adjacent residents on potential sites	U
5.	Retrofit Design	Prepare construction drawings for specific facilities	U
6.	Permitting	Obtain the necessary approvals and permits for specific facilities	-
7.	Construction Inspections	Ensure that facilities are constructed properly in accordance with the design plans	-
8.	Maintenance Plan	Ensure that facilities are adequately maintained	-
Key U: Step is complete - : Step has not been started			

The first step in retrofit implementation is the process of identifying feasible and appropriate sites to locate them. This involves a process of identifying as many potential sites as rapidly as possible. The best retrofit sites fit easily into the existing landscape, are located at or near major drainage outlets or existing stormwater control facilities, and are easily accessible. For example, the existing stormwater detention facilities on the UVM Redstone campus provide a good opportunity as do some of the Burlington Country Club ponds. Table 3.2 lists some of the most likely spots for locating facilities and some common applications.

Table 3.2 Some of the Best locations for Stormwater Retrofits

Location	Type of Retrofit
Existing stormwater detention facilities	Usually retrofitted as a wet pond or stormwater wetland capable of multiple storm frequency management
Immediately upstream of existing road culverts	Often a wet pond, wetland, or extended detention facility capable of multiple storm frequency management
Immediately below or adjacent to existing storm drain outfalls	Usually water quality only practices, such as sand filters, vegetative filters or other small storm treatment facilities
Directly within urban drainage and flood control channels	Usually small scale weirs or other flow attenuation devices to facilitate settling of solids within open channels
Highway rights-of-way and cloverleaves	Can be a variety of practices, but usually ponds or wetlands
Within large open spaces, such as golf courses and parks	Can be a variety of practices, but usually ponds or wetlands capable of multiple storm frequency management
Within or adjacent to large parking lots	Usually water quality only facilities such as sand filters or other organic media filters (e.g., bioretention)

The first step is completed in the office using topographic mapping (the 5' contour interval GIS mapping is quite satisfactory), low altitude aerial photographs, the storm drain master plan, and land use maps. Scouting for potential candidate sites follows the guidance discussed in Table 3.2. Two important tasks need to be undertaken before venturing into the field. First, the drainage area to each retrofit is delineated and second, the potential surface area of the facility is measured. The drainage area is used to estimate a potential capture ratio. This is the percentage of the overall watershed that is being managed by all retrofit projects. The potential surface area is used to compute a preliminary storage volume of the facility. A short cut storage volume can be computed by multiplying two-thirds of the facility surface area times an estimated depth (b @ SA @ d). These two bits of information are used as a quick screening tool.

In general, an effective retrofitting strategy attempts to capture at least 50% of the watershed area. A minimum water quality target storage volume for each retrofit is equal to approximately 1 inch per impervious acre[10]. For channel protection purposes, a target storage volume is to provide extended detention for the 1-year return frequency storm (the 1-year storm for the Englesby Brook vicinity is approximately 2.1 inches)[11].

The candidate retrofit sites are then investigated in the field to verify that they are feasible. This field investigation involves a careful assessment of site specific information such as identifying the presence of sensitive environmental features, the location of existing utilities, the type of adjacent land uses, the condition of receiving waters, construction and maintenance access opportunities, and most importantly, whether or not the contemplated retrofit will actually work in the specified location. In conjunction with the field investigation, a conceptual sketch is prepared and photographs are taken. Appendix D contains completed inventory forms for each site.

3.1.1 Englesby Brook Retrofit Inventory

In Englesby Brook, 17 candidate stormwater retrofit sites were identified (see Figure 3.1 for locations). Three of these sites are at, or immediately adjacent to, a storm drainage outfall (designated as "SD" sites). Another six candidate sites are at existing stormwater retention or filtering facilities (designated as "SM" sites). The remaining eight sites (designated as "other" or "O") are at locations with a significant drainage area upstream from an existing road culvert or at the intake of a major drainage system.

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[10] The justification for targeting 1 inch per impervious acre is based on a rainfall frequency analysis approach that attempts to capture and treat approximately 90% of the annual events. This sizing criteria: (1) captures 90% of the annual runoff load providing water quality treatment for all but the larger storms; even the larger storms will receive some degree of treatment; (2) captures and treats more than just the so called, "first flush"; and (3) ensures fairly high level of treatment at highly impervious sites that are often hotspot areas such as parking lots, gas stations, and convenience stores.

[11] Channel protection in stormwater management attempts to minimize the downstream channel expansion and erosion which normally occurs with urbanization of a watershed. As pervious surfaces such as fields and forests are converted to impervious surfaces, the volume and frequency of runoff is increased significantly. Researchers have demonstrated that urbanization causes channels to expand two to five times their original size to adust to the increased volume and frequency of runoff from impervious surfaces and the increased routing efficiency of curbs, gutters and storm drains (Moriwasa and LaFlure, 1979, and Allen and Narramore, 1985). A 1999 study by the Center on nine Vermont streams indicated that, even for relatively modest amounts of urbanization (i.e., 10 to 20% watershed imperviousness), channel enlargement between 1.25 and 2 times the original size could be expected (CWP, 1999). Typically, the "channel forming" events have a recurrence interval of between 1 and 2 years, with approximately 1.5 years as the most prevalent. The premise of the 1-yr, 24-hr extended detention design criteria is that runoff is stored and released in such a gradual manner that critical erosive velocities are seldom exceeded in downstream channels.

An important element in the determination of the drainage areas to each proposed site was to determine the areas where combined sewer systems exist and to subtract these areas out of the tributary area to the site. This was accomplished using storm drain, combined system, and sanitary sewer mapping that was provided by the Burlington Department of Public Works.

Of the 17 original candidate sites, four were deemed not feasible or practical based on the field reconnaissance (one "SM" site, and three "O" sites). The reasons for dropping a site from further consideration were because of too little available management area or poor or impractical construction and/or maintenance access. In addition, sites SM1 and SM2 (the two existing stormwater ponds at UVM Redstone campus) were combined into a single candidate site due to the close proximity of the ponds and the hydraulic connection between them. The inventory forms in Appendix D describe in detail the reasons why particular sites were dropped from further consideration. Table 3.3 provides a summary of the retrofit sites that are considered feasible.

Table 3.3 Summary Information for Feasible Retrofit Sites

SITE ID	LOCATION	PRACTICE	AREA [AC]	% IMPERVIOUS	% WQv Provided	% Cpv Provided
O2	Shelburne and Prospect	Wet ED Pond	225	20	66	96
O3	Rice High School	Bioretention	11	30	40	100
O6	Champlain Elementary	Dry Swale with Bioretention	5.3	25	100	NA
O7	Elan/Together.net site	Bioretention	6.5	75	94	NA
O8	School Maintenance Grounds	Wet ED Pond	118	30	100	20
SD1	Burlington Country Club	Shallow Marsh	64	25	45	75
SD2	S. Prospect St. @ BCC	Culvert Upgrade w/ Micropool	187	18	10	NA
SD3	Flynn Ave Coop	CDS Hydrodynamic Device	25	25	100	NA
SM1 & SM2	UVM Campus	Wet ED Pond	43	30	100	100
SM3	Burlington Country Club	Shallow Marsh	6.4	45	83	NA
SM5	Burlington Country Club	Wet ED Pond	152	20	100	100
SM6	Flynn and Richardson	Shallow Marsh	38	25	54	NA
Notes: WQv = water quality volume; Cpv = channel protection volume; NA = not applicable						

3.1.2 Ranking System

The Center developed a retrofit ranking system that represents our thinking as to how various factors should be employed to prioritize individual candidate retrofit sites. The following discussion provides the reasoning for selecting the factors and assigning the relative weight of each.

The proposed retrofit ranking system includes the following major factors:

1. Pollutant Removal Potential
   – Impervious area treated
   – Percent of water quality target volume treated
   – Pollutant load reduction
2. Channel Protection Criteria
3. Project cost
4. Implementation feasibility based on ownership, access, maintenance, utility, and permit issues
5. Supplemental benefits such as habitat, wetland creation, riparian/forest enhancement, and public benefit

The ranking system is based on a 100 point scoring system. The basic concept is to evaluate the relative merit of proposed retrofit sites by assigning points to a site based on its ability to meet various criteria under each of five major factors. Summing the assigned points for each of the factors gives an overall site score. Sites with the highest score represent the best overall candidates for implementation from a stormwater management technical vantage point.

The current draft of the ranking system places an emphasis on (by weighting more heavily) the pollutant reduction potential. Specifically, 45% of the total points have been allocated to this category. A total of 10% of the points have been allocated for channel protection, 30% of the points have been allocated to project cost and implementation. The remaining 15% of the points is divided between supplemental environmental benefits and public benefits.

The rationale for the emphasis on the area and volume of water treated as well as the cost and feasibility of a project is two-fold. First, one goal of the retrofit approach is to manage a large percentage of the untreated impervious area runoff, in order to meet target water quality goals for Englesby Brook and Lake Champlain. Therefore, those retrofit sites that are able to capture and effectively treat a larger area of impervious surface are deemed to be more important and valuable and thus assigned higher point values.

Secondly, the feasibility of a proposed retrofit, in terms of both cost and implementation is important. Simply put, there are frequently "fatal flaws" for proposed retrofits in the form of capital costs, utility conflicts, private ownership, and access (to name a few). There is little point in proceeding with a retrofit design concept if there is a high probability that an existing constraint can not be overcome. Therefore, proposed retrofits where these types of constraints are minimal or non-existent will be awarded higher point values.

Somewhat less emphasis is placed on the environmental and public benefits of the proposed retrofits. This is mostly due to the fact that there are a limited number of candidate retrofit locations and there is not a lot of variability between the sites for these factors. It should be noted, however, that to the extent practical, the concept designs for the candidate sites attempted to minimize environmental impacts and maximize educational opportunities.

Table 3.4 presents the ranking criteria with the associated point breakout. Using the described ranking system, the Center evaluated the 13 candidate retrofit sites. The results of the analysis are presented in Table 3.5, with the candidate sites sorted from highest ranking to lowest ranking.

It is instructive to compare the information presented in Tables 2.6 and 3.5, as this provides a good measure of both the load reduction potential of a candidate site (Table 2.6) and the overall feasibility and effectiveness of a site (Table 3.5). For example, site O8 is the highest ranking candidate site (Table 3.5) and it also provides the greatest load reduction potential of all the candidate sites (Table 2.6). Other sites that appear to have similar benefits include O2 and SM5. These results are largely intuitive as these three sites treat three of the largest drainage areas and have fairly high pollutant removal efficiencies associated with the proposed treatment practice at the site. The ranking system also weights pollutant removal potential as the highest of all the criteria.

Sites SM6 and SM1/SM2 round out the top five ranked candidate sites; however, there is a significant drop in the total score between O2 (third ranked with 50.4 points) and SM6 (fourth ranked with 35.5 points). Site SD1 (sixth ranked with 33.4 points) is essentially interchangeable with SM6 and SM1/SM2. From a pollutant removal standpoint, the third through sixth ranked sites have significantly less pollutant removal capability than the first tier of sites, but provide slightly more treatment than the remaining six sites. Lastly, while site SD2 has limited functionality from a water quality standpoint (the retrofit is a culvert upgrade that has a forebay providing only a small amount of water quality treatment), it is important in terms of providing relief from nuisance flooding in the area and may warrant special consideration for implementation.

Table 3.4 Retrofit Ranking Point Weighting

Stormwater Retrofit Technical Feasibility (Maximum Score = 100 points)	Total Possible Points
1. Pollutant Removal Potential	**45**
equals the product of 1a times 1b times 1c times 45: ([(1a)(1b)(1c)]45)	
1a. *Impervious Area treated*	
= A/45, where A = is the total impervious drainage area to the facility in acres	
1b. *% of Water Quality Volume Treated (based on 1.0" per impervious acre)*	
= percent of target volume within facility	
1c. *Pollutant Load Reduction: (based on type of facility and ability to remove TSS*)	
= pollutant removal efficiency divided by 0.9	
micropool ED or wet ED pond (efficiency = 0.6)	
wet pond (efficiency = 0.75)	
wetland (efficiency = 0.8)	
filter/bioretention (efficiency = 0.8)	
infiltration (efficiency = 0.9)	
open channel (efficiency = 0.4)	
2. Channel Protection Control	**10**
% of Channel Protection Volume Managed (based on 2.1" of rainfall)	
3. Project Cost ($/acre tributary to facility) - costs include consideration of design, construction, permitting, and contingencies	**10**
$ $5,000	[0]
$4,000 # project cost < $5,000	[2]
$3,000 # project cost < $4,000	[4]
$2,000 # project cost < $3,000	[6]
$1,000 # project cost < $2,000	[8]
< $1,000	[10]

4. Implementation : ownership + access + maintenance + utilities + permits		**20**
ownership:	site is on private land	[0]
	site is partially on public land	[3]
	site is on public land	[5]
access:	poor	[0]
	good	[5]
maintenance burden:	high maintenance	[0]
	medium maintenance	[3]
	low maintenance	[5]
utilities (water, sewer, gas, etc.):	major impacts	[0]
	minor impacts	[3]
	no impacts	[5]
5. Supplemental Benefits (Environmental + Public)		**15**
habitat score:	does not provide additional habitat	[0]
	provides additional habitat	[2]
wetlands score:	net loss > 1acre of wetlands	[-10]
	net loss < 1acre of wetlands	[-5]
	no net loss or gain	[0]
	< 1 acre additional wetland	[2]
	$ 1 acre additional wetland	[4]
forest score:	net loss >1 acre of forest	[-10]
	net loss <1 acre of forest	[-5]
	no net loss or gain	[0]
	< 1 acre additional forest cover	[2]
	$ 1 acre additional forest cover	[4]
public benefit:	benefits another habitat project	[1]
	because of location and nature of facility, can easily be incorporated into a public/student education program	[2]
	can be either constructed or maintained, in part, by volunteers	[1]
	no permanent loss of recreational features	[1]

Table 3.5 Summary of Retrofit Ranking Analysis

Site #	1. Removal Potential (45 possible points)	2. Channel Protection (10 points)	3. Cost (10 points)	4. Implementation (20 points)				5. Supplemental Benefits (15 points)				Total Score
				Ownership	Access	Maintenance	Utilities	Habitat	Wetlands	Forest	Public	
O8	31.5	0.0	8	5	4	5	5	2	0	-5	3	**58.5**
SM5	27.0	10.0	10	0	3	5	5	1	0	0	1	**52.0**
O2	26.4	9.6	10	0	3	5	5	2	0	-5	4	**50.4**
SM6	4.5	0.0	10	5	3	4	5	2	2	-5	5	**35.5**
SM1/SM2	11.5	10.0	4	0	5	5	0	2	2	0	5	**34.5**
SD1	6.4	7.4	8	0	5	4	5	2	2	0	1	**33.4**
SD2	3.7	0.0	10	3	5	5	0	0	0	0	1	**27.7**
SM3	2.1	0.0	6	0	4	4	5	2	2	0	2	**27.1**
O6	1.3	0.0	0	5	5	3	5	1	0	0	3	**23.3**
O3	1.2	10.0	2	0	5	3	5	1	0	0	4	**21.2**
O7	4.1	0.0	0	0	5	3	3	1	0	0	4	**20.1**
SD3	2.1	0.0	6	0	3	0	3	0	0	0	1	**15.1**

3.2 Englesby Brook Stream Rehabilitation

Stream rehabilitation involves the recovery of eco-system functions and processes in a degraded or disturbed habitat. Rehabilitation, however, does not necessarily reestablish the predisturbance condition, but does involve establishing hydrologically stable landscapes that support the natural ecosystem (USDA, 1998). Stream rehabilitation can cover a broad range of practices including riparian reforestation, wetland creation and enhancement, habitat creation, and streambank stabilization. For this phase of the Englesby Brook project, the stream rehabilitation focus is primarily on channel erosion and opportunities for streambank stabilization using both “hard” or structural practices and bioengineering practices (practices that employ live vegetation).

The rehabilitation strategy for the channel erosion areas involves a combination of stabilization measures such as boulder revetments and revegetation in the form of tree and shrub plantings. For the depositional areas, the strategy involves first identifying and controlling the major sediment sources to reduce the load, and then planting vegetation along the most active channel. This approach is intended to impede sediment transport by “tying up” the sediment with the root masses and plant material of the vegetation. The goal of this stategy is to reestablish a single channel where a braided channel exists.

Channel daylighting (i.e., replacing storm drain pipe with open channel) was initially considered by the Center as a potential stream rehabilitation strategy as well. Candidate sites for daylighting included several hundred feet of stream on the golf course and the long (350 feet) culvert under Shelburne Road. After evaluating the likely benefits and costs associated with a daylighting effort, it was decided that there would be major disruptions and only marginal benefits provided by daylighting the stream. The primary purpose of stream daylighting on Englesby Brook would be to provide meaningful fish and macroinvertebrate habitat, which requires that a substantial stream buffer be included in the daylighting concept. On the Burlington Country Club property, this would prove to be incompatible with the golf course. Moreover, due to the ephemeral nature of the stream in this area, it is not likely that a substantial fish community can establish here. The Shelburne Road culvert perhaps has more benefit that could be realized through a daylighting project; however, the channel would likely have to be confined (i.e., channelized) due to the existing physical constraints and property ownership in the area.

3.2.1 Stream Rehabilitation Inventory

The stream rehabilitation inventory was incorporated into the modified RBP field study to identify reaches of stream that show signs of degradation and instability. The RBP stations were used as the initial inventory locations; however, stream reaches in need of rehabilitation sometimes extended over consecutive RBP stations. Consequently, candidate stream rehabilitation sites have been given a unique site identification, designated as “SR-1,” where the numbering is from downstream to upstream (see Figure 3.1). Site characteristics such as length of impacted reach and adjacent vegetation were documented. Areas in need of rehabilitation were mapped in the field and preliminary concepts for rehabilitation were noted. Reaches in need of rehabilitation were both erosional areas and depositional areas. It should be noted that the inventory concentrated on the more extreme cases of bank erosion and deposition. There are several more "spot" areas throughout the watershed that exhibit signs of instability; however, these areas were determined to be relatively minor or areas where rehabilitation would probably not make a measurable impact on the condition, particularly considering the cost, access, and disturbance that would be required.

The most significant areas of active bank erosion along Englesby Brook were previously identified in Section 2 (see Figures 2.2 and 2.3) and are shown again on Figure 3.1. The reaches were generally located west of Shelburne Road and downstream of culvert crossings, except for an upstream reach on Burlington Country Club property. Isolated areas of bank erosion were also observed upstream of Shelburne Road. The most impacted depositional reach is lower in the watershed between Pine Street and the railroad culvert, where the stream gradient is quite flat. Another significant depositional reach is the southern tributary on the Burlington Country Club property.

The following provides a description of the major categories used in the inventory to document conditions at each location. Table 3.6 provides a summary of the candidate stream rehabilitation sites.

Length of Treatment Area: "Length of Treatment Area" (LTA) is defined as that portion of the study area which will likely receive rehabilitation treatment. The lengths identified are preliminary estimates and will need to be refined in the concept design phase.

Adjacent Vegetation Type: This category efers to vegetation types adjacent to rehabilitation sites; described as "forest," "shrub," "turf," or combinations thereof.

Access for Construction: Access is described as "good," "fair," or "poor" based on land ownership of the access and treatment areas, and whether sensitive natural resources such as forests, streams, or wetlands would be affected during access or construction work..

Affected Facilities and Resources: This category refers to public and private resources and facilities such as utility lines, pathways, roadways, and recreational features which are in jeopardy due to existing stream conditions (erosion).

Potential Rehabilitation Techniques: Potential rehabilitation techniques are provided for each treatment area. Techniques are based on notes and photos taken during RBP field work.

Estimate of Cost per Linear Foot for Construction: Estimated costs are based on "potential rehabilitation techniques" listed for each treatment area according to the following scale:

Bioengineering . . . . $50/l.f.
Boulder Revetment . . . . $100/l.f.
Remove Existing Structures . . . . $50/l.f.

Estimate of Total Cost for Construction: Total construction costs are determined by multiplying the LTA by the estimated construction costs per linear foot.

Table 3.6 Englesby Brook Stream Rehabilitation Inventory

Rehab Site # (RBP stations)	Length of Treatment Area (ft.)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
SR-1 (201-3)	50	forest/shrub	poor	none	Vegetation enhancement along areas where toe failure is occurring. Debris removal.	$50	$2,500
SR-2 (201-5 - 201-7)	700	forest/shrub	poor	none	Plantings along main channel to hold sediment in place.	$50	$35,000
SR-3 (201-10 - 201-12)	500	forest/shrub	fair	none	Stabilize areas of toe failure with boulder revetments and plant the upper banks with shrubs and other stabilizing vegetation. Remove berm on right side of channel to provide access to floodplain.	$150	$75,000
SR-4 (201-13)	100	forest	fair	none	Plantings along main channel to hold sediment in place.	$50	$5,000
SR-5 (201-16 - 201-17)	100	forest	poor	none	Stabilize isolated areas of toe failure with boulder revetments and plant the upper banks with shrubs and other stabilizing vegetation.	$150	$15,000
SR-6 (102-2)	30	turf	good	golf course	Stabilize pipe outfalls with large rock and plantings in association with bank shaping.	$50	$1,500
SR-7 (102-1 - 102-2)	200	turf	good	golf course	Plantings along main channel to hold sediment in place.	$50	$10,000
SR-8 (103-1 - 103-2)	300	turf	good	golf course	Stabilize bank through combination of bank shaping and plantings of shrubs.	$50	$15,000

SECTION 4. PUBLIC PARTICIPATION AND PLANNING WORKSHOPS

The Englesby Brook study is structured to involve the public at various levels throughout the course of the project, with a strong emphasis on getting early input and involvement from the public in the planning process. This allows for contentious issues to be identified and addressed early in the planning phases and helps identify the important issues are to watershed residents.

With this in mind, two planning workshops were conducted with interested stakeholders to generate citizen involvement and input. The first workshop was held in March 2000 to discuss pollution prevention opportunities and public education techniques. A second workshop was held in May 2000 (in conjunction with Vermont Green-Up Day) to discuss the preliminary findings of the stream assessment and retrofit and stream rehabilitation inventories. Stakeholders at the workshops included (but were not limited to): citizen associations, interested homeowners, environmental planners, Lake Champlain Committee, and staff from the City of Burlington and ANR.

Despite the positive turnout, several key stakeholders were not represented, including Burlington Country Club representatives, industry, developers, and large office building interests. Keeping these players informed and engaged in the watershed study will be critical to the overall rehabilitation effort in the watershed. A more detailed description of each workshop is provided in the sections below.

4.1 Pollution Prevention Workshop

A Pollution Prevention Workshop was conducted at Burlington High School on March 15, 2000. The workshop was attended by almost 50 interested individuals (27 of whom lived in the Englesby Brook watershed) and consisted of a presentation by the Center and a series of interactive exercises.

In the first of two exercises, a watershed behavior survey was given to the attendees, in which they answered a series of questions about the practices they engage in with respect to lawn fertilization, pet waste management, and vehicle maintenance and washing. The results of the survey were somewhat encouraging, compared with results from other surveys from around the country. Specifically, it was good to see an awareness and diligence about not using pesticides and about recycling of automotive fluids. There were, however, some watershed behaviors with room for improvement. These include lawn fertilization frequency and timing of application, pet waste management, and car wash water disposal. The survey also identified preferred outreach techniques (i.e., various forms of media to get the message across). The respondents included brochures, public service announcements, and newspaper columns/ads as the most desirable. A detailed presentation of the survey results is provided in Appendix E.

The second exercise at the workshop involved breaking into smaller 6 to 8 person groups and developing a watershed media campaign and associated budget that targeted specific behaviors that affect the health of streams and lakes. A total of six groups were formed, each of which presented their campaigns to the entire group at the end of the evening. A summary of the group themes and campaigns is presented below:

Group 1:
Theme:
BLANCHARD BEACH IS COOL
Bring Back Blanchard Beach–Here's the Scoop

Components:
- increase awareness of one's actions on watershed
- target schools, children, swimmers, pet owners and neighbors
- communicate with electric bill stuffers, TV, school, education, info kiosk at park

Group 2:
Theme:
PICK IT UP–PET POOP

Components:
- target pet owners
- theme: pet waste makes Blanchard Beach unusable
- signs at hot spots, bins, barrels, bags, flyers, presentation at PTA meetings, educate in school so that the kids can change parents
- Use Red Roberts as spokesperson

Group 3:
Theme:
LINKS–YOUR LAWN AND THE LAKE (AND YOU THOUGHT YOU DIDN'T HAVE WATERFRONT PROPERTY)

Components:
- target lawn care companies, schools
- use mobile soil testing unit
- set up demonstration lawn
- electric bill notice, potluck dinners with guest speakers, ward planning assemblies, resource list for more info
- computerized interactive kiosk
- get channel 3 in watershed to report on the community
- Use UVM student interns

Group 4:
Theme:
WHY CAN'T WE SWIM AT BLANCHARD BEACH?

WE HAVE MET THE ENEMY AND IT IS US

Components:
- have a single ad, with different themes that state the problem and how to help–top of ad would have main theme and then dog pooping in lake and guy fertilizing lake
- use handouts, neighborhood planning, condo newsletter, commercial tv, public tv
- barrels in park with pictures of dog

Group 5:
Theme:
THIS IS YOUR LAKE (LIVE HAPPY HEALTHY FISH)
THIS IS YOUR LAKE ON LAWN DRUGS (DEAD FISH, LOTS OF ALGAE....)

Components:
- target property owners
- use public access TV
- develop symbol (e.g., sunflower with smiley face)--instead of ugly plastic chemical lawn tags, neighborhoods can earn nice cast iron lawn ornament only if entire block pledges it
- neighbor to neighbor campaign
- get natural fertilizer company to donate product and with initial distribution of free product provide brochure and symbol

Group 6:
Theme:
WHEN IT RAINS---DO YOU KNOW WHERE IT POURS???

Components:
- cartoon on different land practices educating people about where the pollutants go
- target at residents
- refrigerator door magnets, posters

The workshop appeared to generate a lot of enthusiasm and support for the effort underway. Many good ideas were developed by the attendees for effective outreach and education approaches. The Center will incorporate the comments and concepts in the pollution prevention, outreach, and education guidance document that will be a component of the final watershed plan prepared under Phase III of the project.

4.2 Watershed Planning Workshop

A second public workshop, focusing on watershed planning and the results of the stream assessment and retrofit inventory, was held at the Flynndog Gallery site on May 6, 2000 in conjunction with the statewide “Green-Up” day. About 30 attendees remained after a morning of stream cleaning in

Englesby Brook to hear a presentation by the Center and to participate in both on site and take home exercises.

The presentation focused on the preliminary findings of the watershed assessments and emphasized the proposed stormwater management retrofit locations in the watershed. In addition to providing a progress report on the project, the presentation also provided the necessary background for the attendees to complete a take home exercise.

The first exercise of the workshop challenged the attendees to develop a basic conceptual design for a stormwater management retrofit site. The workshop location (208 Flynn Avenue) coincidentally served as the case study for the retrofit exercise. This location was also one of the retrofit sites identified in the retrofit inventory conducted for Englesby Brook watershed (see Section 3 and Appendix D). Attendees were divided into groups and provided with basic information such as drainage area, impervious cover, property ownership, etc. Their challenge was to identify likely pollutant sources at the site, develop a series of potential pollution prevention strategies for the site, and to represent the management plan in the form of a concept drawing.

Several innovative ideas were offered during the reporting period of this exercise, and many were similar to the concept developed by the Center for the site (see Appendix D, Site O7). The majority of groups emphasized collecting and conveying the runoff from the parking lot at the site to either a wetland or "pocket" pond to provide water quality treatment prior to discharge to the stream.

The take home exercise that attendees were asked to complete involved a retrofit ranking exercise, where the task was to evaluate and rank the ten potential retrofit concepts that were developed by the Center during the field assessment. Attendees were given detailed site information for each proposed retrofit including drainage area, impervious cover, water quality volume provided, channel protection volume provided, and cost. Based on the information provided to them in handouts and during the presentation, attendees were asked to fill out a "score sheet" where they ranked the ten proposed sites from highest value to lowest value (in terms of providing pollutant removal and channel protection functions to the watershed). Stamped addressed envelopes were provided to facilitate the return process.

Response to the take home exercise was somewhat disappointing, with only five surveys being completed and returned. Despite the limited return, the responses still provide some interesting insight from the stakeholders. For example, site O2 (the wet pond proposed for the corner of Prospect Parkway and Shelburne Road) was one of the top 3 sites for all respondents, and site O3 (Rice High School) was one of the lowest ranked sites by all respondents. Other generally favored sites included site SM6 (Flynn Street and Richardson Street) and site SM5 (Burlington Country Club). It is interesting to note that these results actually agree well with the more rigorous retrofit ranking analysis that is discussed in Section 3. For example, based on the average score that the participants awarded each site, their top three sites (O2, SM6, and SM5, respectively) corresponded with three of the top four sites resulting from the rigorous retrofit ranking. The top site from the more rigorous ranking, O8, was actually not available for the participants to consider, since the concept was developed subsequent to the workshop.

SECTION 5. POLLUTION PREVENTION PROGRAM GUIDANCE

In this section, a brief overview of recommendations for citizen-directed watershed outreach and potential municipal/commercial pollution prevention practices in the Englesby Brook watershed are provided. A more detailed presentation of these concepts and recommendations is provided in Appendix F.

5.1 Background

With any watershed restoration effort, the involvement of those that live and work in the watershed is vital to ensure long term success. Many people may be unaware of the impact of their actions on stream quality and aquatic habitats, and might be willing to make changes to those behaviors if they better understand the relationship between their individual behaviors and the water quality of the watershed they live in. By learning to eliminate actions that can produce non-point source pollution, concerned citizens can reduce the overall impacts of polluted stormwater runoff while creating a sense of partnership in the success of the watershed restoration plan.

The primary goal of the pollution prevention program is to alter current behaviors that contribute to pollutant loading within the watershed and assist in accomplishing the overall goals of the watershed restoration plan. The program will also benefit larger city-wide pollution prevention efforts. The use of public outreach and pollution prevention education efforts will allow those charged with implementing the watershed restoration plan to directly meet a number of the identified watershed protection goals for Englesby Brook (see Section 1.1). Specific goals that can be targeted, in part, with a pollution prevention program include:

- Increase local awareness and expand public awareness both in and beyond the Englesby Brook watershed.
- Reduce bacteria loads to Blanchard Beach and strive to make it "swimmable" the majority of the time.
- Reduce pollutant load and impact to Lake Champlain
- Reduce and/or eliminate odor and debris within Englesby Brook

In addition, public outreach can indirectly assist in meeting two additional goals of the plan.

- Enhance riparian buffer zones and increase stream corridor access
- Reduce stream channel erosion, and improve stream habitat

The Englesby Brook Watershed Restoration Project will need to incorporate both structural and nonstructural stormwater practices to mitigate many of the impacts and stresses on the ecosystem. The nonstructural practices refer to pollution prevention techniques that can be implemented by either residents, businesses, and/or the local municipality to reduce stormwater pollutant loads. Advantages to incorporating these nonstructural stormwater practices into the Englesby Brook

Watershed Restoration Project include:

- They are relatively inexpensive to implement in relation to structural stormwater practices.
- Some of the suggested practices only require an alteration in current practices to ensure they result in less pollution runoff.
- They encourage citizen and business involvement in the Englesby Brook watershed restoration process, and foster a sense of ownership of the local watershed.
- In some of the more densely developed portions of the watershed, alterations in citizen behavior may be the best way to realize pollutant reduction targets.
- For some of the recommended practices, organizations that can assist in outreach efforts are already present in the watershed.

5.2 Recommendations

Control of nonpoint source pollution through watershed education and increased stewardship is vital to the success of the Englesby Brook watershed restoration effort. The importance of public outreach was acknowledged in the watershed restoration plan when the goal of "Increase local awareness and expand public awareness both in and beyond the Englesby Brook watershed" was established.

The pollution prevention program recommendations presented in this section and detailed in Appendix F are based on both the input of local citizens, local and state agencies familiar with the unique resources of the Englesby Brook watershed, and the experience of the Center's staff who have researched and developed other pollution prevention programs. Many of the pollution prevention suggestions were derived from a survey of local citizens conducted in March 2000 (see Section 4.1 and Appendix E), which also provided the Center with some excellent ideas for outreach campaigns that could be used to educate residents regarding the impacts of their household behaviors on Englesby Brook, Blanchard Beach, and Lake Champlain. Figures 5.1 and Appendix F show some of the campaign ideas from this workshop. Incorporating concepts developed by actual residents will give the campaign local flavor and possibly exert more influence than those made from an organization outside the watershed.

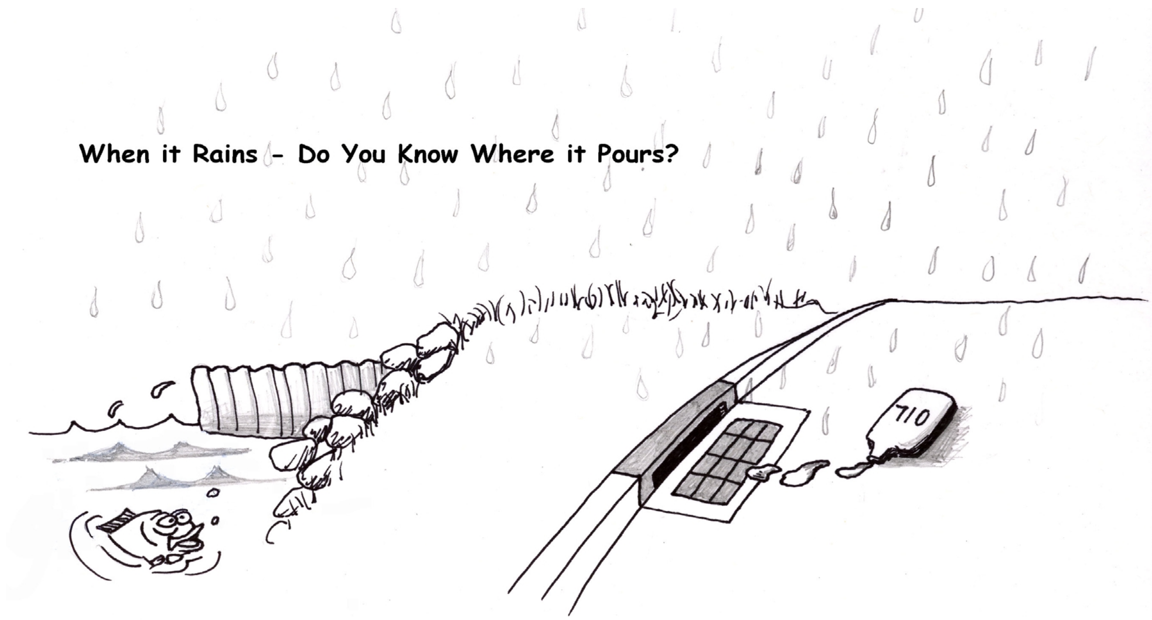


Figure 5.1 Pollution Prevention Education Concept

Table 5.1 summarizes the pollution prevention recommendations for the Englesby Brook watershed. Many of the recommendations can be expanded beyond the watershed to aid the City of Burlington in improving water quality in all urban watersheds within City limits. The recommendations are based on the three major targeted goals (i.e., reduce bacteria loads, reduce pollutant loads, and reduce odor and debris) and are given either a "low", "medium", or "high"ranking based on their likelihood to produce significant improvements in water quality. A ranking of high will contribute the most to pollutant load reductions, with a low priority ranking indicating a recommendation is less critical to meeting restoration goals either due to cost or to limited data on the effectiveness at reducing total pollutant loads.

Section 6 provides a summary of a modeling analysis (building from the analysis conducted in Section 2.2) showing the pollutant load reductions that might be expected with the higher priority programs in place.

It is important to recognize that a pollution prevention program should be dynamic and evolving to reflect the current needs or concerns. As such, the recommendations and information provided here are only a starting point in pollution prevention planning and implementation. In the future, water quality friendly practices such as car and fleet maintenance, the care of septic systems, illegal dumping, winter de-icing, and bridge and roadway maintenance are additional outreach areas that may become important for the City to consider. Whatever recommendations the City of Burlington ultimately chooses to implement, it is suggested that indicator monitoring be performed to assess the ability of these recommendations to reduce pollutant loads (see Section 7).

Table 5.1 Prioritization of Pollution Prevention Efforts for Englesby Brook

Goal: Reduce bacteria loads to Blanchard Beach and strive to make it "swimmable" the majority of the time.		
Recommendation	**Priority**	**Cost**
Place signage and waste disposal stations in all parks and vacant public areas	High	Low
Institute a dog park in the Englesby Brook watershed and identify citizen group as partner/liaison[12].	High	Medium
Monitor and eliminate illicit connections[13]	High	High
Create veterinarian and pet shop fact sheet	Medium	Low
Institute downspout disconnection program	Medium	Low
Provide rain barrels to residents	Low	Medium
Media campaign regarding pet waste	Low	High
Enforce pooper scooper ordinance	Low	Medium
Goal: Reduce pollutant load and impact to Lake Champlain		
Recommendation	**Priority**	**Cost**
Promote soil testing services available at University of Vermont	High	Low
Recognize citizens in the watershed who use proper lawn care practices	High	Low
Design dedicated snow storage sites with treatment practices to reduce pollutants	High	Medium

[12] It is of note that there have been discussions with regard to the establishment of a dog park in the City of Burlington; however, to date there has been no action taken. Recommendations and considerations for effective dog park establishment and designs are presented in Section 2.1.1 of Appendix F.

[13] Through conversations with Burlington DPW staff, it has been hypothesized that if there are no significant illicit connections detected in the Englesby Brook watershed, that there is likely a significant inflow and infiltration (I/I) problem associated with the sanitary and combined sewer systems. This phenomenon is fairly common in old infrastructure areas and is unfortunately a costly undertaking to remediate. I/I assessment and correction is not a specific recommendation of this watershed restoration plan, due to the magnitude of the undertaking and because it is more of a city-wide public works issue. However, I/I may be a significant impact to Englesby Brook and improved information (perhaps throught TV video and/or pressure testing) on the severity of the condition would be useful in the overall understanding of the adverse influences within the watershed.

Identify and map new hotspot facilities in the watershed[14]	Medium	Low
Sweep streets and parking lots to remove sediment and debris	Medium	High
Promote "good housekeeping"pollution prevention practices at municipal and commercial locations	Medium	Low
Establish a routine catch basin cleaning schedule	Medium	Medium
Create a lawn care fertilization and water quality segment for Extension TV	Medium	Low
Use integrated pest management for public vegetative maintenance practices	Medium	Medium
Goal: Reduce and/or eliminate odor and debris in Englesby Brook		
Recommendation	**Priority**	**Cost**
Stress dumpster management at municipal sites to reduce debris and liquids entering stream or storm drain.	High	Low

[14] Baseline hotspot identification was conducted as part of the field reconnaissance work (i.e., pollution prevention survey) for this project, as described in Section 2.3.

SECTION 6. WATERSHED MANAGEMENT RECOMMENDATIONS FOR ENGLESBY BROOK

A suite of stormwater retrofit and stream rehabilitation sites were identified and prioritized for further design, as detailed in Section 3. The pollutant loading and removal analysis presented in Section 2.2 provided supporting information for the selection of retrofits and serves as a good analysis tool to assess the benefits of the proposed management plan. This section summarizes the results of Phase I, which helped formulate the basis for developing specific management recommendations and identified targeted areas of the watershed as priorities for project implementation. In addition, this section describes how the structural retrofit and stream rehabilitation recommendations from Phase I were carried forward to concept design phase. Lastly, the overall watershed management strategy, combining both structural and nonstructural (i.e., pollution prevention programs) approaches, is presented and assessed in terms of pollutant reduction potential.

6.1 Watershed Rehabilitation Management Strategy

It was previously established that, due to the existing conditions of Englesby Brook, it falls under the "impacted stream" classification and that management approaches and expectations should be consistent with this designation. However, it is also important to establish some ambitious goals for rehabilitation as a component of an effective and successful management plan for an "impacted stream." The specific Englesby Brook watershed protection goals (see Section 1.1) were developed with this in mind. The goal of reducing bacteria loads to Blanchard Beach to make it "swimmable" most of the time is a good example of a higher (yet realistic) goal that is an important focus point of the overall management plan. The management strategy presented in this Section strives to achieve the more ambitious protection goals.

As past research and discussion has revealed, there are several watershed management tools available to help restore an "impacted" watershed. Some of the tools are "structural" practices that involve physical watershed control measures. Other tools are "nonstructural" practices that include citizen behavior modification to encourage pollution prevention, watershed stewardship education, reforestation, and aquatic buffer enhancement. An effective watershed plan should have a balance of both structural and nonstructural approaches to help achieve the goals, because we can't achieve the goals with one alone.

6.2 Structural Controls

As described in Section 3, 17 candidate stormwater management retrofit sites were originally identified (using available watershed mapping resources) and field investigated to verify technical feasibility and to identify the most likely management practice for each site. (Appendix D contains the completed retrofit inventory form for each of the 17 candidate sites.) Four of the 17 candidate sites were dropped after the field screening for a variety of reasons (again, see Appendix D). Initial retrofit recommendations were prepared for the remaining 13 sites and a prioritization process ranked the sites for future implementation. The process identified seven priority candidate sites for further investigation through the development of detailed conceptual designs. The Project Oversight Committee reviewed and discussed the priority sites at a July 26, 2000 meeting. Subsequent to the meeting, the Center was instructed to proceed with the concept designs for the seven priority sites. These priority sites represent the "Tier 1" retrofit projects. Appendix G contains the detailed drawings and associated computations for each site. "Tier 2" projects are comprised of the remaining 6 candidate sites, and may be desirable for future consideration or if some Tier 1 sites are subsequently eliminated.

Section 3 also identified eight locations as candidates for stream rehabilitation. A formal ranking system for these sites was not necessary since the logical implementation of the sites compliments the implementation of the priority retrofit sites. Based on this complimentary relationship, five stream rehabilitation sites were identified as Tier 1 sites that should be pursued through the development of detailed conceptual designs. Similar to the stormwater management retrofit sites, the Project Oversight Committee reviewed and discussed the priority stream rehabilitation sites at the July 26, 2000 meeting, and agreed that the Center should proceed with concept designs for the five sites.

The Tier 1 structural controls component has been developed to optimize the pollutant removal and channel protection capabilities of retrofits by associating the retrofit(s) with stream stabilization improvements where feasible. Table 6.1 describes the individual concepts that comprise the Tier 1 recommendations. Table 6.2 presents the justification for grouping and prioritizing the Tier 1 retrofits and stream rehabilitation sites. Figure 6.1 illustrates the locations of the recommended retrofit and stream rehabilitation sites that comprise the management plan. Figures 6.2 through 6.5 show selected Tier 1 sites (O8, SM5, SR8, and SR7, respectively) as they currently exist.

Table 6.1 Description of Tier 1 Structural Controls

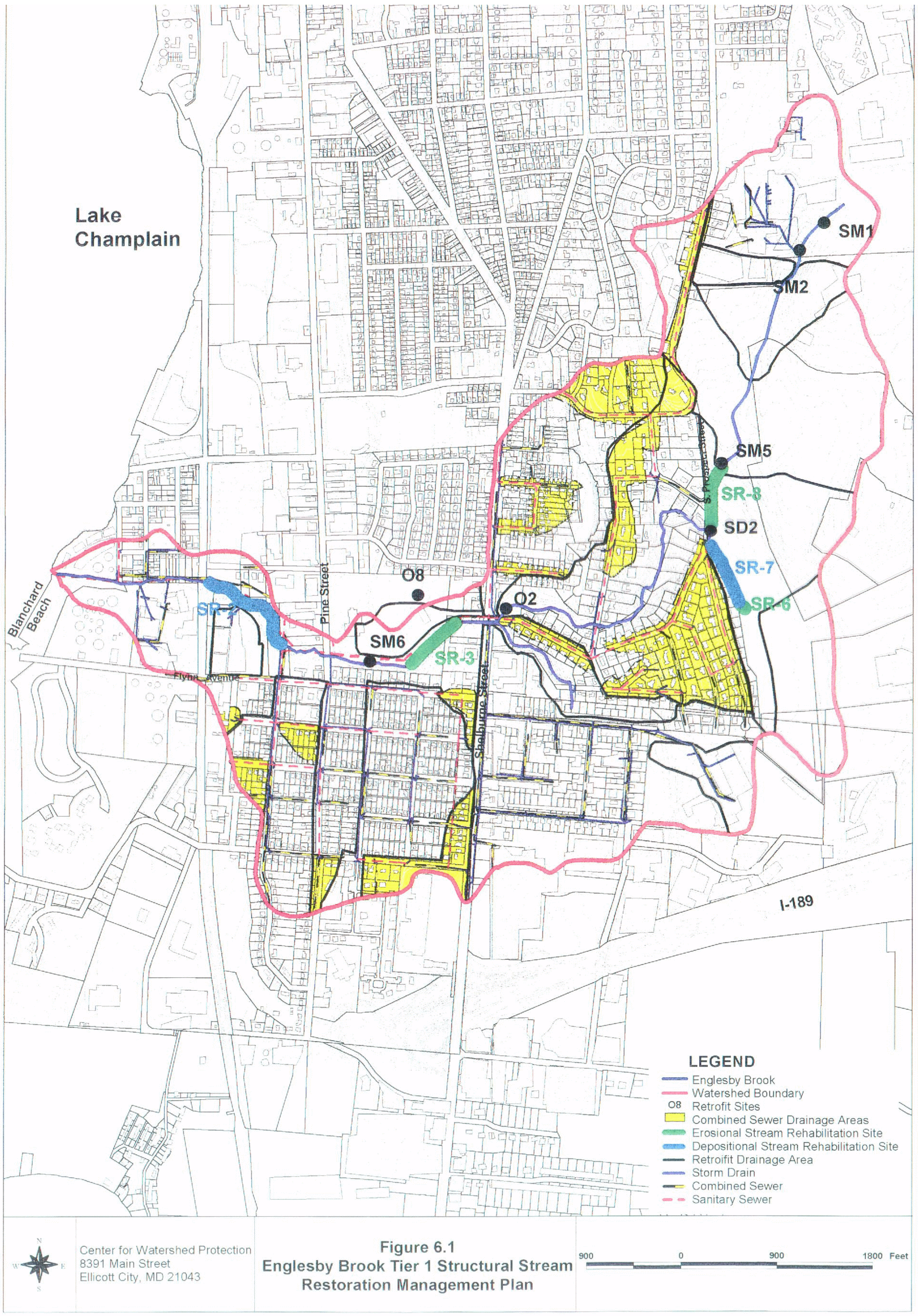
Site ID	Description
O8	This site is located just northwest of the Burlington School District Maintenance facility behind Champlain Elementary School. The site is located entirely on public land. The site concept entails excavating a wet extended detention (ED) facility at the site to receive the discharge from over 100 acres of drainage from the Shelburne Road corridor. The entire water quality storm (i.e., 1 inch rainfall) from this large drainage area will be conveyed to the wet pond. Excess flows and volume will be bypassed at several locations to existing and planned outfalls to Englesby Brook. The major features of the wet ED pond facility include a forebay and deep pool area with some aquatic benches around the periphery. A concrete riser will serve as the principle spillway, with a low flow reverse-slope pipe to allow for extended detention. An earthen emergency spillway is also provided to safely convey extreme flows to downstream conveyances.
O2	This site is located on the northeast corner of the intersection of Shelburne Road and Prospect Parkway. The site is located on private property, which is a significant limitation. The concept is to create a wet ED facility in the existing landscape depression to provide water quality storage. The existing culvert under Prospect Parkway will be modified for the design. The facility is "on line" and the major features of the include a forebay and micropool area with some aquatic benches around the periphery.
SR3,SR6 & SR 8	These three stream rehabilitation sites, while located along different reaches of stream, all incorporate the same basic design concept to address the channel erosion that has occurred in the vicinity. Specifically, the concept design involves sloping back and shaping the upper portion of the bank and planting the areas with shrubs and trees.
SM5	This site is on the Burlington Country Club property. The concept involves expanding two of the existing ponds to provide water quality and channel protection storage. The modification is also intended to improve the irrigation system for the golf course. To the extent feasible, existing infrastructure (i.e., outlet structures and pipes) are used to meet the design goals. Both ponds discharge to channels that ultimately flow to site SD2.

Site ID	Description
SD2	This retrofit is primarily a drainage/conveyance system improvement. Any water quality benefits will be fairly minor. Nevertheless, the improvement to the culvert will relieve flooding pressure on downstream homeowners and reduce the frequency for necessary maintenance.
SR7 & SR2	Similar to the other three stream rehabilitation sites, these two sites share the same basic design approach. Both of these sites are areas where aggradation (i.e., sediment deposition) has occurred. The concept involves plantings along the main channel to hold sediment in place.
SM1/SM2	This site is the location of two existing stormwater ponds on the UVM Redstone Campus. The concept for the site involves converting the two ponds, which are not currently in series, to a single facility to provide both water quality (100%) and channel protection (87%) storage volume. The major features of the multiple pond facility include forebays at multiple inflow points and deep pool areas with some aquatic benches around the periphery on both ponds. A weir wall will serve as the principle spillway from the upper to the lower pond and a concrete riser will serve as the principle spillway from the lower pond.
SM6	This site is located where there is an existing compost filter just north of Richardson Street and Flynn Avenue. The site concept entails removing the existing filter, realigning the existing stream channel to the north, and construction of a shallow marsh wetland in the vicinity of the current channel to receive the discharge from the water quality storm (i.e., 1 inch rainfall) for the 38 acres of residential land use that drain to the site. About 40 percent of the target water quality volume will be treated by the facility. Excess flow and volume will bypass downstream at a stabilized outfall. The major features of the shallow marsh wetland facility include a forebay and deeper pool areas with some aquatic benches. A weir wall will serve as the principle spillway, with a low flow notch to allow for some extended detention.

Table 6.2 Justification for Tier 1 Retrofit and Rehabilitation Projects

Recommended Projects for Implementation	Justification
Stormwater retrofit: O8	Provides the greatest pollutant load reduction of any proposed retrofit and represents one of the few areas (and perhaps only) where management of the runoff from this drainage area can occur.
Stormwater retrofit: O2 Stream Rehabilitation: SR3	Combines retrofit with downstream stream rehabilitation efforts and provides substantial pollutant load reduction opportunities.
Stormwater retrofit: SM5 and SD2 Stream Rehabilitation: SR6, SR7, and SR8	SM5 provides 100% of channel protection storage volume and a large percentage of the 5-year storm which helps the conveyance of site SD2. Combines stream rehabilitation with upstream retrofits to reduce sediment and nutrient load generated at and upstream of the golf course. Consolidates construction disturbances.
Stormwater retrofit: SM1/SM2	One of the few opportunities where 100% of the target water quality and channel protection volumes can be provided. Provides initial treatment in the headwaters of the watershed.
Stormwater retrofit: SM6	Good opportunity to use more natural approach to improve the effectiveness in vicinity of current compost filter, which has had a nominal ability to reduce loads. Effectiveness will be enhanced by upstream stream rehabilitation and stormwater retrofit efforts.
Stream Rehabilitation: SR2	A minimum disturbance approach to improving the habitat along this reach. Effect of effort will be largely dependent on success of upstream implementation.

Figure 6.1 Watershed Analysis Map



The site concept at O8 entails excavating a wet extended detention facility at the site to treat runoff from over 100 acres of drainage from the Shelburne Road corridor. The entire water quality storm (i.e., 1 inch rainfall) from this drainage area will be conveyed to the pond. Excess flows and volume will be bypassed at several locations to existing and planned outfalls to Englesby Brook.

Figure 6.2 Retrofit Site O8 (School Maintenance Facility)

This concept at Burlington Country Club involves expanding two of the existing ponds to provide water quality and channel protection storage. The modification is also intended to improve the irrigation system for the golf course. To the extent feasible, existing outlet structures and pipes are used to meet the design goals. Both ponds will continue to discharge to channels that ultimately flow to site SD2.

Figure 6.3 Retrofit Site SM5 (Lower Pond)

This reach is downstream of a golf course pond and is experiencing channel degradation in the form of toe erosion and subsequent bank sloughing. The design concept is to provide toe protection in the form of a boulder revetment. The upper portion of the bank will be sloped back and revegetated with plantings (i.e., live stakes).

Figure 6.4 Stream Restoration Site SR8 (Looking Upstream)

Significant deposition of sand and silty sand sediment is occurring along this reach. The concept along this reach of stream is to better define a low flow channel using coir fiber logs. The intent of this linear vegetative practice is to stabilize the eroding streambanks and provide a means of "tying up" introduced sediment loads.

Figure 6.5 Stream Restoration Site SR7 (Looking Upstream)

The pollutant loading analysis presented in Section 2.2 provided additional information that was used to evaluate the benefit that individual and groups of retrofits have on the watershed and receiving water. The analysis assessed the relative effectiveness of the proposed retrofits on reducing the load to the watershed. One of the important considerations in the analysis was how to treat "nested" stormwater management practices (i.e., practices that occur in a series whereby runoff is being managed more than once). As previously mentioned, it is important to recognize that sites O2, SM5, and SM1/SM2 are "nested," such that the tributary drainage areas to sites SM1/SM2 and SM5 are fully contained within the tributary drainage area of O2. To account for this in the assessment of the proposed plan above, the same approach as described in Section 2.2 was used. Simply stated, a reduced removal efficiency is assumed for the second (SM5) and third (O2) retrofit facility in series. Any additional tributary area that is introduced between practices, however, is assumed to receive the higher removal rates for the practice.

Using this analysis, it was possible to assess the pollutant removal capability of the Tier 1 management plan on a watershed basis. Table 6.3 presents the results of this analysis.

Table 6.3 Watershed Load Removed Assuming Tier 1 Management Plan in Place

Candidate Site ID	TN (lbs/yr)	TP (lbs/yr)	TSS (lbs/yr)	E. coli (# x 10^9/year)
Total Watershed Load	1071	248	145551	16486
O2	67	18	7082	757
O8	168	37	18302	1780
SM1,SM2	49	12	5542	530
SM5	89	25	9257	980
SM6	22	4	2273	259
SD2	0	0	0	0
Total Removed Load	**397**	**95**	**42456**	**4307**
% of Watershed Load	**37%**	**38%**	**29%**	**26%**

The total drainage area controlled by the Tier 1 retrofit sites is approximately 380 acres. Since the drainage area of Englesby Brook is approximately 600 acres, approximately 63%[15] of the watershed will ultimately drain to an effective stormwater management facility under the Tier 1 approach. As shown in Table 6.3, implementation of these retrofit measures should result in as much as a 38% reduction in pollutant load (for total phosphorus). While the sediment load reduction of 29% may not appear to be that significant, it is important to remember that this removal estimate is conservative, in that it does not take into account the additional pollutant load reduction that will result from implementation of the stream rehabilitation measures, channel protection storage provided by retrofit ponds (which is effectively provided for entire watershed east of Shelburne

[15] As mentioned in Section 3.1, an effective retrofit strategy attempts to capture at least 50% of the watershed.

Road), nor pollution prevention efforts. It is difficult to quantify the load reduction associated with the above measures; however, it is of note that the priority stream rehabilitation sites have a total length of approximately 1,730 linear feet, which is approximately 90% of the total length of eroding stream. An estimate of the pollutant removal effectiveness of proposed pollution prevention measures is provided in Section 6.3.2. Continued monitoring at the USGS gage will provide a good measure of the collective effectiveness of the management plan measures (see Section 7 for discussion of follow-up monitoring).

Cost is another important factor to consider when evaluating proposed retrofits. A preliminary cost estimate was developed and considered for each of the candidate retrofits as part of the ranking exercise (see Section 3.1.2). More refined planning level construction cost estimates are possible for the Tier 1 sites due a higher level of detail associated with the concept drawings. Table 6.4 provides a summary of the estimated planning level construction costs for the Tier 1 sites. More detailed cost breakdowns for the stormwater retrofit sites are provided at the end of Appendix G. These costs represent construction costs only, and do not reflect likely additional costs such as: planning/engineering design, geotechnical investigation, construction administration, land acquisition, and legal services.

Table 6.4 Planning Level Construction Costs for Tier 1 Sites

Practice Type	Site ID	Estimated Cost [$]
Stormwater Management	O2	$63,000
	O8	$232,000
	SM1,SM2	$65,000
	SM5	$87,000
	SM6	$88,000
	SD2	$66,000
	Sub-Total	**$601,000**
Stream Rehabilitation	SR2	$35,000
	SR3	$75,000
	SR6	$1,500
	SR7	$10,000
	SR8	$15,000
	Sub-Total	**$136,500**
	Total	**$737,500**

It is important to recognize that there are additional operation and maintenance (O&M) costs that need to be taken into consideration for long term planning for any proposed facility. These annual costs can vary, but as a general rule of thumb, are approximately 5% of the capital cost of a pond or wetland facility (Caraco, 1998). Appendix H contains guidance and a checklist for the operation, maintenance and inspection of the Tier 1 structural retrofits (i.e., ponds and wetlands).

A comparison of the Tier 1 structural controls versus implementation of all of the structural control sites is instructive in terms of logical and economic benefits that the proposed management approach provide. Table 6.5 summarizes some of the key points.

Table 6.5 Comparison of Watershed Benefits Between Tier 1 Implementation and Full Implementation

	Tier 1 Implementation	Full Watershed	Tier 1 as a % of Full Watershed
Watershed Area Treated (Ac)	380	418	91%
% of Total Watershed Load Removed (TN)	37%	44%	84%
% of Total Watershed Load Removed (TP)	38%	45%	84%
% of Total Watershed Load Removed (TSS)	29%	35%	83%
% of Total Watershed Load Removed (E. coli)	26%	30%	87%
Estimated Construction Cost	$601,000	$907,300	66%

Note: Stream rehabilitation sites are not included in Table 6.5 due to the uncertainty of the pollutant removal capabilities of these practices. From a cost standpoint, the difference between the Tier 1 and Full Watershed implementation is proportionally about the same (i.e., 67%), when stream rehabilitation sites are considered.

Table 6.5 indicates that for about two thirds of the cost, the Tier 1 approach will still achieve approximately 85% of the potential pollutant load reduction that full watershed implementation can yield.

The exact amount of pollutant load reduction and channel erosion mitigation will depend on the ultimate design configurations of the stormwater retrofits and stream rehabilitation sites, as well as the number of sites that are ultimately constructed.

While all of the stormwater retrofit and stream rehabilitation sites are valid candidates for further investigation and design, the reality is that fiscal and staff resources will limit the number of projects that can be implemented in a timely fashion. In addition, it is most appropriate to implement projects that complement each other and limit the overall disturbance of existing natural resources as much as possible. In other words, those sites that should be pursued first should be pursued in the context of the overall benefit to the watershed and Lake Champlain through a management strategy and approach that seeks to combine stormwater retrofits with other rehabilitation strategies. Ultimately, however, the City may wish to implement all of the sites to maximize the benefits.

6.3 Nonstructural Controls

Nonstructural controls are, in our view, an equally important component to a watershed management plan. It has been a long standing tenet of stormwater treatment that it is more cost effective to prevent or minimize pollution at the source than to treat it once it is in the drainage and receiving water system. The challenge of nonstructural controls is that they often require behavior modification and a sustained commitment to change. Equally imposing is the challenge of assessing the efficacy of nonstructural controls, which is often needed to maintain funding mechanisms.

Section 5 and Appendix F identify priority pollution prevention efforts for the Englesby Brook watershed. The recommendations are directed towards the following important goals established for the watershed restoration project:

- Reduce bacteria loads to Blanchard Beach,
- Reduce pollutant loads to Lake Champlain, and
- Reduce odor and debris in Englesby Brook.

Based on the priority assigned (which is a function of anticipated program effectiveness) and relative cost of various pollution prevention efforts (see Table 5.1), the following six nonstructural programs are recommended for Tier 1 implementation (Table 6.6). Estimating costs for these programs is challenging and will vary substantially based on outside resources. For example, public education costs can be significantly reduced if they are combined with other efforts that are spearheaded by the Lake Champlain Committee efforts. As a rough planning estimate, it can be assumed that all of the programs listed in Table 6.6 can likely be implemented over a one year period in the Englesby Brook watershed for between $80,000 and $120,000. However, to have long-term effectiveness, most of these programs need to be in place and supported over a period of several years or indefinitely (as in the case of street sweeping).

Table 6.6 Tier 1 Nonstructural Pollution Prevention Program Recommendations

Tier 1 Program Recommendation	Program Components
Pet Waste Management	• Signage and waste disposal stations • Establishment of dog park • Fact sheets and limited media campaign
Lawn Care	• Promotion of soil testing through UVM • Recognize citizens using proper practices
Disconnection of Directly Connected Impervious Areas	• Institute downspout disconnection and rain barrel program
Street Sweeping	• Maintain and enhance current street sweeping program
Illicit Connection Detection and Removal	• Monitor and eliminate illicit connections
Dumpster Management	• Locate away from storm drain inlets and riparian buffers • Promote/require use enclosed holding areas

6.3.1 Comprehensive Urban Source Spreadsheet (CUSS) Background

Estimating the pollutant load reduction capability of these recommendations is obviously quite challenging, as unlike stormwater treatment practices, most stormwater pollution prevention programs do not have a great deal of monitoring data to assess their performance. Recently, however, the Center has developed a simple spreadsheet model called the Comprehensive Urban Source Spreadsheet (CUSS), which has a subroutine component that estimates pollutant removal associated with pollution prevention practices (CWP, 2000). Using the CUSS Model and the results from the pollutant load modeling conducted in Section 2.2, the Center developed estimates of program effectiveness and load reduction capability for the Englesby Brook Tier 1 nonstructural recommendations[16].

The CUSS Model methodology is somewhat unusual in that it estimates ideal pollutant removals based on current technology, and then "discounts" the removal based on programmatic limitations and design flaws. For example, factors such as participation in a public education program will affect the ultimate removal rates of pollution prevention practices or programs. The CUSS model accounts for these reductions by applying a series of discount factors to the ideal pollutant removal calculated for a program in order to reflect the true long-term removal efficiency. This approach gives credit to programs with adequate staff and design standards to ensure that practices perform well over time. It also reflects the loss in practice effectiveness that results when practices are improperly designed or maintained. Assumptions used in the model are based on available national data, and best professional judgement. Where possible, local watershed information is used to supplant the CUSS defaults (CWP, 2000). For example, information from the watershed behavior survey (Appendix E) was used to develop refined estimates of nutrient application rates for lawns. Table 6.7 summarizes the load reduction procedures and discount factors associated with the Tier 1 program recommendations. A brief overview of the algorithms and assumptions used to develop both the ideal load reductions and discount factors are provided below. A more detailed description and supporting documentation is provided in Appendix I.

[16] Dumpster management was not modeled with CUSS since the primary benefit of the practice is odor and debris control, which are not modeled parameters.

Table 6.7 Procedures for Calculating Load Reductions from Tier 1 Programs

Management Practice	Target Pollutant(s)	General Procedure for Determining Ideal Removal	Discount Factor(s)
Residential Education	Nutrients, Bacteria	Depending on the educational program, reduce the load associated with the behavior	D_1: Applicability D_2: Awareness D_3: Interest
Street Sweeping	Sediment, Nutrients	Reduce the concentration of pollutants in street and parking lot runoff depending on the type of sweeper and sweeping schedule.	D_1: Frequency D_2: Technique
Impervious Cover Disconnection - Residential	All	Eliminate the rooftop component of impervious cover.	D_1: Applicability D_2: Awareness D_3: Interest
Illicit Connection Removal	All	Eliminate the load from illicit connections	D_1: Survey D_2: Implementation

Residential Education
A variety of public education programs may help to reduce the concentration of nutrients, sediment and bacteria in urban streams. In this section, the focus is only on programs to address lawn care and pet waste. Several other residential pollution prevention programs improve water quality, but have little effect on nutrients, suspended solids, and bacteria specifically. For example, household hazardous waste programs are effective at reducing toxics but do not have a large impact on the loads of suspended solids, nutrients, or bacteria.

Lawn Care
The ideal pollutant removal associated with lawn care would be achieved if all the additional fertilizer applied to turf (e.g., residential pervious land) were eliminated. The nutrient cycle in urban lawns is not very well understood, and data on citizen behavior is quite variable as well. The assumptions presented below represent broad generalizations derived from a review of scientific literature (Starr and DeRoo, 1981; Petrovik, 1990; Schueler, 1995a). It is important to note also, that there is very little information on the fate of phosphorous fertilizers applied to turf grass. Assumptions made when calculating load reduction include the following:

- Residents apply approximately 117 lbs/acre/year of nitrogen, and 13 lbs/acre/year of phosphorous.
- Citizens will reduce this application rate by 50%.
- Twenty five percent of the reduction in application of nitrogen would have been lost in runoff or infiltration, or returned to the watershed after volatilization of ammonia.
- Although very little data are available on the fate of phosphorous applied to turf grass, it is assumed that much less is lost to the environment, because phosphorous does not generally leach into groundwater, and does not volatilize. Thus, it was assumed that only

10% of applied phosphorous is lost to the environment.
- 80% of residential pervious surfaces are managed as turf.

Pet Waste
In the urban watershed, dogs are a significant contributor of bacteria, and may also contribute a substantial amount of nutrients. Ideally, a pet waste program would reduce this source to zero, with all homeowners properly disposing of waste. The following assumptions can be made regarding the contribution of pet waste to urban nonpoint source pollution:

- 50% of households own a dog (based on survey response).
- 65% of fecal coliform die before reaching the stream (based on a decay rate of 1/day and a decay time of one day on average; Hydroqual, 1996)
- 75% of nitrogen is delivered to the stream
- 75% of phosphorous is delivered to the stream
- Dog waste characteristics are described in Table I.1

Discount Factors
Residential pollution prevention programs are limited primarily by the community's ability to reach the public and change their behavior. The values of these factors depend on the type of program (e.g., pet waste versus lawn care) and the type of media used to distribute the message. Three discount factors that reflect the challenge of changing the public's behavior are as follows:

D_1: Applicability: Fraction who are in the target audience
D_2: Awareness: Fraction who remember the message
D_3: Participation: Fraction who are willing to change their behavior

D_1: Applicability Factor
The fraction of the watershed in the target audience depends on the behavior being addressed. Estimates of the target audience fraction for the two education programs were based, in part, on the results from the survey conducted at the March 2000 workshop. For this assessment, values of 0.3 and 0.2 were applied as the applicability factor for lawn care and pet waste management, respectively.

D_2: Awareness Factor
Even if a message reaches the target audience, many of the individuals in the audience may not remember it. Research suggests a wide range of possible "recall rates," depending on the intensity of effort, the type of media used, and the population targeted. For this assessment values of 0.5 and 0.3 were used for lawn care education and pet waste management awareness, respectively. These factors are slightly higher than national recall estimates and are based on the assumption that the campaign would be quite targeted and focus on Englesby Brook residents. A lower awareness factor would likely be more appropriate if the campaign were simply a citywide initiative.

D_3: Participation Factor

In a voluntary program, some fraction of the population will be unwilling to change its behavior. This fraction depends on the activity targeted with the education effort. For this analysis, values of D_3 for lawn fertilization and pet waste clean-up were assumed to be 0.8 and 0.5, respectively. The high participation factor assumed for the lawn care reflects the anecdotal evidence that Burlington residents are generally avid lawn and garden care participants.

Street Sweeping
The CUSS Model accounts for street sweeping by reducing the concentration value of TSS, N and P from road runoff. The user inputs the acres of roadway swept for four types of streets: roadways (i.e., highways), residential streets, commercial streets, and industrial streets. For each street type, the load reduction from street sweeping is calculated by multiplying the load by the efficiency of street sweeping. The load from each street type swept is the product of the total load from the associated land use and the fraction of impervious area swept in that land use.

The "best case" estimate of street sweeping efficiencies assumes weekly sweeping. Sediment removals are derived from a modeling study conducted in Portland, Oregon (Claytor, 1999). Other research suggests that the performance of street sweeping for phosphorous is roughly 80% of the performance for suspended solids (Kurahashi and Associates, 1997). The CUSS model assumes that the removal for nitrogen is the same as for phosphorous. In addition, the performance for different constituents will vary depending on the type of sweeper being used (e.g., mechanical, regenerative air, or vacuum assisted).

Discount Factors
Discount factors for street sweeping reflect the frequency of sweeping and "technique" (i.e., the amount of the street surface that is swept). The "frequency factor" (D_1) reduces effectiveness if sweeping is less frequent than once per week. Reducing sweeping frequency to monthly can reduce the efficiency to approximately 60% of the efficiency for weekly sweeping (Claytor, 1999). The "technique factor" (D_2) accounts for reductions in efficiency caused when sweeper operators do not sweep the entire road surface. This typically happens when cars are parked on the streets, or when operators are improperly trained. For the Englesby Brook assessment, it was assumed that a sweeping program would have a mixture of monthly and weekly frequency, depending on road type ($D_1 = 0.73$), and that parking restrictions and operator training existed ($D_2 = 1.0$).

Impervious Cover Disconnection
The CUSS Model evaluates impervious cover disconnection from both residential and commercial rooftops. While the same basic methodology is used to calculate removal from each type of disconnection, specific values and assumptions for each differ.

Residential
Disconnecting the runoff from residential rooftops can effectively reduce the total impervious cover in a drainage area. The CUSS Model calculates the load reduction as based on the ratio of rooftop area to total impervious cover in a subwatershed. In some cases, it may be possible to disconnect

rooftops from commercial land as well.

Discount Factors
Discount factors for rooftop disconnection reflect the fraction of households or businesses where rooftop disconnection is applied. Participation is estimated based on three discount factors: the fraction of land where the technique can be practically applied, the fraction of residents who are aware of the educational message, and the fraction of residents willing to participate in the program. For this Englesby Brook assessment the assumed discount factors for residential areas were 0.2, 0.08, and 0.25, respectively. For commercial areas, the three factors were 0.25, 1.00, and 0.1, respectively.

Slightly different methodologies are used to predict participation in commercial and residential rooftop disconnection programs. For residential rooftop disconnection, the Model assumes that a broad education program is implemented. For commercial programs, the Model assumes that the community uses a more targeted program that addresses businesses individually.

In general, the Model assumptions regarding participation in rooftop disconnection programs are conservative when compared with other urban educational programs. This conservative approach is used primarily because disconnecting rooftop runoff requires some structural modification. In a commercial setting in particular, where little space is available to direct rooftop runoff, the Model assumes that a relatively small fraction of businesses (roughly 10%) will participate without an economic incentive. Further, it assumes that disconnection is only feasible on approximately 25% of commercial land.

Illicit Connection Removal
Optimistically, an illicit connection program would remove the load from illicit connections. This reduction is then multiplied by two discount factors: a survey factor (D_1) which represents the fraction of the sewer system where the illicit connection survey is conducted, and an implementation factor (D_2), which represents the fraction of illicit connections found that will be removed.

6.3.2 Nonstructural Load Reduction Estimates

In addition to the general assumptions and discount factors that are applied in the CUSS Model, it is also necessary to provide estimates of various input information, such as number of dwelling units, average rooftop area, soil type distributions, and area of roads and parking lots. Where feasible, these estimates were based on the available GIS coverages. In the absence of this level of information, best professional judgement was used based on communications with Burlington DPW staff and numerous watershed reconnaissance surveys. Table 6.8 presents the results of the modeling analysis in terms of estimated load reductions.

Table 6.8 Estimated Load Removed Assuming Tier 1 Pollution Prevention Recommendations in Place

Tier 1 Pollution Prevention Program Recommendation	TN (lbs/yr)	TP (lbs/yr)	TSS (lbs/yr)	E. coli (# x 10^9/year)
Total Watershed Load	1071	248	145551	16486
Pet Waste Management	79	11	0	5298
Lawn Care	230	10	0	0
Disconnection of Impervious Areas	9	0	122	19
Street Sweeping	84	10	3779	0
Illicit Connection Detection and Removal	15	21	127	1666
Total Removed Load	**417**	**52**	**4028**	**6983**
% of Watershed Load	**39%**	**21%**	**3%**	**42%**

The results of the modeling analysis indicate that the proposed measures have the greatest effect on reducing nutrients (primarily nitrogen) and bacteria loads, and that resident behavior (associated with lawn care practices and pet waste management) and illicit connection detection and correction are the programs that appear to be the most effective. The fact that there is not a significant reduction in sediment load projected by the model is consistent with observations that have been made in the watershed as well as recent street sweeper monitoring data. Specifically, and as discussed in Section 2, there is a significant portion of the total watershed sediment load that is channel derived and therefore unavailable for treatment or removal. In addition, while street sweeping had an order of magnitude greater load removal capability than the other pollution prevention programs, recent research out of Madison, WI (Bannerman, 2000) indicates that the effectiveness of even the most advanced street sweeper technology (i.e., vacuum assisted) is limited, with preliminary reported TSS removals of about 30%. Other researchers have reported vacuum assisted sweeper efficiencies as high as 80% (Sutherland, 1997); however, these data are associated with modeling (i.e., simulation) efforts, as opposed to actual field monitoring (as Bannerman and his colleagues are doing).

As a result of these initial street sweeping estimates and field data, it is not recommended that the City of Burlington pursue the acquisition of a state-of-the-art vacuum assisted sweeper at this time. While street sweeping appears to have a relatively small contribution to the overall sediment load reduction in Englesby Brook, the Center still recommends that a routine sweeping frequency (particularly during the spring) with the City's mechanical equipment be maintained. Indirect benefits of such a program include improved aesthetics, reduced maintenance on storm drains, combined sewers, and catch basins, and improved air quality.

6.4 Full Tier 1 Load Reduction Estimates

In order to understand planning level watershed benefits derived by a broad-based watershed restoration effort, it is instructive to combine the load reduction projections associated with both the Tier 1 structural and nonstructural practices (Tables 6.3 and 6.8, respectively). In actuality, these projections (Table 6.9) are slightly higher than what should be expected due to the fact that nonstructural pollution prevention efforts will be occurring upstream of some of the structural retrofit sites. In general, this will lead to reduced pollutant loads being delivered to the structural facilities which often results in somewhat lower removal efficiencies at the structures. This is similar to the "nested" treatment practice phenomenon that was previously described in Sections 2.2 and 6.2. Using site O8 as an example, and assuming that a lawn care education program is in place, there will be a reduced nutrient load delivered to the facility. As a result, instead of the estimated nitrogen and phosphorus removal efficiencies of 33% and 50%, respectively, one might expect removals in the range of 25-30% and 40-45%, respectively.

Table 6.9 Total Potential Watershed Benefits for Full Tier 1 Implementation

	Tier 1 Implementation
% of Total Watershed Load Removed (TN)	76%
% of Total Watershed Load Removed (TP)	59%
% of Total Watershed Load Removed (TSS)	32%
% of Total Watershed Load Removed (E. coli)	68%

Note: The load reduction benefits from stream rehabilitation sites are not included in Table 6.9 due to the uncertainty of the pollutant removal capabilities of these practices.

While it may not be realistic to expect that all of the Tier 1 projects and programs will be implemented (especially some of the structural retrofits), it is nonetheless encouraging to know that 50% annual load reduction for nutrients and bacteria should be attainable over time with most of the recommended projects and programs in place. The reduction in annual sediment load is more difficult to project and is probably underestimated in Table 6.9 because it does not account for the reductions resulting from water quantity control (in the form of channel protection storage) at the proposed structural retrofit sites and the streambank stabilization efforts. It is of note that the identified stream rehabilitation sites have a total length of approximately 1,730 linear feet which is approximately 90% of the total length of eroding stream. Since almost half of the watershed sediment load is estimated to be derived from channel (or non-upland) sources (see Section 2.2), it is reasonable to assume a total potential watershed sediment load reduction exceeding 50%.

6.5 Keystone Recommendations

It is probably apparent to the reader at this point that there are a number of challenging decisions and evaluations that need to be made in the process of developing a watershed restoration plan. Many of these factors were considered in the development of the Tier 1 recommendations. Nevertheless, the reality of watershed planning and restoration efforts is that there are usually insurmountable obstacles that prevent some of the recommendations from being implemented, whether it be due to property ownership, fiscal, political, or other reasons. With this in mind, the Center has developed what we consider to be the "Keystone Recommendations" of the proposed Tier 1 management plan. The Keystone Recommendations should be thought of as those practices and programs that will not only provide some of the best opportunities for pollutant load reduction, but also seem to have the most realistic opportunity for being implemented in the watershed. That is certainly not to say that the other projects are less valuable or not worth pursuing further, but rather that the Keystone Recommendations can hopefully be implemented easier than the other Tier 1 recommendations and can help initiate a process which, when measurable improvements in watershed health are observed, will lead to implementation of remaining Tier 1 projects. Table 6.10 presents the Keystone Recommendations and provides justification for including them.

Table 6.10 Keystone Recommendations and Justification

Keystone Recommendations for Implementation	Justification
Stormwater retrofit: O8	Provides the greatest pollutant load reduction of any proposed retrofit and represents one of the few areas (and perhaps only) where management of the runoff from this drainage area can occur. Site is located on public land which may ease approval process.
Stormwater retrofit: SM5 and SD2 Stream rehabilitation: SR6, SR7, and SR8	Combines stream rehabilitation with upstream retrofits to reduce sediment and nutrient load generated at and upstream of the golf course. Consolidates construction disturbances. Initial indication of a willing partner.
Pet waste management and lawn care education	Together provide the most cost effective form of pollution prevention for nutrient and bacteria loads. Indirectly, the education effort should foster a sense of ownership of the residents in the watershed and increase awareness about the resource that they share.
Illicit connection detection and removal	This is a critical pollution prevention effort that directly relates to whether Blanchard Beach will reopen and specifically addresses dry weather loads that may impair the beach. There is clearly a bacteria load problem with the infrastructure associated with the Shelburne Road corridor. This type of program should provide conclusive evidence on the primary source of the loads.

SECTION 7. WATERSHED MANAGEMENT PLAN ASSESSMENT

It is critical to view this Englesby Brook Watershed Restoration Plan as a living document that is subject to change as more and better information is collected and compiled. Having a method to assess the efficacy of the implemented measures and a basis from which to recommend modifications to the plan is a critical piece to the overall plan. Together, the implementation and assessment of the restoration plan effectively becomes a watershed management cycle, where various management issues are revisited on a staggered but regular basis. This management cycle allows for the plan to evolve and grow with changing watershed conditions. This section discusses recommended methods to assess and monitor the effectiveness of the proposed watershed restoration measures.

Traditionally, the focus of monitoring efforts to assess the quality of receiving waters has been end-of-pipe chemical and physical water quality criteria and analysis. In the last decade, however, many stormwater management professionals have begun to question the ability of traditional monitoring to accurately describe existing conditions in receiving waters, evaluate the overall integrity of aquatic communities, and assess the degree of improvement in stream systems. Instead, there has been a steady shift towards the use of "environmental indicators" to more accurately assess the condition(s) of receiving waters and the performance of stormwater management efforts.

Environmental indicators can be viewed as analogous to economic indicators such as housing starts, new construction gains, and the Dow Jones Industrial index which, although based on diverse measurements, when examined in combination, give a general indication of improvements or downturns in the economy and the success of various economic strategies. Similarly, environmental indicators, when examined in combination, give a general indication of improvements or downturns in the environment and the effectiveness of resource management strategies.

Environmental indicators can include a vast array of monitoring parameters applicable to a variety of management goals and environmental resources. The focus of this section is on a subset of environmental indicators referred to as "stormwater indicators," which specifically focus on urban stormwater runoff impacts and can be used to assess the success (or failure) of stormwater management efforts.

7.1 Recommended Englesby Brook Stormwater Indicators

A goal of the Center's recommended watershed restoration plan assessment approach is to utilize stormwater indicators to the maximum extent practical to guide current and future management decisions. The recommendations presented in this section are oriented towards conducting inexpensive, repeatable, and scientifically valid monitoring to assess future stream quality health. The monitoring of indicators will provide a key frame of reference and basis for updating and adjusting the Englesby Brook Watershed Restoration Plan.

The indicators, organized into five categories, represent both traditional and less frequently used assessment methods. A total of ten indicators (Table 7.1) have been identified and recommended for implementation to comprehensively assess the efficacy of the Englesby Brook Watershed Restoration Plan. Short summaries of each indicator are provided below, and Appendix J provides detailed "Profile Sheets" for each indicator summarizing key information such as: description of indicator, tools used to measure indicator, advantages and disadvantages, and usefulness. Appendix J also contains planning-level cost information[17] for implementing the various indicator monitoring efforts.

Table 7.1 Stormwater Indicator Profile Categories

Indicator Category	Indicator Name
Water Quality Indicators	• Water quality pollutant constituent monitoring • Human health criteria
Physical and Hydrological Indicators	• Stream widening/downcutting • Physical habitat monitoring • Increased flooding frequency
Biological Indicators	• Macroinvertebrate and fish assemblage
Social Indicators	• Public attitude surveys • Public involvement and monitoring • User perception
Site Indicators	• BMP performance monitoring

Water Quality Pollutant Constituent Monitoring

Water quality monitoring has traditionally focused on examination of chemical parameters such as nutrients and metals, and physical parameters such as pH and temperature. Stormwater monitoring usually requires collection of water samples from stormwater facilities, conveyance channels, stormwater outfalls, and receiving waters during storm events. Evaluation of the parameters is conducted in the laboratory (e.g., for chemical parameters) or in the field (e.g., pH and temperature). Monitoring results may be used to assess current water quality conditions at a specific location; evaluate changes in water quality throughout different seasons or over a period of years; or identify longitudinal or spatial trends in water quality along a stream.

Building on the detailed water quality and flow data collection effort at the Englesby Brook gaging

[17] It is important to note that the indicator costs are planning-level estimates and are not all-encompassing. There are several different methodologies that can be used to perform indicator monitoring, and implementation costs can vary significantly. The cost information is taken from the Center's 1996 publication, "Environmental Indicators to Assess Stormwater Control Programs and Practices,"and is based on a broad regional survey. Where appropriate, adjustments to cost estimates may be necessary to reflect Burlington and Vermont specific conditions.

station installed by the City and USGS, it will be possible to perform supplemental monitoring to assess the effectiveness of implemented retrofit, stream rehabilitation, and pollution prevention projects. For example, the gage record provides an estimate of the total pollutant load generated in the watershed and should help to refine the pollutant load modeling that has initially been performed as part of this watershed restoration plan.

Human Health Criteria

Bacteria (usually fecal coliform, *Escherichia coli*, or *enterococci)* are often used as indicators of human pathogens in the water column. Large bacteria concentrations are assumed to be indicative of harmful levels of pathogens. Pathogens are of special concern in recreational contact waters. Water quality criteria for these uses are among the strictest of all water use classifications. When bacteria levels exceed established standards, beaches typically close, such as the case with Blanchard Beach.

Because bacteria concentrations tend to sharply increase following storm events, it is strongly suspected that stormwater runoff contributes significantly to elevated bacteria levels. A change in the frequency of standard exceedances, therefore, can provide an early indication of improvement and may be used to assess the effectiveness of stormwater management programs.

To date, a small scale reconnaissance survey has been conducted in the Englesby Brook watershed to try to target bacteria sources in wet and dry weather flows. This effort has narrowed a likely major source area to the Shelburne Road corridor and will be continued in an attempt to remove possible illicit connections. Continued wet and dry weather sampling at the established locations as well as new trouble shooting locations should be continued by DPW on a fairly regular basis (e.g., quarterly dry weather sampling and four to eight wet weather samples per year). Lake measurements near Blanchard Beach also should be collected periodically, particularly within 24 hours of significant storm events (i.e., >0.5").

Stream Widening/Downcutting

The change in stream geometry is measured over time to determine the extent of channel widening/downcutting in response to changes in the magnitude and frequency of stormflows. Stream channel and bank erosion can be documented by measuring channel cross-sections at monumented locations, by measuring channel bankfull width and depth of representative reaches or by measuring the percent of channel-bank scour within specified channel reach lengths.

A preliminary baseline assessment of channel geometry was conducted as part of the Phase I work (see Section 2.1). Follow-up assessment, including the establishment of monumented cross-sections would strengthen the existing database and provide a more reliable and repeatable measure of channel degradation or aggradation. These data should not be considered essential, but rather useful indicator data that can be used in conjunction with less intensive data collection efforts such as the physical habitat monitoring. It may be possible to take advantage of UVM research graduates in the establishing and surveying of cross-sections.

Physical Habitat Monitoring
Physical habitat evaluations are conducted to determine the potential of waterbodies to sustain aquatically healthy systems. Degradation is evaluated to assess whether or not habitat or water quality is the limiting factor to aquatic biodiversity. Specific measurements of streams include channel stability, channel cover, instream sediment embeddedness and substrate condition, riffle, run, pool structure, and riparian habitat.

As stated above, a preliminary baseline assessment of the stream physical condition was conducted as part of the Phase I work. Quantitative scoring was established at approximately 400-foot intervals, which provides a continuous assessment along the length of stream. This assessment is easily repeatable and provides a useful basis for comparison with past surveys and to reference stream conditions. Repeating the assessment in five years to document changes in the watershed condition is recommended.

Increased Flooding Frequency
The number and magnitude of flooding events (in response to rainfall or snowmelt) for a particular location or specific stream segment is documented and compared with the relative changes in land use or improvements in stormwater management. For example, the gage record should help to document the impact of flow reduction strategies (e.g., upstream detention, disconnection of directly connected impervious areas, etc.). The amount of debris and obstructions identified and documented for a given stream reach also provides an indirect measure of flooding potential. Obstructions are identified through stream channel reconnaissance assessments.

Since the Englesby Brook watershed has been largely developed for several decades or more, the intent of this indicator monitoring recommendation is not to suggest that sophisticated flood gaging equipment be purchased and installed at multiple locations. Rather, the monitoring would be quite informal and simply measure the frequency with which citizen or business complaints are reported with respect to flooding issues. Emphasis on the monitoring would be on areas that have historically been subject to nuisance flooding, such as South Prospect Street. It would be presumed that an absence of flooding in areas that historically have flooded (for a given storm frequency) would suggest that the implemented upstream management measures were effective at some level of flood mitigation.

Macroinvertebrate and Fish Assemblage
Benthic macroinvertebrates and fish are used to evaluate the aquatic health of waterbodies. Several metrics (e.g. richness, diversity, ratio of sensitive to tolerant species, abundance, etc.) are used to assess the relative health of a given system. Aquatic systems are usually compared to a reference condition which is defined as the natural or "least impacted" habitat of a particular region.

An advantage of using this indicator on Englesby Brook is that the State of Vermont Agency of Natural Resources already has a well established biological monitoring program in place and has previously sampled macroinvertebrate and fish assemblages in Englesby Brook, thereby providing an existing baseline database. With an assessment protocol in place and the likelihood of State staffing, this indicator monitoring is one of the most economical and beneficial. It is recommended that DPW request and encourage ANR to continue with the sampling program on either an annual or bi-annual frequency after implementation of some of the Keystone Recommendations.

Public Attitude Surveys, Public Involvement and Monitoring, and User Perception

While most social indicators have limited effectiveness (see Table 7.2) due to their dynamic complexity and challenging goals, they are nevertheless critical indicators from the standpoint of educating and communicating with the public. Furthermore, social indicators are a necessity to achieve one of the Englesby Brook Watershed Restoration Project goals: "Increase local awareness and expand it beyond Englesby Brook."

Public attitude surveys are directed at targeted groups to assess general awareness of key water quality problems and willingness to finance (via government spending) restoration efforts. A targeted group is solicited with a direct mailout, an interview or other mechanism of communication to gather information regarding an existing or potential program. The results of a survey are usually compiled into a summary report which may, for example, indicate that the public believes urban runoff to be the most significant source of pollution in the watershed or that funding for restoration efforts should be increased. This information can then be used by decision makers in helping to formulate watershed management policy, develop restoration budgets and workplans, or implement stream restoration programs.

Public participation in stormwater programs is one measure of overall program effectiveness. Successful implementation of stormwater programs depends, in large part, upon the active support and participation of the public. Citizen monitoring programs, watershed stewardship groups, public education (including school curricula), participation in watershed education events (e.g., Green Up Day) are all components of public involvement programs. Other measures of public participation include participation in household hazardous waste recycling efforts, number of calls made to report illegal dumping into the storm sewer system or streams, and membership in citizen advisory groups.

Successful stormwater management efforts also depend on public support. Public support, in turn, depends upon its valuation of water resources. The public's valuation of a particular water body is usually based on more than water chemistry. Appearance, surroundings, ease of access, and apparent water quality are all considered by the average user. Being aware and understanding the public concerns and perceptions is an important, yet challenging, component in watershed restoration. Knowing who the staunchest advocates and critics are can go a long way towards being able to implement various programs and restoration measures.

The type and frequency of monitoring of public behavior and awareness can vary. Informal monitoring can occur by assessing attendance and interest at annual functions such as Green Up Day and other environmental awareness initiatives. More formal resident surveys also have a role, and are recommended after about one year of the institution of a major public education campaign (e.g., pet waste and lawn care education). Questions in the survey should target whether the individuals are aware of the campaign, whether it has had impact on their behavior, and what recommendations they have to improve the message.

BMP Performance Monitoring

Stormwater BMPs are specifically designed to reduce pollutant loadings into natural water bodies. The evaluation of BMP performance can provide a more accurate assessment of pollutant removal capability. BMP effectiveness is evaluated based on stormwater sampling of the mass and concentration of pollutants into and out of the facility. Alternatively, biological and/or physical indicators can be evaluated upstream and downstream of a facility to aid in assessing effectiveness of a specific practice or series of practices.

Performance monitoring can be expensive, but often times federal monies or grant dollars are available to pursue these efforts. With the detailed concept drawings of five significant structural stormwater treatment practices that have been prepared as part of Phase II of this project, there will be good opportunities to pursue performance monitoring of some of these facilities once they are constructed.

A recommended site for future monitoring is SM5 (Burlington Country Club wet pond), as this facility is the last in a fairly long treatment train (UVM ponds, swales and wetlands on the golf course property, and multiple ponds on the golf course). Another site that would be instructive to monitor is SM6 (proposed shallow marsh wetland that replaces compost filter). The monitoring data could be directly compared with monitoring data from the compost filter to determine if a meaningful improvement in treatment has been achieved.

7.2 Framework for Using Indicators

Identification of appropriate stormwater indicators for monitoring programs should be conducted within a framework based upon regional and watershed-specific considerations. Several "tools" can be used over a broad range of physical, chemical, and biological conditions to measure environmental indicators including:

- Watershed Simulation Modeling
- Geographic Information Systems (GIS)
- Comparison to Reference Conditions
- Photographic Records

Watershed simulation modeling can include pollutant load, hydrologic, and hydraulic assessment. Modeling efforts can cover a broad range of complexity and can be extremely expensive and data intensive efforts. For this project, the Center approach was to avoid the use of complex models and focus more on "on-the-ground" implementation of management measures. Instead, the Center used a fairly simple spreadsheet model (see Section 2.2) to provide an estimate of pollutant loads generated from specific land uses within the watershed and to provide a preliminary indication of potential load reductions that could be realized with stormwater management measures in place. In addition, limited, site-specific hydrologic and hydraulic analyses were conducted in association with stormwater retrofit conceptual designs. Future modeling efforts may be useful to determine the effectiveness of restoration efforts, and with the USGS gage data, there is at least one source of reliable calibration data available.

Geographic Information Systems are used to assemble and compile watershed characteristics and other information into a graphical and/or tabular format for assessment of various conditions. GIS and watershed simulation modeling can be used in combination to calculate various land use/BMP combinations and their impacts on downstream water quality. The City of Burlington currently has a GIS with much useful data in it. However, the utility of the system from a watershed management perspective can be enhanced with input of updated information and more detailed information such as infrastructure specifics (e.g., pipe size, material, age, invert and rim elevations, etc.).

Reference conditions are used to establish a benchmark for assessing existing conditions or to measure trends in conditions. The combination of the Phase I tasks of this project (physical stream assessments, pollutant load analysis, channel geometry assessment) and the ANR macroinvertebrate and fish reference stations in the region, provides a significant set of reference conditions to measure against and assess program effectiveness. In most cases, these reference conditions are easily repeatable.

Photographic and video records can be used to document many different indicators, but are perhaps most suited to assessing changes in physical conditions. The use of digital cameras to document conditions can be integrated with GIS watershed mapping to convey this information to a wide range of potential viewers. This type of documentation is particularly important from the public perception and education perspective.

7.3 Crafting an Indicator Monitoring Program - A Methodology

When selected correctly, stormwater indicators can assess the long-term effectiveness of stormwater management programs as well as provide required baseline data. Many of the initial steps that should be pursued in an indicator monitoring program have largely been accomplished as part of this Watershed Management Plan (Phase I). These steps include defining watershed restoration goals, assessing baseline conditions, identifying receiving water impacts, and development of management approach and priorities. The methodology for assessing watershed restoration efforts and the effectiveness of a stormwater indicator monitoring program is outlined in Figure 7.1. The last step in Figure 7.1 is worth emphasizing and has been raised previously in this report. Namely, it is critical to view the watershed restoration plan and stormwater indicator program as dynamic and evolving entities. As improved and updated data are collected and analyzed, management priorities and implementation focus may shift. This flexibility will be critical to the overall success of the restoration efforts.

ï DEFINE MANAGEMENT FRAMEWORK

Determine who will be responsible for implementation (e.g., Burlington DPW)

Can this program be developed and implemented on a watershed-wide or basin basis (e.g., teaming opportunities with Lake Champlain Committee)?

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ð INVENTORY PRIOR AND ONGOING EFFORTS

Identify what programs and studies have already been implemented in the watershed (e.g., Englesby Brook Watershed Restoration Plan, ANR biomonitoring data, USGS gage data).

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ñ INVENTORY RESOURCES AND IDENTIFY CONSTRAINTS

Determine manpower and funding limitations.

Identify regulatory-mandated deadlines and programs

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ò DEVELOP AND IMPLEMENT INDICATOR MONITORING PROGRAM

Based on goals, program structure, resources and constraints, select indicators to be used to assess success of stormwater management program. Level II indicators will likely be more quantitative in comparison to Level I techniques. Quantitative analysis is required to identify pollutant sources and assess success of program.

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ó ASSESS INDICATOR RESULTS

Analyze indicator monitoring results.

What do the monitoring results indicate about the success of the stormwater management program? Have the indicators accurately reflected the effectiveness of the management program? What do the indicators suggest about the ability of the stormwater indicator monitoring program to measure overall watershed health?

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ô RE-EVALUATE WATERSHED RESTORATION PLAN AND MONITORING PROGRAM

Re-evaluate resources and constraints.

Update (if necessary) assessment of baseline conditions.

Review and revise program goals.

Review and revise indicator monitoring program.

Implement revised management program

Figure 7.1 Watershed Restoration and Stormwater Indicator Effectiveness Assessment Methodology

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